The British Sundial Society

BULLETIN

VOLUME 27(iii)
September 2015

BSS Bulletin 27(iii)
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A SHORT CHECKLIST FOR AUTHORS

The editorial team welcomes contributions to the *Bulletin* on the subject of sundials and gnomonics. They may be articles, photographs, drawings, designs, poems, stories, comments, Reader's Letters, notes, reports, reviews.

Authors of *Bulletin* articles are encouraged to read the following notes.

Layout Matters

- Have you looked at recent articles to help you follow usual *Bulletin* style?
- Are the title lines (Title and Author's name) centred and in upper-case bold letters?
- Does the author's email address appear at the end of the article, right-aligned and in italics
- Have you followed *Bulletin* style in setting out References?

Figures

- Have you sent the Figures as separate email attachments? Please don't use Dropbox.
- Does each associated file title include the Figure number?
- Are all the Figures referred to in the text in numerical order?
- Have you provided a list of captions? Are they at the end of the file containing the text, in italics?
- Have you included any illustrations that are not your own? If so, then you **must** obtain permission to use them and should acknowledge the source in the caption, expressed as directed by the copyright holder.

Readability

- Have you asked someone else to check the clarity and grammar of your article?.

Please send material to *editor@sundialsoc.org.uk*

The full Guidelines for Contributors were printed in the June 2015 issue of the *Bulletin*.

Front cover: *The new dial (SRN 7637) at the Nature in Art Museum, Twigworth, Gloucestershire, installed for the 25th anniversary of the Museum's opening. See page 30 for Ben Jones's account of its design and construction. Photo: ` Sarah George, Nature in Art.*

Back cover: *Newly restored and painted pillar dial (SRN 7613), a memorial to Cecil Hopkinson in the Ascension Parish Burial Ground, Cambridge. Ian Butson tells the story of Cecil Hopkinson and his family, and describes the restoration of the memorial and its sundial, on page 34. Photo: Frank King.*

Editorial team: John Davis, Frank King and Christine Northeast

Printed by The Lavenham Press Ltd, Lavenham 01787 247436

BULLETIN

OF THE BRITISH SUNDIAL SOCIETY

ISSN 0958-4315

VOLUME 27(iii) - September 2015

CONTENTS

EDITORIAL

The editorial team has received gentle hints that the formal Guidelines for authors (most recently printed on the inside front cover of the March 2015 *Bulletin*) are not read with great enthusiasm! Accordingly, we have prepared the short Check List that appears on the inside front cover of the current issue and we hope that our contributors will find this helpful.

The editorial team continues to welcome articles on any subject relating to sundials. We are also interested in receiving short items that will fit into a spare corner of a page. A photograph of a dial taken on your summer holiday with a line or two of explanation will serve very well.

Our current star helpers who have been editing articles for us are Mike Cowham, John Lester and Mike Shaw. Additionally, we owe considerable thanks to Fiona Vincent who has kindly proof-read recent issues. We should very much like to hear from more members who have previous experience checking the text of others.

Familiar Faces in Victoria, BC

Three UK BSS members gave talks at the recent NASS Conference in Canada. Here they are, together with NASS President Fred Sawyer. Further details will feature in the December *Bulletin*.

Left to right: Frank King, Doug Bateman, Jackie Jones and Fred Sawyer.

THE SUNDIAL HERM AT ANCIENT MESSENE, GREECE

ANDREAS GALANAKIS and MARTIN JENKINS

Some friends of ours recently returned from one of their many trips to Greece and its numerous islands. Like all of our friends, they have been 'conditioned' to look out for sundials and to make sure that they take photographs for us. In the olden days of photography, friends were reluctant to use valuable film for what they considered to be 'trivia' but the advent of digital photography has resulted in a change of attitude so that we now receive lots of pictures of sundials but of course very little information about their discovery! Such was the case with the sundial that is the subject of this article. We had lovely photographs of it but scant information about the dial itself, its exact location at Messene, or the reason for it being there.

Martin Jenkins

Background History

Ancient Messene is a UNESCO World Heritage Site of great importance. The city lies in a fertile valley approximately in the centre of the Regional Unit of Messenia, south of Mount Ithome.

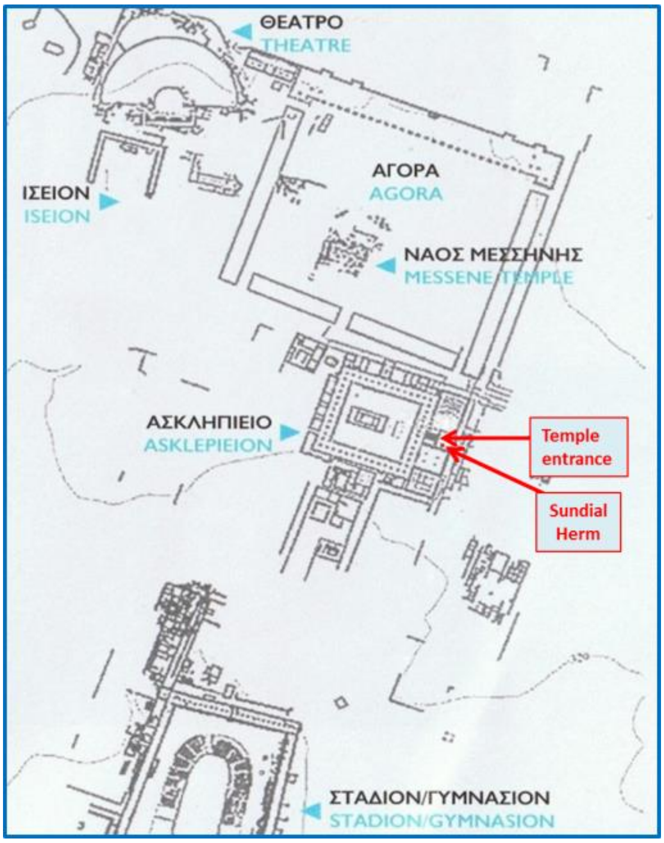

Fig. 1. Plan of part of the Messene complex.

Fig. 2. View of the Asklepieion (top right) taken from the Theatre location. Photo: Beryl and Pete Hill.

Fig. 3. Sundial and column. Photo: Beryl and Pete Hill.

Fig. 4. Information plaque. Photo: Beryl and Pete Hill.

Fig. 5. Hour plate detail, shadow indicating just before noon. Photo: Beryl and Pete Hill.

Fig. 6. Side view of the dial showing the gnomon design and hour plate angle. Photo: Beryl and Pete Hill.

It was the strongest natural, and man-made, fortress of Messenia, controlling the valleys of Stenyclaros to the north and Makaria to the south. The city was founded in 369 BC by the Theban general Epaminondas after the Battle of Leuctra in 371 BC, which resulted in Spartan defeat and the establishment of the Theban Hegemony.

The city became the capital of the free Messenian state following a period of about four centuries of occupation of the Messenian territory by the Spartans. In size, form, and preservation Messene is one of the most important cities of antiquity. It contains not only religious and public buildings, but also imposing fortifications, houses and funerary monuments. Strong fortification walls with towers and gates are preserved along a boundary of 9.5 km surrounding the city and Mount Ithome, within which the sanctuaries of Zeus Ithomatas (9th to 8th century BC), Artemis Limnatis and Eileithyia (3rd to 2nd century BC) stood. The extensive complex of the Asklepieion (3rd to 2nd century BC) and the Doric sanctuary of Asklepios are remarkably intact. Luxurious Roman villas with mosaic floors complete the urban plan, while a multitude of inscriptions shed light on the historical events that took place during the period of Alexander's successors, the Macedonian Kingdom, the Achaean League, the Koinon of the Arcadians and the Aetolians, and Roman interference in Greek affairs. Statues, vessels and other moveable artefacts are on display at the nearby Archaeological Museum, testifying to the thriving society of Messene.[1]

The Sundial

The sundial is situated in the Asklepieion, part of the temple and theatre complex (Fig. 1). It is located in the top right-hand corner in the distant photographic view of the Asklepieion (Fig. 2). The sundial is mounted on top of a tall square-section stone column (Fig. 3), on one side of which is mounted a plaque providing information regarding the type, location, and maker of the sundial (Fig. 4). Martin's initial thoughts about the sundial were along the following lines:

"The plaque states that the sundial is of the equatorial type but to my eye, on first inspection, the sundial appeared to be more of the form of a polar sundial utilizing a plate gnomon and, from the shadow projections, facing in the wrong direction (Fig. 5)! However, on closer analysis of the photographs, several interesting features of the sundial emerged. The latitude is given as 37° 10′ 31″ but measuring from the photographs gives the sundial plate angle relative to the horizontal as 53°, that is, the co-latitude (Fig. 6). In addition, the shadows in the photographs indicate that the hour plate is leaning towards the south and therefore it is the top edge of the gnomon which forms the style and the highest point the nodus. Cleverly, this arrangement thereby provides hour angle lines more akin to a vertical sundial rather than the equal hour lines of a conventional equatorial sundial or the progressive hour line spacing of a conventional polar sundial. The sundial is undoubtedly intriguing in concept and a very nice piece of workmanship, beautiful in its simplicity and execution. The hour numbering is unique in using a series of dots accompanied by clear half- and quarter-hour lines. I think that the significance of the five mark points incised on the sundial plate to the right of the gnomon is to indicate the summer solstice."

The Maker

The information plaque provides the name of the maker as Andreas Galanakis, so Martin decided to do an Internet search to see whether any information about the sundial and its maker was available. The search revealed that Andreas is a sculptor. He was born in Piraeus and studied economics in Thessalonica from 1974 to 1978. From 1979 to 1989 he worked as a set constructor and designer for German and Greek television companies. In 1985 he started making objects and artistic sculptures using aluminium alloy material. He has since held many exhibitions of his work, and has published various articles relating to furniture design, and art and design. For the past few years he has concentrated on sculptured sundials and in 2007 held an exhibition of eleven sundials in Palaio Faliro. He lives and works in Faliron and is an active member of the Greek Chamber of Arts.

The search also revealed that he had a website[2] so Martin decided to contact him as there were several questions that he wanted to ask about the sundial. Martin wanted to know why the sundial is located at that particular place on such an important archaeological site. He also wanted to establish why the sundial and abacus are not aligned with the plinth, column, and capital, which surely would be more pleasing to the eye.

Andreas and Martin have now corresponded regularly. In addition to answering Martin's questions, Andreas has provided substantial further information about the sundial and consented to producing this joint article for the BSS *Bulletin*.

During their collaboration Martin realised that Andreas was co-author on a previous article in the *Bulletin* about equatorial sundials.[3]

History, Thinking, and Location

Andreas has named the sundial at Messene 'Sundial Herm', and provides the following to support his reasoning for a sundial at Messene and its name of Sundial Herm:

Vitruvius, in his work *De Architectura*, advocated that:

"*for every architect to build a house the basic tool would be a sundial*."

However, when building a temple, as well as a sundial, a need for greater means arises, in this case the building details should also be determined by the priests; which orientation would be proper for the temple, let the god be Apollo, Aphrodite, or Athena; when were the festivities celebrating the patron god or goddess held so that the godly statue would be illuminated by sun rays; and furthermore, towards which constellations would the temple be directed?

In addition, Porphyry in his work *De Antro Nyphaeum,* 3, 23 states:

"*In addition to these things likewise, this is admirable, that the cave should have a twofold entrance; one made for the descent of men, but the other for the ascent of Gods. And again that the gate, which is pervious by men, should be said to be turned against the north wind, but the portal of the Gods to the south; and why the poet did not rather make use of the west and the east for this purpose, since nearly all temples have their statues and entrances turned towards the east; but those who enter them look towards the west, when standing with their faces turned towards the statues they honour and worship the Gods…*"

Andreas' love of sundials is constrained to their function as pieces of art, which aspire not just to inform, although they comprise a typical case of a measuring instrument, but also to identify and raise questions. In addition, any work of art must be in unison with the place where it is intended to be installed and not put in a museum just for exhibition. The idea of installing a sundial at an archaeological site had been dwelling in his mind for a considerable period of time. To win approval for such an idea the sundial would have to be specific to that place, but how could he achieve his ambition as no-one had ever requested such a piece of artwork and no-one would be likely to want to sponsor it? He would probably have to finance it himself. Although a beautiful concept, it would require official permission at the highest level to add a modern artefact to an ancient monument; it was undeniably a challenge! However, if he could obtain approval for such an idea it was an endeavour that would provide a chance to create a thread to connect present and past at a long-standing Greek cultural heritage monument. Additionally, there were other positives to support the general idea. Visitors would have a sundial as a reference point to meet and start their exploration of the site. They would also be able to see the actual solar time of the place, in the same way as the Greeks measured and visualized their time. More important though, they would try to understand the reason for the orientation of the monuments they were about to see and would be equipped to investigate the varying shades of light on the monuments during the solstices and equinoxes. From what is known from historical documents, the orientation of monuments was not chosen at random but towards the cardinal points and towards specific star constellations.

Why was Ancient Messene chosen for the site of a sundial in preference to other Greek archaeological sites of importance? At the idea stage, Andreas communicated with Mr Stavros Ioanis Benos, the president of Diazoma, a society whose focus is ancient theatres, with the aim of enhancing them, finding funding for them and, wherever feasible, including these monuments in daily life.

Fig. 7. Hermaic column with bust atop. Photo: Andreas Galanakis.

A few days later, however, Mr Benos contacted Andreas and said that a contact of his, Professor Petros Themelis, showed a keen interest in the idea of a suitable sundial at an ancient site. Professor Themelis is a retired professor of archaeology who from 1986 directed the excavation of ancient Messene for the Archaeological Society and subsequently directed the restoration project of the site for the Greek Ministry of Culture. In 2005, Professor Themelis received the Commander of the Order of the Phoenix from the Greek President Konstantinos Stephanopoulos for his outstanding work. A discussion between Andreas and Professor Themelis followed at the site of Ancient Messene, leading to an outline agreement for the idea. Hence the dial at Messene!

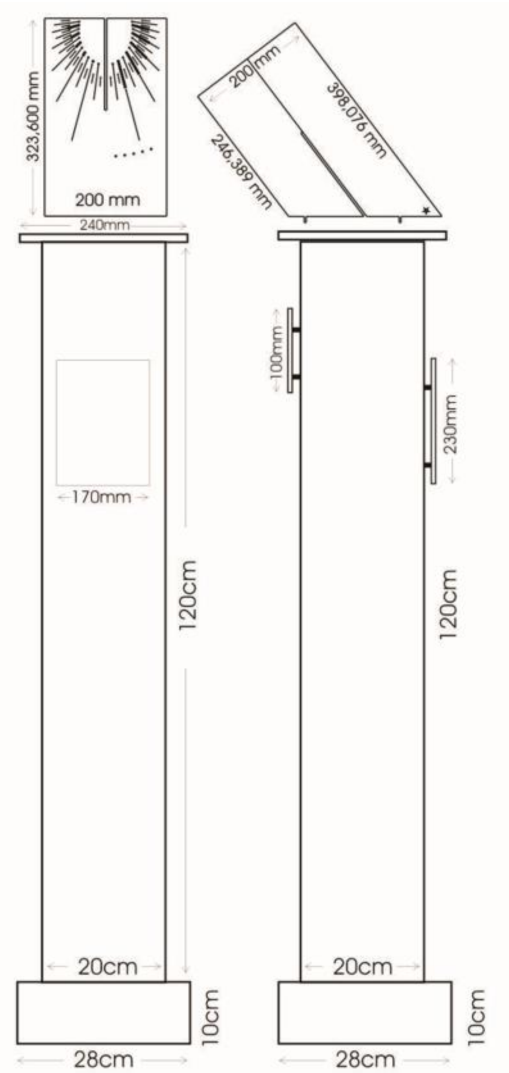

Fig. 8. Dimensional drawing of the Sundial Herm (drawn by Andreas Galanakis).

Andreas returned home with much to think about! To gain approval for a modern artefact to be incorporated into an ancient site, certain criteria would have to be met. The proposed sundial would have to be in harmony with the environment. It should inform but not be dominating and it should fit in with the legacy of ancient Hermaic columns, hence the name Sundial Herm. It should fit in with its ancient origins yet clearly be a modern addition. Technical parameters that would need to be taken into account were the type of sundial to be erected, its shape, the construction material, the size, the hour plate design and style of hour line and time notation, and the sundial base design. Although Andreas had given much thought to the overall project idea beforehand, details had not at this time been specified but from his experience of other projects it is the details which always end up being of paramount importance!

But why a Hermaic column sundial?

Hermaic Column

The Herm, or Hermaic column, was a local signpost reference point that also carried significant information. In ancient Attica, one could find Herms along the streets leading to different municipalities. Ipparchus had them installed to provide distance and direction information. Proverbs and symbolical expressions were also inscribed on them (Fig. 7). There were also Herms of stone in the city of Athens in the entryways and in the shrines. According to Suda's lexicon[4] on the origins of Herms,

"*they were constructed rectangular since the god Hermes was the curator of logos and truth. Truth corresponded to quadrilateral herms for should they fall they would always stand upright and be based on a meaningful basis.*"

So the Sundial Herm was to be on a column to resemble a Hermaic column, where the head of the column would be the sundial. The sundial would thus be a point of reference that would provide silent information regarding both space and time. The column would be made of stone, the same material that had been used for ancient Herms. The overall height of the column and sundial would be a little over 1.6 metres (Fig. 8).

Dial Design

The sundial is of the equatorial type; its northern side provides readings from 21 March to 23 September, its southern side readings from 23 September to 21 March. The cross-like shape consists of two bisecting perpendicular plates.

Viewed from the north the sundial's shape resembles an open book. Andreas chose the shape of a cross as it is an ageless symbol of the Hellenic civilization as well as being an axis measurement system. It marks the four cardinal horizon points to assist visitors in orientating themselves. Additionally, the shape technically favours a robust construction with one plate oriented along the meridian line forming the gnomon, whereas a rod-type gnomon would be vulnerable to damage.

To indicate the hours, Andreas did not want to employ the commonly used Hindu–Arabic numerals we use today or Roman numerals which he considers tend to denote a heavy, slow, and tiresome pace to the passing of time. On the other hand, ancient Greek numerals would restrict the time reference only to the ancient Greek past and the aesthetic outcome would lose its timelessness. The solution was to identify each hour with a corresponding number of 'through the plate' holes, a perpetual and graceful primeval numbering system, which would enable the sundial to be illuminated from the rear at night on special occasions. In addition, the equatorial attitude of the sundial plate provides for indications of the summer solstice on the north side (21 June) and the winter solstice on the south side (23 December). The five extra holes on the hour plate indicate the summer solstice; there is no shadow on the sundial plate at the equinoxes. The hour plate is made of stainless steel, sand blasted so that the shadows are clearly seen and also to avoid the modern look of shiny metal. For aesthetic reasons the hour plate dimensions and the overall Herm dimensions follow the golden ratio rule (Fig. 9).[5]

The Dial Location

Although the site of Messene was to be the agreed location for the sundial, the exact position at Messene for the Sundial Herm had not been finalized when the overall approval had been obtained. The initial thought was to place the sundial at the Messene complex entrance but after further visits Professor Themelis considered that the appropriate location for the sundial was the entrance to the Asklepieion. Up to this point in the project, however, no proper directional measurements had been taken. Andreas thought that the entrance to the Asklepieion would be facing in the direction of equatorial east with the north–south line perpendicular to the entrance, but it wasn't. In fact the entrance was orientated towards the winter solstice east. As such, the column as an axis measurement system should align with the axis of the monument, while the sundial should be in line with the north–south axis. Hence the reason that the column is set squarely on the stone slab and the sundial is rotated to face true north. This is not ideal

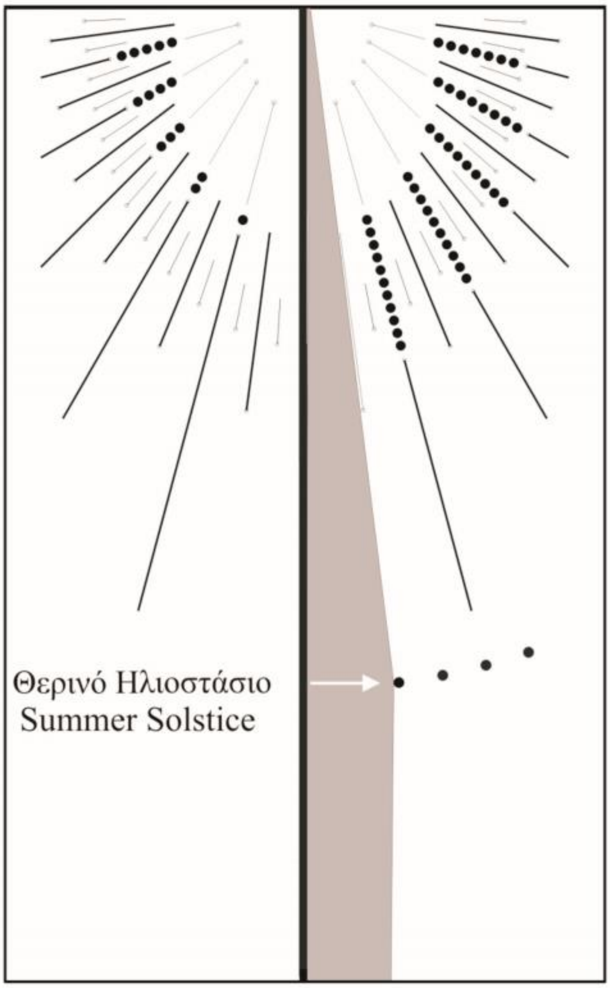

Fig. 9. Hour plate drawing indicating the summer solstice shadow (Andreas Galanakis).

aesthetically, but after all, this was one of the aims of the project: to indicate the orientation of the ancient monument with respect to the cardinal compass points. So that is why the abacus is turned relative to the capital!

