# The British Sundial Society

# BULLETIN

VOLUME 20(i) March 2008

# GUIDELINES FOR CONTRIBUTORS

1. The editor welcomes contributions to the *Bulletin* on the subject of sundials and gnomonics; and, by extension, of sun calendars, sun compasses and sun cannons. Contributions may be articles, photographs, drawings, designs, poems, stories, comments, notes, reports, reviews. Material which has already been published elsewhere in the English language, or which has been submitted for publication, will not normally be accepted. Articles may vary in length, but text should not usually exceed 4500 words.
2. Format: The preferred format for text is MS Word or text files sent by email to *john.davis@btinternet.com*. Material can also be sent on CD or as a single-sided typescript, single- or double-spaced, A4 paper.
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4. Mathematics: symbols used for the common dialling parameters should follow the conventions given in the Symbols section of the *BSS Glossary* (available online on the Society's website). Consult the editor if in doubt or for help in laying out equations.
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   For books: Author's name; Title of book, in italics; Name of publisher, Place and date of publication.
   For papers and articles: Author's name; Title of article in single quote-marks; Name of journal, in italics (this may be abbreviated); volume number, underlined in Arabic numerals; first and last page numbers; date, in brackets.

   Examples:

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

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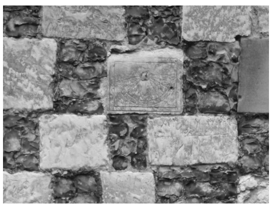
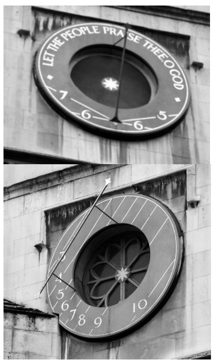
***Front cover:** The South and West faces of the dials on the church of St Margaret of Antioch, Westminster, designed by C Daniel and featuring platinum gilding on blue painted faces. They were made in 1982 by Brookbrae Ltd. The tower also has N and E faces (right). Photos: John Davis.*



***Back cover:** A transitional dial at White Waltham church, Berks. Looking like a mass dial but with Roman hour numerals, it is dated 1583 and is inscribed on part of a chequerboard knapped-flint wall.*
*Photos: Mike Cowham.*



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# BULLETIN

## OF THE BRITISH SUNDIAL SOCIETY


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## VOLUME 20(i) - March 2008


## CONTENTS



## EDITORIAL

**New Author Award 2007**

I am delighted to announce that the award for the best paper by a new author in the 2007 *Bulletin* has been made to Stefano Barbolini, Guido Dresti, Frank King and Rosario Mosello for their paper 'The Sundial in La Specola Museum, Florence' (*Bull.* 19(i) pp.33-39). This is only the second time we have run the award scheme so it is pleasing that it has gone to an overseas writing team on this occasion. In all, 10 papers over the year were by authors who had not previously written Bulletin articles and they were judged irrespective of the length of the paper, the nationality of the authors or whether they were BSS members or not.

The three judges (Peter Baxandall, Jill Wilson and myself) assessed the articles for features such as how interesting the article was, the quality and appropriateness of the illustrations, the writing quality and understandability, the advancement to dialling knowledge, technical accuracy and the references quoted. The Barbolini et al paper came out with the highest overall mark as well as being top for two of the three judges.

The prize, a certificate and a small replica portable dial, will be presented at a later date.

A close runner-up was the paper by Maxwell Craven on 'Derbyshire Sun Dials'.

# THE CLEF-CALLIER AND THE EQUATION OF TIME

**MIKE COWHAM**


*Fig. 1. The Clef-Callier showing (left) the month and day and (right) the Equation of Time on the reverse.*

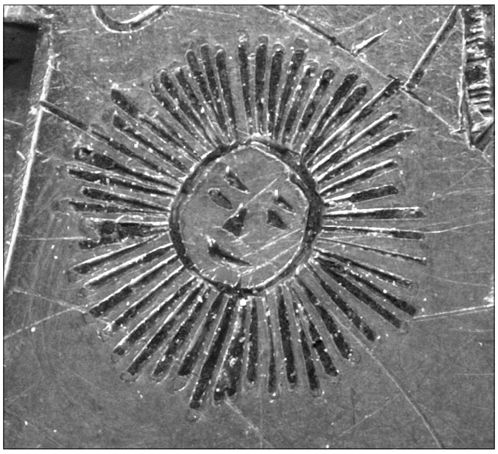

*Fig. 2. Close-up of the sun face.*

I came across this unusual calendar device (Fig. 1) some time ago. It has an elliptical body and was obviously made for the pocket. In size it is just 32.5mm high, 24mm wide and 3.5mm thick. When the small button on the side is pressed the date in the lower aperture advances by one day and the month (MOIS) advances as the date passes 31 back to 1. On the reverse is a more interesting feature. This Clef-Callier shows the Equation of Time for the 5th, 15th and 25th day of each month. 'A' in front of the figure displayed means *avance* or fast and 'R' means *retard* or slow. An interesting and detailed image of the sun's face is depicted to the right of this aperture (Fig. 2). The heading TEMS MOYEN should of course read TEMPS MOYEN or *Average Time*. The device carries the date of *1842*.

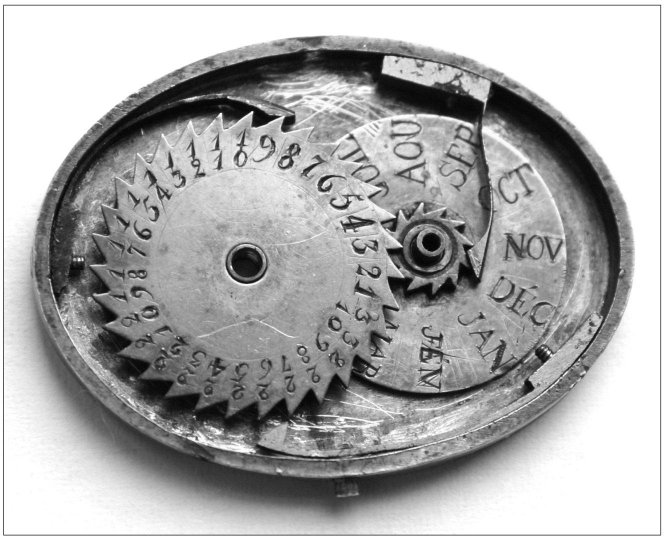


*Fig. 3. The internal workings of the Clef-Callier.*

This would have been a very useful device to carry in the pocket at a time when public sundials were still relatively common so that suitable corrections could be made. Checked against modern figures, the corrections are generally within one minute but there are some slight differences.

The internal mechanism is shown in Fig. 3. As the button is pressed it advances the date wheel on the left. As this rotates through 31 a small pin on the 'day' wheel engages a tooth in the centre of the 'month' wheel, advancing it to the following month. Note an engraving error where FEV has had to be engraved on top of JAN.

| Month | Day | | |
|---|---|---|---|
| | 5 | 15 | 25 |
| JAN | R5 | 9 | 12 |
| FEV | R14 | 14 | 13 |
| MAR | R11 | 9 | 6 |
| AVR | R2 | 0 | A2 |
| MAI | A4 | 4 | 4 |
| JUI | A2 | 0 | R2 |
| JUIL | R4 | 5 | 6 |
| AOU | R5 | 4 | 2 |
| SEP | A2 | 5 | 8 |
| OCT | A12 | 14 | 17 |
| NOV | A17 | 15 | 13 |
| DÉC | A10 | 5 | 0 |

*Fig. 4. The EoT values.*

Why is it called Callier's Key? It appears that this device was named after one of two men called Callier, both working in Paris in the 1840s. These were Jean Baptiste Callier and Bernard Callier. Both men made precision clocks but Bernard made chronometers, winning a gold medal in Paris in 1870. He died in 1908 aged 88 years. It is therefore likely to be a device of his, made when he was still in his early twenties.

I would like to thank Alain Ferreira and Marcel Gay who have given me the information about Callier.

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# THE SUNDIAL AT THE PITTI PALACE IN FLORENCE


## STEFANO BARBOLINI, GUIDO DRESTI, GAROFALO GIOVANNI & ROSARIO MOSELLO


**The Monumental Complex of the Pitti Palace – Boboli**

The main body of the palace was built around 1440 by Luca Fancelli to a design by Filippo Brunelleschi for the Pitti family. Around a century later (1543) Grand-duke Cosimo I, who in the meantime had purchased the palace and the land to its rear, moved his residence to the Pitti Palace and appointed Bartolomeo Ammannati to make it fit to receive the grand-ducal court. This gave the impetus for major extension work, involving the construction of the superb arcaded interior courtyard (Fig. 1 on page 5 in colour). In 1549 the adjoining Boboli Gardens were laid out by Buontalenti, again appointed by Cosimo I de' Medici.

From 1640 Leopoldo de' Medici, the brother of Ferdinando II and a future cardinal (1667), a lover of art and the natural sciences (in which he took an active part), held frequent meetings of scientists and scholars in a variety of disciplines. These learned assemblies, in which Ferdinando II also enjoyed taking part, and the research carried on by the members of the cultural circle were behind the origin of the famous Accademia del Cimento (1657); despite the brevity of its existence, the Accademia left a significant mark on the cultural world of Florence.[1]

This was the environment of scientists and scholars into which the Gran Principe Ferdinando de' Medici was born in 1639. While still very young he became interested in studying, initiated by members of the Court. He took no active part in politics, preferring to devote himself to art and science, and he never ascended to the grand-ducal throne. Thus he decided to move into a secondary wing of the palace, in the south-western part of the building. The apartment was first refurbished and decorated by a number of Florentine artists, and then embellished with a fine sundial crafted by Vincenzo Viviani, who was responsible for calling the building the Palazzina della Meridiana (the small palace of the sundial) (Fig. 2).

A series of changes was made in the following centuries; in particular in 1776 a new building was constructed around the Palazzina della Meridiana, shadowing the gnomonic hole and preventing the sundial from working.

The main body of the Pitti Palace was first laid out as a museum (1828), then chosen as the official residence of the king when Florence became the temporary capital of the Kingdom of Italy (1865-1870), with further restoration and improvements.[2]

The Costume Gallery was opened in the Palazzina della Meridiana in 1983. Apart from its historical galleries, the Pitti Palace also houses many major artistic and cultural events.

In 2007, thanks to the work of one of the authors (Stefano Barbolini), the gnomonic hole was restored to a condition of being able once again to receive the midday shaft of sunlight which allows the sundial to work.

*Fig. 2. The Palazzina della Meridiana.*

In this publication we shall describe the sundial and the room in which it is housed. Together they form a unique, harmonious environment, with the theme of Time and the splendours of science in Tuscany, in the persons of Galileo Galilei and Amerigo Vespucci, evoked in the frescoes painted on the vault by Anton Domenico Gabbiani.[3]

## The Designer of the Sundial

Vincenzo Viviani (Florence 1622-1703) was a pupil of Galileo and was his successor as court mathematician with the Grand-duke of Tuscany; he continued Galileo's studies and published some of his works (Fig. 3). He gained great fame and was offered honours and prestigious appointments, also by King Casimir of Poland and Louis XIV. He was a member of various academies in Italy, including the Accademia del Cimento, and abroad, such as the Royal Society of London and the Académie Française.

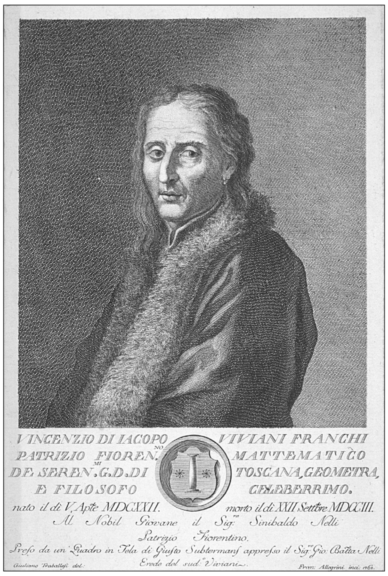


*Fig. 3. Vincenzo Viviani (from an engraving by F. Allegretti, 1763).*

Viviani's devotion to Galileo was proverbial, and according to the historian Thomas Frangenberg[4] was the reason for his undoubted influence on the design of the pictorial decorations (by Anton Domenico Gabbiani) for the mezzanine apartment, where the sundial room is located.

Viviani was determined to honour Galileo's memory with a major monument, but for the whole of the 17th century no member of the Medici family – however much they might have approved of the scientist in private – would have dared to authorize the erection of a public monument in his honour, as Galileo had been condemned by the Roman Catholic Church. In 1692 Viviani decided to transform the façade of his Florentine house into what amounted to a private memorial to Galileo.[5] Furthermore, on his death in 1703, Vincenzo Viviani left a sum of money in his will for the construction of a tomb monument in honour of Galileo; this was built in the Basilica of Santa Croce in Florence, opposite the monument to another great man, Michelangelo Buonarroti.

## The Sundial

The sundial is located in the south-western wing of the Palace, today the Costume Gallery, in the northern corner of a room (Fig. 4) close to the entrance to the Boboli Gardens. It is a pinhole sundial, a type of dial in which the function of the gnomon is performed by a small hole through which a ray of sunlight passes. The ray penetrates the interior of a room which is usually dimly lit, forming an upside-down image of the sun on the surface of the meridian line and reaching the line itself by crossing it at the instant of real local noon. The hole is called the 'gnomonic hole' and its height compared to the horizontal plane on which the meridian line is marked is called the 'gnomonic height'.

As well as verifying the time of the sun's transit on the local meridian (local apparent time), pinhole sundials have been used for many astronomical and calendar observations, which were the focus of great interest especially in the years following the reform of the calendar initiated by Pope Gregory XIII in 1582. The attention of the Church to these instruments was justified by their function as calendars, used particularly to determine the date of Easter.[6] For this reason many sundials were constructed between 1600 and 1700, especially in churches, where it was possible to reconcile the size of the buildings with the semi-darkness required for the instrument to work. Sundials of this type were also present in astronomical observatories, where they were used, for example, for measurements such as the obliquity of the Ecliptic and its variation over time, the seasonal variations in the diameter of the sun, and other astronomical observations. Many of the greatest astronomers and mathematicians of the time experimented with their construction. But pinhole sundials were also found in aristocratic houses, as an indication of an interest in science: this is the case of the Pitti Palace sundial which is the object of this description.

The meridian line in the Pitti Palace consists of a brass strip 68mm wide and 2mm thick. The small size of the room in relation to its height means that the sundial has had to be split into two parts (Fig. 5). The horizontal part, set into the floor, measures noon from the summer solstice to the autumn equinox, while the vertical part, along the northern corner of the room, is active from the winter solstice to the spring equinox. At the end of the part of the horizontal section there is a semicircular plate bearing an engraving with the date of construction: ***Fer: Medici Etr: Prin: Posuit A. D. 1696*** *Ferdinando de' Medici, Principe dell'Etruria, pose A.D. 1696* (Ferdinando de' Medici, Prince of Etruria, laid this A.D. 1696). On the upper part of the vertical element is another semicircular plate with a hole for fixing it to the wall, on which another inscription

*Fig. 1. Panoramic view of the Pitti Palace from the Boboli Gardens.*

*Fig. 4. Interior of the sundial room.*

*Fig. 6 a, b. Detail of the parts of the sundial referring to the winter and summer solstices.*

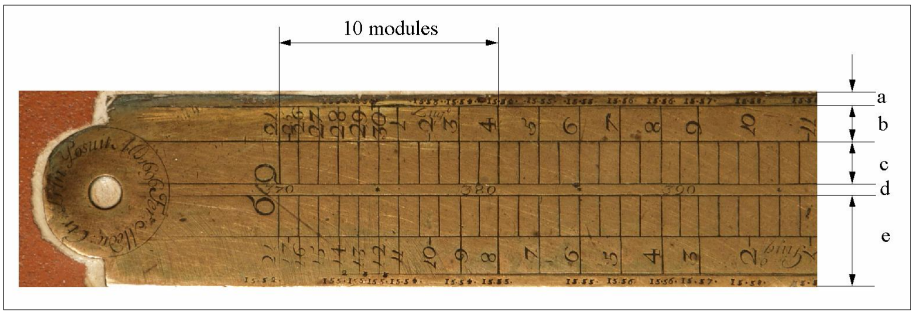


*Fig. 7. Detail of the meridian line and the information on it: a) Italic bell tower hours; b) days of each month; progressive number of modules (1 module = 7.065mm); e) same indication as a,b,c for the other month.*

*Fig. 8. The frescoes in the sundial room.*

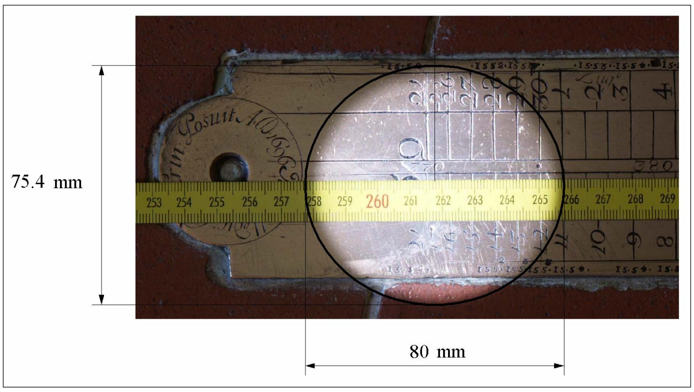


*Fig. 10. Noon on 23/06/07, successful test of the working order of the sundial, after 231 years of darkness.*

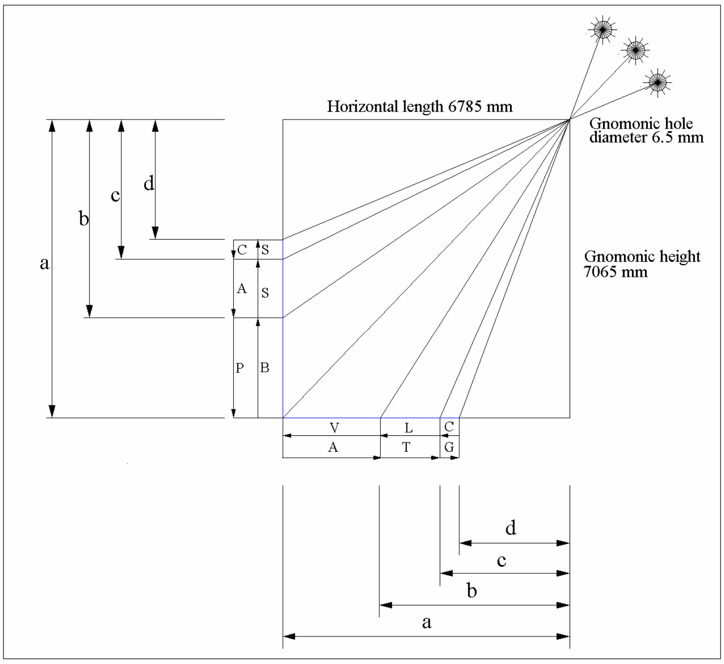


*Fig. 5. Diagram of the sundial.*

with the date of construction is visible: ***Prin: Ferd: Med: Pos : 1696.*** (Fig. 6a & b).

The whole length of the line is divided into 'modules', each of which corresponds to 1/1000 of the gnomonic height for the horizontal part and 1/1000 of the distance between the gnomonic hole and the vertical wall for the vertical line (Fig. 7). The use of modules to construct the meridian, which was a fairly common practice, simplifies the trigonometric calculations required to obtain (for example) the value of the zenith angle and the relative height and diameter of the sun.

The most significant measurements of the instrument are shown in Table 1.

In addition to indicating the passage of the sun at real local noon, the line contains the elements which allow its use as a calendar: the signs of the zodiac of the intermediate months are also engraved along the line. The signs are usually in pairs, because the sun reached one in the course of its journey from the winter solstice to the summer solstice and another during its return journey (Fig. 5). The width of the line is subdivided into sectors (Fig. 7): from the upper outermost sector we can find the time of local noon, according to the system of Italian 'bell tower hours';[7] the days and the names of the months, the limits of the modules and the signs of the zodiac. The same information is contained in symmetrical form in the lower part of the meridian line, for the period from the equinox to the summer solstice. The vertical section measuring noon from the equinoxes to the winter solstice is subdivided in the same way.

| | |
|---|---|
| Latitude N | 43° 45' 53" |
| Longitude E | 11° 14' 58" |
| Altitude (m a.s.l.) | 78 |
| Gnomonic height, mm | 7065 |
| Horizontal length, mm | 6785 |
| Horizontal module, mm | 7.065 |
| Vertical module, mm | 6.785 |
| Diameter of the gnomonic hole, mm | 6.5 |
| | |
| Obliquity of the Ecliptic 2007 | 23° 26' 17" |
| Obliquity of the Ecliptic 1696 | 23° 28' 34" |
| Semi-diameter of sun on 23/06/2007 | 15' 44" |

*Table 1. Characteristic elements of the meridian line.*

The gnomonic hole located in the fresco on the vault comprises a moveable element with two small holes which enable it to be dismantled using a spanner. The explanation for this contrivance is uncertain, but it might be surmised that the element could thus be replaced to vary the diameter of the hole. This made it possible to adapt the observation conditions to the different seasonal situations and the different distances and dimensions of the sun, and to make physical experiments, in line with the spirit of scientific research of the time and of the Medici courtiers.

The optimal diameter of the hole is a function of the gnomonic height. Experimental practice suggests values of around 7mm for a gnomonic height of 7 metres. The Pitti Palace sundial had a hole of 30mm, surely oversized. This, along with the mobility of the plate in which the hole is bored, justifies the previous question and makes the previously formulated hypothesis a possibility.

The sundial room is covered with a vault, marvellously frescoed by Anton Domenico Gabbiani (Fig. 8) with allegorical motifs inspired by Time and Science; the influence of Viviani is clearly in evidence in the composition.

Although the meridian line was made in 1696, the design of the instrument was apparently earlier. There are in existence letters (1694) testifying to a collaboration between Viviani and the great astronomer Giovanni Domenico Cassini, then director of the Astronomical Observatory of Paris but who had temporarily returned to his former Observatory, La Specola in Bologna, to check on the sundial in San Petronio. Cassini helped Viviani in the astronomical observations which preceded the construction of the dial.[8] It may therefore be hypothesized that Viviani had already planned his sundial in 1693, coming to an agreement with G. B. Gabbiani about the frescoes for the vault, which show quite clearly many of the iconographic themes from Palazzo Viviani, the façade of which is contemporaneous with these frescoes. Between 1693 and 1696 Viviani carried out the observations and the calculations required to construct the instrument, with the collaboration of G. D. Cassini, his friend and fellow member of the Accademia del Cimento.

It is not certain, but very likely that the gnomonic hole was sited, or at least planned, as early as 1693, and that the fresco was painted taking the position of the hole into consideration, such is the perfect correspondence of the hole with the most significant of the iconographic elements, the figure of Father Time. He is represented with the face of an elderly man, with a beard and angel's wings, flanked by two *putti* carrying his symbols (the scythe, a circle and an hour glass), and by two female figures, the first representing Knowledge, with a mirror and a globe, while the second holds a clock. A third figure, lying on the ground and with the ears of a donkey, represents Ignorance conquered by Knowledge. Father Time points with his right hand to the Temple of Glory, to which the two personages celebrated in the fresco, Galileo and Vespucci, are destined. The figure of Galileo is flanked by a cannon and a mortar, which recall his ballistic studies. His astronomical studies, however, are more important, and these were performed with the telescope, which in the fresco is used by a female figure, Astronomy, to gaze at Jupiter and its moons; Galileo had dedicated these to the Medici family, calling them 'Medicean planets'. Amerigo Vespucci is pictured on a medallion, and his maritime explorations are represented by a sailing ship with a massive figurehead. The two personages are shown side by side because of their contribution to knowledge, their discovery of new spaces, one in the heavens, the other in the oceans, but both deserving of eternal glory. The opposite part of the fresco shows another allegory of Time, depicted with the four seasons. The four corners of the fresco are decorated with stucco cornucopias (Fig. 8).

Taken as a whole, the fresco represents nothing less than a hymn to the scientific culture of the late 17th century, of which the great Pisan mathematician and astronomer and the Florentine navigator were unrivalled as outstanding figures. The unity of the themes is also quite obvious, between the meridian line, on the floor and the wall, and the fresco, where Time is the dominant element.

*Fig. 9. The skylight set into the roof.*

**The Restoration to Working Order**

A detailed survey of the surroundings of the sundial, started in autumn 2006, revealed that the sunlight was unable to reach the gnomonic hole due to two obstacles. The first was the pitch of the roof; the second was the wall on which the roof rested, which had been raised a storey.

These observations offered some hope that the sundial could be reactivated after two centuries of inactivity. A project was devised and submitted to the administrators of the Costume Gallery and the official in charge of the Pitti Palace infrastructure.

An initial intervention to remove the first obstacle opened a skylight in the roof, protected by a pane of glass (Fig. 9); this introduces a slight refraction of the optical path, with a minimal deviation of the ray of light. The second obstacle has so far not been removed, which means that for the moment the sun's ray reaches the dial only from the beginning of May to the beginning of August. The diameter of the gnomonic hole (30mm) was reduced to 6.5mm through the insertion from above into a specially devised brass aperture.

On the 9th of May 2007, on completion of the first part of the work, the sun once again, after 231 years, touched the meridian line. This was an immensely exciting experience, diminished only by the awareness that the work of restoration was not yet complete. All that remained was to wait for the first real noon to verify the result of the work that had been done. This occurred completely for the first time on 12th May 2007, with a further test on the 23rd of June (Fig. 10), just after the summer solstice, on a cloudy day. The result was a complete success.

A further test of the distances in millimetres on the meridian line of the starting points of the various signs of the zodiac, performed taking account of the different obliquities of the ecliptic in 1696 and at the present (Table 2), showed differences of between less than 4mm at the summer solstice to around 20mm near the equinox. We think that these differences are partly due to the different parameters of calculation used and, more significantly, to the structural subsidence which may have affected the building in the course of more than two centuries, both as a result of restoration work to the *palazzina* and more traumatic events like the earthquake that affected Florence in 1895.

The successful restoration of the sundial and its opening to the public were celebrated in a historic exhibition at the Pitti Palace from 15 May to 3 September 2007. This included a series of explanatory panels and a documentary film illustrating the history, the characteristics and the iconographic context of the sundial. The dial was also

*Table 2. Comparison between the recently-measured values of the lengths on the meridian line, values calculated by Viviani and today. The letters indicating the various parts of the sundial refer to Figure 5.*

| **Solar longitude** | **Signs of the Zodiac** | **Distances along the line mm** | | | | **Ref. fig. 5** |
|---|---|---|---|---|---|---|
| | | **Measured values** | **Calculated values** | | | |
| | | | **1696** | **2007** | | |
| | | **A** | **B** | | **B-A** | |
| **Horizontal line** | | | | | | |
| 90° | Cancer | 2615 | 2611.32 | 2616.55 | -3.68 | d |
| 120°/60° | Leo/Gemini | 3066 | 3083.87 | 3088.61 | 17.87 | c |
| 150°/30° | Virgo/Taurus | 4480 | 4461.47 | 4464.44 | -18.53 | b |
| 180°/0° | Libra/Aries | 6785 | 6764.55 | 6764.55 | -20.45 | a |
| **Vertical line** | | | | | | |
| 180°/0° | Libra/Aries | 7065 | 7086.36 | 7086.36 | 21.36 | a |
| 210°/330° | Scorpio/ Pisces | 4686 | 4708.53 | 4711.32 | 22.53 | b |
| 240°/300° | Sagittarius/Aquarius | 3300 | 3319.62 | 3324.10 | 19.62 | c |
| 270° | Capricorn | 2836 | 2849.38 | 2854.45 | 13.38 | d |

included in the exhibition 'The Line of the Sun. Great sundials in Florence', which opened at the spring equinox and stayed open to the public until the autumn equinox, at the Florence Institute and Museum of the History of Science, introducing the 8 monumental sundials of Florence.[9]

## ACKNOWLEDGEMENTS

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Lastly, Ms Sandra Spence of Oggebbio, Italy, for translating the text into English.