The Sundial Herm was completed and erected at Messene in August 2011.

Summary

It was serendipity that from a few photographs taken by friends on holiday an interesting story unfolded about a special sundial. For a modern sundial to be located within a UNESCO ancient historical site makes it not only special but truly unique. At some point in the not too distant future, Janet and Martin plan to visit the Messene Sundial Herm and hopefully meet up with its creator, Andreas.

ACKNOWLEDGEMENTS

Martin would like to thank Beryl and Pete Hill for providing the incentive for this article by bringing back photographs of the Sundial Herm together with a pamphlet describing the site. Martin is also particularly indebted to Andreas for providing such in-depth information about his dial and for permitting him to submit this article to the BSS for publication in the *Bulletin*.

Andreas would like to thank Martin Jenkins for his contribution to the publication of the article and Michael H. Moutzourides for his help in the production of the English text.

REFERENCES and NOTES

1. UNESCO report 5859, *http://whc.unesco.org/en/tentativelists/5859/*, accessed April 2015.
2. Andreas Galanakis, *www.galanakis.gr*, accessed January 2015.
3. A. Galanakis, E. Theodossiou and V.N. Manimanis: 'An equatorial sundial with a reference to Anaximander's Skiatheron', *BSS Bulletin*, 22(iv), 22–25 (December 2010).
4. Suda on Line: Byzantine Lexicography, *www.stoa.org/sol/*, accessed January 2015.
5. The golden ratio is used to divide an object into two parts so that the ratio of the larger to the smaller part is the same as the ratio of the whole object to the larger part. Its value is the irrational number $(1+\sqrt{5})/2 = 1{\cdot}618$. The ratio often appears in architectural work as objects so designed are considered more pleasing to the eye.

Andreas Galanakis was born in Piraeus with grandparents from both sides born on the small island of Antikythera.
He has been working as a sculptor for the last 30 years. Besides art sculpture he uses mostly recycled cast aluminum, making various objects for everyday use. With regard to sundials he aspires to make his artwork pieces display an aesthetic construction and also serve as measuring instruments. In the course of undertaking projects he enjoys cooperating with technicians, machinists, mathematicians, and philologists. His interest in ancient Greek literature and language brought him in contact with the text of Diogenes Laertius, and the word 'skiothiron' (instrument hunting the shadow), which led him to become involved with sundials over the last 12 years. Andreas can be contacted at *galanakis.gr@gmail.com*

For a portrait and CV of **Martin Jenkins**, see *Bulletin* 27(i) (March 2015). He can be contacted at *sundialduo@gmail.com*

IS THIS THE WORLD'S HARDEST-TO-SEE SUNDIAL?

Shortly before setting off for the 2015 NASS conference in Canada, a friend sent me a web link to a sundial in central Vancouver.[1] Even though it is over 40 metres across, almost no-one knows about it, not least because it is on the roof of a shopping mall. Photographing this dial became an irresistible challenge! I booked a room in an adjacent hotel and, when checking in, I asked the proprietor how I could gain access. He knew nothing about the dial despite living just across the street from it. The security people in the mall said they couldn't let me onto the roof and advised a visit to the management office but no-one there would let me up either. No amount of flattery, pleading or bribery made any difference.

The shopping mall occupies almost an entire block but, in one corner, there is a high-rise building. I pressed the intercom button and talked my way inside. The concierge said that his employers wouldn't allow in uninvited visitors. I asked whether I could speak to his boss. He telephoned her and passed me the receiver. This time pleading and flattery worked and the concierge took me up in the elevator to floor 22 and then up a series of concrete steps until we were on the roof. I found my way to the north side. The parapet hardly came up to my knees so I was very careful! There, 200 feet below, was my photographic target and you can see the results of my adventure.

I claim to be the only diallist to have set eyes on this dial. It won't take readers long to see that neither the designer nor the installer merit being described as diallists!

Sundial on the roof of the International Village Shopping Mall in Vancouver, BC, Canada.

You can get superb views of this dial courtesy of Google Earth: key the coordinates 49.2803 –123.1067 into the Search box and zoom in.

Roger Bailey, Secretary of the North American Sundial Society, lives reasonably locally and is investigating whether some remedial steps might be taken.

1. *www.vancitybuzz.com/2014/02/international-village-vancouver-sundial/*

Frank King

THE MAGNETIC AZIMUTH DIAL

MIKE COWHAM

Many portable sundials incorporate a magnetic compass. Commonly, such dials have a polar-oriented gnomon which may be in the form of a folding plate or a length of string. To read the time, the dial is first set up on a horizontal surface and, by checking the compass, the user ensures that the gnomon is correctly orientated. Of course, due allowance has to be made for the local magnetic declination. Once the dial is set up, the position where the shadow of the gnomon falls indicates the time. This is exactly as for a typical fixed dial; if the dial is left alone the shadow tracks the time.

Fig. 1. A magnetic azimuth dial set with the shadow of its lid directly over its base. This dial is by Nicolas Crucefix of Dieppe and was made around 1650.

A magnetic azimuth dial is used in a quite different way. The compass needle itself indicates the time. Given that the compass needle always points in the same direction, this requires a little explanation. The dial shown in Figs 1 and 2 (by the little-known maker, Nicolas Crucefix of Dieppe) serves as an illustration. This is a typical magnetic azimuth dial and is made with a horizontal elliptical silvered chapter ring. There are no hour lines, only hour points which are marked by prominent dots above the hour numerals.

The dial has a hinged lid and, to read the time, the entire instrument is rotated so that the shadow of the lid falls directly over its base (Fig. 1). This aligns the axis of the dial with the sun so, at noon, the lid is on the south side. (With a standard diptych dial the lid is to the north.) The *south* end of the compass needle then indicates the time on the hour scale.

As the sun moves across the sky, the dial has to be turned clockwise so, relative to the dial, the compass needle moves anti-clockwise which explains why the hour numbers are arranged in that sense. Assuming that the magnetic declination is zero, the south end of the needle correctly tracks the time.

Fig. 2. The usual form of magnetic azimuth dial has a moving chapter ring. When closed, its dimensions are 59 × 48 × 15 mm.

The azimuth of the sun at a given time of day varies with the time of year. To deal with this, this dial operates in much the same way as a conventional analemmatic dial. This is why the hour points lie in an ellipse but, instead of a fixed dial with a moveable index (such as a human gnomon), the chapter ring as a whole is moved relative to the pivot point of the compass.

On the underside of the dial there is a calendar disc and hidden on its reverse is a circular groove, offset from the centre, in which a pin, fixed beneath the chapter ring, runs. The user selects the date on the calendar disc and the ring is

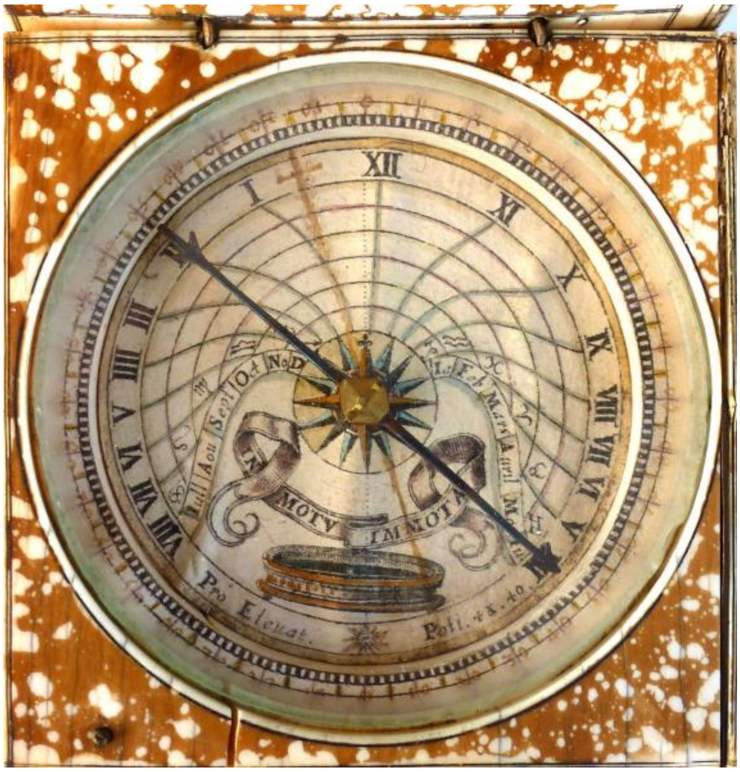

Fig. 3. An early magnetic azimuth dial made by Charles Bloud of Dieppe that may be dated by its magnetic declination to around 1640. When closed, its dimensions are 76 × 59 × 15 mm.

thereby moved to the correct position for that day. The 12 noon hour point is relatively close to the compass pivot point in summer and relatively distant from it in winter.

Most magnetic azimuth dials of the type shown in Figs 1 and 2 were made in Dieppe, nearly all from ivory. (The mottled pattern on the ivory surfaces is a rather uncommon decoration found on just a few of these dials.) Most authors believe that this type of dial was first made by Charles Bloud around 1660. At that time the magnetic declination in the area was conveniently around zero. In due course, other makers in Dieppe produced similar dials.

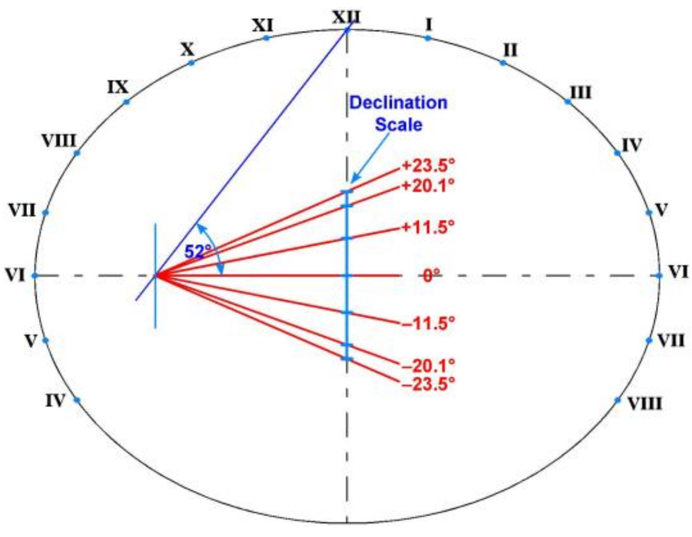

Fig. 4. Preparing the sun's declination scale.

A different type of magnetic azimuth dial was sold by Christie's in Paris a few years back (Fig. 3). It was signed by Charles Bloud but it probably predates those normally found by 10 or even 20 years. It can be roughly dated by its magnetic declination which is about 4° east as indicated by the fine dotted line just to the left of the noon line.[1]

As with the dial in Fig. 1, this instrument has to be aligned so that the shadow of its lid falls over its base.

Instead of having the usual moveable chapter ring, the dial has fixed and equally spaced concentric Zodiac date circles; the time is read from where the compass needle crosses the circle for the current date. At the summer solstice the compass needle, as shown in Fig. 3, would indicate a time about 2 pm. At the winter solstice the needle would indicate a time about 4 pm.

With zero magnetic declination, the compass is an ideal hour pointer. In the Bloud dial, the whole layout is rotated by 4°, thus allowing the compass needle to indicate the time correctly. The dial in Fig. 2 is also slightly rotated, so that too dates from before 1660.

How were the hour lines of the Bloud dial produced? This intrigued me, and I set about trying to replicate the calibration on my computer using a simple drawing program. This time the dial was to be made for my own latitude of 52°. I proceeded much as I would for designing a human analemmatic dial. See Fig. 4. First I drew a circle with 24 equally spaced hour points around its periphery. This was then squashed so that the vertical dimension was sin 52° (0.788) of the horizontal dimension. The declination scale was then constructed as explained by Mayall and Mayall in their book *Sundials*.[2]

Next, from each of the seven points on the declination scale I noted the 17 directions to the 17 hour points.

To construct the dial, an outer circular scale (corresponding to the summer solstice) was drawn with six other concentric circles inside; see the seven circular arcs drawn with heavier lines in Fig. 5. Each circle represents a date, here being the entry into each Zodiac sign. These circles were equally spaced as shown in the figure.

On each circle, (up to) 17 hour points can be marked simply by noting the direction to each point from the centre as determined from Fig. 4.

Through each set of hour points, a curved hour line was drawn from the innermost circle to the outermost circle. The ends of the circular arcs show times of sunrise and sunset; these times are taken from tables by Waugh[3] for 52°. This layout replicates fairly exactly the scale in Fig. 3 by Bloud.

Later, extra date circles were added to subdivide each Zodiac division into three so that the months could be labelled. The half-hour lines were also added.

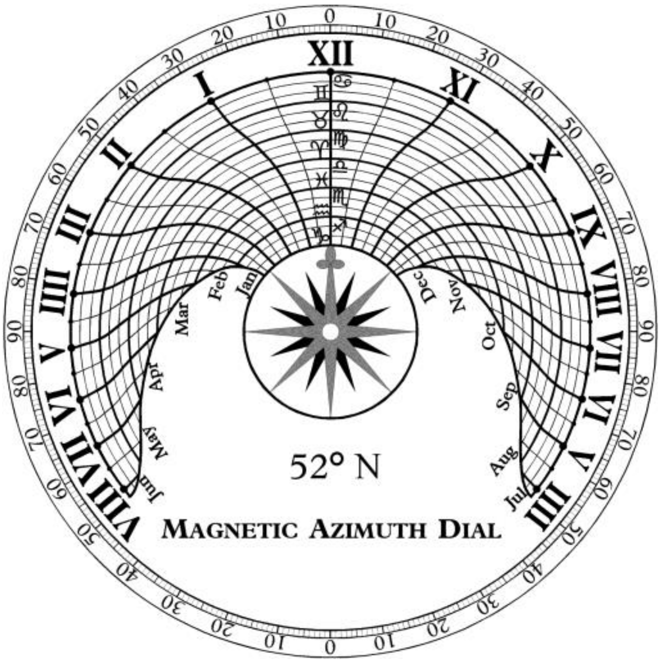

Fig. 5. Construction of a dial for 52° North.

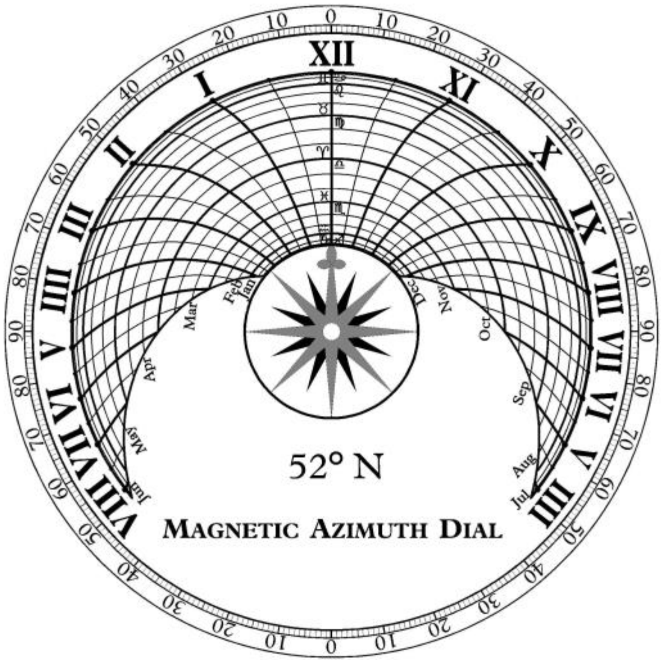

Fig. 6. The version with a non-linear date scale.

The finished dial was tested with a small portable magnetic compass set at its centre. Generally the results were quite accurate but, when done inside the windows of my house, the compass was often wildly out of line, probably due to metal frames etc. I even tried it on the floor and the results were seriously wrong, then I remembered that our concrete floor was built on a heavy steel mesh! The best results were obtained in our garden, some distance away from the house.

An alternative version was tried using date circles in a non-linear format (Fig. 6). Its hour lines were now shaped as a single curve but this idea was rejected as the linear form with S-shaped hour lines was simpler to use owing to its equal date increments.

The hour-line spacings on the dials in Figs 3, 5 and 6 give the summer hours a much larger spread than the winter ones, so a different approach was tried. This involved reversing the calendar markings. The result is shown in Fig. 7 where the summer and winter hours are now spread more equally. This layout also allows the dial to be made smaller, if desired, by making its outline a rectangle.

A working model was made (Fig. 8). A printout of the dial was stuck to some stiff card and a small pin, as a gnomon, was added in the 'XII' position. The shadow of the pin falling along the 12 noon hour line takes the role of the shadow of the lid of one of the Dieppe dials. In order to extend the line of the compass needle, a transparent circular plastic sheet, with a blue radial line marked on it, was placed under the compass. The compass was then glued to the plastic sheet and aligned so that the blue line extended outwards from the 'S' on the compass card.

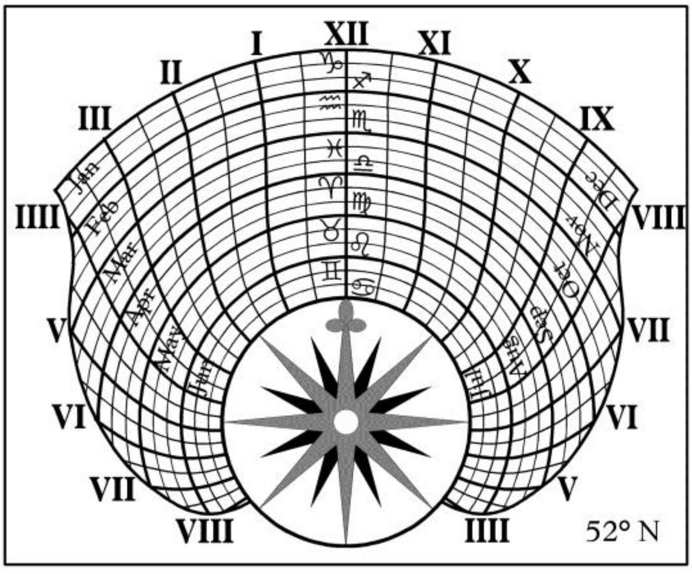

Fig. 7. Dial layout with reversed date lines and cropped to fit a rectangular plate. The compass will sit in the centre.

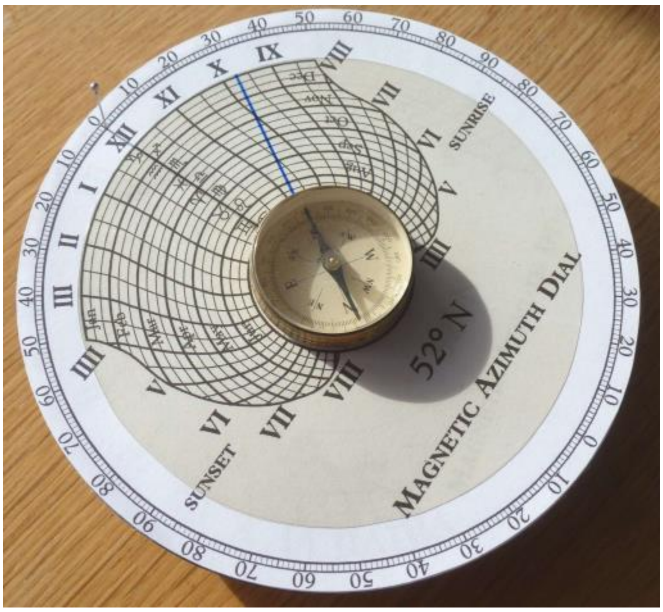

Fig. 8. The finished model, now with reversed date lines.

Fig. 9. Magnetic azimuth dial by Walter Hayes. The dial is 140 mm diameter.

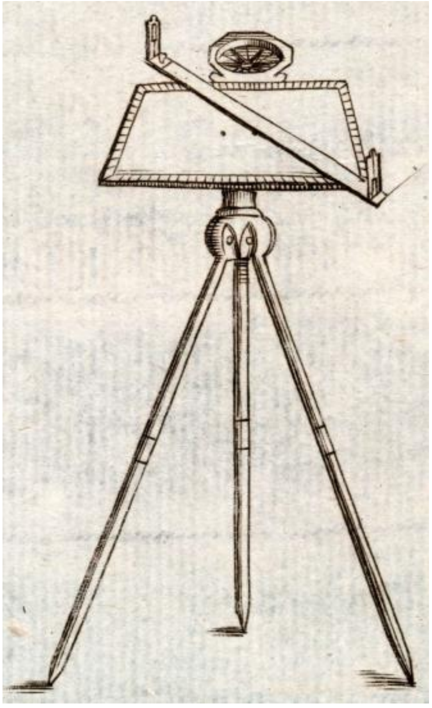

Fig. 10. The plane-table compass fitted at the far side of the board.[5]

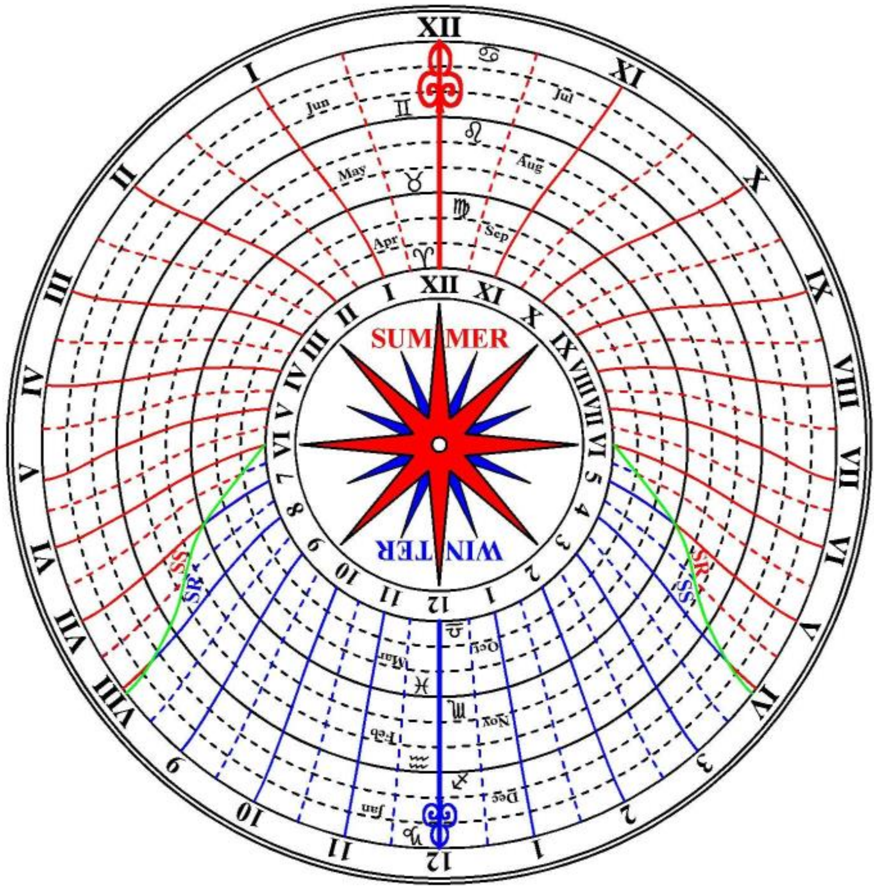

Fig. 11. Layout of the Walter Hayes dial with equally spaced date lines.