## BIBLIOGRAPHY AND NOTES

1. The *Accademia del Cimento* was founded by Leopoldo de' Medici, the brother of Ferdinando II, Grand-duke of Tuscany, with the aim of "searching for and ascertaining the truth" through experimentation performed jointly by the Academicians. The Accademia imposed no rules or constitution on its members. It met for the first time on 18 June 1657 in the room next to the Library in the grand-ducal palace. The first experiments regarded air pressure, vacuum effects, the properties of heat, the propagation of sound and light, magnetic phenomena and electrical attraction. The scientific activities went on for some years, then continued in a fragmentary fashion until 1667, the year in which the Accademia ended its existence.
2. On the history of the Pitti Palace, see: Conti Cosimo, Il Palazzo Pitti: la sua prima costruzione e successivi ingrandimenti (*Palazzo Pitti: the original building and subsequent enlargements*), Le Monnier, Florence (1887). On the Palazzina della Meridiana, see: I.Ciseri, La Palazzina della Meridiana: oltre due secoli di storia (*The Sundial Palazzina: over two centuries of history*), in S. Bertelli and R. Pasta (Ed.), *Vivere a Pitti. Una reggia dai Medici ai Savoia (Living in the Pitti. A palace from the Medici to the Savoys*), Accademia di Scienze e Lettere 'La Colombaria' – 'Studi' CCXX, Leo S. Olschki Editor, Florence, pp. 463-486 (2003).
3. On the life and work of Anton Domenico Gabbiani (1652-1726) see E. Hugford, Vita di Anton Domenico Gabbiani pittor fiorentino (*Life of Anton Domenico Gabbiani, Florentine painter*), Florence, 1762; Frangenberg, T: 'A private Homage to Galileo: Anton Domenico Gabbiani's frescoes in the Pitti Palace', in *Journal of the Warburg and Courtauld Institutes*, LIX, pp.245-273 (1996); R. Spinelli (ed.), Il Gran Principe Ferdinando de' Medici e Anton Domenico Gabbiani. Mecenatismo e committenza artistica ad un pittore fiorentino della fine del Seicento (*Grand Prince Ferdinando de' Medici and Anton Domenico Gabbiani. Patronage and artworks commissioned of a Florentine painter of the late 17th century*), Exhibition catalogue, Noè Editor, Poggio a Caiano (2003). The scientific work of Galileo Galilei (1564-1642) is well-known and the object of many treatises. Amerigo Vespucci (Florence, 1454 – Seville 1512) was a navigator who explored much of the eastern coast of South America. He was the first to realise that this was a new continent, and not the sought-after Indies. His fame prompted the cartographer Martin Waldseemüller to use the feminine form (*America*) of his name in Latin (*Americus Vespucius*) to indicate the new continent in a map of the world drawn in 1507.

4. Frangenberg 1996, *op. cit.* note 3.

5. The Palace of the Viviani family (known as *Palazzo dei Cartelloni*), with the monument to Galileo, is at 11 Via S. Antonino in Florence.

6. For information on pinhole sundials see: J.L. Heilbron: *The Sun in the Church*, Harvard University Press, Cambridge (1999); F. Bonoli, G. Parmeggiani and F. Poppi: 'Il Sole nella Chiesa: Cassini e le grandi meridiane come strumenti di indagine scientifica' (*The Sun in the Church: Cassini and large dials as tools of scientific research*), Proceedings of the Conference held in Bologna, Italy, 22-23 September 2005 (2006). In 1582 Pope Gregory XIII corrected the difference that had arisen between the official calendar and the astronomical cycle, the result of a small error of calculation (around 11 minutes and 15 seconds less per year) at the time of the earlier reform of the calendar by Julius Caesar in 46 B.C. The correction led to 10 days being eliminated from the calendar, from 4 to 15 October 1582. The close correspondence between the official and the astronomical calendars was made necessary by the determination of the date of Easter, which is made according to the Spring Equinox and the lunar cycle.

7. The Italic hour system fixed the beginning of the day at sunset (hour 24), and noon varied compared to real local noon in the course of the seasons. The variation of Italian 'bell tower' time fixed the beginning of the day half an hour after sunset. In this case sunset coincided with 23.30, and midnight (hour 24) half an hour later. This moment was marked by the ringing of the bells for the Ave Maria, giving rise to the name 'bell tower time'.

8. On the collaboration between Viviani and Cassini in designing the sundial see: L. Tenca, Le relazioni epistolari fra Giovanni Domenico Cassini e Vincenzo Viviani (*Correspondence between Giovan Domenico Cassini and Vincenzo Viviani*), Bologna, p. 162-177 (1955). Giovan Domenico Cassini (Perinaldo (Bologna) 1625; Paris 1712) was professor of astronomy at Bologna. Famous in Europe for his scientific activity, in 1669 he was invited by the French King, Louis XIV, to join the *Académie Royale des Sciences*, and became the first director of the Paris Observatory. He founded a dynasty of astronomers in Paris, as his son Jaques Cassini (1677-1756), his grandson César François Cassini (1714-84) and his great-grandson Jean Dominique Cassini (1748-1845) followed him as directors of the Paris Observatory.

9. A colour brochure of the Pitti Palace sundial marking this first event is available at the bookshop of the costume museum. Also available is a catalogue of the exhibition on the eight monumental sundials of Florence: Camerota, F.. La Linea del Sole. Le grandi meridiane fiorentine. (*The Line of the Sun. Great sundials in Florence*). Institute and Museum of the History of Science, Meridiana Editor, p.111 (2007). Both publications are in Italian and English. Web site www.imss.fi.it.

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# DOWN AT THE GARDEN CENTRE
## A Recorder's Afternoon

**Tony Wood**

The chappie in the picture is not one of Roger Bowling's long lost supporters from a past age but a modern day Atlas with a modern day armillary aloft. It seems to be in a well planted garden but in fact is in a garden centre - a nursery, actually.

Some of our members are a bit sniffy about 'garden centre' dials but the arrow points up truly at 52°, there is a nice motto about flowers and love and the delineation is all present and correct – BUT – in view of the substantial pedestal, a two foot cube of best limestone, is it a permanent feature or is it for sale? We magpie recorders are alert to such matters and keen to get things right; no use recording it if it will be sold next week. Only one way to find out. Enquiry of an assistant brought a little flurry and a young lady with a catalogue and a hopeful look,

"Yes, sir - £10,000"

Further enquiry reveals that it is the handiwork of Richard Heron of Heron Metal Crafts in Maidenhead. Richard was production manager for David Harber and now has his own company producing a range of sundials.

The dial is at Stubbings Nursery near Maidenhead and, as it is not entirely in keeping with my own landscaping… Hurry along if you might wish to buy it as there is only one in stock!

Acknowledgements to Oliver Good of Stubbings Nursery.

*Churchdown*
*Gloucester*

# HISTORICAL OVERVIEW OF THE LISTING/RECORDING OF ENGLISH SCRATCH (MASS) DIALS

CHRIS H K WILLIAMS

Over 5000 English scratch dials have been recorded. Whilst scratch dials have been found throughout Europe, even the higher mainland country listings are only in the lower hundreds. The longevity and extent of scratch dial listing and recording has been a particularly English activity.

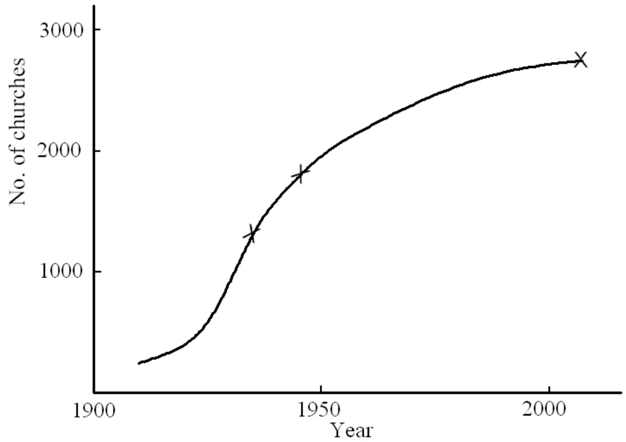
Four distinct historical periods can be discerned

1. Scratch dials first came to the notice of antiquarians during Victorian times.[1] Their work tended to be piecemeal and unsystematic. Considerable uncertainty surrounded their interpretation as sundials. Some even questioned whether they were dials at all.[2]

2. In some senses the interwar period marked the heyday of scratch dial study. Its achievement is encapsulated by Horne's classic study and Cole's synthesis. Horne[3] completed the first thorough and exhaustive county[4] survey – to this day it serves as a benchmark. In addition to collating hitherto published listings, Cole also took into account those that were unpublished. In his citations Cole[5] names approaching 50 individuals (far beyond recognised authors in the literature) as well as several "…and others" mentions. One can only conclude the active research community was in excess of 50. In 1935[6] there were 1350 and in 1945[7] 1800 churches with listed scratch dials. It became universally agreed they were primitive sundials, and their purpose and development was deduced – albeit on an outline presumed basis rather than an academically rigorous one.[8]

3. Turning to the post-war period, one might be excused for thinking the scene was set for the pioneers' achievements to be crowned and embellished. It never happened. Lone individuals laboured in isolation, painstakingly listing and recording within their own counties. Much of this went unpublished and were it not for the subsequent focus provided by the BSS much more would have been lost.[9]

4. The BSS Mass Dial Group under the leadership of Edward Martin[10] and Tony Wood, fuelled by an instinctive recognition of how many dials had been, and were being lost, prioritised the detailed recording of surviving dials. By 2007 the number of known churches with dials had increased to almost 2800. Approaching 5500 individual dials have been listed – most of which have been recorded in detail by the BSS. The Mass Dial Group has averaged about 10 active members, just a fraction of the inter-war community.




**Notes**

1. x marks statistical benchmarks. Cole (1935 & 1945) and BSS (2007).
2. 1935-45 by linear interpolation.
3. pre 1935 extrapolated by author's analysis of the published scratch dial listing literature.
4. 1945-2007 illustrative interpolation indicating progressive saturation effect.

The historical evolution of dial listing is shown above.

Some might be surprised at the apparent modest post-1988 contribution. In fact the BSS has ensured the survival of the entire post-war findings, both through acquiring unpublished works (thereby guaranteeing survival) and the 'rediscovery' of dials (lost in the unknown unpublished work) – note 9. In addition the Mass Dial Group has made detailed recordings of the majority of known dials.[11] In short, a twin achievement which history will always judge to have been monumental.

**REFERENCES AND NOTES**


1. An interest that extended to Saxon dials.
2. Theories included Sexton's Wheels (a device to choose fast days by chance) and mason's protractors.
3. E. Horne: *Primitive Sun Dials or Scratch Dials. Containing a list of those in Somerset*. Barnicott & Pearce, Taunton (1917). See also Tony Wood, 'Dom Ethelbert Horne. Founding Father of Mass Dial Studies', *Bull BSS*, 17(iii), 128-9 (2005).
4. The county has become the traditional statistical unit in scratch dial listing. However this article focuses on the English total; county considerations will be discussed in subsequent articles.
5. T.W. Cole: *Scratch-Dials on Churches Interim List*. The Hill Book Shop. Wimbledon (Undated, 1934).
6. T.W. Cole: *Origin and Use of Church Scratch-Dials*. The Hill Bookshop, Wimbledon (Undated, 1935).

7. T.W. Cole: ‘Church Sundials in Medieval England’. *Journal of the British Archaeological Association*, 10 (3rd Series), 77-80 (1947).
8. See C.K. Aked, ‘Treasures of the Church by T.W. Cole’, *Bull BSS*, **91.3**, 5-12 (1991) for a somewhat harsh assessment of Cole’s legacy. Without Cole we would not have such a vivid insight into the 1930s scratch dial community, nor have the historical statistical datum points that included unpublished listings.
9. The Chambers, Goodwins, Hesketh, Watts and Winzar archives, all now in the BSS library, are of course only examples of known survivals from the 1950s to 70s: sadly an unknown quantity has been lost (or not yet found its way to the BSS).
10. A.O. Wood, ‘Obituary: Edward Rankine Martin 1925-2007’, *Bull BSS*, 19(iii), 104 (2007).
11. Earlier work (before the Mass Dials Group’s activities) was in the main confined to listing, with any recording being typically limited to dial position and abbreviated description. Imaging, photographic or drawing, was very much the exception.

# Another Scaphe Dial By Mary Watts

## Douglas Bateman

Elizabeth Hutchings wrote about a sundial pedestal by the prolific potter Mary Watts (1849-1938) and included a photograph of a scaphe dial with a cherub, which is in the Watts Gallery.[1] (The Watts Gallery in Compton, Surrey, contains a remarkable collection of paintings and sculpture by G F Watts. The gallery was a runner up in the popular BBC series Restoration.) Not far away in Farnborough, Hampshire, there is a similar dial although it has suffered from over 90 years of weathering.

The dial has a plaque on the pedestal that states *In memory of our dear friend Edward T Busk pioneer of the stable aeroplane who died by fire in the air on 5th November 1914. Erected by the staff of the Royal Aircraft Factory*. The Factory became the well known Royal Aircraft Establishment and the house journal recorded in 1971 that Edward Busk was one of the greatest British aviation pioneers. He joined the Royal Aircraft Factory in 1912 and devoted much of his time to the mathematics and dynamics of stable flight. In addition, he was in charge of chemical, metallurgical and physical research, and test work. He died at the age of 28.

A former Director designed a wooden pedestal and “bought a small sundial to go on it from an antique shop in Chelsea” to be a suitable memorial. The pedestal eventually decayed and the dial was moved in 1970 to overlook a small lily pond created near one of the main gates. The site has been extensively redeveloped (the Royal Aircraft Establishment no longer exists as such) and the dial in now in the safe keeping of the Farnborough Air Sciences Trust, a small and active museum dedicated to the history of aviation and aerospace in Farnborough, where Britain’s first man powered flight took place on 16 October 1908.

**REFERENCE**

1. Elizabeth Hutchings: ‘Isle of Wight Mystery Sundial Solved’ *Bull BSS*, 19(iii), pp.112-113 (2007).

# READERS' LETTERS

**New Glossary Terms?**

Reading through *Mrs. Byrne's Dictionary of Unusual, Obscure and Preposterous Words*, I encountered the following three words which, with recasting of their definitions, have some application to dialling. They are unlikely to be that useful, but might be called for one day.

Antiscians: Dials located on the same meridian, but on different sides of the equator, thus casting noon shadows in opposite directions.

Ascian: One without a shadow. Applied to dials between the tropics, where the sun is vertically overhead at noon on certain days. Also, some equinoctial dials around the time of the Equinoxes.

Ghurry: (i) a Hindu period of 24 minutes; an Anglo-Indian hour, (ii) a clepsydra, (iii) any timepiece.

*Graham Stapleton, North Harrow*

**Almost but not quite!**

In Readers' Letters, *Bulletin*, 18(ii), I proudly announced my best to date 'Almost Sundial', the anchor memorial at Tower Hill, London (above). Pity I did not look at it more closely at the time, as I recently established that it would more realistic to categorise it as 'Almost but not quite'. What I had not spotted earlier were the small but incorrectly positioned hour marks around the side. As my latest photo shows, it is perhaps all for the best that they were not placed more prominently.

*John Moir, London*

**Analemmatic Dials**

The *Bulletin* for June which contained my article on Analemmatic Dials also included on page 58 an illustration of a dial of this type in use - the delightful photograph 'The Time of my Life' by Robert Sylvester. Unfortunately this picture shows how not to use this type of dial! The child should not stand with feet in the 'month box', but with feet straddling the centre-line, one foot in the appropriate box. I ought to have made this clear in my article, but I did state that the gnomon lies on the minor axis of the ellipse.

Nevertheless I think it is a lovely photograph.

*Ken Head, Cobham*

**Bath Tompion dial**

I was interested to see the photograph of the Bath Tompion sundial on the cover of the latest *Bulletin* and thought that for the sake of posterity I ought to tell you my (slightly vague) memories of it. The Society may wish to make a note of them for future reference.

In the late 1960s I worked for Meyrick Neilson of Tetbury, who dealt in fine antique clocks. One day a woman walked into the shop, carrying the beautiful Tompion sundial-plate in a bag. She said that it had been found in some nettles just outside Bath, either at Corston or Corsham. I am afraid that I was never sure which. Anyhow, Brigadier Neilson bought the dial.

At that time a universal ring dial (on loan from the Clockmakers' Museum) was displayed in a glazed case next to the Tompion Equation clock in the Pump Room at Bath, with a label explaining that that was the sort of dial that might have been used to set the clock. I do not think that the stone plinth, now supporting the Tompion dial outside the Pump Room window, then existed.

Brigadier Neilson had a great flare for publicity and also occasional flashes of great kindness and generosity. I suspect that it was a combination of these that led him to present the Tompion sundial to the city of Bath a little while after.

To the best of my knowledge there was never any evidence that the dial related to the Pump Room Tompion. It had merely been found in the countryside several miles away. If the nettles were in Corsham, there is always the possibility that it was made for Corsham Court, a substantial 16th century house which is now the seat of the Lords Methuen. If Corston, alternative origins are less obvious.

I would welcome correction from other members of the Society, but I have a feeling that it is probably unsafe (as the *Bulletin*'s caption did) to link the Tompion dial positively to the Tompion clock without further research. It may be of course that someone has done the research and that the doubts I have expressed are ill-founded. Either way, both the dial and the clock are wonderful objects by an exceptional maker.

*George White, Gloucs.*

# FINDING THE SUN'S POSITION IN THE ZODIAC

**MIKE COWHAM**

*Fig. 1. Universal equinoctial ring dial by Edmund Culpeper.*

I recently saw a universal equinoctial ring dial (Fig. 1) signed "Edm: Culpeper" and noticed that it bore some unusual markings on the calendar scales across its bridge (Fig. 2). For a start, these markings mystified me but I was reading the new catalogue of dials from the Instituto e Museo di Storia della Scienza in Florence[1] (reviewed in the December *Bulletin*) and noticed some similar, but somewhat different markings. This gave me the clue to solving my problem.

Firstly, I will take the markings from two of the quadrants in Florence as detailed in the catalogue. The circular tables at first look quite strange. In Fig. 3 there are three rings of letters and numerals with XIII at the centre. Closer inspection shows that the second ring has the months of the year (MA = March, AP = April etc.). The outer ring has the initial letters for the signs of the zodiac (P = Pisces, A = Aries etc.), spaced such that they cover half of two successive months. This notation places the change of zodiac sign to mid month. The calendar on this quadrant is actually Julian, or Old Style, so around the 11th of the month would be more correct. However, with mid month, as constructed, it will serve almost as well for the later Gregorian, or New Style, calendar.

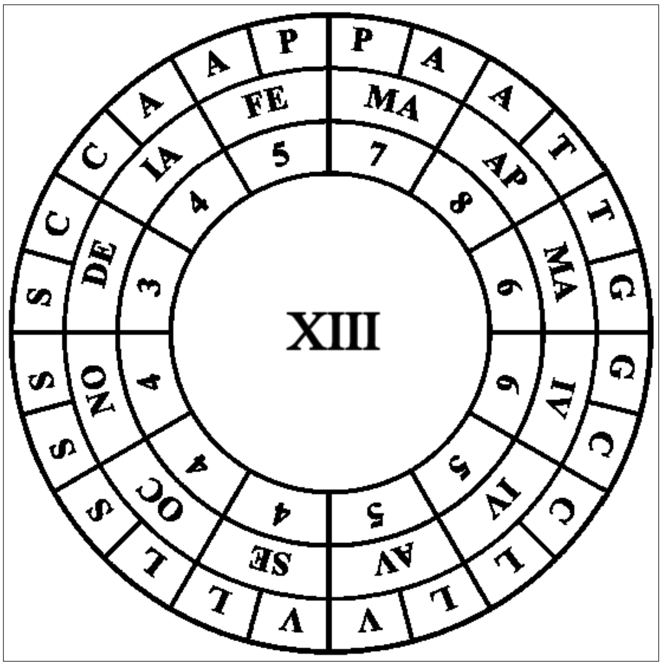



*Fig. 3. Solar Course diagram from Italian horary quadrant by Girolamo della Volpaia, 1570.*

The inner circle of numbers do not immediately make sense. Looking carefully, the sequence, 7, 8, 6, 6, 5, 5, 4, 4, 4, 3, 4, 5 etc., appears to show a cyclic formation throughout the year. First thoughts were that it should be something to do with the date of entry into each of the zodiac signs. However, in the Old Style calendar entry is around the 11th day of each month, and in the New Style around 21st day.

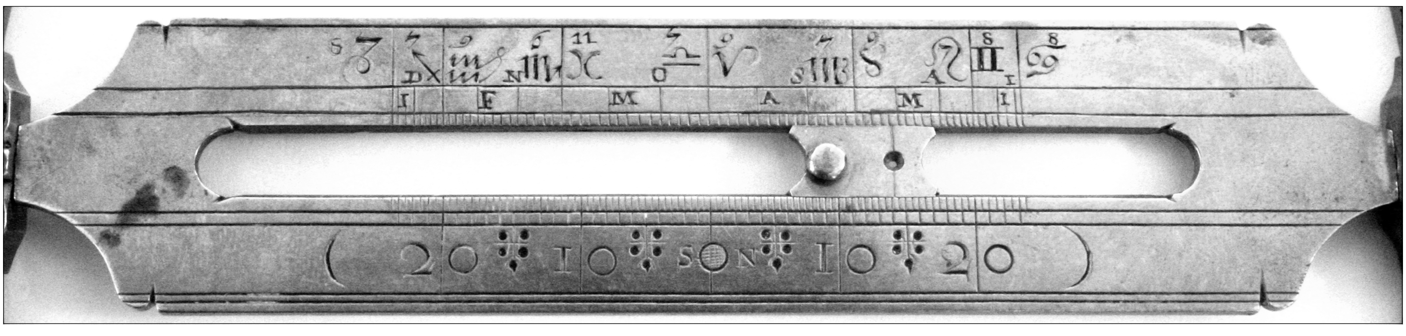


*Fig. 2. Calendar Scale and Zodiac Sigils, New Style on the bridge on the Culpeper universal equinoctial ring dial.*

These numbers do not agree with either system. I then found out that these numbers need to be added to the XIII (or 13) that is shown in the centre of the circles. Again, this still gives neither 11 nor 21.

These are Solar Course diagrams, quite popular with Italian instrument makes of the period. The numbers plus 13 need to be added to the date in the month and the result will give the degrees of Zodiac for that particular date. If the number exceeds 30 then this will place it into the next sign. Therefore 30 should be deducted from such figures. Checking the Vernal Equinox which should be 11 March Old Style or 21 March New Style we find that 11 + 7 (from the inner ring for March) + 13 = 31. If we deduct 30, this gives 1°, virtually correct for the First Point of Aries.

As a further example I have taken the date that I am writing this, which is 24 August 2007 (note that this day would have been 14 August Old Style), we have 14 + 5 + 13 = 32, then deducting 30 means that we are 2° into Virgo. Referring to our trusty *Sundial Glossary*[2], Virgo runs from 23 August. The result therefore ties in quite closely. Notice that some of the figures on these Solar Course diagrams do vary by one or two days. The entry into the signs too may vary by a day depending on which part of the leap year cycle we are in. Therefore, the results may not be perfect, but generally are quite close. This method is a very simple way of finding the position of the sun in the Zodiac for any day in the year.

Fig. 4 shows another variant, again from a quadrant in Florence. The Zodiac ring now uses sigils and the months are abbreviated to just one letter - but what has happened to the numbers on the inner ring? Apparently, these have been replaced by letters running sequentially from A = 1, B = 2

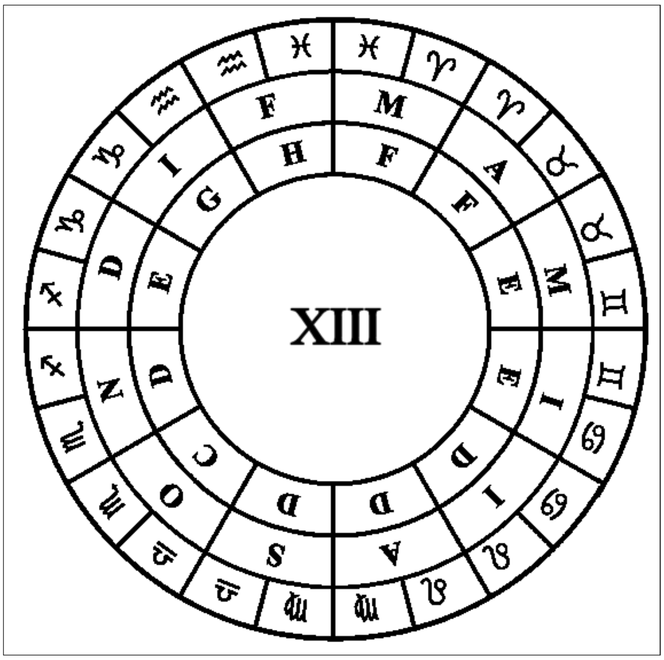



*Fig. 4. Solar Course diagram from Italian nocturnal and horary quadrant by Lorenzo della Volpaia (1511).*

etc. Therefore, checking the date of the Vernal Equinox gives 10 + F (or 6) + 13 = 29, in this case just one day in error.

Returning now to the Culpeper ring dial (Fig. 2) we find a similar, but different set of numbers. Here I have placed them in sequence so that they may be seen more clearly.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 9 | 9 | 8 | 8 | 7 | 7 | 7 | 6 | 7 | 8 | 9 | 11 |
| ♈ | ♉ | ♊ | ♋ | ♌ | ♍ | ♎ | ♏ | ♐ | ♑ | ♒ | ♓ |

Again, the numbers seem to follow a cyclic form. Notice in the photograph, Fig. 5, how Culpeper has placed the **7** inside the loop of ♌ **(**Leo). The scale with these figures is set above a calendar of months, Fig, 2. In this case there is no need to add 13, just add the number to the date. Again, if we take the Vernal Equinox, this time New Style, we have 21 + 9 = 30, then deducting 30 we get 0° of Aries. Similarly with 24 August we get 24 + 7 = 31, deducting 30 we get 1° Virgo. Again correct.

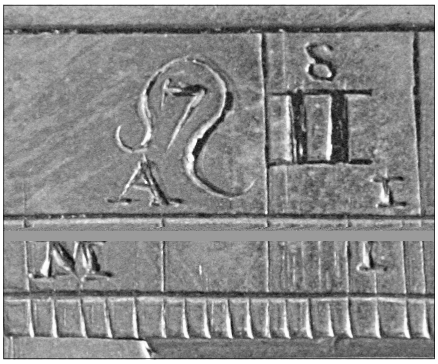


*Fig. 5. Numeral 7 artistically placed within the loop of Leo and the New Style calendar below.*

This may appear to us to be an unusual way of finding the sun's RA (right ascension) but it was often done using the zodiac in those days, starting from the First Point of Aries. Conversion to hours and minutes, if required, is quite simple, each zodiac house being 30° or 2 hours long.

What is also very interesting about this dial is the fact that it was made around 1705 putting it about 45 years before the introduction of the New Style or Gregorian calendar into Britain. The reverse of the bridge, Fig. 6 shows the equinoxes (after 1700) around 10 March and 12 September, so clearly Old Style. However, a New Style calendar has been added, in very small letters, just below the zodiac signs of Fig. 2. The conversion to degrees of zodiac (on this dial) therefore only works for New Style. The scale shown on the lower edge of Fig. 2 refers to ±23½° solar declination between the two solstices.