When reading the time, the compass case with its transparent disc is turned so that the south end of the needle falls on the 'S' on the compass card. The blue line thereby extends the south point of the compass.

Fig. 8 shows the arrangement assuming zero magnetic declination. If the declination is not zero, the compass should be attached to the plastic sheet with the blue line offset appropriately from the north–south axis of the compass card. The compass case is still turned so that the south end of the needle falls on the 'S' of the compass card, the blue line indicating true south.

Another way to accommodate the local magnetic declination would be to indicate the declination with a dotted line, as in Fig. 3, and place the gnomon pin on the extension of that line. Whenever the time is read, the instrument is rotated until the shadow of the pin falls on the dotted line. The blue line should not be offset from the north–south axis of the compass card.

A different type of magnetic azimuth dial was produced by several makers. The one in Fig. 9 was made by '*Walter Hayes in Moore Fields, London*' and is dated *1663*. It is actually the design of Henry Sutton, and Hayes uses his printing plate, now with his name applied.[4] Its main use is as a compass for surveying purposes, but it has a magnetic azimuth dial at its centre, the time again being read from the compass needle. The instrument is designed to be fitted to a plane table, the tongue on the right fitting into a slot in the main board. This may then be aligned with the sun. In Fig. 10, as illustrated in Bion's book,[5] it is seen mounted at the back of the plane table (in some books, such as Bion's, it is called a Plain-Table).

Its azimuth dial calibrations, however, are somewhat different from those already described. Basically, the dial has been split into two, having the summer months on one side of the scale and winter on the other. Therefore, in use, the section of the dial appropriate to the season is held towards the sun. The compass needle then tells the time on the appropriate scale, using the north end for one half of the year and the south end for the other. Interestingly, with this layout, the sunrise and sunset lines merge for both seasons. Note also that the whole area of the disc is used for the dial markings.

Fig. 11 shows the layout modified using equally spaced date lines, each Zodiac sign being divided into three so that the months can be added. The green lines show the sunrise and sunset lines.

Advantages of the Magnetic Azimuth Dial

As a portable dial it clearly shows the time.

If the sky is overcast then, as long as the sun can be seen through cloud, the dial may be aligned to this point and the time may be found.

If an event happens and the sun's position can be remembered, such as just above a certain tree, the dial may be used at any time later to check when that event actually happened. Similarly, if the sun's position is required, perhaps for a party in the garden, where trees or buildings may put the tables in the shade, the dial will also tell this information.

These dials will also easily show times for sunrise and sunset for any day of the year.

Disadvantages of the Magnetic Azimuth Dial

As with any instrument that employs a compass, the compass may need damping in order to get quick readings. A liquid-filled compass may be better.

The compass must not be used in the vicinity of any magnetic force, such as close to a steel frame. Even screws and nails, such as occur in windowsills, can cause substantial errors if the dial is placed there.

If made with a pin gnomon, it will be very fragile and may easily be bent.

An article on a fixed form of the azimuth dial will follow in the next issue of the *Bulletin*.

NOTES and REFERENCES

1. The faint sword-shaped red line in Fig. 3 is a later addition to the dial. It was possibly drawn to attend to a local magnetic declination of about 16º west (this was applicable in Paris around 1740). At 12 noon, the axis of the instrument and Bloud's dotted line are aligned north–south. The south end of the compass needle will fall on the red line which is then offset by 16º to the west. This red line is much less useful at other times of day.
2. R.N. Mayall and M.W. Mayall: *Sundials, how to know, use and make them.* Sky Publishing, Cambridge, Mass., 2nd ed. (1973).
3. A.E. Waugh: *Sundials, their theory and construction.* Dover, New York (1973).
4. M. Cowham: 'An interesting compass by Walter Hayes', *Bulletin of the Scientific Instrument Society*, 81, 8–9 (June 2004).
5. N. Bion (transl. E. Stone): *The Construction and Principal Uses of Mathematical Instruments*, London (1758).

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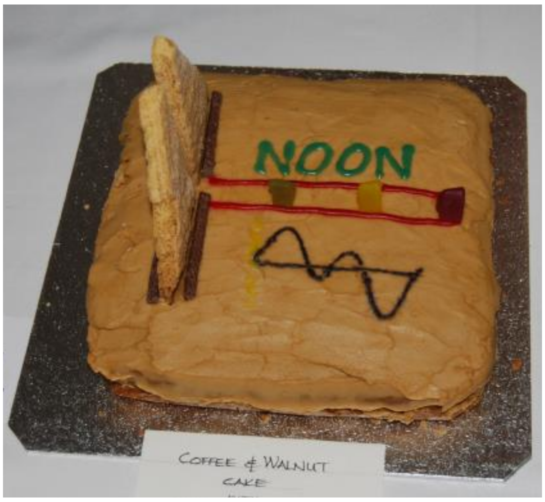
CAKES FROM THE 2015 CONFERENCE

"I'm no good at telling the right time, but I can tell you when to have a cake". By Pauline and Mike Faraday.



Noon dial cake by David and Susan Hawker.

Photos: Chris Lusby Taylor

ARTISTIC IMAGES OF SUNDIALS

VALERY DMITRIEV

"People, lions, eagles and partridges ..."
Anton Chekhov "The Seagull"

On the one side, a sundial is an astronomical instrument for measuring time, on the other side, an element of urban or landscape architecture, being part of the surrounding space. Obviously, sundials modify the surrounding space. The perception of changed space and the perception of the element that changed this space are always figuratively associated with the image of this element.

Any sundial is the symbol and the image of Time. However, in some sundials a variety of decorative art elements (symbols and images) are presented that are not directly related with time. What artistic images are the most popular in sundials? That is the question to which I should like to find the answer. In some ways, this is the answer to the question, "What are the most popular sundials?"

Decorative Sundials

Let us place all sundials into two classes:

- Sundials with artistic décor in any part of the sundial, its gnomon, dial plate or pedestal: call them 'Decorative Sundials'.
- Sundials without artistic décor: call them 'Functional Sundials'.

Sundials of the first group are the subject of this article. Let us do a statistical study to ascertain the proportion of sundials in the two above-mentioned groups. This and all other statistical evaluations in this article were made on the basis of data obtained from the profusely illustrated book edited by Mike Cowham entitled *Sundials of the British Isles*.[1] My study has used the data given of 339 sundials in urban and landscape architecture: 232 vertical sundials, 70 horizontal sundials and 37 sundials of other types from Saxon times up to 2005. Stained glass, painted glass and portable sundials were not included.

Fig. 1. A small piece of the world of Decorative Sundials.[2]

Of the 339 sundials used in this study, sundials with obvious artistic décor, 'Decorative Sundials', form 48% (163 sundials) of the total. So, approximately one half of the sundials used in this analysis have some artistic decoration. For all sundials, apparently, the number of decorative sundials is much less than half, as the source that was used describes the most interesting British sundials, being "A selection of some of the finest sundials from our Islands". Perhaps the ratio of sundials between these two types corresponds to the Pareto principle, that is, 20/80.

Artistic Images of Decorative Sundials

The World of Sundials, including decorative sundials, creates a small part of our big world. Images of the big world are inevitably reflected in the small world of decorative sundials (Fig. 1). What artistic images can be found and which are the most popular among decorative sundials?

Any classification is arbitrary and subjective, but in this study assumptions are required. We will focus on images of the four basic elements, which are: Earth, Water, Air and Fire. Let us take them as a basis and then add some more elements: God, Sun and Man. This makes seven images in total; the unintentionally obtained number is nevertheless symbolic. In the Russian philosophy of images, Earth is a symbol of faith, Water symbolizes hope, Air symbolizes love and Fire is a symbol of transformation (conversion). Man is a symbol of mind, the Sun a symbol of knowledge.

Earth. The first group consists of sundials that include images of the Earth's firm ground and all that grows and lives in it, such as flowers, trees, animals, and so on. All of this can be real or allegorical. It is one of the most popular types of décor, especially for classic sundials. The Earth's globe is represented in armillary spheres and the so-called 'globe dials'.

Water. Sundials of the second group contain images or symbols of water: the sea, rivers, lakes and their inhabitants, such as fish, marine animals, both real and fictional. It is not a very popular decorative element of sundials.

Air. The third group consists of sundials that contain images not quite of the air or the atmosphere, but its elements, and inhabitants such as clouds, butterflies and birds (real or imaginary). It is a rare type of décor for sundials.

Fire. The fourth group of sundials contains an image of fire and all that it transforms, sometimes irreversibly, such as destruction or death. Fire is a very rare decorative element in sundials.

God. The fifth group consists of sundials containing images of gods, angels, devils and demons. These are a special class of creatures from a mythical or non-manifested world. The gods of time and war, sea and so on, angels and seraphim, are more frequent symbols in sundials. Devils and demons appear extremely rarely in sundials, pre-sumably because of their general unpopularity.

Sun. The sixth group of sundials includes images of the Sun. It also includes images of the planets and the stars of the solar system. Unsurprisingly, the Sun is one of the most popular decorative symbols used in sundials.

Man. The seventh group of sundials presents the image of man, the creator, owner of the mind and soul. It is both of existing real persons and fictional, including historical personages, literary characters, or collective images. This group also includes images of man-made objects, such as ships, aircraft and so on. It is a popular decorative image used for sundials.

Now let us switch from qualitative to quantitative descriptions. We can do some statistical analysis of Decorative Sundials and define what art images are the ones most often present in sundials. The distribution (popularity rating) of sundials in the seven groups of artistic images for the 339 sundials in the study is shown in Fig. 2. The fact that the overall sum (54% + 28% + 19% + 12% + 8% + 5% + 1% = 127%) exceeds 100% is due to several different artistic images being present in some sundials.

The quantitative estimates obtained show that more than half of the Decorative Sundials in the present study have symbols (images) of the Earth and almost one-third of the Sun: these two images are the most widespread and therefore the most traditional. It is sufficient to recall the large number of sundials with floral decoration on a gnomon, floral and sun-related decorations on the dial plate and symbolic floral ornaments on the pedestal. These are a classic component of sundials.

The middle part of the bar chart of artistic images relates to Man and God.

The remaining three groups of images are far less popular. There are some images of Water and Air in sundials, but Fire is seldom represented.

Curiously, the four main (most popular) artistic images (Earth, Sun, Man and God) compared with the four basic

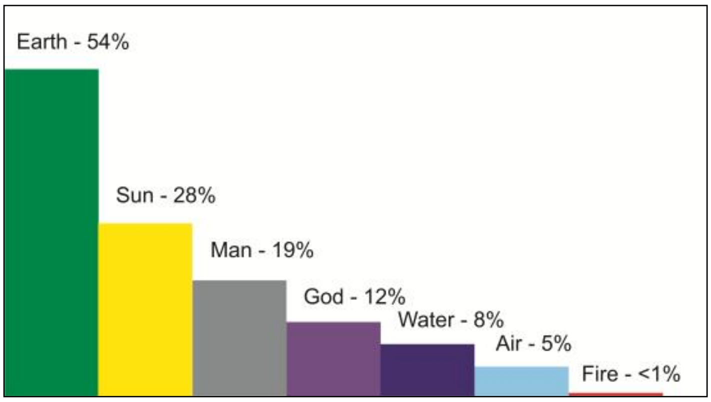


Fig. 2. Distribution (popularity rating) of Decorative Sundials in the seven groups of artistic images.

elements (Earth, Water, Air and Fire) have only one common element, Earth.

Why have we got such a distribution? What is the reason for the popularity of some images and the unpopularity of others? Frankly, I do not have a clear and precise answer to these questions. Apparently, these are human preferences and sympathies, fears and dislikes. Of course, they are the preferences of those who are designing or commissioning the making of sundials.

Analysis of influencing factors, among which are the different periods of time (historical periods of development of sundials as utilitarian and design objects), traditions, religious and national motifs, type of sundial and other aspects is a quite complicated and interesting problem. For such analysis we need more information and it is beyond the scope of this study. However, for me it is important to define, or at least estimate, whether there is a significant difference between the popularity of various artistic images in old and modern decorative sundials.

For this analysis, all the decorative sundials were divided into two groups. These were relatively 'old' (98 sundials) made before the end of the 19th century, and 'modern' (65 sundials), made between the early 20th century and 2005. The results of this analysis are shown in Figs 3 and 4. I do not presume to comment in detail on these results, although it is impossible not to notice that the ratings of 'old' and 'modern' sundials show one important feature: in general, although the characteristics of the images in both rankings are similar, 'modern' sundials have a much lower percentage of images of God. Evidently it is the fashion of our modern times.

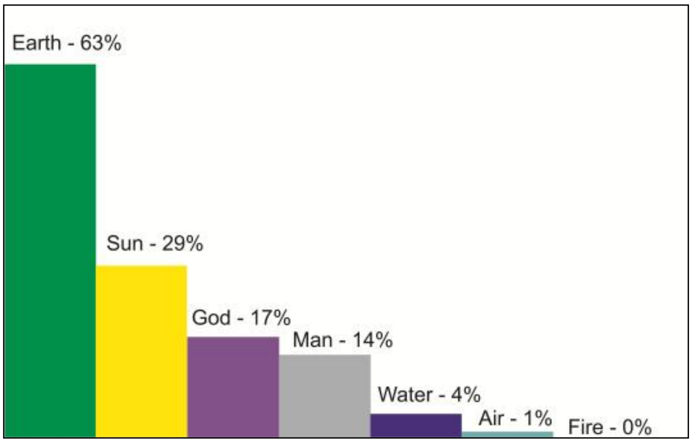


Fig. 3. Distribution (popularity rating) of 'old' Decorative Sundials in the seven groups of artistic images.

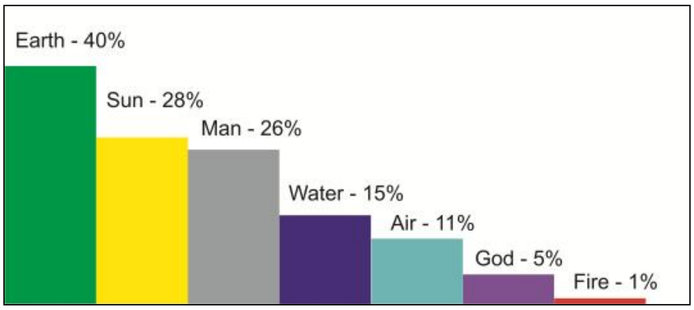


Fig. 4. Distribution (popularity rating) of 'modern' Decorative Sundials in the seven groups of artistic images.

Fig. 5. A piece of the world of Artistic Sundials.[3]

Artistic Sundials

Within the class of Decorative Sundials there are sundials whose décor is an integral part of the functional sundial, and these bear the operational load of the time-keeping device. In this type of sundial, unlike conventional Decorative Sundials, decorative items cannot be removed without loss of functional properties of the sundial. Functionality of this type of sundial is 'hidden' or 'secondary' from the visual perspective. We can say that in terms of visual perception such a sundial is primarily an art object, and secondarily, a sundial. The best examples of such sundials are a rare 'fusion' of the science and the art of sundials.

We call these sundials 'Artistic Sundials' (Fig. 5). Just a few Decorative Sundials (<4%) are sundials of this type.

Classifying Artistic Sundials in terms of the popularity of their included artistic image is unproductive since sundials of this type are extremely rare. The only factor that can be noted is that in the main these sundials do not have the traditional artistic images of decorative sundials. Apparently, this is due to the overall unconventional artistic solutions.

In conclusion, I would like to say that the use of popular artistic images as well as the complexity and originality of artistic decisions, in my opinion, are not always the determinants of successful decorative sundials. Although harmony of the artistic image of the sundial is a subjective category, it seems to me that this is the only characteristic

Fig. 6. Sundial "The Little Prince", by Valery Dmitriev.

that defines its artistic appeal. Simpler and brighter is expressed by the Little Prince: *"Voici mon secret. Il est très simple: on ne voit bien qu'avec le coeur. L'essentiel est invisible pour les yeux".* (Here is my secret. It is very simple: one sees clearly only with the heart. The essential is invisible to the eyes.)

ACKNOWLEDGEMENTS

I should like to thank the following for the photographs and for help in preparing this article: Mike Cowham (MC), Martins Gills (MG), Douglas Bateman (DB) and Larry Magnier (LM).

REFERENCES and NOTES

1. M. Cowham (Ed.): *Sundials of the British Isles*, Cambridge (2005).
2. The individual photographs were provided by the following.
   Top row, all MC.
   Middle row, left to right: MC, MG, MC, DB.
   Bottom row, left to right: MG, MG, MG, MC.
3. Photos by (left to right): MC, LM, MC.

Valery Dmitriev is an engineer who has spent 35 years working on the design and manufacture of equipment and control systems used in oilfield exploration. Since 2007 he has made around 40 sundials in Russia, mostly in St Petersburg. He has been a member of the BSS since 2008 and is interested in the study and restoration of historic (particularly 18th-century) sundials in St Petersburg. He enjoys teaching children and adults about sundials. He can be contacted at *sundials_spb@mail.ru*

ALAN COOK

Alan Cook, who died in March 2015, made a considerable contribution to the work of the Mass Dial Group. He compiled the complete Register for Yorkshire, and decided that accurately drawn diagrams would be an aid to identification. He lived in Copmanthorpe, not far from York, at the centre of OS square SE and his survey was published by the Society in 2000 as Monograph 3 *Mass Dials on Yorkshire Churches*.

Subsequently he visited all the medieval churches in Yorkshire's three ridings (now four regions) and produced Monograph 9 *Addendum to Mass Dials on Yorkshire Churches* in 2011.

It was not until later, following the death of Edward Martin, that it was discovered that Alan had, in fact, taken photographs of all the dials and reported them fully to Edward. At present the two monographs are regarded as part of the Mass Dial Register; the photographs and reported details will be published as County listings in due course.

Alan was an engineer at Ferrybridge power station. He came with his wife, Margaret, to the Southwell, Nottingham, mass dial safari in 1999, and is shown in the photograph at Upton Hall, Newark, headquarters of the British Horological Institute, explaining a Benoy dial (SRN 4074) to fellow members.

Tony Wood

THE SHETLAND ISLANDS – REPORTING ON BRITAIN'S MOST NORTHERLY SUNDIAL

DOUGLAS BATEMAN

This dial (Figs 1 and 2), adjacent to the Esha Ness Lighthouse, 60° 29.3′ N, 1° 37.6′ W, was 'found' on a shore excursion of the Shetland Islands, during a cruise to the Faroes to observe the eclipse of the sun on 20 March 2015. The most striking features are the steep angle of the gnomon and the elegant fluted cast iron pedestal. Sundials were common features of lighthouses, generally their only means of determining the time. A panel adjacent to the lighthouse gave much biographical and other information, stating that the lighthouse was constructed in 1929 by David A. Stevenson. The light is owned and operated by the Northern Lighthouse Board who are based in Edinburgh. It was automated in 1974 and its character is flashing white every 12 seconds. As the purpose of my cruise was to observe the eclipse, it was interesting to have confirmation from the Northern Lighthouse Board that the Esha Ness optic switched off as normal at 07:17 on the morning of 20 March then switched on at 09:41 for 8 minutes, switching off again at 09:49.

David Alan Stevenson was a member of the well-known Stevenson family of lighthouse builders, started by Robert Stevenson (1772–1850) who built the famous Bell Rock Lighthouse in the North Sea for vessels plying between the Firths of Tay and Forth, and 16 others. His son David (1815–86), with his brothers Alan and Thomas, designed a further 46 lighthouses, in places such as Muckle Flugga and the Butt of Lewis. Next in the dynasty was David's son

Fig. 1. The Esha Ness dial in the Shetland Islands on a cast iron pedestal, newly registered SRN 7704.

Fig. 2. The lighthouse above the 45 metre high cliffs.