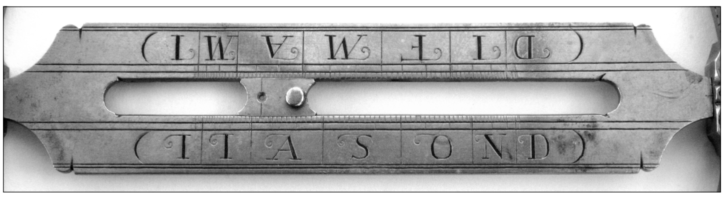


*Fig. 6. Calendar scale, Old Style, on the bridge on the Culpeper universal equinoctial ring dial.*

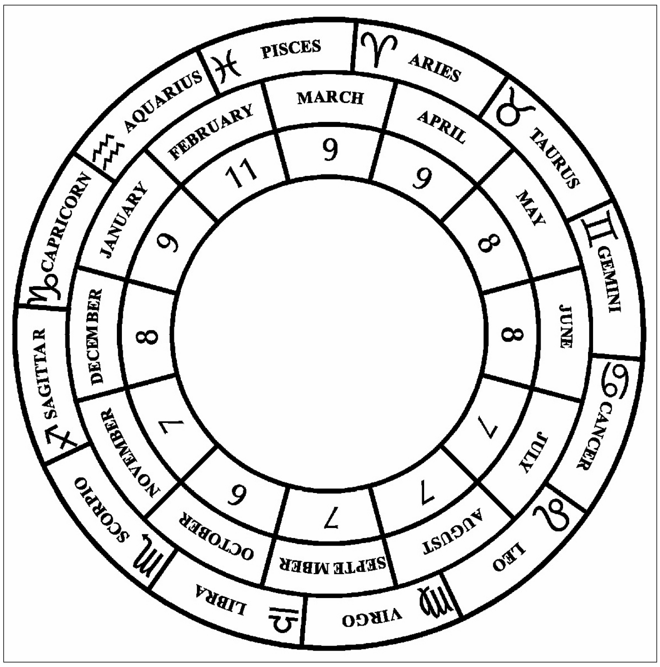



*Fig. 7. Modern Solar Course diagram drawn for the Gregorian calendar using the Culpeper figures.*

This is one of the rare cases where instrument makers were already pre-empting the change of calendar that Britain made in 1752. It is hard to say now why they were doing this, and only a few examples are known, but the dial may have been made for a Catholic customer who was already using the New Style calendar in his church services.

A modern Solar Course diagram has been constructed (Fig. 7) from the figures used by Culpeper, with the First Point of Aries set at 21 March. I am now looking for further examples of such Solar Course diagrams on other instruments and also for examples of New Style calendars on dials from the Julian period.

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1. A.J. Turner: *Catalogue of Sun-dials, Nocturnals and Related Instruments.* Giunti, Fireneze (2007).
2. J.R. Davis: *BSS Sundial Glossary,* 2nd edition, BSS Crowthorne, (2004).

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# THE SWEAR-BOX SUNDIAL

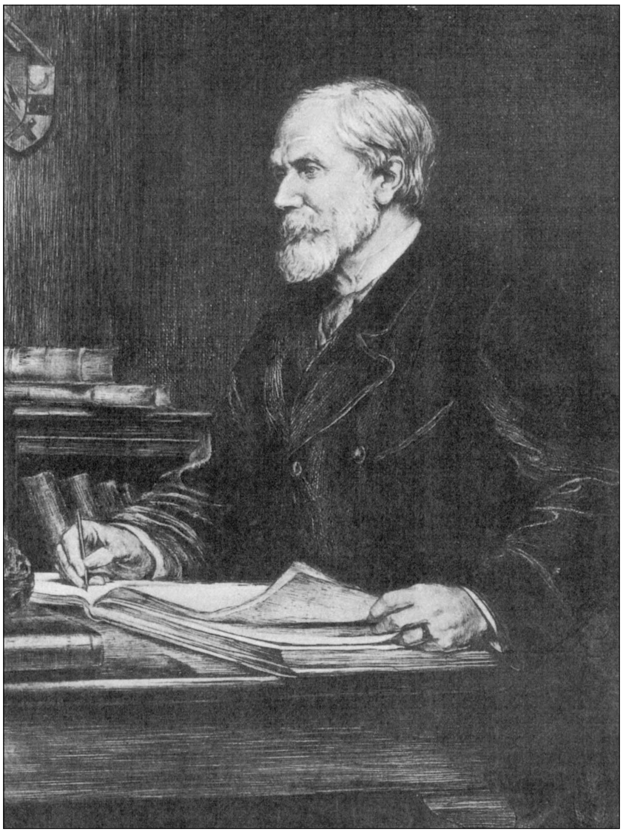
## JOHN FOAD

Sir Henry Yule is best known for his edition of the *Travels of Marco Polo*, published in 1871. As well as being an Orientalist, Yule was a geographer and an officer in the Bengal Engineers, and in the 1840's he was working on the Upper Ganges Canal near Delhi. The story goes ...

> At Roorkee were the extensive engineering workshops connected with the canal. Yule soon became so accustomed to the din as to be undisturbed by the noise, but the unpunctuality and carelessness of the native workmen sorely tried his patience, of which Nature had endowed him with but a small reserve. Vexed with himself for letting temper so often get the better of him, Yule's conscientious mind devised a characteristic remedy. Each time that he lost his temper, he transferred a fine of two rupees (then about five shillings) from his right to his left pocket. When about to leave Roorkee, he devoted this accumulation of self-imposed fines to the erection of a sun-dial, to teach the natives the value of time. The late Sir James Caird, who told this legend of Roorkee as he heard it there in 1880, used to add, with a humorous twinkle of his kindly eyes, "It was a *very* handsome dial."

I wonder if the dial can still be seen. Is any member planning a trip to India? Jaipur is not so far from the Upper Ganges Canal.

The story is taken from a 'Memoir of Henry Yule' by his daughter A F Yule, in the introduction to: *The Book of Ser Marco Polo, the Venetian, Concerning the Kingdoms and Marvels of the East*, Ed Col Sir Henry Yule & Henri Cordier, John Murray, London, 1903, 2 vols. 8vo.



*Sir Henry Yule (1820-1889) by Theodore Blake Wirgman, c.1890.*

# BOOK REVIEWS

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# ASTROLOGICAL SYMBOLS ON SUNDIALS


## FIONA VINCENT


Sundials fascinate us for many reasons – scientific, artistic, historical. Nowadays, few people would regard astrology as scientific; but astrological symbols still have a place on sundials, old and new.

For example, a sundial can indicate the date as well as the time. On wall-mounted dials, particularly, there may be a nodus on the gnomon which marks a particular point on the shadow. This point traces a line across the disc each day from sunrise to sunset; and as the Sun climbs higher towards midsummer, the line moves further down the dial. Two recent articles by Michael Lowne and John Davis[1] and by Tony Belk[2] describe how some of these lines may be drawn on to the dial to mark particular dates: most commonly these are midsummer, midwinter and the equinox line.

We might label such a line MIDSUMMER, but it is more convenient to use the astrological symbol for Cancer, because the Sun enters the sign of Cancer at (northern-hemisphere) midsummer. For astrologers, the Sun's annual path around the sky is divided into twelve equal 30° segments, starting at the March equinox, where the Sun crosses the celestial equator heading northwards. These astrological *signs* were named, around 2000 years ago, for the corresponding *constellations* on the sky; so the March equinox is also known as the First Point of Aries.

Unfortunately, nothing in the sky keeps still! The Earth is very slowly precessing, like a spinning top; its north pole is slowly changing direction, and this means the celestial equator is also shifting. Nowadays, the First Point of Aries actually lies in the constellation of Pisces. Should diallists be concerned about this? If so, perhaps we should replace the symbols for Aries, Cancer, Libra and Capricorn with those for Pisces, Gemini, Virgo, and Sagittarius. But it's not possible to *see* what constellation the Sun is in, except at a total solar eclipse! And nowadays the symbols are very rarely used to indicate constellations – astronomers have their own three-letter abbreviations for those, such as Psc, Gem, Vir and Sgr. It seems perfectly reasonable to continue to use the old symbols to represent the zodiacal signs.

J Davis

*Fig. 1. The lunar volvelle on the c.1610 Isaack Symmes dial in the Oxford Museum of the History of Science.*

Of course, we are not limited to marking just the equinoxes and the solstices. For example, K. H. Head[3] built a dial in 1999 which marks the Sun's entry into all twelve of the Zodiacal signs. The 17th century Symmes dial at the Museum of History in Oxford, described by Lowne and Davis (ref.1, figure 6, p.130), does the same – although Symmes chose to spell out the name of each sign in full, instead of using the symbols!

Symmes did, however, use some less-common symbols on the lunar volvelle in the Oxford dial (ref.1, figure 10, p.132, reproduced as Figure 1 here). In order to use the Moon as a time-keeper, we need to know its *elongation* – its angular distance from the Sun. At New Moon, Sun and Moon lie in the same direction, so the elongation is zero. But if it happened to be five days after New Moon, the Moon would be about 60° to the east of the Sun (the elongation increases by roughly 12° a day). The Earth, of course, turns 15° in a hour, so the Moon would transit about four hours later than the Sun – as described by Michael Lowne[4] in this Bulletin in 2005 – and 'Moon time' would be about four hours slow compared to 'Sun time'.

The lunar volvelle on the Symmes dial can be set in this way, using the age of the Moon in days. Alternatively, it can be set using the lines in the centre, which indicate particular phases of the Moon. The lowest pair of lines are marked with a small six-pointed asterisk, the astrological symbol for *sextile*: this indicates that the two bodies in question are 60° apart. The next pair of lines are marked with small squares: here the bodies are 90° apart, an aspect known as *square* or *quadrature*. The upper lines are marked with small triangles, for *trine*, or 120° separation.

Would the 17th century sundial user be likely to know the Moon's elongation on any given date? Surely, if he did, he would also know the Moon's age, which could be set more

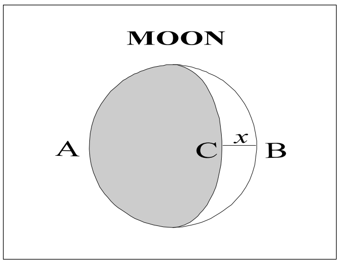


*Fig. 2. The Moon showing the illuminated crescent.*

accurately? The fact is that sextile, quadrature and trine can all be recognised simply by looking at the Moon.

Quadrature is easy: it's simply First or Last Quarter, when exactly half of the Moon's disc is illuminated. What about the other phases? Figure 2 shows a crescent Moon, which is less than 90° from the Sun. A and B mark the mid-points of the dark and bright limbs; C is the mid-point of the terminator (the edge of the illuminated area). The width of the crescent is labelled $x$.

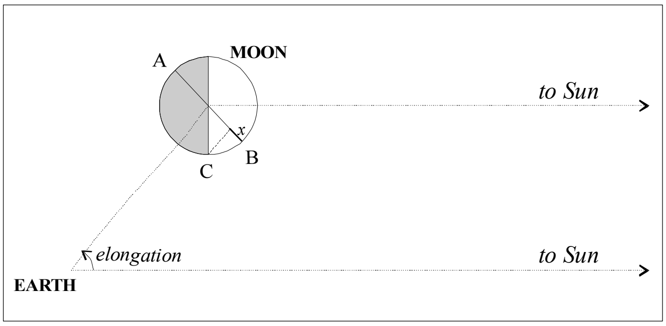


*Fig. 3. The elongation of the Moon.*

To understand the relationship between $x$ and the elongation, look at Figure 3. The Sun is so far away, compared with the Earth-Moon system, that the lines marked "to Sun" can be taken as parallel; but the size of the Moon has been enormously exaggerated to show its phase. Now we can see that $x$ is the projection of CB on to the diameter AB. As the Moon moves anti-clockwise around the Earth, the elongation increases, C moves towards A, and $x$ increases. A little trigonometry shows that, if the Moon is taken as a sphere of radius 1 unit, then

$$x = 1 - \cos(\textit{elongation})$$

So at sextile, when the elongation is 60°, $x$ is 0.5: the terminator lies half-way between the Moon's bright limb and its midpoint.

The diagrams for a gibbous Moon would be different, but the result is similar: in this case the width of the dark portion is $1 + \cos(\textit{elongation})$. Thus at trine, when the elongation is 120°, again $x$ is 0.5: the terminator lies half-way between the Moon's midpoint and its dark limb.

So, even if we don't know the age of the Moon, by estimating the position of the terminator we have another way of determining its elongation.

Incidentally, it's one thing to find the position of the terminator, but what proportion of the Moon is actually illuminated? If the Moon is crescent, what we see is half of a circle minus half of an ellipse. The area of the half-circle is $\pi/2$ (since we are taking the radius as 1 unit), while the ellipse has semi-major axis 1, semi-minor axis $(1 - x)$, so half its area is $\pi(1 - x)/2$. This means the illuminated fraction of the Moon is:

$$\{\pi/2 - \pi(1 - x)/2\} / \pi = x/2$$
$$= \{1 - \cos(\textit{elongation})\}/2$$

So at sextile, exactly ¼ of the Moon is illuminated; and, by a similar argument, at trine exactly ¾ is illuminated – as stated by Lowne and Davis.[1]

Estimating the elongation of the Moon by eye like this may not seem very accurate. But the Moon's orbit is extremely complex; it doesn't actually move around the sky at a steady 12° a day, so even if we know its age in days, using this to set the volvelle can also be inaccurate. In fact, as Lowne[4] explains, the difficulties of actually reading a dial by moonlight mean that such a device is of limited scientific use anyway.

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3. K. H. Head: 'A Home-Made Vertical Declining Dial', *Bull BSS* 18(iii), 118-119 (2006).
4. M. Lowne: 'Moondials and the Moon', *Bull BSS* 17(i), 3-12 (2005).

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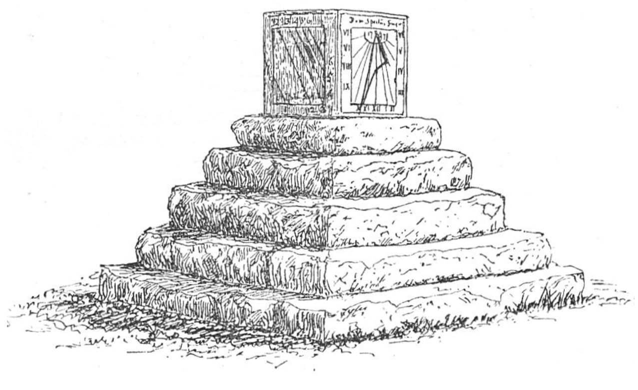


This dial is described by Gatty as having three dials on the sides and one on the top and was located at Thorp Perrow in Yorkshire. It does not seem to be in the BSS Register. The motto is:

This fourfold index of swift time
On which y$^{e}$ shadow veereth round
Should man excite to themes sublime
Since noug$^{t}$ but shadows here are found.

**A Nodal dial in Co. Louth**

The seaside village of Blackrock, Co. Louth, is 6km south of Dundalk on the east coast of Ireland, Lat. 53° 58' N. The superb sundial in the centre of the seafront promenade was unveiled in November 2000, the culmination of three years work by a village committee to mark the Millennium Year in a meaningful and lasting way. They commissioned a 3 metre high bronze sculpture of a female diving figure on a hexagonal stone pedestal by local artist Tanya Nyegaard to form the centrepiece of the dial.