David Alan (1854–1938) who with his brother Charles Alexander was responsible for a further 91 lights, of which 21 were traditional lighthouses, including Esha Ness.[1]

The iron pedestals of many Scottish lighthouse sundials are very distinctive and I am indebted to the Registrar, John Foad, for the following with similar pedestals: Cape Wrath (SRN 4211; lighthouse by Robert Stevenson, 1828), Turnberry (SRN 7142; David Stevenson, 1873) and Islay (SRN 7626; Robert Stevenson, 1825). Lighthouse sundials get a mention in the *Bulletin* 11(i) (February 1999), page 49, where M.J. Kenn passed on a photograph from the *Scotsman* newspaper of 18 September 1997. This showed 15 dials for sale, all with 'open' gnomon shape (Figs 4 and 5). A more informative letter by D. Scott-Kestin in the *Bulletin* 97.2 (April 1997), pages 57–58, mentions three lighthouse sundials in the Museum of Scottish Lighthouses in Fraserburgh and that "They were usually mounted on a

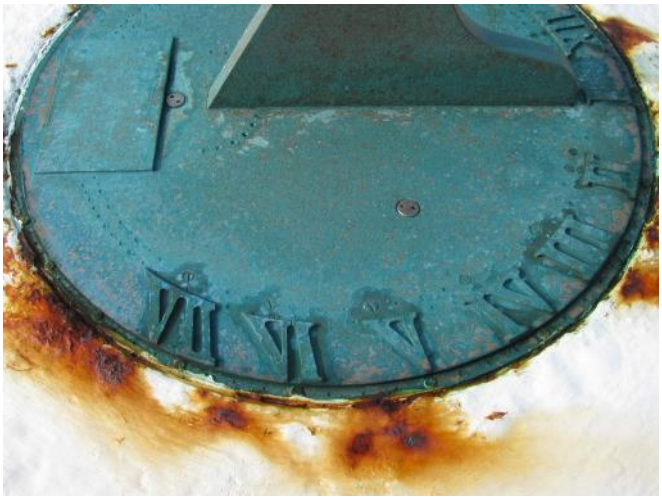


Fig. 3. The hour numerals are laid out for summer time and the intervals are 15 minutes. The dial appears to be in two layers, and any detail on the small panel is no longer visible.

stone or cast iron column and placed behind the principal keeper's cottage". The then editor, Margaret Stanier, added a note and an illustration very similar to the Esha Ness pedestal. The illustration is for the Dunnet Head dial, the most northerly mainland dial, and "There is a similar dial at the nearby port of Scrabster, both being on cast iron columns, and pretty weather-worn from being in such exposed positions."

Concerning the Esha Ness dial itself, it looks as if a second plate (Fig. 3) has been added. It has the unusual detail of numerals in relief, there are small screw heads adjacent to each set of numerals, and the very handsome gnomon is non-standard compared with other Scottish lighthouse dials.

Fig. 4. The well maintained dial at Sumburgh Head. Photo: John Mackenzie.

Fig. 5. The Sumburgh Head dial plate, polished to advantage for visitors! Note the design of the gnomon and the sturdy method of attachment, typical of Scottish lighthouse dials. Photo: John Mackenzie.

The dials mentioned above that appeared for sale have much more engraved detail, almost certainly with watch-faster and watch-slower scales.

As always, follow-up enquiries with the Shetland Amenity Trust yielded more useful information. It transpired that the American author, Sharma Krauskopf, who has written many books on lighthouses, purchased the Esha Ness lighthouse in 1999 and lived there for a number of years. John Mackenzie of the Amenity Trust found that Ms Krauskopf did indeed have a new dial made, presumably because the original dial had become badly corroded. To supplement this article, Mr Mackenzie supplied the two fine images of the dial and pedestal at the Sumburgh Head lighthouse (Figs 4 and 5). The least I can do, in return for the favour, is to mention that these two lighthouses, and one at Bressay, are available as holiday accommodation, as per *www.shetlandlighthouse.com*.

ACKNOWLEDGEMENT

Thanks to Lorna Hunter of the Northern Lighthouse Board for additional information on Scotland's lighthouses including the detail that the Esha Ness light came on when the eclipse darkened the sky! More background material can be found at *www.nlb.org.uk*.

NOTE

1. The number of lighthouses attributed to each member of the Stevenson family differs according to various sources. The figures in this section were supplied by Lorna Hunter of the Northern Lighthouse Board.

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IN THE FOOTSTEPS OF THOMAS ROSS

Part 12: A Foray into England

DENNIS COWAN

What, Thomas Ross identified sundials in England? Well yes he did. Actually no he didn't. Well he did, sort of.

He did identify and provide sketches of two dials in Berwick-upon-Tweed, which changed hands between Scotland and England more than a dozen times. But although Berwick has been in English hands since 1482, there have been many anomalies since then.

Even though Berwick-upon-Tweed is now in England, the county of Berwickshire, until its dissolution in 1975, was in Scotland. Many organisations in Scotland that were in the old county of Berwickshire still have Berwickshire in their names, such as the *Berwickshire News*, the Berwickshire Housing Association and the Berwickshire Sports Council.

Indeed both Berwick's football and rugby teams play within their respective Scottish systems and not in England. It is nearer to Edinburgh than to the nearest city in England and many people believe that Berwick should rightly be in Scotland. It appears that Thomas Ross was one of them. As recently as 2008, the Scottish National Party made calls in the Scottish Parliament for Berwick to become part of Scotland again.

We may find in the future that not only Berwick, but the whole of Northumberland, will join Scotland in the new United Kingdom of Scotland and Northumberland. The capital of course will be Edinburgh and the name of the country will probably be shortened to Scotland!

In volume 5 of *The Castellated and Domestic Architecture of Scotland* [1] of 1892 Thomas Ross described the dial on Berwick Parish Church as follows:

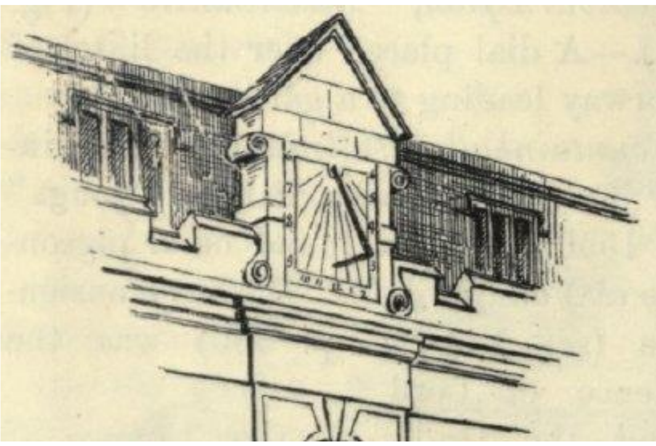

Fig. 1. Ross's sketch of the dial at Berwick Parish Church.

Fig. 2. The dial at the renamed Holy Trinity Church in Berwick today.

"*This fine dial* [Fig. 1] *forms the termination of the south aisle wall of the nave, immediately over the compartment of the third window from the west end. The face of the dial is of a white stone and measures about 4 feet 8 inches square; the width across, including the frame, is about 5 feet 10 inches; and the height to the apex of the gablet is about 8 feet 2 inches. The gnomon is of iron, and projects 2 feet 4 inches. The church was erected in 1652.*"

That last sentence is interesting. It was one of the very few churches to be built in England during the Commonwealth of Oliver Cromwell.

Now known as Holy Trinity Church, the dial is very much as it was in Ross's day (Fig. 2) although it was restored around 1991. However, it does not have the appearance of white stone as described by Ross. It is a direct south-facing dial mounted high above the south doorway of the church. It has Arabic numerals from 6 am to 6 pm with a simple open gnomon.

Next we move on to the Old Bridge that crosses the River Tweed at Berwick. Ross says:

"*The dial here, shown by a plan and elevation* [Fig. 3]*, is similar to the one just described at Ayr. It is placed on the down-stream parapet, in a recess over the first pier from the Berwick side. The bridge dates from 1624, and the dial, it is believed, was put up about the beginning of this century; but whether it replaced an older one or was then quite new does not appear to be known.*"

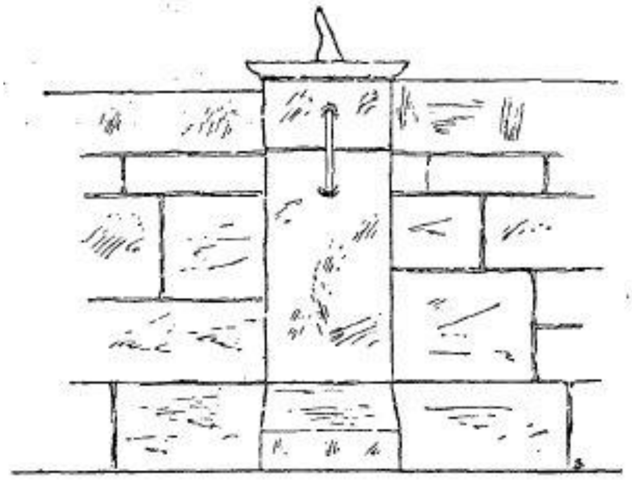

Fig. 3. Ross's drawing of the dial on the Old Bridge in Berwick.

Fig. 4. The modern dial on the Old Bridge.

When Ross stated that the dial was put up about the beginning of "this century", he was of course referring to the 19th century. The dial that is in this position now is not the dial from Ross's day. The story goes that in 1953, a salmon fisherman tied his net to the sundial. It was evidently pulled into the river. It must have been a large salmon! The current dial, according to a plaque fixed to the pillar, was restored at the behest of Ruth Lister of Berwick-upon-Tweed in 1995. It is a simple circular metal dial about 8 inches in diameter with Roman numerals from 5 am to 7 pm, but with no hour lines (Fig. 4). The gnomon is in the shape of a sail, but its angle is not correct for the latitude of Berwick. It should be 55° 47′ N whereas the gnomon is set at somewhat less than that.

Did Ross actually visit Berwick though? Probably not, as he thanks a Mr W.D. Purves for procuring drawings of these two dials. However, he did consider them to be ancient sundials of Scotland.

Apparently Berwick is at war with Russia. As Berwick changed hands between Scotland and England several times, it was often regarded as a separate entity. Some proclamations referred to England, Scotland and the town of Berwick-upon-Tweed. One such was the declaration of the Crimean War against Russia in 1853. When the peace treaty was eventually signed, Berwick-upon-Tweed was left out. Accordingly, Berwick is still at war with Russia. When the London correspondent of *Pravda* visited Berwick in 1966, a mutual declaration of peace was made with the Mayor of Berwick. The Mayor said "Please tell the Russian people through your newspaper that they can sleep peacefully in their beds".

Is it a true story? I don't know, but it's a good one.

REFERENCE

1. D. MacGibbon and T. Ross: *The Castellated and Domestic Architecture of Scotland,* David Douglas, Edinburgh (1892).

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WHO WERE THE MAKERS OF THESE ATTRACTIVE 'FLOWER' DIALS?

MIKE COWHAM

Many attractive diptych dials such as the ones shown in Figs 1–3 are beautifully decorated with flowers or sometimes animals. They have been seen in several museums and collections. Most people have assumed that they were made in Nuremberg, probably because this was the main site in Europe for making ivory dials. However, these dials bear few common features with those from Nuremberg and I believe that they probably came from Austria.

Austrian? Flower Dials, c. 1720

These are quite small ivory dials typically measuring, when closed, about 47 × 30 × 10 mm (1·85 × 1·2 × 0·39 inches). Measurements of the hour lines on these dials place them at a latitude of about 46·6° N and the magnetic declination of their compasses can date them to around 1720. Their origin, which *may be* from Austria, is only a guess and they could originate from anywhere on the 46·6° latitude, or close to it, from France, through Switzerland, Austria and even into Hungary. However, one feature that suggests a

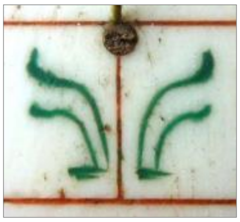
Figs 1–3. Small ivory diptych dials decorated with flowers, possibly from Austria.

Germanic origin is the style of the numeral '2' which is in the form of a 'Z' with sharp corners.

There are two distinct types known, possibly from different makers but probably made in the same workshop. That illustrated in Figs 1 and 4 has a line border around the flower both on the lid and on the inside. The others have no borders.

Figs 4–6. Decoration on the lids of the dials shown in Figs 1–3.

Most of the dials have another flower or an animal on the lid, usually a deer, but sometimes a dog (Figs 4–6). On the inside of the lid there is nearly always a red flower. Two other interesting features are to be seen on many of these dials. They are the plant-like patterns, of four leaves, just south of the compass (Fig. 7) and the numerals, 'I', which frequently have dots over them (Fig. 8). The dial in Fig. 1, with the border around the flower, lacks the plant pattern and the dots over the numeral 'I', and its maker may therefore be different from that of the other two.



Common features found on many of these dials:
Fig. 7. Plant-like emblem (red or green) as in Figs 2 and 3.
Fig. 8. 'I' numerals with dots over as in Figs 2 and 3.

From their small size and decorative features I believe that these dials were made for ladies. They are attractive and small enough to be carried in a bag. Owing to their size they would not be particularly accurate and with their flower decoration they are not really the type of dial that a gentleman would want to carry. Note also that they usually consist of only one horizontal dial, not having another on the vertical face as most other diptychs do. However, one of these dials is known with a vertical dial as well but this still has a flower at its centre, albeit somewhat smaller.

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ANALYSIS OF A ROMAN PORTABLE DIAL

FRANK H. KING

The instrument shown in Fig. 1 is in the Museum of the History of Science in the University of Oxford[1] and is a fine example of a Roman portable sundial. Of the several authors who have written about it, three are of particular note: Rene Rohr,[2] Michael Wright[3] and Stephen Johnston.[4] Rohr gives a good introduction but without any analysis. Wright provides a historical account as well as a mathematical treatment. Johnston alone derives the simple relationship between indicated hour and solar altitude. It is noted below that the same relationship governs the operation of the horary quadrant.

Fig. 1. A Roman portable sundial. Photo by permission of the Museum of the History of Science, University of Oxford. MHS inv. 51358.

The present article introduces a novel construction which makes reasoning about the instrument very straightforward.

It is shown that, although there are scales for setting the latitude and the current solar declination, it is not strictly necessary to know either. Also, the instrument is much more universal than its designer seems to have appreciated.

Dial Components

The dial features an inner disc which sits in a recess in an outer disc whose external diameter is 61 mm. This is suspended by a length of cord. The most important component is the gnomon assembly, which includes the gnomon proper and a scale which incorporates engraved lines; these are hour lines that indicate unequal hours. An unequal hour is one-twelfth of the daylight period.

Simple Example – Measuring Solar Altitude

The gnomon assembly can be swivelled about a horizontal axis which runs through the centres of the discs. The schematic diagram in Fig. 2 shows the gnomon assembly in profile and arranged so that it is vertical.

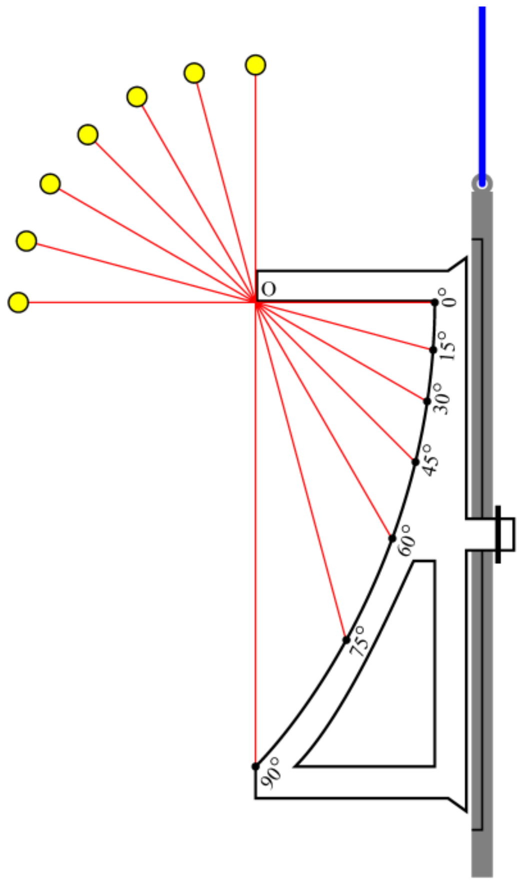

Fig. 2. The gnomon assembly seen in profile.

The gnomon is the finger at the top and O marks the edge between its two most important faces. The discs are assumed to be much heavier than the gnomon assembly so that, when the instrument is hanging freely from the blue cord, the discs (seen in cross-section) are vertical.

Dots mark the positions of the engraved hour lines on the curved surface and these dots are provisionally labelled with angles at 15° intervals ranging from 0° to 90°. The lines on the instrument itself are not labelled.

The instrument is classed as an altitude dial. It determines the unequal hour from the solar altitude. When the gnomon assembly is set as in Fig. 2, the instrument can measure solar altitude directly. The user first checks that the instrument is hanging vertically and then follows this golden rule:

Ensure that the sun is in the plane of the gnomon assembly.

The user has to twist the suspension cord so that the sun shines equally on the two cheeks of the gnomon assembly. The shadow of the edge of the gnomon at point O will then fall on the curved surface and, by interpolating between the two nearest dots, the user can determine the solar altitude.

In Fig. 2, schematic suns are shown at seven altitudes from 0° to 90° at 15° intervals and, from each sun, a red line runs to the relevant dot on the curved surface. In the diagram, the seven suns are shown in the same plane. In general, the azimuth of the sun changes continuously during the day and, at each observation, the user has to face the instrument in a different direction but, in following the golden rule, it is never necessary to know what that direction is.

During the period of daylight, the altitude of the sun is 0° at sunrise, then rises to a maximum at noon, before returning to 0° again at sunset. The maximum possible noon altitude is 90° and *in that special case* (and subject to two caveats) the arrangement in Fig. 2 can be used to determine the unequal hour by dividing the indicated altitude by 15. For example, if the altitude is 30° then the unequal hour is 2.

The first caveat, which applies to all altitude dials, is that the user needs to know whether it is morning or afternoon because the sun reaches each particular altitude twice during the course of a day. If the altitude is 30° and the sun has gone past its highest point then the unequal hour is 10 not 2. The result obtained by dividing by 15 has to be subtracted from 12.

The second caveat is that the underlying mathematical model is slightly flawed. When exactly two-twelfths of the day have elapsed, the solar altitude can be almost a degree below 30°, a small error.

Of course, a noon altitude of 90° is a special case. If the solar altitude at noon is, say, 40° then an observed altitude of 30° will not indicate that we are at hour 2 or at hour 10 but at some time much closer to noon.

In general, the user has to follow another rule:

> *Set the gnomon assembly so that its slope (relative to the horizontal) is the altitude of the sun at noon.*

In the case illustrated in Fig. 2, the sun has an altitude of 90° at noon so the gnomon assembly has to be vertical. If the solar altitude at noon is 40° then the slope of the gnomon assembly has to be 40° too.

A Modified Instrument – An Aid to Understanding

It is considerably easier to understand the operation of the instrument if the gnomon assembly is replaced by the quadrant construction shown in Fig. 3. The slope of the quadrant is the solar altitude at noon, taken here as 40°.

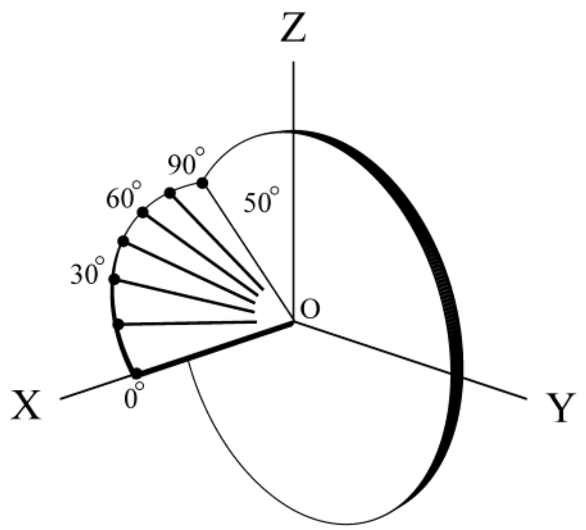

Fig. 3. The gnomon assembly replaced by a quadrant whose angle to the horizontal matches the solar altitude at noon, taken here as 40°. The angle to the vertical is 50°.

There is now a single vertical disc and the sloping edge of the quadrant is attached to a radius of that disc. The other edge of the quadrant is horizontal and perpendicular to the plane of the disc.

An X, Y, Z system of rectangular coordinates, with origin O, has been added for reference purposes. The X–Y plane is horizontal; the positive X–axis coincides with the horizontal edge of the quadrant and the Z–axis is vertical.

The origin O equates to point O in Fig. 2. Seven hour lines with dots at their outer ends are shown radiating from point O at 15° intervals ranging from 0° to 90°.

Now imagine a bug stationed at point O. When the bug sights along the 0° line it is looking at some point on the horizon; the altitude of the line is 0°. When the bug sights along the 90° line it is looking at some point in the sky whose altitude is 40°.

If the bug scans along every radius from the 0° line to the 90° line its gaze must span every altitude from 0° to 40° and this is exactly the range of altitudes of the sun on a day when the altitude at noon is 40°.

To determine the unequal hour, the user first ensures that the quadrant is in the plane of the sun (see Fig. 4) and then notes which radius on the quadrant aligns with the line from the sun to point O. (The bug will have no difficulty but, for humans, it is better to use the gnomon assembly!) The angular offset of this radius from the 0° line on the quadrant is divided by 15 and the result (subtracted from 12 if it is the afternoon) gives the unequal hour.

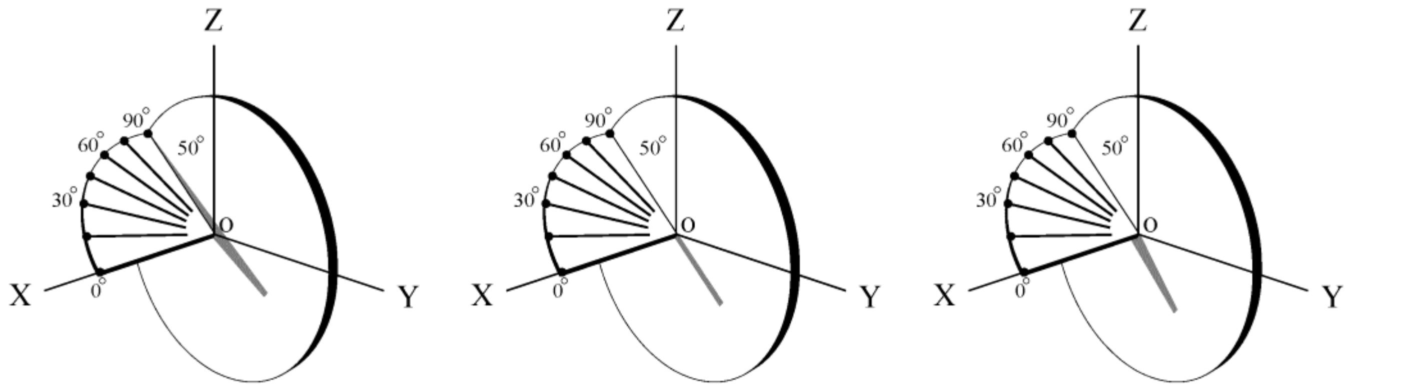

Fig. 4. In the central figure the shadow aligns with the sloping edge of the quadrant; the sun is shining equally on both faces of the quadrant as required. In the figure on the left the sun is shining on the lower face. In the figure on the right it is shining on the upper face. To correct these latter cases, the user has to rotate the supporting disc slightly about its vertical axis.

Clearly the altitude of the sun at hour 0 (sunrise) matches the altitude of the 0° line on the quadrant and the altitude at hour 6 (noon) matches the altitude of the 90° line.

There is an underlying assumption that this correspondence applies more generally, thus the altitude of the sun at unequal hour u [or $12-u$] matches the altitude of the radius which is offset by an angle of $15u°$ [or $15(12-u)°$] from the reference 0° radius on the quadrant. In practice the match may be imperfect but the error is usually small.

Inherent Asymmetry

One may imagine that first thing each morning an assiduous user would set the slope of the quadrant to the noon altitude for the day and leave it fixed.

Such a user might take the instrument out a dozen times in the course of the day, quite possibly in different locations, and it is necessary only to follow the golden rule to tell the time. No ordinary user would think to keep a record of the solar azimuth at each observation but anyone who does would be in for a surprise. This is a consequence of an inherent asymmetry which can be a distraction when trying to understand the instrument's behaviour.

Fig. 5 shows one way of recording the observations. In each little diagram *south* is at the top, and the quadrant and the supporting disc are seen in plan (which makes the sloping edge of the quadrant appear foreshortened). Only four hour lines are shown, those for 0°, 30°, 60° and 90°. The position of the sun (strictly its azimuth) is also indicated.

Each row illustrates the orientations of the instrument at the even-numbered daylight unequal hours from hour 0 (sunrise) to hour 12 (sunset). At hours 0, 2, 4 and 6 the sun aligns with hour lines 0°, 30°, 60° and 90° respectively. At

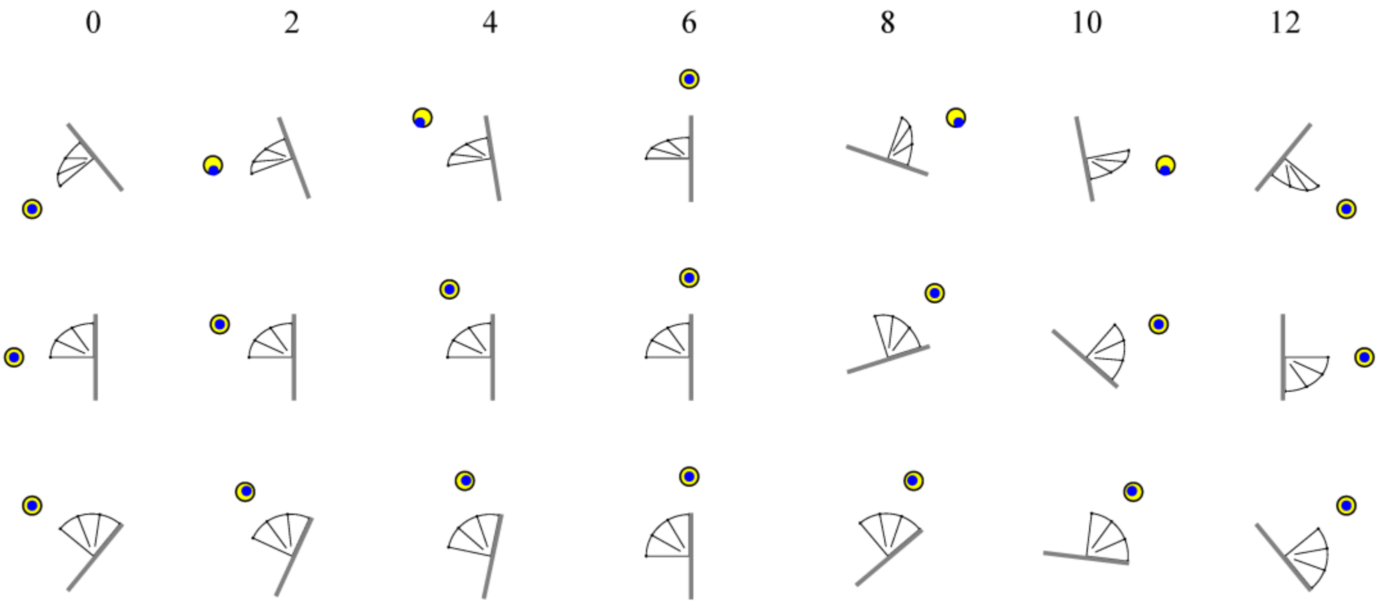

Fig. 5. Each of the three rows of figures shows plan views of the instrument (with south at the top) when making observations at the unequal hours 0, 2,…12. In each case, a schematic sun is shown which aligns with the relevant hour line; a blue dot indicates the actual azimuth of the sun at the unequal hour in question. In all cases the local latitude is 52° north. The solar declinations in the three rows are +23°, 0° and –23° so the noon altitudes (and quadrant slopes) are 61°, 38° and 15°.

hours 8, 10 and 12 the sun aligns with hour lines 60°, 30° and 0° respectively.

The three rows of figures depict the instrument at three different settings. In the top row, the slope is 61°, in the middle row it is 38°, and in the bottom row it is 15°.

Asymmetry is immediately apparent. In the middle row, the orientation of the instrument is fixed all morning but it is rotated 180° clockwise in the afternoon. In the top row the instrument is rotated in the morning but not by very much whereas in the afternoon it is rotated well over 180°. In the bottom row the instrument is rotated anti-clockwise in the morning but clockwise in the afternoon. Why?

The positions of the schematic suns give some clues. In the middle row the sun rises due east (on the left) and sets due west (on the right). This is the day of an equinox when the sun travels along the celestial equator. Given that the solar altitude at noon is 38°, we may infer that the local latitude is 52° north (90°–38°).

In the morning, the quadrant is fixed in the plane of the celestial equator but this cannot continue after noon. At hour 8, the instrument has to be rotated so that the 60° hour line aligns with the line to the sun. At hour 12 (sunset) the instrument has to be rotated so that the 0° hour line is due west. This accounts for the 180° afternoon rotation.

The same latitude, 52° north, also applies to the top and bottom rows; the noon solar altitudes are 61° and 15° so we may infer that the declinations are +23° and –23°, close to the summer and winter solstices. In the top row, the sun rises well to the north of due east and sets well to the north of due west. In the bottom row the sun rises well to the south of due east and sets well to the south of due west.

In each diagram, the blue spot indicates the actual solar azimuth at the unequal hour in question. At sunrise, noon and sunset, and also throughout the day of an equinox, the blue spot exactly aligns with the schematic sun. In most other cases the alignment is fairly close. The largest errors are at the summer solstice.

The instrument ranks as a universal sundial. It can certainly be used south of the equator. Fig. 6 shows three more rows of diagrams and they all apply to the southern hemisphere. South is still at the top but the sun is due *north* at noon.

In each case the noon solar altitude is 61°. The latitudes are 6° south in the top row, 29° south in the middle row and 52° south in the bottom row. The declinations this time are +23° (top row), 0° (middle row) and –23° (bottom row).

The middle row again depicts the day of an equinox with the sun rising due east and setting due west but notice that the instrument is rotated in the morning and held steady in the afternoon. The blue spot exactly aligns with the schematic sun throughout the day.

The top row relates to 6° south (in the tropics); the sun rises to the north of due east and sets to the north of due west. The instrument is rotated nearly 180° anti-clockwise in the morning; it is rotated clockwise in the afternoon but not by very much. The blue spot alignment is almost perfect.

The bottom row relates to a day close to the summer solstice at 52° south and should be compared with the top row in Fig. 5. The row of diagrams is identical to the top row in Fig. 5 turned upside down! The instrument is rotated well over 180° anti-clockwise in the morning and continues being rotated anti-clockwise in the afternoons but not by very much. The blue spot alignment is not very good.

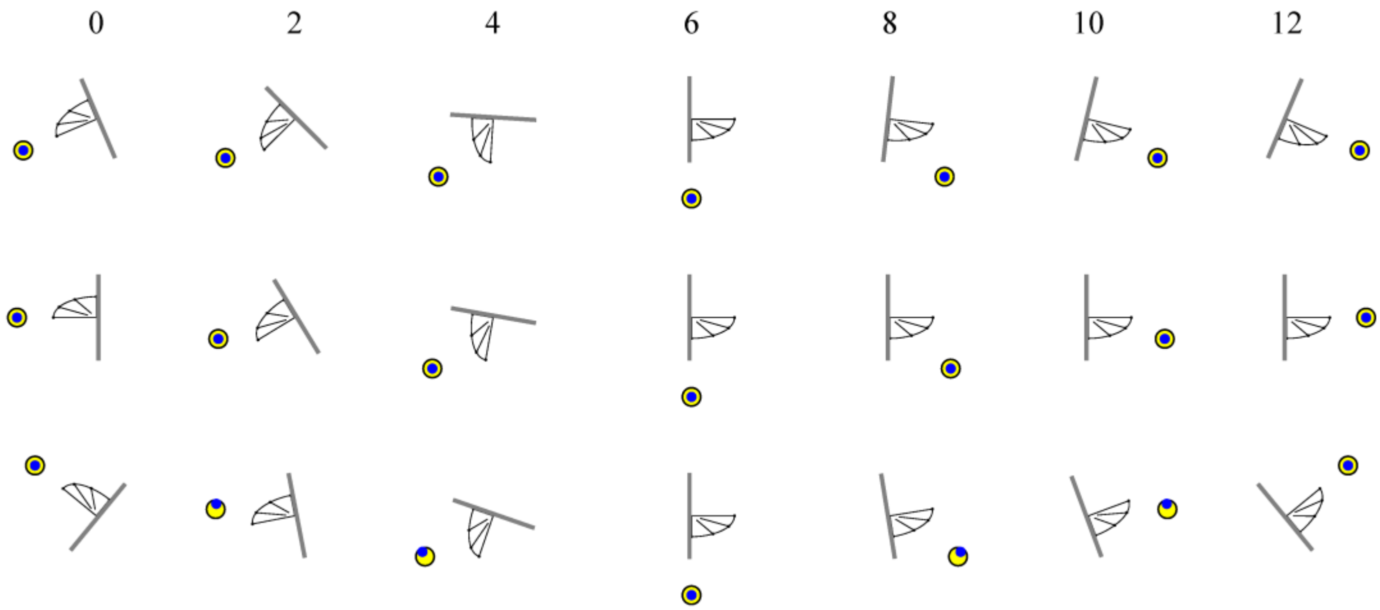

Fig. 6. Another set of plan views of the instrument (again with south at the top) when making observations at the unequal hours 0, 2,…12. The latitudes of the observer in the three rows are 6° south, 29° south and 52° south and the sun is due north at noon. The solar declinations are +23°, 0° and –23° respectively. Accordingly, in each case, the noon altitude (and quadrant slope) is 61°.

Determining the Altitude at Noon – Method I

The user of a Roman portable dial needed to know how to set the gnomon assembly to the correct slope. The supporting discs incorporate two scales (see Fig. 7) which together suggest that the designer took the solar altitude at noon a_N to be:

$$a_N = 90° - latitude + solar\ declination$$

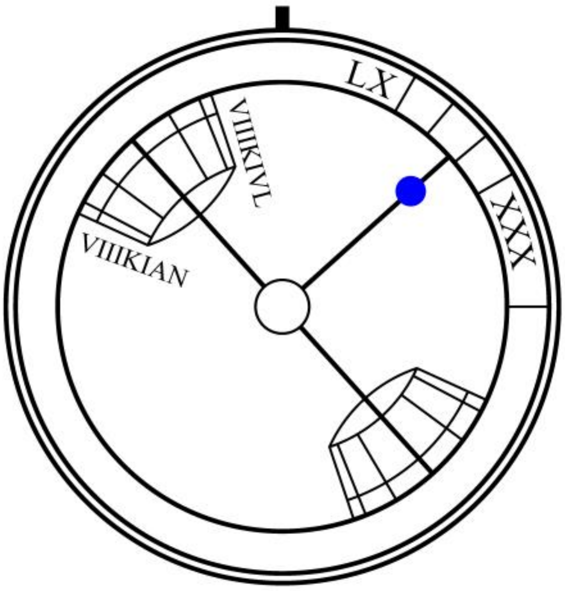

Fig. 7. The supporting discs with the top of the outer disc marked by the bracket for the suspension cord. The outer disc incorporates a latitude scale and the inner disc has a pair of declination scales.

The outer disc has four tick marks between the labels XXX and LX. The tick marks are at 30°, 40°, 50° and 60° anti-clockwise round from a horizontal reference tick mark and, together, they constitute a latitude scale.

The inner disc is rather richer in markings and in Fig. 7 these are dominated by a diameter and a radius which together form a T-shape. The inner disc can be rotated by means of the knob on the tail of the T. In Fig. 7 the tail has been set to a position between the 40° and 50° tick marks to indicate a latitude of 42°, the latitude of Rome.

Given that the cross-bar of the T is at right angles to the tail, the slope of the cross-bar is 90°–42° or 48°. The T-shape thus provides a simple mechanical way of determining the co-latitude, 90°–*latitude*, which, on the day of an equinox, is the solar altitude at noon.

At an equinox, the gnomon assembly should be set to align with the cross-bar of the T. At other times of year the gnomon assembly should be offset from the cross-bar by an angle which matches the solar declination.

Each end of the cross-bar is flanked on each side by three radial lines. One of the outer lines is labelled VIIIKIAN which rather cryptically refers to the winter solstice, the first point of Capricorn. At the other extreme, the summer solstice, the first point of Cancer, is labelled VIIIKIVL. The labels refer to eight days (VIII) before the Kalends (K) of, respectively, January (IAN) and July (IVL). The in-between lines refer to the first points of the other signs of the Zodiac, the lines indicating the solar declinations at these first points.

We have a simple circular slide rule. By setting the tail of the T to the local latitude, the slope of the cross-bar indicates the co-latitude and, by off-setting the gnomon assembly relative to the cross-bar by the declination, we complete the formula and set the slope of the gnomon assembly to the noon altitude of the sun.

The user was expected to know the local latitude and the position of the sun in the ecliptic. To help with the former, a list of 30 places is shown on the reverse side of the supporting disc together with the latitude of each; ROMA is shown as having latitude XLII. To attend to the latter, the user needed to know the dates of the first points.

If it happens to be the day of the summer solstice then the slope of the gnomon assembly should be set so that it aligns with the VIIIKIVL line. At the winter solstice, the slope of the gnomon assembly should be set so that it aligns with the VIIIKIAN line.

There is no compelling reason why the latitude range should be so limited. Rohr suggests that the range reflects the outermost limits of the Roman Empire. Certainly the latitudes of the 30 places listed on the reverse are all within this range.

It is also possible that the designer realised that the formula doesn't straightforwardly hold at low latitudes. For example, if the latitude is 20° and the declination is 23° the formula gives a noon altitude of 93° which is greater than the 90° maximum! This is not really a problem. If you set the slope of the gnomon assembly to 93° it will slope at 87° to the horizontal reference tick mark and this is the noon altitude. The assembly will now slope from top right to bottom left but that is of no consequence.

The designer might also have been wary of southern hemisphere latitudes. At latitude –50° at an equinox, the formula gives a noon altitude of 140° but the circular slide rule will again give a sensible result. The cross-bar will slope at 40° to the horizontal which is the noon altitude. The VIIIKIVL line will now be *below* the end of the cross bar so at the June solstice the slope of the gnomon assembly would be reduced. This is correct because at latitude –50° the June solstice is the *winter* solstice.

The latitude scale could go all the way from –90° to +90° and the two-step procedure for setting the slope of the gnomon assembly would always set it to the noon altitude of the sun.

The only intractable difficulty is that in very high latitudes (in the polar regions) there are times of year when the sun is below the horizon all day or above the horizon all day. With no sunrise or sunset, the whole concept of unequal hours fails and attempts to use the instrument will lead to nonsense results.

Determining the Altitude at Noon – Method II

A naive user who doesn't know the local latitude and doesn't know where the sun is in the ecliptic can nevertheless set the gnomon assembly to the correct slope!

The user should take the instrument out in the morning and align it so that the sun is in the plane of the supporting discs instead of in the plane of the gnomon assembly. Twist the suspension cord so that the sun shines equally on both the vertical faces. Then, keeping the support so aligned, adjust the gnomon assembly so that the sun is in its plane too.

This is most unlikely to give the correct slope and the procedure should be repeated at intervals. During the morning, the slope will gradually be increased. At noon it will be correct and it won't matter much if the exact moment of noon is missed. The altitude of the sun generally changes fairly slowly around noon. As soon as the slope seems to need decreasing, the user will know that the sun has passed its highest point and the gnomon assembly should be left alone. The instrument can then be used in the afternoon in the normal way and the slope will usually hold good for the morning of the following day too.

The user will need to make daily checks around noon. If the slope is too low, the sun will shine on the upper surface of the gnomon assembly even if the supporting disc is aligned with the sun. If the slope is too high, the indicated time will never reach hour 6.

This approach[5] works in both the northern and southern hemispheres. It makes no use of latitude or declination or of time of year, and dispenses with the need for any scales other than that on the gnomon assembly. It certainly dispenses with the need for an inner disc. A much cheaper model could therefore have been marketed which was easier to manufacture, very simple to set, and just as good at indicating unequal hours!

Underlying Theory – Preliminary Error Analysis

Fig. 8 shows a simplified version of Fig. 3. The quadrant has just three hour lines: the 0° line and the 90° line and one in between which has an angular offset of $15u°$ to the reference 0° line. For the moment u is assumed to be in the range 0 to 6, a morning unequal hour.

It is further assumed that the noon altitude is $a_N°$ and that this is the slope of the quadrant. The 90° line therefore makes an angle of $90–a_N°$ to the vertical, as shown. Finally assume that the quadrant has unit radius; this is why the $15u°$ line is shown with length 1.

Now suppose that a_u is the slope of the $15u°$ line relative to the horizontal X–Y plane; a_u is the altitude of the point in the sky seen by the bug when it sights along the $15u°$ line. From the instrument's point of view, at unequal hour u the solar altitude is a_u whatever the latitude and declination.

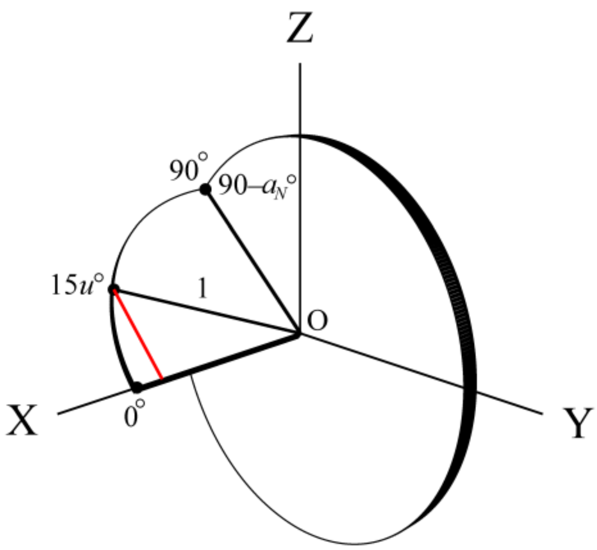

Fig. 8. In this variant of Fig. 3, the slope of the quadrant is $a_N°$, the solar altitude at noon. The hour line appropriate for unequal hour u is also drawn; it is at an angle $15u°$ to the reference 0° line.

The next step in the analysis is to determine the slope a_u in terms of u and a_N and then assess how close this value is to the actual altitude of the sun at unequal hour u.

Taking a_u as the slope of the $15u°$ line, and the length of the line as 1, the height of the outer end of the $15u°$ line above the X–Y plane is $\sin(a_u)$.

Now note the red line in Fig. 8. This is the perpendicular from the outer end of the $15u°$ line to the 0° line and its length is $\sin(15u)$. Moreover, the red line is parallel to the 90° line so its slope (relative to the X–Y plane) is a_N. Accordingly, the height of the outer end of the $15u°$ line above the X–Y plane is $\sin(15u).\sin(a_N)$.

These two values for the height can be equated:

$$\sin(a_u) = \sin(15u).\sin(a_N)$$

This relationship is well known. For example, exactly the same relationship underlies the design of the horary quadrant.[6]

Given the noon altitude a_N the relationship enables us to determine a solar altitude a_u at any unequal hour u. The sine function takes care of the afternoon hours so there is no need to subtract u from 12. The result may not be quite the correct altitude but the error is normally sufficiently small that it can be ignored. Let's investigate the errors…

Clearly if $u=0$ or $u=12$ then $a_u=0$ and if $u=6$ then $a_u=a_N$ so the error is always zero at sunrise, noon and sunset. It can also be shown that the error is always zero at the equator (latitude 0°) whatever the time of year and is always zero at an equinox (declination 0°) whatever the latitude. In all other circumstances the relationship will give a solar altitude that is not quite correct.