The final result is one of the largest sundials in Ireland with a 7.3 metre diameter chapter ring formed with 30 centimetre wide black granite blocks showing the time from 6am to 6pm in Roman numerals. Set in a grey granite paved area, the completed project incorporates seating and landscaping, and is floodlit at night.

This is a nodal dial, with the diver's toes acting as the nodus. In order to tell the time one should project an imaginary line on the dial face from the clearly marked origin of a virtual gnomon passing through the shadow of the diver's toes onto the chapter ring.

An inscription on one face of the pedestal reads*: Anno Domini 2000 - To commemorate the jubilee of the birth of Christ, and to mark the beginning of a new millennium***,** and on another the year is written in Roman numerals MM and in binary notation 11111010000 to reflect modern computer technology. The Irish version of the inscription reads: *Chun iubhaile bhreith Chriost a cheilliuradh, agus chun tus mi-laoise nua a chomoradh.*

An Irish proverb on the face of the sundial emphasises the linkage between the sea and time: *Ag tuile 'is ag tra a chaitheann an fharraige an la. (Ebbing and flowing is how the sea spends the day)*

A poll in the village in 2001 assigned the name 'Aisling' to the sculpture. Aisling was a form of 18th century Irish poetry in which a female figure, in various guises, appears to the poet and …..

Larry Magnier, Chairman of the Blackrock Millennium Project Committee, did the calculations and delineated the dial, stonework and engravings were by Butterly Stone Enterprises, Dundalk.

*Michael J. Harley*

**Stouffville, Ontario**

This dial, on the side of Christ Church, Sunset Boulevard in Souffville, is believed to be only the second one on an Anglican church in Canada. It was officially unveiled on the vernal equinox, 23 September 2007.

The dial was delineated by BSS member Don Petrie and donated by him and his wife Jacquelin. They are well-known to many members through their participation on our foreign tours. Designed using *Shadows* software, it is at latitude 43° 45' N and declines 9° 44' E. It indicates the hours and half-hours, with, unusually, the longitude correction (17 min 1sec) for its location of 79° 15' 12" West of Greenwich built in. It also has declination lines for the equinoxes and solstices, read from the shadow of a 20mm disk nodus.

The dialplate is from a new material to dialling – High Density Urethane (HDU). This is quite widely used in America for making commercial signs. Its makers claim it to be unaffected by temperature or moisture, not to rot or decompose, to have a virtually unlimited lifespan in any environment inside or out and to allow for the application of any paint finish. Don comments "we shall see!". The artistic design of the dial, and its execution, were by local artist/sculptor/designer Shane Durnford.

The hourlines were incised using a router and template. The lettering for the motto was hand cut – HDU is relatively soft and can be cut with woodworking tools. The lines where then painted with a latex paint and the motto gilded with 24k gold leaf (as are the stainless steel gnomon and its hemispherical base). The half-hour lines and the numerals were surface painted by hand.

The dial is accompanied by a brass plaque on the wall below it which gives details of how to read the time and and an equation of time table giving the corrections to half-minutes for the 1st, 11th and 21st of each month. An 8-page brochure on the dial has also been produced as part of the project. There is relatively little awareness of dialling in the locality so Don wanted to stimulate some interest. It includes a brief history of sundials on churches as well as technical details of the Christ Church dial and instructions on how to read it.

The motto, "SOLI DEO OMNIS GLORIA" translates as *To God alone be all the Glory*, though perhaps the makers deserve some too.

Larry Magnier


*The Stouffville dial. The picture bottom right shows, left to right, the delineator Don Petrie, the maker Shane Durnford and installer Ivan Harris. It also illustrates how large a dial needs to be when it it mounted high on a wall.*

*Left: At the dedication ceremony. Don and Jacquelin Petrie are flanked by the Christ Church rector Robert Shields and associate Jason Prisley.*

**Barrow-upon-Soar, Leicestershire.**

In early 2002 a group of villagers in Barrow-upon-Soar in Leicestershire first came together with the idea of marking the recent Millennium by creating a community garden on a theme of time and history. They decided on a large horizontal sundial as the main attraction.

Patrick Powers was approached to perform the necessary calculations and to be the technical adviser to the project and the villagers themselves came together with local firms and suppliers to create their own simple yet highly imaginative design which intrigues all who see it. A design diameter of 12m and a tubular gnomon was chosen with the use of inset Arabic hour markers which are further marked outside the chapter ring by fifteen local sandstone rough cut blocks.

The dial was formally opened to the public by HM Lord-Lieutenant of Leicestershire, Lady Gretton on 3 July 2004. Those with access to Google Earth might also like to see an aerial view of the dial - amazingly in sunshine too - at coordinates 52° 45' 16.28" N, 01° 08' 12.33" W.

# The Hole Park Cary Dial

## John Foad

Lovely gardens and cream teas – who would be without the National Gardens Scheme in summer? Hole Park, near Rolvenden in Kent, has all that you could ask for – lakes and bluebell woods and flowering meadows, rhododendrons, azaleas and wisteria, and later blazing autumn colour – and to top it all, a nice Cary dial.


I snapped it, of course, and it was well I did, for within the year it was stolen. A local paper carried the pictures and the dial was spotted in an antique shop in Tunbridge Wells, and restored to its proper home. The police and the insurers can be hard to convince about rightful ownership, but the photographs clinched the matter. Another grateful owner, who in this case was kind enough to make a donation to the Society's Restoration Fund.

# ASTROLABES
# Part 4 – Universal Astrolabes


## TONY ASHMORE


### INTRODUCTION

The astrolabes illustrated and described so far in this series, both Western and Arabic, are usually described as ordinary astrolabes. They are designed for use at one latitude, although by the provision of a number of extra plates they can be made useable over a greater range of, specific, latitudes. This increase of usefulness adds to the bulk and cost of the instrument.

By the fifteenth century the Renaissance was well underway with its increase in learning, spread of knowledge by the discovery and translation of ancient and Arabic sources aided by the development of printing, the number and skill of instrument makers and the more extensive travel of learned men. This all gave rise to the desire for, among other related astronomical instruments, an astrolabe capable of use at all latitudes and which could show celestial coordinates and bodies at all declinations for astronomical and timekeeping purposes. That is, a universal instrument was needed.

The fundamental ideas for the universal astrolabe can be found in a number of eleventh century, and later, treatises written in Muslim Spain. Particularly influential was a treatise written by ibn al-Zarqalluh, also known as Azarquiel, an instrument maker in Toledo. He invented and constructed an astrolabe – called a *safiha* – the subject of his treatise. The important innovation was the change of viewpoint for the projection of the celestial sphere from the south celestial pole, used for the ordinary astrolabe, to the vernal equinox, on the conjunction of the celestial equator and the ecliptic. Azarquiel's treatise was translated into Latin in the twelfth century by Gerard of Cremona and copies found their way to a number of centres in Europe, especially the Low Countries in the twelfth and thirteenth centuries. In Europe the design became known as the *saphea Arzachelis* in the later thirteenth century and is more frequently just referred to as the *saphea*.

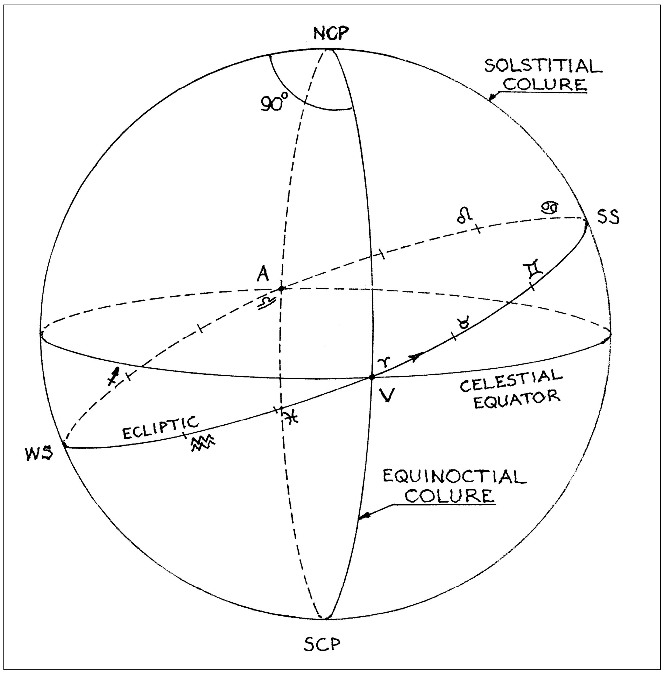



*Fig. 24. Circles on the celestial sphere.*

### GENERAL

The saphea later gave rise to two further projections, the Rojas and the De la Hire projections, to be described below. All three use projections of the celestial sphere from the side, and from a position in the plane of the celestial equator, instead of from the south celestial pole as used for the ordinary astrolabe. (Refer to Part 1, figures 3 and 4.)

Figure 24 shows the celestial sphere and some of the circles used in the universal astrolabe projections. **V** is the position of the sun at the vernal equinox (the first point of Aries) and **A** is its position at the autumnal equinox. **SS** and **WS** are, respectively, the positions of the sun at the summer and winter solstices. A *colure* is a great circle (one in which its centre is at the centre of the sphere) passing through the poles. The equinoctial colure is the great circle passing through the poles and the two equinoctial points **V** and **A**. The solstitial colure passes through the poles and the solstices **SS** and **WS**, the plane of this colure, as drawn in the figure, being the plane of the page. The arrow on the ecliptic is the direction of the sun's apparent motion, from **V**, during the year. The position indicated by the marks on the ecliptic shows the sun's entry into each zodiacal sign, a few of the sigils being included on the figure.

### THE SAPHEA

This uses two similar stereographic projections (see Part 1, page 93). The origins of these two projections are the two equinoctial points **V** and **A**, Fig. 25. The plane onto which the celestial bodies, the ecliptic, the parallels of latitude and the meridian circles are projected is the plane of the solstitial colure. The hemisphere containing the vernal equinox, **V**, is sometimes referred to, in the literature, as the 'near' side and the other hemisphere containing the

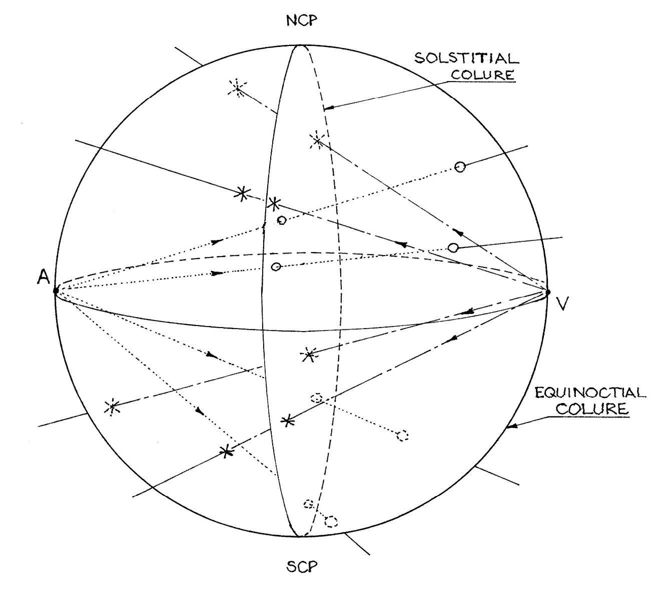



*Fig. 25. Principle of the Saphea projection.*

autumnal equinox, **A**, as the 'far' side. From the vernal equinox, objects on the far side, such as the star-shaped ones, are projected onto the solstitial colure whilst objects on the near side, the little circular ones, are similarly projected from the autumnal equinox. As the great and small circles of the celestial sphere are identical in each hemisphere, their projections from the two points are also identical and coincident on the plane of the solstitial colure. When the two parts of a circle need to be distinguished this is achieved by suitable labelling or, in the case of stars, by different symbols as has been done in Fig. 25. The equinoctial points, **V** and **A**, are at the centre of the projection. Other circles on the sphere, parallels of latitude and meridians, will appear as parts of circles on the saphea by the properties of the stereographic projection.

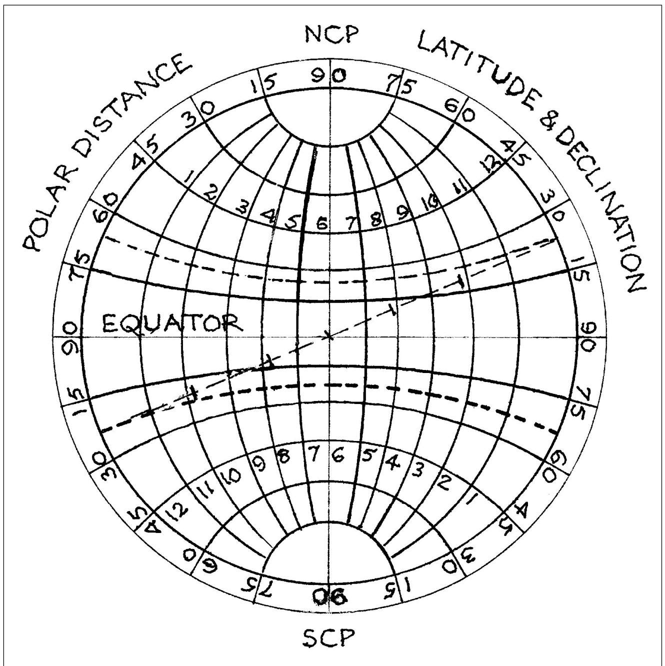



*Fig. 26. General impression of the Saphea.*

An indication of the complete saphea is given in Fig. 26. For clarity, in this sketch the parallels are only drawn for every 15º whereas on actual instruments they are more likely to be at 1 or 2 degrees, depending on the size of the instrument. The dashed lines are drawn for 23½º, that is they show the Tropics of Cancer and Capricorn. The diagonal dashed line is the ecliptic, tangential to both tropics as on the ordinary astrolabe. For calendrical purposes the cross ticks on the ecliptic represent the entry to the zodiac signs, as in Fig. 24, and are further sub divided on actual instruments. Due to the complexity of the engraving, very few stars are normally included on the saphea, sometimes none at all. If not included star data could be found from tables, giving declination and right ascension, these being used to locate the star position on the saphea by the user. Similarly, Fig. 26 shows the meridians drawn at 15º intervals and as such have been labelled as hourly intervals, the sun traversing from the left hand edge to the right hand edge and back again, along its current declination parallel, in 24 hours - 15º being traversed in 1 hour as all sundiallists know. The left hand edge thus represents midnight, the right hand edge noon with the hour numbers between being times before noon. The sun traverses from noon at the right side, through the afternoon hours to the next midnight at the left. Hours am are marked in the upper half of the saphea and hours pm in the lower half, as in Fig. 26.