For example, Fig. 2 illustrated a special case in which $a_N=90°$, so the relationship simplifies to $a_u=15u$ implying that when $u=2$ the altitude is 30°. This is true on the equator at an equinox but the noon altitude can be 90° anywhere in the tropics, for example at latitude 23° on a day when the declination is 23°. There, at unequal hour 2, the altitude of the sun is actually just over 29° and not 30°.

Errors – More General Considerations

In general terms, the errors are always zero at the equator and become greater as the latitude increases.

The error can be measured in three ways. An error in altitude means that there will be an error in azimuth (as illustrated in Figs 5 and 6) and an error in the indicated time. Since the error in altitude is the source of the other two errors, it merits particular attention.

Consider the range of latitudes where the noon solar altitude can be 46°. The range extends from latitude 21° (when the declination is –23°) via latitude 44° (at equinoxes, when the declination is 0°) to latitude 67° (when the declination is +23°).

In all cases the gnomon assembly has to be set so that it slopes at 46° to the horizontal and the expression for $\sin(a_u)$ gives rise to the red curve in Fig. 9. This is exactly right for the mid-range latitude of 44° where 46° is the noon altitude at an equinox.

At the tropical end of the range, latitude 21°, the correct *altitude-versus-u* relationship is shown by the top black curve in Fig. 9. This almost coincides with the red curve.

The second black curve, immediately below the red curve, applies to a British latitude 52° and again there is minimal error. The third black curve down applies to latitude 62° and the errors are starting to be significant.

The bottom black curve applies to latitude 67°, just inside the Arctic circle. The errors are large and, informally, it is easy to see why. The red curve assumed by the instrument shows the altitude climbing steadily at roughly 10° per (unequal) hour for four hours and then levelling off. There is a flat peak around noon. There is also a flat bottom around midnight but, since the sun is usually out of sight then, this is not generally noticed. In the circumstances of the bottom curve, there are (just) 24 hours of daylight. The curve is noticeably more S-shaped and hence significantly diverges from the red curve.

There is nothing special about choosing 46° for the noon altitude. Other values would give similar curves in Fig. 9.

At a given latitude (north or south), the general rule is that there are no errors at an equinox and the errors increase with increasing daylight (as we approach the flat bottom). There is also an increase with *de*creasing daylight but very much less so because there is no tendency to an S-shape.

Errors – The Polar Limit Theorem

As noted, an altitude error translates into an azimuth error and an error in indicated time. In exploring a computer model of the Roman portable dial it was noted that at $u=2$ the error in the bottom curve in Fig. 9 translated into

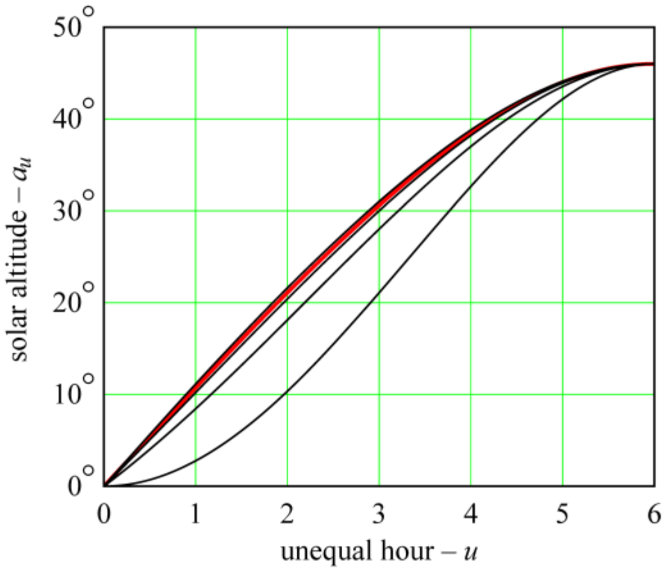

Fig. 9. Five examples where the noon altitude is 46°. The red curve shows the quadrant's understanding of the solar altitude for unequal hours from 0 to 6. At latitude 44°, on the day of an equinox, this exactly matches the actual solar altitude over this period. The lowest curve shows the solar altitude at latitude 67° on a day when the solar declination is 23°. The sun is on the horizon at midnight but otherwise above the horizon for all 24 hours of the day. The errors are large. The other curves are for latitudes 21°, 52° and 62°. The errors are small.

exactly two (common) hours. Moreover this is true whenever *latitude* + *declination* = ±90°. Although this observation would have been of no interest to those who once used the instrument, the explanation is entertaining and worth exploring…

Take the latitude as ϕ and the declination as δ. At the threshold of 24-hour daylight $\phi+\delta=90$. Now, noting that $a_N=90-\phi+\delta$, we have two simultaneous equations which give $\phi=90-a_N/2$ and $\delta=a_N/2$

Using the normal formula for solar altitude we can write:

$$\sin(a_u) = \sin(\phi).\sin(\delta) - \cos(\phi).\cos(\delta).\cos(H_{au})$$

Here H_{au} is the hour angle (since midnight) at which the sun has altitude a_u. Equating this to $\sin(15u).\sin(a_N)$ and substituting the expressions for ϕ and δ above leads to:

$$2\sin(15u).\sin(a_N) = \sin(a_N) - \sin(a_N).\cos(H_{au})$$

The three instances of $\sin(a_N)$ cancel and we are left with:

$$\cos(H_{au}) = 1-2\sin(15u)$$

This is a remarkable result. If the sum of the latitude and declination is ±90°, the hour angle when the instrument indicates unequal hour u is independent of latitude, declination and noon solar altitude. The hour angle at unequal hour u is actually $30u$ (24-hour daylight means 30° per unequal hour). The result applies only in the polar regions but theoretically it holds more generally, such as at latitude 52° when the solar declination is (impossibly) 38°.

I call this the Polar Limit Theorem since it applies in the polar regions when the declination is on the threshold that gives 24-hour daylight. If $u = 2$ then $\cos(H_{au}) = 0$ and $H_{au} = 90°$. But with 24-hour daylight the actual hour angle at hour 2 is 60°. The error equates to a difference in hour angle of 30° which is two common hours or one unequal hour. We may guess that the designer did not know this!

Conclusions

The foregoing is presented primarily as a guide to how the instrument is used and how it works both in the mornings and in the afternoons. For a historical context see Rohr[1] and Wright[2]. Neither says who might have owned and used such instruments but both note that a few similar dials have been found and that the design was used by Greeks and Romans. Neither suggests that the design has predecessors or successors and here is some speculation…

A large-scale version of the gnomon assembly could be used as a hand-held instrument. Without the supporting disc, it would be difficult to hold the gnomon assembly at the correct angle but, in principle, it would be possible. As a stand-alone instrument, the gnomon assembly is a little like an ancient L-shaped stick dial but with the longer leg curved instead of straight. Could such sticks have been the inspiration that led to the design of the gnomon assembly?

Noting that the horary quadrant shares the same underlying mathematics, could there be some conceptual link there?

The horary quadrant was simpler to make, was as easy to use, did not have a gnomon assembly to break off or lose, and did not swing around in the breeze at the end of a length of cord. On the other hand, the hour lines on an horary quadrant bunch together when the noon altitude is low and the instrument becomes harder to read.

APPENDIX
Mathematical Relationships

Readers who wish to set up and explore a computer model can easily achieve this with a simple spreadsheet. Just five relationships are needed to determine the error in indicated time:

$\cos(H_{sr}) = \tan(\phi).\tan(\delta)$: H_{sr} is the hour angle of sunrise (in degrees since midnight) given latitude ϕ and solar declination δ.

$H_u = H_{sr}+u(180-H_{sr})/6$: H_u is the hour angle of the sun at unequal hour u.

$\sin(a_u) = \sin(15u).\sin(a_N)$: a_u is the solar altitude when the instrument *indicates* unequal hour u; the instrument is set to indicate a solar altitude of a_N at noon.

$\cos(H_{au}) = (\sin(\phi).\sin(\delta)-\sin(a_u))/(\cos(\phi).\cos(\delta))$: H_{au} is the hour angle of the sun when the solar altitude is a_u. If $u>6$ then subtract the value of H_{au} from 360.

$E_{HA} = H_u-H_{au}$: E_{HA} is the difference between the hour angle at u and the hour angle when the instrument indicates u; $4E_{HA}$ is the error in (common) minutes.[7]

To determine the errors in solar altitude and solar azimuth further relationships are required:

$\sin(a_{Hu}) = \sin(\phi).\sin(\delta)-\cos(\phi).\cos(\delta).\cos(H_u)$: a_{Hu} is the altitude when the hour angle is H_u. The altitude when the instrument indicates hour u is a_u.

$E_{alt} = a_{Hu}-a_u$: E_{alt} is the difference between the altitude at u and the altitude when the instrument indicates u.

$\tan(A_u) = (\cos(\delta).\sin(H_u))/(\cos(\phi).\sin(\delta)+\sin(\phi).\cos(\delta).\cos(H_u))$: A_u is the azimuth (measured clockwise round from due north) when the hour angle is H_u. If $u>6$ then add 360 to the value of A_u.

A_{Hau}, the azimuth when the hour angle is H_{au}, is determined likewise but use H_{au} instead of H_u. If $u>6$ then add 360 to the value of A_{Hau}.

$E_{az} = A_u-A_{Hau}$: E_{az} is the difference between the azimuth at u and the azimuth when the instrument indicates u.

When the instrument indicates hour u it will, in general, be rotated from its rest position (the disc facing due east) and two final relationships are required:

$\tan(O_u) = \sin(15u).\cos(a_N)/\cos(15u)$: O_u is the offset, *in plan*, of hour line u from the reference 0° hour line. If $u>6$ then u must be replaced by $12-u$ in the expression.

$R_u = A_{Hau}-O_u-90°$: R_u is the angle by which the instrument is rotated from its rest position (the discs facing due east) when the instrument indicates hour u.

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7. Wright (Ref. 3, page 183) gives a graphical representation of the errors but expresses these in unequal minutes (1/60 of an unequal hour). To reproduce his results scaling is required.

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THE NATURE IN ART MUSEUM SUNDIAL, GLOUCESTER

BEN JONES

It was proposed to mark the 25th anniversary of the Nature in Art Museum's opening with a sundial. The museum is at Wallsworth Hall in Twigworth, near Gloucester.

The hall was built about 1740 and is a listed building. A horizontal dial had once stood in the centre of the driveway's turning circle near the main door which is in the east front of the Hall (see Fig. 4). This was deemed to be the best site for a new dial as it would catch any sunlight during the hours that the Museum is open to the public.

BSS member Tony Wood is a friend of the Museum and he had pictures from a sundial exhibition in Oxford[1] which he was able to show to Dr David Trapnell, the Museum's founder and Chairman. Dr Trapnell liked the shield-shaped dial of mine on show there (Fig. 1) and asked me to make a version of it using a rough, natural, straight from the quarry, block of local stone from the Forest of Dean. Rough blocks are wonderful things but finding one just the right size and shape usually takes a long time. Luckily the Museum had used numerous large landscaping stones in the past so it was a relatively easy job to locate a good piece.

Fig. 1. My Oxford shield dial.

The Oxford dial is a fairly straightforward south-facing dial showing local time. The Nature in Art dial would be more complicated as it had to be set out to allow for longitude and also to decline 24° west. Making it decline 24° would allow the dial to face the path leading from the car park to the Museum's entrance and also allow it to be glimpsed when approached along the old drive. Another difference which had a huge effect on how the dial would be made was that it should have a solid brass plate gnomon and not a rod gnomon. A rod gnomon was thought to be too easily damaged.

Once the stone block was at my workshop I worked a flat face on one end of the stone to stand it on. It was then tilted this way and that until it *looked* upright; it was then made secure with wooden blocks and wedges.

The chosen block of stone had no straight edges or any points anywhere that could be measured from, so creating a suitable datum was essential.

To allow the stone to be set up on site in exactly the same vertical position as it was at the workshop, I carved some marks on the back of the stone against which a spirit level could be placed to show when it was vertical.

Using a trigon to mark out a dial face on an uneven surface would have been the obvious solution except that there was no gnomon to put it on; there was no surface to attach a gnomon to and an accurately aligned gnomon would be needed to find the surface!

The solution I came up with was to build a horizontal wooden shelf across the front of the block (Fig. 2). On this I could mark out a horizontal dial and use that to construct the dial in the block of stone. The shelf was very strong though it looked a little Heath Robinson.

The stone dial would be smaller than the temporary horizontal dial so errors in marking out would be reduced in size. If I used a small conventional trigon to delineate the relatively larger dial then errors would be increased.

I drew a straight line across the horizontal shelf as parallel to the rough face of the stone block as possible and deemed this line to decline 24° west. The face of the block might be too uneven to work off but this line could be reliably measured from.

Next the outline of the dial was chalked onto the stone block. On the top surface of the stone I marked a single point a few inches in from the middle of the chalked-on dial face. The morning hour lines and the 1 pm hour line

Fig. 2. The temporary wooden shelf and gnomon, and the chalk outline of the dial to be cut in the stone. A horizontal dial was marked out on the shelf.

would eventually radiate from this point, centre-1. This point was to be the first of four centres from which hour lines would be drawn. A nearby point on the top of the stone would be the centre from which the hour lines after 1 pm would radiate and, as will be explained, two more centres were marked on the horizontal shelf.

Deciding just how far back to mark this first centre required balancing two considerations; the cone had to be worked some distance into the block but, if it was too far in, much of the dial would be in shadow and, if it was too far forward, the dial would be flat or a rather insipid-shaped cone.

On the shelf I stood a wooden gnomon and aligned it north/south by using card templates which were cut at 24° and placed against the reference line. The slope of this gnomon was 51.9°, matching the local latitude.

From the first point on top of the stone block, centre-1, a length of cotton was stretched down to the bottom of the west style of the wooden gnomon standing on the shelf. This gnomon was moved left and right and forwards and backwards (always keeping the foot 24° off being perpendicular to the reference line) until the cotton ran exactly along its west style. Just the slightest movement resulted in the cotton falling away from the style so it was possible to arrange for the cotton to be polar-oriented to high precision.

The lower end of the cotton indicated where on the shelf to mark the second centre, centre-2, from which a horizontal dial could be set out. Think of a diptych dial; the length of cotton from centre-1 (at the top of the stone) to centre-2 (on the shelf) was treated as the common (west) style for two dials. The east style was ignored at this stage.

The cotton style and the wooden gnomon were removed and the morning side of the horizontal dial was drawn radiating from centre-2 (on the shelf). The 1 pm hour line was also drawn radiating from this centre. The dial was adjusted for longitude which, being about 2.2° west, makes the local sun time almost 9 minutes behind Greenwich. The 12 o'clock hour line indicates 12:00 Greenwich solar time. The gnomon would lie between the 1 pm and 2 pm lines.

My plan was to carve this dial using the same method that I had used for the Oxford dial. This was to pitch away the surplus stone between the hour lines as the lines were being carved and then make and fit the gnomon when all the lines were carved.

To do this, the upper end of the cotton was held at centre-1 with a weight and the lower end was held with a thumbnail on an hour line on the horizontal dial and slipped along the hour line until some part of the cotton touched the stone. That piece of stone was marked and the cotton put to one side so the piece of stone could be removed with a chisel and mallet. The lower end of the cotton was again held on the hour line, another mark was made and more stone chipped away.

After carving in a couple of hour lines I decided that, while this method was fine for a dial with a rod gnomon and a single centre for all the hour lines, it was not going to work on this particular dial as it would make finding the size, shape and position of the gnomon too difficult and the chances of error too great.

Plan B. I decided that it would be more practical to work the cone shape into the stone block first and then add the hour lines once the brass gnomon was in place. The cone shape was worked into the stone block and the surface was given as coarse a chiselled surface as possible to keep it close in looks to the Oxford dial. Then, to find the position, shape and size of the gnomon, all the hour lines were found and roughly pencilled in with an allowance for the thickness of the gnomon. This exercise showed that the foot would be uncomfortably close to the 1 pm line so I decided to displace the foot of the gnomon slightly sideways. The two styles of the intended gnomon would remain parallel and polar orientated though moving the position of the gnomon's foot would result in a very slight rotation of the east style about the west style.

The west style was re-established with the cotton stretched between centres 1 and 2 and held in place with weights at both ends. The cotton west style was checked against the west style of the wooden gnomon on the shelf. A cardboard template for the brass gnomon could now be made by placing a piece of thin card on the chosen gnomon base line and holding it gently against the cotton style so the position of the style could be marked on the card.

The real gnomon was cut from a sheet of brass 12 mm thick (Fig. 3) and a deep slot for it was made in the stone. Up until this stage almost any mistake could have been 'rubbed out' by working the cone further into the stone block but the slot was too deep to be corrected in this way.

The gnomon was needed to help mark out the hour lines so it had to be fixed in place very precisely but it also had to be removable (so that the hour lines could be carved) and accurately replaceable.

Fig. 3. The brass gnomon wedged in place in the stone. Note the heavy weight with a few turns of cotton round it on top of the stone and note the packing piece just in front of the weight.

To achieve this I put a dab of grease on the tang of the gnomon (the section that goes into the slot) and a small amount of resin in each end of the slot. The gnomon was then pushed into place and held with little wooden wedges while the resin hardened, checking all the time that the west style of the brass gnomon coincided with the cotton west style. When the resin had set, the gnomon could be eased out and, when slid back into its slot, the gnomon was correctly aligned. It would later be fixed permanently in place using neat cement.

Using the brass gnomon's east style I could now find centre-3 (the top centre of the east style as a whole) by sliding a steel straight edge along the gnomon's edge. The stone needed building up with a little bit of resin so I could put a mark there. Again with a long straight edge or length of cotton I could find centre-4, the corresponding centre on the horizontal shelf. From centre-4, the east side of the horizontal dial could then be marked out on the shelf.

To mark out the hour lines on the stone I again stretched a length of cotton from a top centre (centre-3) to the hour lines on the horizontal dial and marked where the cotton touched the face of the cone. By closing one eye and holding my head against the stone to reduce wobble, I could look across the edge of the gnomon to check the straightness of the line. This was necessary because although this can be called a conical dial, it is far from being a textbook 'right circular cone' with a straight, smooth, reliable surface. Parts were deliberately made curvy so that the cone would make a nice even U-shape on the front of the stone block with its rough surface.

The gnomon was removed and the hour lines were cut into the stone using a 4½″ disc cutter. The metal blade made narrow but deep cuts which cast good shadows. The ends of the hour lines were cut in with a narrow chisel.

If asked to make a similar dial again, I might be tempted to raise the top centres of the dial above the top of the stone; this would make for fewer but more widely spaced hour lines.

The Oxford shield dial has no numerals. This is visually elegant but would have made reading the new dial less than simple for the Museum's visitors. There was much discussion as to whether Roman or Arabic numerals looked best. Finally Arabic numerals were chosen, carved and painted.

Fig. 4. Delivery to Wallsworth Hall.

The stone block was originally going to be set 6″ deeper into the ground but after the dial was finished it was decided to set it higher up. The stone was transported back to Twigworth and lifted onto a cast concrete foundation

Fig. 5. Three-quarter trigon.

(Fig. 4). Later, when there was a reliably sunny day, it was levelled using the marks on the back of the stone, referred to earlier. A three-quarter trigon (Fig. 5) was used to check the alignment. The block was turned, re-levelled, checked and turned again a number of times. Gradually the trigon and the clock began to agree and when they did and this was confirmed by a carved hour line showing the right time, concrete was poured under the base of the block to hold it in place (Fig. 6).

Fig. 6. The newly-placed sundial.

The three-quarter trigon is a mini-equatorial dial with one quarter cut away so that the trigon could be placed on the gnomon with its centre on one or other of the two styles. The face of the trigon was a printed paper protractor. It was aligned with an hour line on the dial and stuck to the plywood with SprayMount adhesive so it could be removed, adjusted and, when all was well, held firmly in place.

There is a reason why I used degrees and not hours divided into minutes but it is lost in the mists of time. Marking the trigon out as a proper little equatorial dial would certainly have reduced the chances of errors being made when converting time to degrees.

Astute readers will notice that the sun is shining on the winter side of the equatorial dial though the photograph appears to have been taken in summer. Installing the dial actually took place in late October on a beautiful sunny day so it is correct that the winter side is receiving the sun.

It was a nerve-wracking business working on a one ton boulder especially one with no straightness or flatness to it

Fig. 7. The finished sundial with a floral surround.

anywhere. All its hour lines decline and recline by different amounts yet it was marked out from a basic horizontal dial.

The sundial fits in well at the Nature in Art Museum and I hope it will be an interesting find for diallists as well as the Museum's many visitors (Fig. 7).

ACKNOWLEDGEMENTS

I thank David Trapnell for commissioning the dial, Tony Wood for getting me involved and Frank King for advice and vast quantities of help with writing this article.

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Kirktonhall and its Obelisk (or Pawn?)

Kirktonhall and its obelisk, August 2014. Photo: Christine Northeast.

This is Kirktonhall in West Kilbride, once the home of Robert Simson (1687–1768), who was Professor of Mathematics at the University of Glasgow. He designed the obelisk dial in the foreground (SRN 1184).

Why 'Pawn'? See Dennis Cowan's article 'Scottish Obelisks and the Kirktonhall Project' on page 40.

A LITTLE-KNOWN CAMBRIDGE SUNDIAL
…and the Story of its Restoration

IAN BUTSON

The story begins with a chance finding on the internet…

One of the projects involving several members of the BSS is to record memorials that also include sundials, for a UK National Inventory of War Memorials which is being assembled by the Imperial War Museum.

Whilst seeking such memorials, an item was found recording a memorial with a sundial at the Ascension Parish Burial Ground, Cambridge. Having previously checked (or so I thought) all churches, graveyards and cemeteries in Cambridgeshire I was surprised to have missed this one.