Outside, the saphea is surrounded by a scale of degrees. The upper right quadrant, zero at the equator to 90º at the pole, can represent both the observer's latitude and celestial body declination. The upper left quadrant gives *polar distance*, zero at the pole to 90º at the equator, that is the angular distance from the pole. These scales are repeated in the diagonally opposite quadrants. Note that this graduation of the scales means that the angle between any given value on the two scales is always 90º.

The same circles and meridians on the celestial sphere may be used to indicate the coordinates of objects in three ways: latitude and longitude, declination and right ascension, altitude and azimuth. Similarly, the corresponding lines on the saphea can be taken to represent all these quantities and this gives the design great flexibility and ease in converting between coordinate systems. It also provides a simple way of solving spherical triangle problems without calculation as the stereographic projection preserves angles between lines. This makes the saphea very useful for astronomers and astronomical purposes. The one thing that it does not do very easily is to find the time!

The ordinary astrolabe needs two superimposed displays. The static display, the plate, provides data about the observer's position and the moving display, the rete, shows

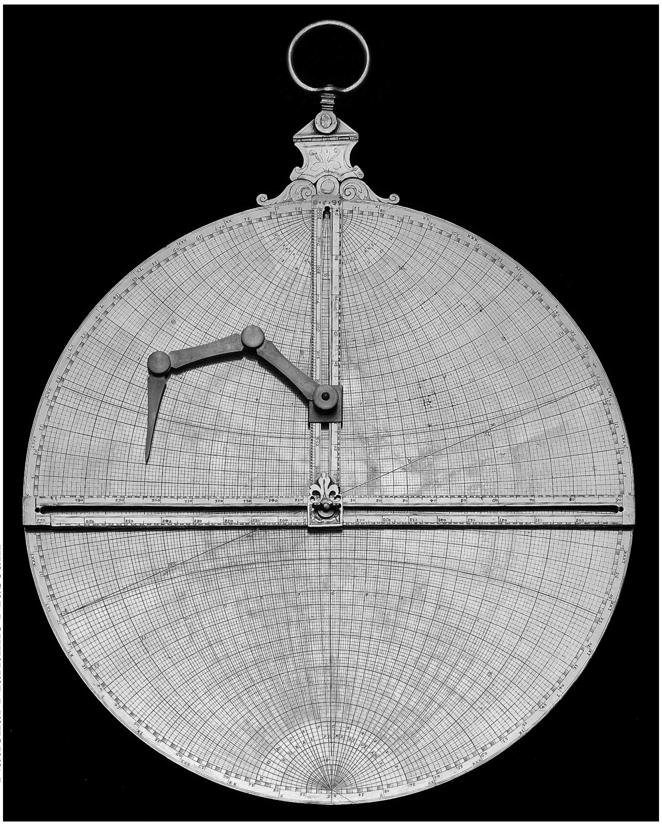

National Maritime Museum

*Fig. 27. Complete Saphea with regula, cursor and brachiolus.*

information about the moving celestial objects. Similarly, the universal instrument needs two displays but in this case the static display, as described above, carries the celestial information whilst the observer's situation is largely related by moveable components.

Figure 27 shows a complete saphea. The latitude/ declination arcs are delineated at one degree intervals and the time arcs at four minute intervals. The tropics are shown by more deeply engraved lines. The general impression is of a mass of densely packed lines. Close to the poles the markings become almost unusable and are often not included above 85º or even 80º. The observer's horizon is set by a *regula*, a rule pivoted at its centre with its graduated edge coincident with the centre of the projection. The regula is engraved in degrees, from zero at the centre to 90º at the right hand edge, progressing via 180º at the centre to 270º at the left hand edge, and then to 360º back at the centre. The 90º to 270º are marked on the lower edge of the regula. These graduations are not even but are spaced according to the stereographic projection rules. This provides a degree measurement for the meridians as an alternative to the hour graduations marked on the saphea itself. Also mounted perpendicular to the regula is a *cursor* which can slide along the slot in the centre of the regula. At the base of the cursor is a wing nut to lock the two together at any position. The cursor has a 0º, at the centre, to 90º scale, also stereographically spaced. Attached to the cursor is an articulated arm of three parts ending in a point which can be adjusted to any point on the saphea independently. This device is called a *brachiolus*. This can be positioned at any height on the cursor using the slot in its centre. It also has a screw fixing. The joints of the brachiolus are sufficiently tight to prevent relative movement of the parts as the regula is moved. For time related uses of the saphea the cursor is not required and may be omitted, the brachiolus then being attached at the centre of the regula. It may also have only two parts instead of the three seen in Fig. 27. The brachiolus on this instrument looks very much like a later addition or replacement.

The instrument in Fig. 27 is interesting in that the outer edge has two angular scales on it. The inner scale, with the alternate shaded and unshaded blocks, is delineated from zero at the equator to 90º at the poles in each quadrant and marked with normal numerals. The outer scale is engraved with polar distance values using Roman numerals, again each quadrant is the same. This system will provide added flexibility with some of the astronomical uses. This is probably an example of the individuality of the maker or his client.

**USING THE SAPHEA TO FIND TIME RELATED QUANTITIES**

To set the instrument for the observer's *latitude,* the end of the regula is set to the value of his latitude on the *polar distance* scale. As noted above with regard to the relation between the polar distance and latitude scales, setting the regula in this way means that his zenith, at 90º to his horizon, will be at the correct latitude on the latitude scale in the top right quadrant. For example, if the user is in central England at a latitude of, say, 52º his zenith will be at 52º above the equator on the latitude scale and his horizon will be at 90º to his zenith.

There are two aspects of time that may be found using the saphea. Firstly, the times of sunrise and sunset, hence the length of daylight, and, secondly, the time of day.

Sunrise and sunset: See Fig. 28. The date needs to be translated to the zodiacal calendar marked on the ecliptic or, alternatively, the declination of the sun for that date needs to be known. The regula is set for the latitude. The declination curve is then followed to meet the edge of the regula and the time of sunrise, being before noon, is read from the upper hour scale and sunset, being after noon, read from the lower hour scale but on the same time arc. The example drawn in Fig. 28 represents May 20, the zodiacal date being Taurus 29, when the declination of the sun is 20º and the regula is set for a latitude of 39º N. The 20º declination arc meets the regula at about 4.50 am and 7.10 pm, giving a day length of about 14h 20m. The hour lines are shown at 20 minute intervals and times are local

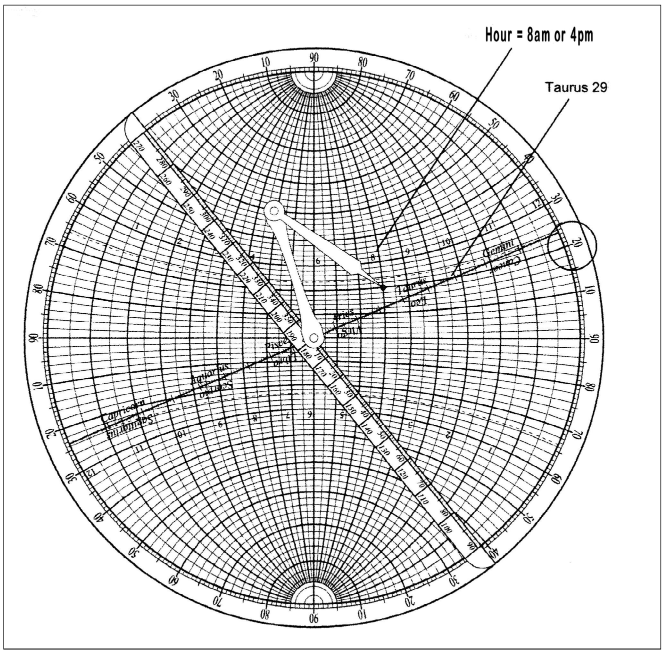



*Fig. 28. Saphea plate with regula and brachiolus.*

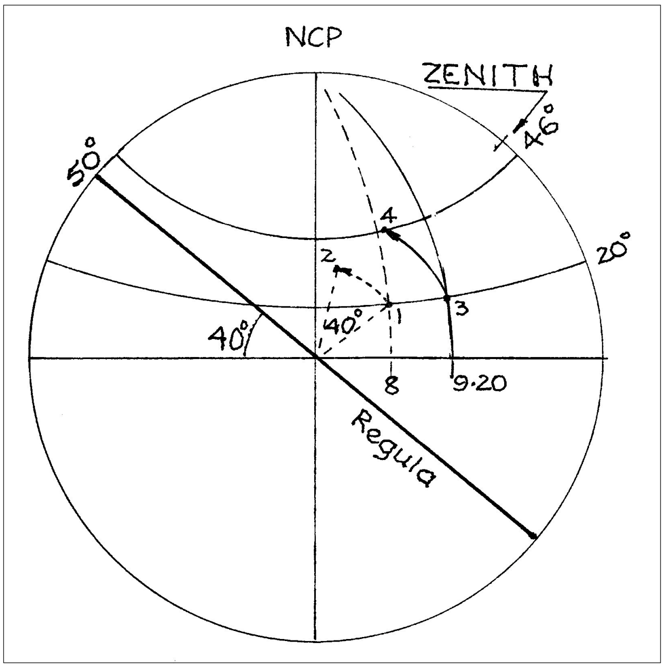



*Fig. 29. Time finding by trial and error.*

apparent, as were used before standardisation and agreed time zones. The brachiolus is not needed for this exercise. Note that in Fig. 28 the lower hour figures are engraved inverted to indicate times pm.

Time of day: Compared with the ordinary astrolabe, determination of the time of day is more complicated on the saphea and requires the use of the regula and the brachiolus. It cannot be done with one setting but involves a trial and error process. After ascertaining the altitude of the sun a series of steps needs to be followed. It is helpful, but not essential, to make a reasonable guess as to the approximate time.

1. The regula is set for the latitude, as before, using the polar distance scale.

2. The point of the brachiolus is set to a point on the declination arc of the sun and on the hour arc at the time which has been guessed. Note this time.

3. The regula is then turned to align its edge with the equinoctial line (the equator). The brachiolus retains its relative position and turns with it.

4. Is the tip of the brachiolus then on the parallel of the measured altitude of the sun? If so, the time 'guessed' was correct. If not, return to step 1, adjust the tip in an appropriate direction and by a likely amount and repeat the process through steps 2, 3 and 4. Continue the repeat process until the tip is on the measured altitude of the sun established at the start. The time of day is that of the hour arc finally selected at stage 2. If a sensible guess of the time was made initially the correct time should be found with very few repetitions. If the initial estimate was several hours out, rather more repetitions of the process would likely be required. Naturally, the more experienced the user the more easily he will judge how much the adjustment at stage 2 should be made.

Figure 29 illustrates this procedure. From a latitude of 50º N the sun's altitude is measured at 46º on May 20th (Taurus 29) and the sun's declination is 20º that day. The regula is set to 50º on the polar distance scale, step 1. The tip of the brachiolus is set to the estimated time, say 8am on the +20º declination arc, step 2 and point 1 in Fig. 29. The regula is rotated 40º anticlockwise to the equator, step 3, which causes the brachiolus tip to move 40º to point 2 in the figure. It is well below the 46º altitude line. Go back to step 1, the regula is returned to the latitude position, the tip moved to a new position on the 20º parallel, followed by steps 3 and 4. After perhaps two or three attempts the tip is tried on the 9:20am arc, point 3 in the figure, the regula rotated to the equatorial line and the tip is found to be at the desired altitude of 46º, point 4. The time of the observation was 9:20am.

The same procedure would be followed if the altitude of a star of known declination, either if marked on the saphea or if its declination is read from tables, had been observed. In that case a correction to the result would be required to account for the difference in the hour angles of the sun and the star.

The universal astrolabe may have the saphea on one side, with regula and brachiolus as described, and the other side engraved similarly to the ordinary astrolabe with degree scale with an alidade for altitude measurement, zodiac/date calendar, shadow scale and unequal hour design. Alternatively, the saphea may be provided at the front on a plate or engraved in the womb along with one or two usual plates and rete. The rete, etc, would not be used with the saphea plate.

**THE ROJAS PROJECTION**

This projection is named after Juan de Rojas, a member of an old and noble Spanish family. Details of his life are rather obscure. He was probably born in the early 1520s and he later accompanied the Emperor Charles V, the Holy Roman Emperor, to the Netherlands. He spent some time in Louvain where he studied with Gemma Frisius (meaning a Frisian), Professor of Medicine and teacher of mathematics and astronomy. Gemma and his nephew, the eminent instrument maker Arsenius, were well acquainted with the saphea, enabling de Rojas to study it as well. Ideas about using an orthographic projection for a universal astrolabe were being considered at this time. De Rojas seems to have taken a particular interest in this idea. Whilst in Louvain he became acquainted with one Hugo Helt, also a Frisian. Helt is also somewhat obscure but was from a wealthy, but not noble, family and seems to have been a gifted student at the university. On returning to Spain in the late 1540s de Rojas wrote a book on the universal instrument using the orthographic projection, likely assisted by Helt who moved to Spain with de Rojas.[5] The publication of his book, in Paris in 1550, was very popular and a second edition followed the next year. The book drew together the various ideas on the universal instrument which were extant at that time. De Rojas did not claim to have invented or made an astrolabe with the projection but the book's popularity resulted in the projection being known by his name. There are, however, a very few examples, notably by Hans Dorn, with an orthographic projection that antedate the publication of de Rojas' book.