It required a visit to investigate further.

The Burial Ground is located on the Huntingdon Road, just over a mile north-west of the city. Set out as an extension burial ground for two of the city centre parish churches, St Peter's and St Giles', it is small, difficult to find and easily missed. With the remains of many eminent university academics interred, it has also been jokingly described as "Britain's brainiest cemetery".

My first visit in November 2012 completely enthralled me. The splendid memorial, in the form of a tall stone column (Fig. 1), has carved decoration in the Art Nouveau style, of flowers on the stone block and the pyramid-shaped finial, and with a simple sundial (Fig. 2). Alas, the sundial was missing its gnomon.

Fig. 1. General view of the memorial prior to restoration.

Fig. 2. View of sundial on stone block.

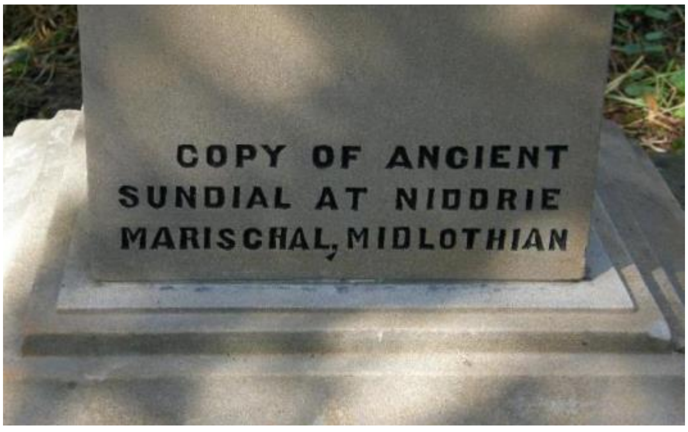


Fig. 3. Inscription on SE base of column (after restoration).

Fig. 4. Rudolf Cecil Hopkinson.[2]

Fig. 5. John Hopkinson. Photo by permission of the University of Cambridge Department of Engineering.

The inscriptions to Rudolf Cecil Hopkinson (and also his mother) are poignant, including in particular sentiments expressed by the men who served under him. I found the whole memorial to be very inspirational – and it demanded to be restored.

An inscription at the base of the south-east face of the column asserts that this is a copy of an ancient sundial at Niddrie Marischal (Fig. 3).

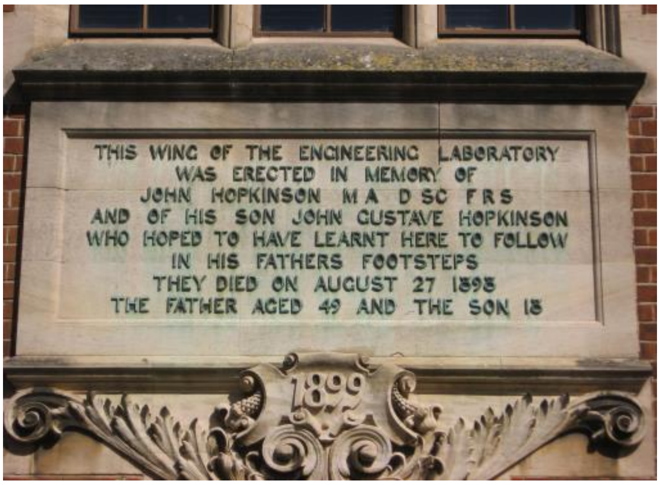
In volume 5 of *The Castellated and Domestic Architecture of Scotland* [1] of 1892 Thomas Ross gives a brief description of a sundial at Niddrie Marischal. However, this is a horizontal sundial in the grounds of the house, of a form not similar to that at Cambridge. Assistance was sought from Scottish BSS member Dennis Cowan, but his local investigations failed to establish a direct likeness of any dials known to have existed there in the past, to that on the memorial column at Cambridge, so this inscription may be erroneous.

Further researches were made via the internet, with the discovery that following his death a Memoir[2] with letters had been written by members of the family and friends of Rudolf Cecil (known as Cecil) (Fig. 4), of his life and of his death. With a copy of this Memoir found as a digital download from the library of the University of California, this opened the doors to yet more research, and the knowledge of his being a member of a very illustrious family.

Cecil, born in 1891, was the youngest of John and Evelyn Hopkinson's six children. A Lieutenant in the RE/Signals, he was wounded in France in November 1915 during the First World War and subsequently died at his mother's home in Cambridge on 9 February 1917. He was also the first winner of the famous long distance downhill skiing race in Switzerland for the "Roberts of Kandahar Challenge Cup" in 1911.

His father John Hopkinson FRS (Fig. 5), of whom many will possibly never have heard, but who has had a profound effect on our lives, died in a tragic mountaineering accident in Switzerland, together with another of his sons and two of his three daughters in 1898. All four are buried together in Switzerland. Along with work on the lighting and optical systems for lighthouses, municipal transport electrical traction systems and patent office work, his most important contribution was the innovation of the three-phase three-wire electrical distribution system that he patented in 1882. He later devised a system for charging customers according to the amount of electricity used.

He is commemorated by a wing of the former Engineering Laboratory in Free School Lane, Cambridge (Fig. 6), largely funded by his widow Evelyn and two of his surviving children, Bertram and Ellen. A plaque on the building (Fig. 7) commemorates him and his son John Gustave. A sundial (Figs 8 and 9, SRN 0653) in the



Figs 6 and 7. Hopkinson Memorial and plaque in Free School Lane, Cambridge, next to the Whipple Museum of the History of Science.

Figs 8 and 9. Memorial sundial to 23-year-old Alice Hopkinson at Newnham College, Cambridge.

grounds at Newnham College, Cambridge commemorates Alice, one of his daughters killed in the accident. The other daughter who died, Lina Evelyn, is still remembered annually by the award of a literary prize at Wimbledon High School. She has no known public memorial.

Cecil's eldest brother Bertram CMG, FRS (1874–1918) was a Professor of Engineering at the University of Cambridge. As a Colonel in the RFC he was accidentally killed in Essex in 1918, whilst flying an experimental plane in low cloud from Martlesham Heath to London. He was instrumental in setting up the experimental station for the Air Ministry at Orfordness, Suffolk where he carried out work on war munitions. He is buried with his wife Mariana (née Siemens) close to his younger brother at the burial ground.

Adjacent to Cecil Hopkinson's grave is that of David William Bragg (1926–2005), a son of Sir William Lawrence Bragg, who at 25 was the youngest winner ever of the Nobel Prize for Physics, which he shared jointly with his father Sir William Henry Bragg in 1915. Together at Cambridge University, Cecil and William Lawrence became close friends, and later Lawrence married Cecil's cousin Alice Hopkinson in 1921.

Bearing in mind that our Chairman, Frank King, is resident in Cambridge and a member of the University community, the opportunity was taken at the 2013 BSS Conference in Edinburgh to ask him whether he knew of this particular sundial and of its association with the Hopkinson family, or indeed whether a 'Hopkinson Society' was known to exist. He knew of none, but he was very much aware of, and indeed a great admirer of, John Hopkinson and his work. He was, however, completely unaware of Cecil's memorial and sundial, not having visited the Ascension Parish Burial Ground, although he had worked close to it for many years. His support and assistance in these enquiries was immediate though.

Fig. 10. Eric Marland at the Ascension Burial Ground.

On an earlier research visit to Cambridge in February 2013, I met the stone mason, Eric Marland (Fig. 10), an American, who now owns the burial ground's redundant chapel which he uses as his workshop.

He was able to provide some details about the memorial and also information about a few of the relations of David Bragg. He suggested that, since the Braggs and the Hopkinsons are related, it was likely that some living members of the Bragg family might be able to help in the researches. Helpfully he provided contact details for Nicholas Heath, a nephew of David Bragg.

With this lead established, events moved quickly, and with the enthusiastic support of members of the Bragg family, and of one of Bertram's granddaughters, contact was

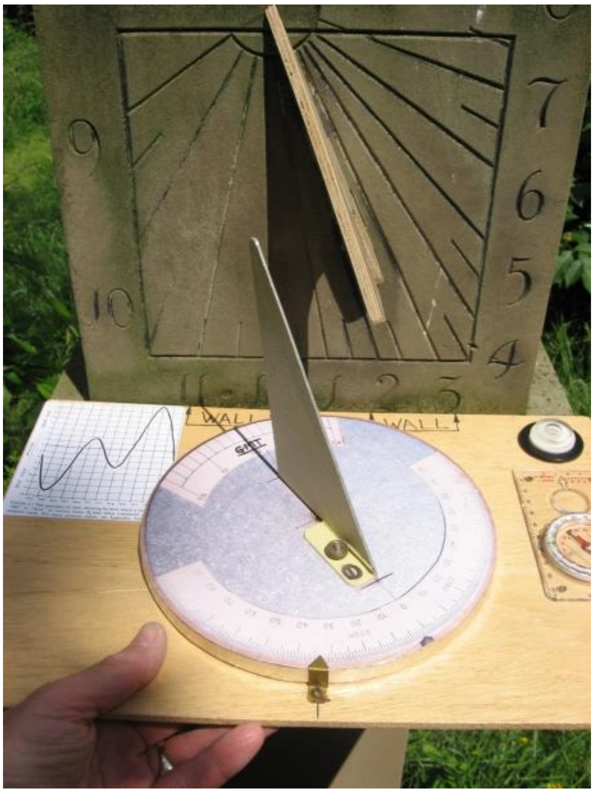


Fig. 11. Checking the delineation and orientation of the sundial.

established with Cecil's closest remaining relation, his niece Mrs Cecilia Scurfield, the youngest of Bertram and Mariana's seven daughters.

Having established these contacts, immediate and wholehearted support for the restoration of the sundial and memorial was given by the family and planning was able to commence on the design for a suitable replacement gnomon, cleaning of the stonework and the repainting of the inscriptions. Accurate measurements of the dial itself were taken, as well as the delineation to allow its orientation to be confirmed (Fig. 11).

With the assistance of another BSS member, John Davis, various styles of gnomon (Fig. 12) were considered for the replacement that would best complement the design of the

Fig. 12. Various suitable gnomon shapes.

Fig. 13. The selected gnomon shape, newly constructed in brass.

Fig. 14. Emi Soto repainting the dial. Photo: Frank King.

Fig. 19. Replacement gnomon fitted to the sundial. Photo: Frank King.

sundial. A gnomon with a simple scrolled support was eventually selected and arrangements were made for its construction in brass by John (Fig. 13).

Considering that the memorial is almost 100 years old, the stonework remains in remarkably good condition, its inscriptions still crisp. Restoration would also include some minor repairs to the pyramid cap-stone and the overall cleaning of the stonework, prior to repainting the engraved sundial markings and the inscribed lettering.

This part of the restoration work was arranged by Frank King, with Eric Marland repairing the minor damage to the stonework and with the repainting work being undertaken by Emi Soto (Fig. 14).

Towards the end of 2014 the repainting and minor repair work had been completed, this having been delayed by periods of unsuitable weather during the summer months. Figs 15–18 show the inscriptions of the restored memorial.

Following this, the new gnomon was eventually fitted in February 2015, being secured in place using the original

Figs 15–18. The restored inscriptions.

method of flat lead side-packing pieces inserted alongside the lugs on the gnomon, to form an 'interference fit' (Fig. 19).

Exactly when the original gnomon was lost is unknown, but before this restoration was undertaken efforts were made to search the surrounding ground area with a metal detector in the hope of locating the missing gnomon, but to no avail (except that several battered metal memorial vase tops were unearthed!).

During the course of these restorations, Eric Marland was also able to supply photographs of the memorial shown leaning precariously, prior to an earlier restoration (Fig. 20). This was probably pre-2005 as these images show grave-kerbing surrounding the memorial. They also do not show the adjacent gravestone of David William Bragg who died in 2005.

Fig. 20. Photograph of the memorial, precariously leaning, before a previous restoration. Photo: Eric Marland.

An Afterthought

Mention should also be made of Sir (James) Alfred Ewing[3] a Scottish physicist and engineer, also known as "The Man of Room 40", famous for his part during the First World War in creating the British Admiralty's code-breaking organisation.

A family friend, Alfred Ewing had been invited to join the holiday party in Switzerland of John Hopkinson in which he and three of his children were killed. Although not taking part in that fateful climb, the task subsequently fell to Alfred to break the news of the accident to John's wife, Evelyn.

Alfred's first wife Annie (née Washington, a descendant of the American president George Washington), died in 1909. In 1912 he married Ellen, the surviving daughter of his old friend and patron, John Hopkinson.

In 1915, following the news of the wounding of Cecil in France, he made arrangements with the Director-General of the Army Medical Service at the War Office for Evelyn and her elder son Bertram to be (unusually) issued with special permits to go to Calais to visit Cecil.

As Vice-Chancellor of Edinburgh University he would almost certainly have known of Niddrie Marischal, and it is possible that he had knowledge of sundials in the Edinburgh area. Perhaps the reference on the commemorative memorial at the Ascension Parish Burial Ground suggests that Alfred might have had a hand in the choice of dial for Cecil's column.

Alfred died in 1935, and is also buried nearby in the burial ground, together with Ellen, who died in 1953.

By a strange coincidence, when the original question of the existence of the memorial, or of a Hopkinson Society was raised with the Chairman at the 2013 BSS Conference in Edinburgh, neither of us was aware that at that moment we were only a few hundred yards from the grounds of the old Niddrie Marischal estate!

ACKNOWLEDGEMENTS

My thanks go to the following people, all of whom have helped to make this such an interesting and rewarding restoration project.

Members of the Bragg and Hopkinson families: Lady Margaret Heath, Nicholas and Penny Heath, Dr Rosemary Summers, Mrs Cecilia Scurfield (now recently deceased).

Members of the British Sundial Society: Dr Frank King, Dr John Davis, Dennis Cowan.

Eric Marland and Emi Soto for their restoration work.

Staff at Wimbledon High School.

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SCOTTISH OBELISKS AND THE KIRKTONHALL PROJECT (and a Chess Set)

DENNIS COWAN

This article is based on the talk given by the author at the 2015 BSS Conference.

Ancient obelisk sundials are unique to Scotland and in 1892 Thomas Ross identified eighteen complete dials throughout the country.[1] One hundred years later, Andrew Somerville catalogued twenty-five complete dials,[2] although two of the eighteen identified by Ross were by then missing.

Most of these obelisks are scattered around the central belt of Scotland, although one is in the far north in Tongue, two are on the island of Mull off the west coast and another is on the Cowal peninsula, again on the west coast.

In 2008, I was lucky enough to discover a twenty-sixth obelisk in the grounds of Cromlix House Hotel near Dunblane, now owned by the tennis player, Andy Murray.

It is possible that there is a twenty-seventh at Dunphail near Elgin in the north of Scotland, but more investigation is required. What is known is that the sculptor, Gerald Laing, created a bronze obelisk that may be a copy of the Dunphail dial. This bronze dial is currently at Kinkell Castle near Inverness and another copy, this time in Portland stone, is at the Wormsley cricket ground in Buckinghamshire. However, it is not certain that the Dunphail obelisk ever existed, as Somerville was known to be in contact with Laing at the time Laing produced the bronze dial in 1988, and Somerville did not include the Dunphail dial in his catalogue. As I said, more investigation is required.

But what is the Kirktonhall Project?

Kirktonhall is a 'B' listed 17th-century mansion in the village of West Kilbride on the west coast of Scotland. It is owned by the local North Ayrshire Council, but has been out of use and has lain empty since 2008. The Council decided to sell the building and the Kirktonhall Creative Media Group (KCMG) emerged as the preferred bidder and has been working with the Council to develop the project.

Their plan is to create a digital creative media suite on the ground floor and a range of small flexible start-up business units on the upper floors, and in the process save the building for the future. Grant applications have been submitted to the Heritage Lottery Fund, Big Lottery Growing Community Assets and Historic Scotland. The outcome of these applications is expected in the early summer.

But what has this to do with obelisk sundials?

One of the twenty-six complete obelisks is in the grounds of Kirktonhall and this gave them the idea to make 3D images of as many of the obelisks as they can, create smaller-scale copies of them and site them in a rooftop garden that they plan to build.

Of course there will be many difficulties. Some of the owners will be hard to contact and some of those that are contacted may not want to be involved. I have suggested that KCMG expand their horizons beyond obelisks and include some of the many other fascinating sundials that Scotland has to offer, and this could give them the opportunity to have a reasonable number of significant dials in their garden.

This is extremely exciting. Not only would there be one location where a number of different Scottish dials could be seen, but more importantly there would be 3D drawings of these dials for an archive. Any deterioration of a dial could be easily identified and action taken. Giving 3D drawings to the owners of the dials may make them more amenable to taking part in the project.

Fig. 1. Two-inch model of the Kirktonhall dial.

Fig. 2. The sundial chess set.

The Group has already created a 3D image of the Kirktonhall obelisk and produced a two-inch 3D model (Fig. 1). It was when I obtained one of these that I immediately thought of a chess set (Fig. 2). The Kirktonhall obelisk would be the Pawns and the unique Ardrossan multi-facetted dial described by Christine Northeast in the March 2015 *Bulletin*[3] is ideally suited to be the Castles. The Knights could be the horizontal dial from Culzean Castle in Ayrshire. The Bishops should obviously be intelligent, so Kelvin's Globe at Glasgow University is ideal. That leaves the King and Queen. There is no more suitable dial to be Queen than the wonderful dial from 1679 by James Gifford at Lennoxlove in East Lothian. The King has to be King Charles' dial at the Palace of Holyroodhouse in Edinburgh, seen by delegates at the 2013 BSS Conference.

So you never know. This is just a bit of fun, but you may be able to buy a sundial chess set in the future.

More importantly, however, having 3D drawings of some of our important sundials would be of immense value. Let us all hope that the Kirktonhall Creative Media Group succeed in their ambitions.

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Postcard Potpourri 32 – Pilling, Lancashire

Peter Ransom

THUS ETERNITY APPROACHETH is the motto above this impressive dial over the south door of the church of St John the Baptist (now a redundant church belonging to the Churches Conservation Trust) at Pilling in Lancashire. You can see the name G Holden and date 1766 on the dial and 1771 on the door. This dial is in the 2010 BSS Register (SRN 1625) where it mentions that the gnomon was missing when recorded in 1992, so if any restoration is to be done this postcard could prove invaluable!

The Reverend George Holden was fascinated by tidal movements and is credited with producing the first set of publicly-accessible tide tables in the UK. Perhaps this is not surprising as Pilling is situated close to the sea and fishing (mainly shellfish and particularly cockles to Blackpool) is part of the local economy.

The postcard was published by [A.J.] Evans of Preston, who seemed to do a lot of postcards local to Preston in the 1920s and 1930s. Though this postcard has been written on, it is not addressed, stamped or dated.

pransom@btinternet.com

DIALLING INSTRUMENTS IN HOLBEIN'S PAINTING 'THE AMBASSADORS'

ALLAN MILLS

This article is based on the talk given by the author at the 2015 BSS Conference.

One of the works on permanent display at the National Gallery is that commonly known as 'The Ambassadors'. It is reproduced here as Fig. 1.

Fig. 1. Hans Holbein the Younger, 'The Ambassadors', 1533. *National Gallery, London, image no. NG1314. Copyright.*

Painted by Hans Holbein in 1533, when he was painter-in-residence at the court of Henry VIII, it was purchased from a dealer in the 19th century and lacked provenance and documentation. The gallery was therefore dependent on the opinions of experts, although Holbein's signature has now been found. By the 1920s, it had been decided[1] and commonly accepted that the two gentlemen featured were Jean de Dinteville and Georges de Selve, the former acting as Ambassador of France. Now a country normally appoints only one ambassador to represent it to another government, so the painting's modern title appears to be based on short appointments of de Selve as ambassador to Venice and elsewhere. De Dinteville was a nobleman – the Bailly of Troyes – and is extravagantly clothed in furs. On the right, de Selve is portrayed in a dark robe.

In more recent years[2–8] this identification has been extensively questioned on the following basis:

- The faces of the two gentlemen are very similar, and it is known that de Dinteville's younger brother visited him around the time the painting was being executed.
- de Selve is wearing a sable robe: the individual skins of dozens of the unfortunate animals (members of the weasel family) may be distinguished. This fur cloak is a very expensive product, far from the cloth robe expected of a bishop (as he later became) but emblematic of a rich and aristocratic family.
- de Selve's pose is awkward: it looks like he was inserted when the painting was partially completed! Surely de Dinteville would be more likely to sanction this for his brother than for a friend!

The Anamorphosis

The strange elongated object occupying the lower quarter of the painting is one reason for its popularity. It is an example of an extreme perspective view known as an *anamorphosis.* Viewed along its axis from the right-hand edge of the frame the distortion is corrected, and the object appears as a human skull peering out of the picture plane (Fig. 2).

Art historians have interpreted this as a comment on the pomp displayed by the two gentlemen: death is a great

Fig. 2. Rectified view of the anamorphosis shown in Fig. 1 – a human skull.

Fig. 3. Dialling instruments on the table.

leveller! This has prompted further search for hidden comments in the painting. Thus, in the original, the lute on the lower shelf may be seen to have a broken string. This has been seen as representing the schism between Catholics and Protestants generated by Henry VIII.

More relevant to us, however, are the instruments shown on the table.

The Dialling Instruments

These are shown in greater detail in Fig. 3, and have attracted the attention of a number of scholars as referenced above.

The globes

Let us begin with the celestial globe and a smaller terrestrial globe on the lower shelf. No problems here, although some attempts have been made to extract date and positional information from the placing of these globes.

The torquetum[9]

This is shown in greater detail in Fig. 4, and more explicitly in Fig. 5. The function of this instrument was to enable measurement of the coordinates of celestial bodies on the three classic systems:

- Local altitude and azimuth
- Right ascension and declination
- Ecliptic coordinates

It could also be set up in a large hall to convert measurements on one system to those on another, sighting upon a distant target fixed at the appropriate point on ceiling or walls.

The torquetum was, even in Holbein's time, obsolescent – just like the slide-rule is today. Calculations were invariably made by spherical trigonometry.

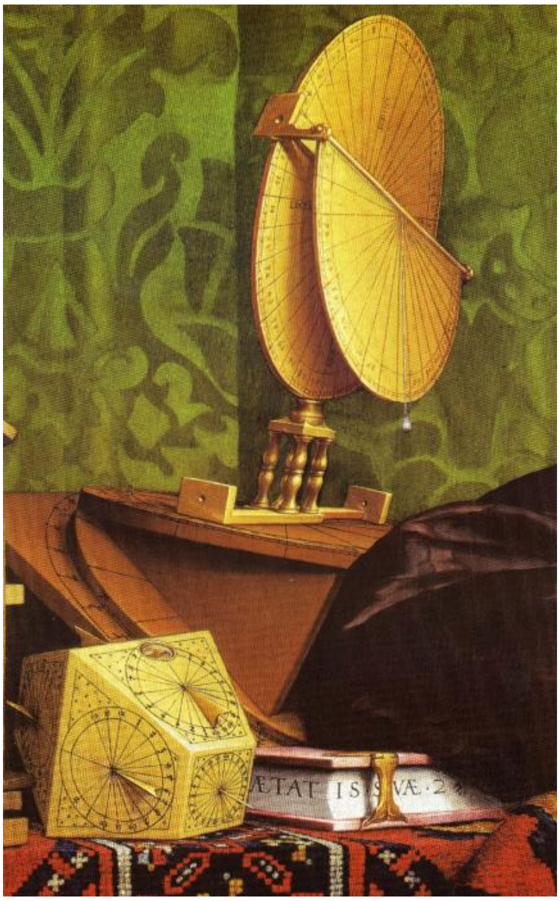

Fig. 4. Close-up view of the torquetum and a polyhedral dial.

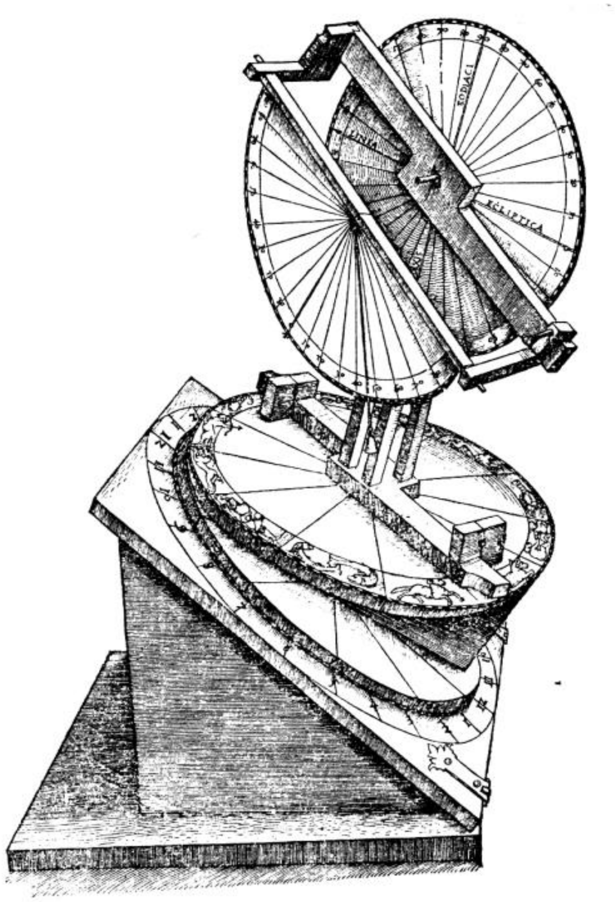

Fig. 5. Engraving of a torquetum shown by Oronce Finé, 1560.[12, 13]

Fig. 6. The shepherd's dial.

Fig. 7. Reproduction of a shepherd's dial.

The shepherd's dial

On the left, close to de Dinteville's sleeve, is a carefully depicted shepherd's or cylinder dial (Fig. 6). This is an *altitude dial*, and as such does not require any knowledge of the direction towards geographic north.[10] It should, however, be laid out to suit the latitude of use, although good for twenty miles around when used as a portable dial provided it is supported vertically by a string or placed on a level table. The dial shown is calibrated for about 52° N, the latitude of London. The day must be set by rotating the gnomon in its ring relative to the date (Zodiac) scale near the base of the instrument, and then the gnomon pointed at the sun until the width of its shadow is minimised. The position of the tip of the gnomon on the scale then indicates the time of day – although you are expected to know if it is morning or afternoon!

The calibration shown in Holbein's instrument is for equal hours,[11] although that for seasonal hours[10] was known in Roman times. The shadow shown on the dial indicates a time of about 3:40 pm, although its curvature suggests a slightly bent gnomon! For this reason, gnomons on cylinder dials are intended to be removed from their socket and safely stored within the hollow body of the instrument. Sundials are not normally associated with telling the time indoors, but can do so if the location is a well-illuminated porch as favoured by artists.

A reproduction of a cylinder dial is shown in Fig. 7.

The universal equatorial dial

Just to the right of the shepherd's dial are two more instruments, shown in greater detail in Fig. 8. In the foreground is a rather complex device that was a source of

Fig. 8. Universal equatorial dial (demounted) and horary quadrant.

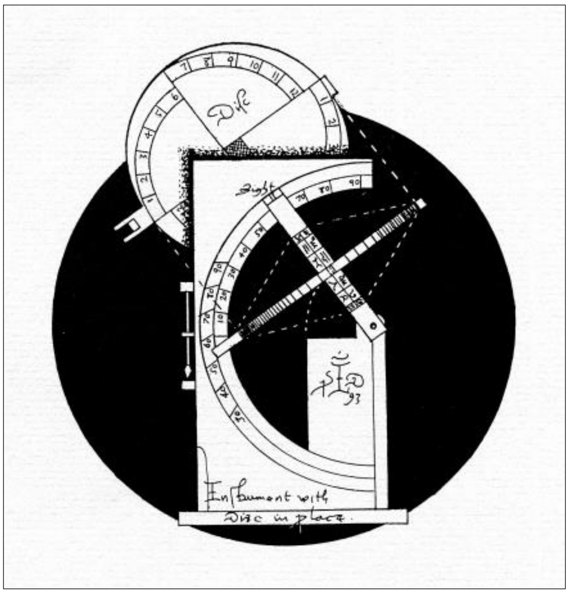

Fig. 9. Drinkwater's graphical reconstruction of the universal equatorial dial.[4,19]

considerable perplexity until Peter Drinkwater[4] pointed out that it should be combined with a component positioned in front of it on the table. The combination (Fig. 9) will be recognised as an equatorial dial adjustable in slope to suit a given site. The pin-gnomon may be set in any one of a certain number of positions perpendicular to the dial in order to avoid shadowing by the supporting structure. It must go all the way through, for both sides of the reversible dial must be calibrated to allow for the movement of the sun from one celestial hemisphere to the other at the equinoxes.

The whole thing is unnecessarily complicated – which is why it did not endure. Much simpler is a reversible dial something like that illustrated[12] by Oronce Finé in 1560 (Fig. 10), mounted upon a hinged support adjusted by a strut and plumb-line.

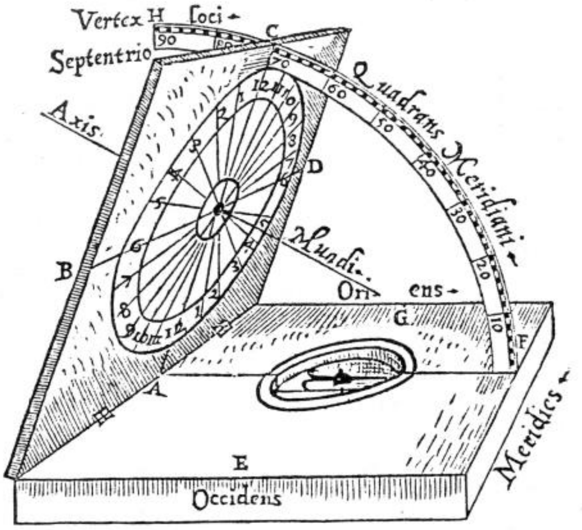

Fig. 10. A simple universal equatorial dial shown in a woodcut by Oronce Finé. 16th century. Reproduced by Drinkwater.[12]

Horary quadrant[7,8,12–15]

Fig. 8 also shows, tucked behind the universal equatorial dial, an 'horary quadrant' printed on heavy white paper mounted on thin board.

At its simplest, a quadrant is a quarter-circle graduated 0–90° around its circumference, and equipped with a plumb-line hanging from its centre. If fitted with sights along a radial edge, it is obvious how it may be applied to measure the angular elevation of a distant object when viewed from a given location. It may similarly be used to determine the instantaneous altitude of the sun if the latter is allowed to shine through a pinhole foresight and form an image on a target at the centre of the rear sight. This angle may then be translated into local time by means of tables, provided latitude and date are known.

More complex dedicated horary quadrants avoided the need for tables by employing a bead sliding stiffly upon the thread of the plumb-line.[13] It could be slid along to the current date on a matrix calculated for the latitude of the

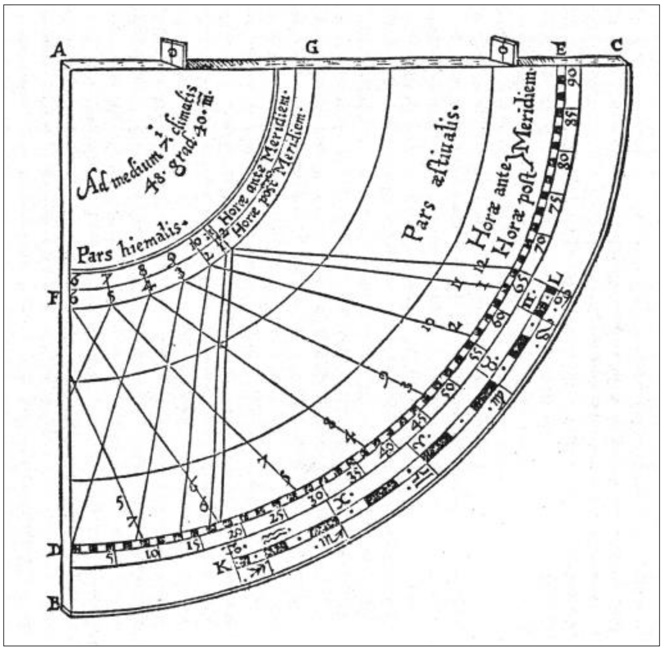

Fig. 11. An horary quadrant with straight hour lines.[12, 13]

place of use. The quadrant was then turned to the sun, and the position of the bead then indicated local time against arcs crossing the face of the quadrant.

However, it will be observed that the horary quadrant pictured by Holbein features *straight* hour lines. Such instruments were known in medieval times[7,8] (Fig. 11). Later quadrants[14] usually employ *curved* hour lines (for example Gunter's quadrant[15]). It would seem that a modern mathematical re-examination of the setting-out of the horary quadrant is required – although John Davis has drawn my attention to recent publications[16,17,18] relevant to this topic.

The polyhedral dial

The polyhedral dial best shown in Fig. 4 has given rise to much discussion.[19] Geometrically, it consists of two truncated square pyramids fixed base-to-base. The small flat-surfaced square at the visible apex carries a perpendicular pin-gnomon, and the dial surrounding its base appears to be a symmetrical equinoctial design. Now a pin-gnomon (or the style of a triangular gnomon) must point towards a celestial pole. However, if the entire polyhedron is tilted so that it rests upon its rear sloping face, then it would seem[4] that this might elevate the pin-gnomon to point upwards at 23.5°. The new horizontal upper surface (that carrying the magnetic compass) could then support a correctly constructed and oriented triangular gnomon, with its style pointing at the same celestial pole. The faces that flank this top face then constitute east- and west-reclining dials. Unfortunately, an elevation of 23.5° corresponds in latitude to the Tropic of Cancer, which mostly crosses the Sahara and the North Atlantic Ocean and passes through no notable towns! The circular dials surrounding these gnomons are a puzzle.

Fig. 12. Nicolaus Kratzer, painted by Holbein in 1528. (The Louvre, Paris). A copy is held by the National Portrait Gallery, on loan to Montacute House, Yeovil. Wikimedia Commons.

The explanation may lie in Holbein's friendship with his fellow-countryman Nicolaus Kratzer[20] who held the post of court astronomer to Henry VIII. Apparently Kratzer never mastered the English language, so would have been particularly happy to chat in his native German with Holbein. Kratzer's main interest and occupation was the design and construction of sundials, and a portrait of him by Holbein (Fig. 12) shows two of the dials we have already encountered on a shelf behind him. In his hands he holds a square bi-pyramid that resembles that in Fig. 4, but with the lower section more severely truncated. He appears to be marking it out as a multi-faced sundial, using dividers and other tools. However, no craftsman carries out such a scratchy procedure upon a finished dial: instead he constructs it upon paper and then transfers the final version by pricking-through the lines.

Now, artists commonly draw or paint only the major features of a portrait (such as the face) at the residence of a sitter: the rest is merely sketched-in for later completion in the artist's own studio. I suggest Holbein did just this, but was subsequently unable to recollect the exact details of the object Kratzer was holding. He therefore embellished it with dials based on the equatorial and horizontal dials familiar to him.

A tentative reconstruction of what Kratzer is working on has been made, employing the procedure given by Mayall and Mayall[21] for drafting reclining dials. This cardboard model is shown in Fig. 13: it will be noted that all the styles are parallel, and it works satisfactorily in sunshine at a latitude around 53°.

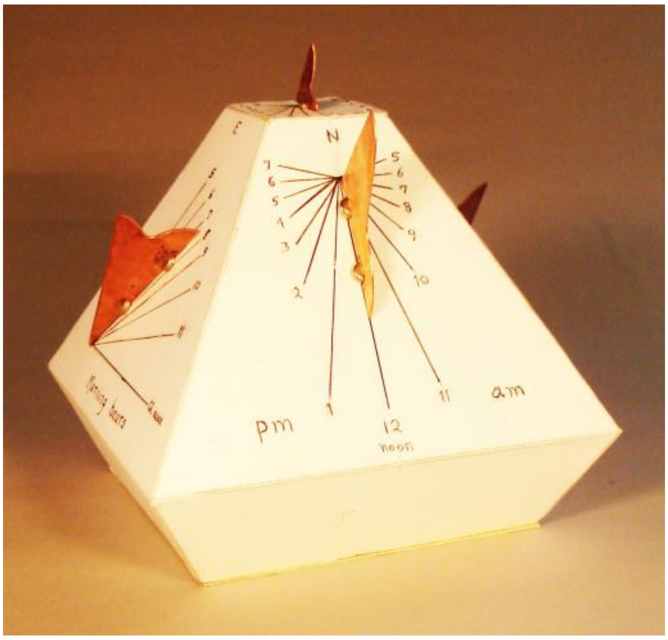

Fig. 13. Completed reproduction of the dial Kratzer appears to be holding in his hands.

Conclusions

Holbein was a highly skilled artist, and like many such gifted individuals appears to have been intrigued by the 'scientific' instruments he saw in Kratzer's workshop. He therefore borrowed some redundant examples to include in his portrait of de Dinteville, and arranged them in what was, to him, a pleasing grouping. But not being a diallist – or even mechanically inclined – he made mistakes. Also, he was not a classical scholar (he came from craftsman and artisan stock) so who instructed him how to compose the hidden 'lessons'? The same objection would seemingly apply to most viewers of the finished painting. I see no need or justification to tease out moral lessons or comments from the instruments or their orientation.

ACKNOWLEDGEMENTS

We are grateful to the National Gallery, London, for permission to reproduce copyright material without charge under their 'scholarly waiver' scheme.

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READER'S LETTER

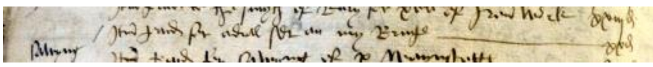
Early Tudor Dials

In my article 'Engraved Decoration on English Horizontal Dials' (*BSS Bull.*, 26(ii), 48–52, June 2014), I said "...there is written evidence of dials in the reign of Henry VII...". Anthony Turner asked me for the source of this statement and, rather sheepishly, I had to admit that I had lost my notes on the topic. I am happy to say that I have now recovered the information.

In 1505, Sir Thomas Lucas, Solicitor-General to Henry VII, was building a new Hall at his property in Little Saxham, Suffolk. He kept meticulous accounts[1] of the project which include, on *xv Julij, A^{o} xx^{o} $Henr^{s}$ vij*

Itm. paid for a dial set on my bruge xx^{d}

Here, 'bruge' refers to the drawbridge over the moat – the accounts also detail the fixtures and fittings for the bridge. It has to be admitted that the item does not specify a horizontal dial and it could conceivably mean a vertical stone dial fixed to the gatehouse at one end of the bridge. The price of 20 pence, though, looks insufficient for a large stone dial, even at 1505 prices which totalled £719 0s 0½d for the building work. Also, the wording "on my bruge" does tend to imply on the actual bridge rather than on the gatehouse. The entry is a very small part of the disbursements and the frustratingly brief description can be read as if the dial is an everyday feature, rather than something new or novel. We are left with the impression that dials were already commonplace, more than a decade before Nicholas Kratzer came to the county and popularized them.



Extract from the Little Saxham accounts.[1] Courtesy of the British Library.

Little Saxham Hall was demolished in 1773. Although the moat still exists, the current bridge over it is a later replacement (c. 1650) and only a fragment of the abutment to the drawbridge remains so the chances of ever locating the dial are now, unfortunately, vanishingly small.

The original abutment to the drawbridge over the moat – no sign of a dial!

1. The disbursements are transcribed in John Gage: *The History and Antiquities of Suffolk: Thingoe Hundred*, John Deck, Bury St Edmunds (1838), pp. 131–53, with the dial mentioned on p.150. The original document is now Brit. Lib. MS Add. 7097, f.197v, the 'Chartulary de Saxham'.

John Davis
Flowton, Suffolk

THE 'PELICAN DIAL' PICTURE AT BROMLEY HOUSE

TONY WOOD

The recent visit by BSS members to Bromley House Subscription Library in Nottingham enabled them to see the Society's library in the Thoroton Room, one-time meeting place for our Council. In the Room as a reminder of the Society's presence is an etching (Fig. 1) of the cubical pillar dial at Corpus Christi College in Oxford, commonly called the 'Pelican Dial' from the topmost item (Fig. 2). The picture is on loan from Tony Wood.

It was produced by Henry G. Walker around the turn of the 19th/20th centuries and initial efforts to find out about the artist proved unsuccessful, the College archivist having no record of such a picture.

Fast forward to the 'Google' age and full details became available:[1]

Henry George Walker (1876–1932) was born in Birchfield, Birmingham and went to the Birmingham Municipal School of Art. He became active as an etcher in about 1921 using soft-ground, dry-point and aquatint, concentrating on popular architectural and topographical scenes.

Fig. 2. The Pelican Dial.

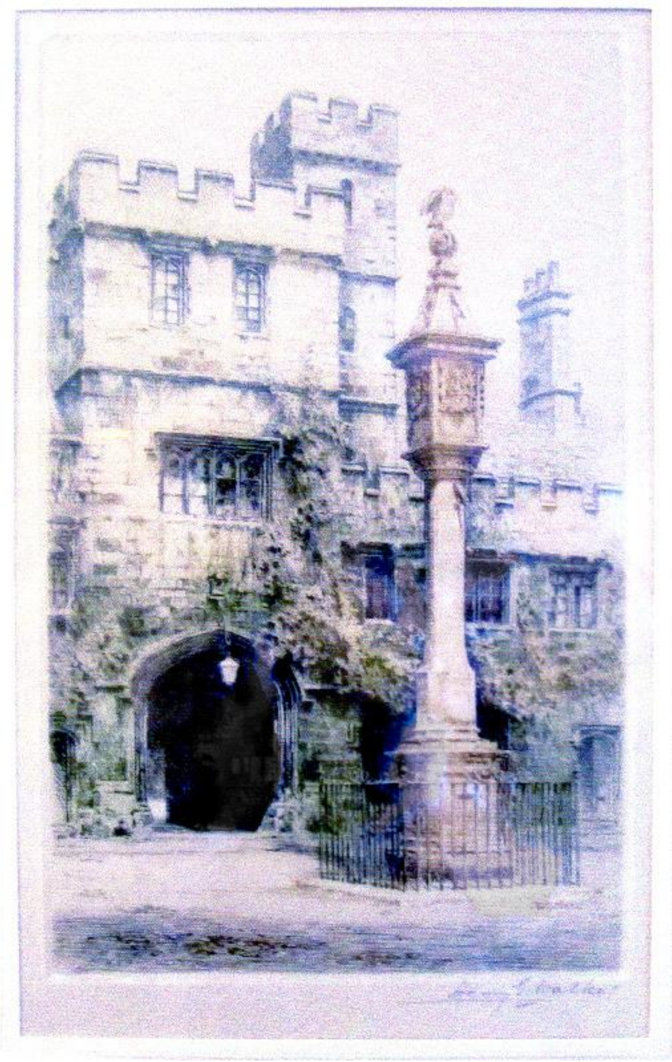


Fig. 1. Etching by H.G. Walker of the Pelican Dial at Corpus Christi College, Oxford.

He later experimented with ink and wash designs for reproduction as coloured prints. He moved to Devon in 1929 and died at Babbacombe in 1932.

Mainly an artist of harbours and landscapes, his pictures are valued today at the price paid 10 or 15 years ago.

NOTE

1. For more details, see *www.thistlefineart.com/WalkerHG.htm*

For a portrait and CV of the author, see *Bulletin* 25(ii), June 2013. He can be contacted at *aowood@soft-data.net*

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