The Rojas projection, like the saphea, uses the two similar simultaneous projections of near and far sides of the celestial sphere onto the solstitial colure. In this case,

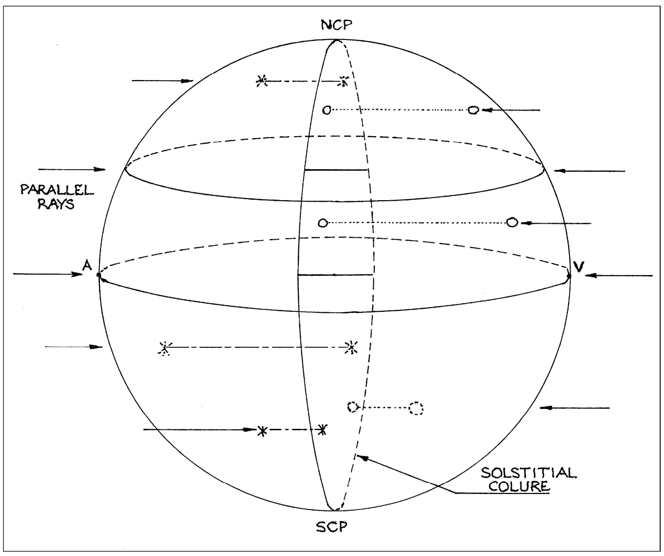
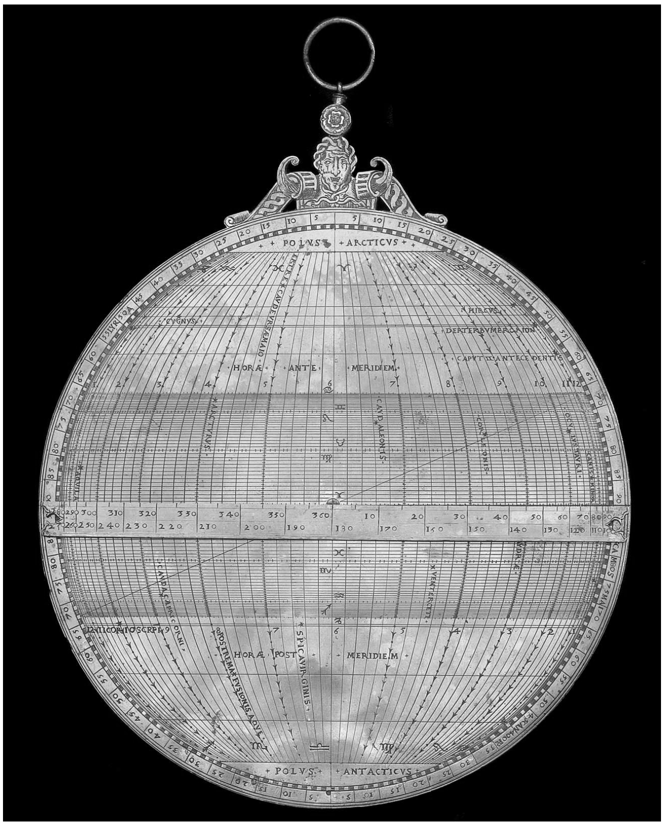



*Fig. 30. Principle of the Rojas projection.*



Oxford Museum History Science

*Fig. 31. Complete Rojas projection with regula.*

however, the projection point is at an infinite distance, the 'projection rays' therefore all being parallel, Fig. 30. As in Fig. 25, V and A are the vernal and equinoctial points. Those readers familiar with technical drawing conventions will be familiar with this idea. Diallists are usually familiar with the concept of the sun's rays arriving in parallel at the earth due to the enormous distance from the sun compared with the size of the earth.

Fig. 31 shows the complete Rojas projection. All parallels are circles seen edge on and so project as straight lines parallel to the equinoctial line. They are most often only shown between the two tropics. Occasionally a few are included outside the tropical region. The declination parallels are engraved according to the zodiacal dates – the interval in this example being every two zodiac days. The entry to each sign is indicated by the lines with little ticks across them, the sigils for the signs being along the central meridian. The meridian or hour lines project as ellipses extending between the north and south celestial poles, thus complicating the construction of the instrument compared with the circular arcs of the saphea. Here the arcs are delineated every 12 minutes. The morning hours, labelled *HORÆ ANTE MERIDIEM*, are given just above the Tropic of Cancer and the afternoon hours below the Tropic of Capricorn and labelled *HORÆ POST MERIDIEM.* The full hour lines are emphasised with arrow heads except between the tropics where cross ticks are used. Fig. 31 has extra interest in that it very closely resembles the illustrations in de Rojas book and this instrument was made and dated in

Paris in 1551 by Anthoine Mestrel, an otherwise unknown maker. In other words it coincides with the publication of de Rojas book. Perhaps Mestrel had a connection with the publisher.

The limb is engraved with polar distances in all four quadrants. The regula is engraved as before from 0º at the centre, the first point of Aries, to 90º at the right hand limb – the noon time arc – and back to 360º at the centre via 270º at the midnight line on the left hand limb. An additional component used with the Rojas projection is a *cursor*. This is an arm attached to the regula at a right angle which can be slid along the regula. The cursor for this instrument is missing but would have been similar to that in Fig. 27. It would have been graduated from 0º to 90º, the graduations coinciding with the declination/altitude parallels. Thus, whatever the position of the regula representing the horizon, the cursor graduations show the altitude above that horizon. There would not have been a brachiolus since the Rojas projection does not need one.

There are 17 stars engraved on the projection. The declination lines for those outside the tropics are included. What appear to be double lines, outside the tropics, are, in each case, for two stars having very similar declinations. Like the saphea, the lines and arcs can represent multiple coordinate systems and allow conversion between systems. Hence, the uses of the Rojas instrument are the same as the saphea except that time finding is much simpler and does not entail the trial and error procedure.

Time of Day: This is determined simply and without the successive approximations needed with the saphea and brachiolus. Fig. 32 illustrates the method. On April 20th, Taurus 0, the sun's altitude is measured at 30º from latitude 50º N. What is the time? On that day the sun's declination is approximately +11½º. The regula is set to 50º on the polar scale. The cursor is slid along the regula until the 30º graduation on it (the altitude above the horizon) lies on the 11½º declination line and the time read off the coinciding arc directly, at point T in the figure, 8:15am or 3:45pm. The observer presumably knows if it is before or after noon. If not, perhaps if the situation is that the altitude is much higher and so the time is close to noon, he can take another altitude reading a short time later and if the altitude has increased the original sighting was before noon. As with the saphea after sunset, a star can be used but again a correction to account for hour angle difference must be made.

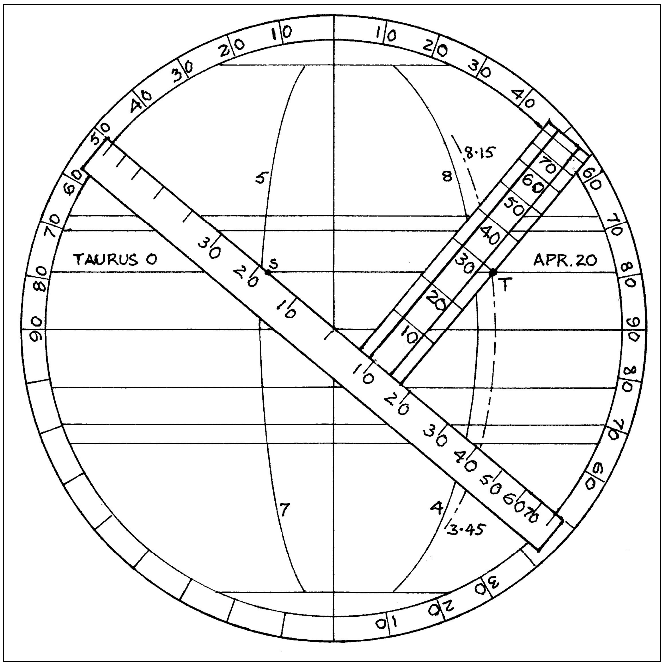



*Fig. 32. Time finding, sunrise and sunset using the Rojas projection.*

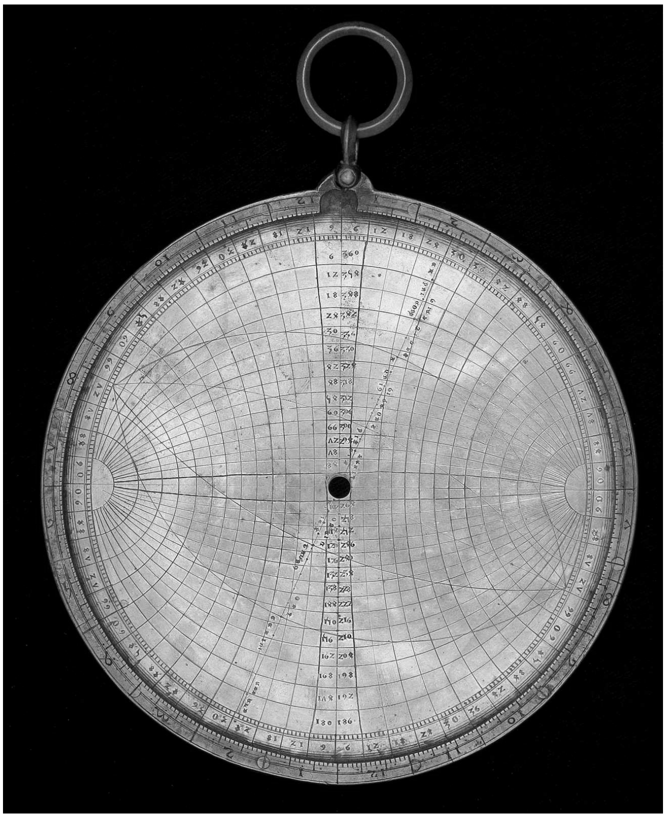
Sunrise and sunset: This is no different from the method used with the saphea, the declination lines being straight and not curved making it a little more convenient. The regula is set to the latitude on the polar distance scale in the upper left quadrant and the intersection of the declination, or zodiac date, line with the edge of the regula shows the sunrise and sunset times, as before, against the upper and lower hour arc times of this intersection point. At point S on Fig. 32, for the same day, April 20th, and latitude, as above, the times of sunrise and sunset are seen to be just after 5am and just before 7pm respectively. The cursor is not required.

## THE DE LA HIRE PROJECTION

On both the saphea and Rojas projections the meridians and parallels are not evenly spaced. On the saphea they are closely spaced near the equatorial line and near the centre meridian whilst the Rojas has the opposite effect, close together near the limb and the poles, the parallels often being omitted in the polar regions. In the latter half of the 17th century Phillipe de la Hire (1640-1718) devised a version of the saphea to avoid this congestion of lines.

De la Hire's projection is essentially the same as the saphea but with the projection points, for the near and far side of the projection, being on the equatorial plane and in line with the equinoctial points but at a distance of 1.707 times the radius of the celestial sphere from its centre. This value was calculated to position the 45º parallels, where they cross the central meridian, midway between the equator and the poles. Similarly, the 3am-9pm and 9am-3pm hour arcs cross the equatorial line midway between the centre and the limb. This gives a very even spacing of both sets of arcs.

This projection, not being from points on the actual surface of the sphere, is not stereographic and results in the arcs being parts of ellipses but each arc is a different proportion of an ellipse to its neighbour. The la Hire astrolabe is used in exactly the same way as the saphea, with regula and



Oxford Museum History Science

*Fig. 33. De la Hire projection.*

brachiolus, but the spacing can give more accurate results in the areas where the other universal projections are very crowded. An example is shown in Fig. 33.

There are fewer universal astrolabes extant than the much more numerous ordinary instruments. None of the versions became popular in the Arabic world. By far the majority of surviving instruments are the saphea type, being the earliest and the easiest to make in terms of the lines all being arcs of circles. By the time of the Rojas design advances in other – especially astronomical – instruments and the beginnings of portable timekeepers the popularity in the Western world was decreasing. This was also affected by the number of instrument makers with the greater skill needed to produce the half-elliptical arcs of the Rojas. Finally, by the time the la Hire appeared, telescopic instruments and accurately divided scales with intervals of minutes, or even seconds, of arc for observing purposes were available together with watches capable of good timekeeping. The design, with all the arcs being varying sections of ellipses, was difficult to make and few had the competence necessary. The instrument was too late, relatively few were made and survivors are rare. The National Maritime Museum at Greenwich has one and the Museum at Oxford has one, previously described as a saphea but now under reconsideration as a la Hire, Fig. 33.

It is possible that perhaps more la Hires were made from printed paper, multiple printings of a single plate being possible, for the purpose of being applied to a wood base. These were likely to not survive very well.

**ACKNOWLEDGEMENTS**

The photographs in this article are reproduced with the kind permission of the National Maritime (Fig. 27) and the Museum of the History of Science, Oxford (Figs. 31 and 33). Fig. 28 is by courtesy of Jim Morrison from his book 'The Astrolabe', reviewed in this *Bulletin*.

**REFERENCE**

5. F. Maddison; 'Hugo Helt and the Rojas Astrolabe Projection', *Agrupament de Estudos de Cartografia Antiga **XII***, Coimbra (1966).

*To be continued*



## NEW BOOK

A new 2-volume work by Andrée Gotteland entitled *Les Meridiennes du Monde et Leur Histoire* (The meridian lines of the world and their history) has recently been published. It describes 1050 meridian lines in 28 countries.

It is published by Editions Le Manuscrit, 20 rue des Petits-Champs, 75002, Paris. Price is €70 plus p&p.

# DIAL DEALINGS 2007

## MIKE COWHAM

Some significant changes have occurred in the last year in the way that scientific instruments are sold (or not sold) at the major auction houses. It seems that the two ‘leaders’, Christie’s and Sotheby’s, have virtually stopped selling these items. They have created new departments encompassing a much wider field of ‘collectables’ and have set rather high minimum lot prices for items. This rules out many types of scientific instruments, including sundials, and reflects a general shift from antiques to modern art which the auctioneers find is much more profitable, its prices being many times those attracted by antiques. The new department created by Christie’s is now known as Science, Exploration and Discovery and it will hold approximately three sales per year. Luckily, Bonhams are still dealing in instruments and have several sales scheduled over the coming year. This means that for 2007 I have fewer sales to report on, but some quite interesting items have been sold, some of which I detail below. Prices quoted include buyer’s premium but not VAT.

The Scientific and Marine sale at Bonhams on 21 March 2007 included several sundials. An early 19th century cube dial by David Beringer from Nuremberg, one of many of its type to be found, was sold for £1320. These dials are calibrated on five faces and are made from printed paper scales applied to a wooden cube, with brass gnomons added. A magnetic compass, for correct alignment, is sunk into its base and the dial may be tilted so as to function over a small range of latitudes.

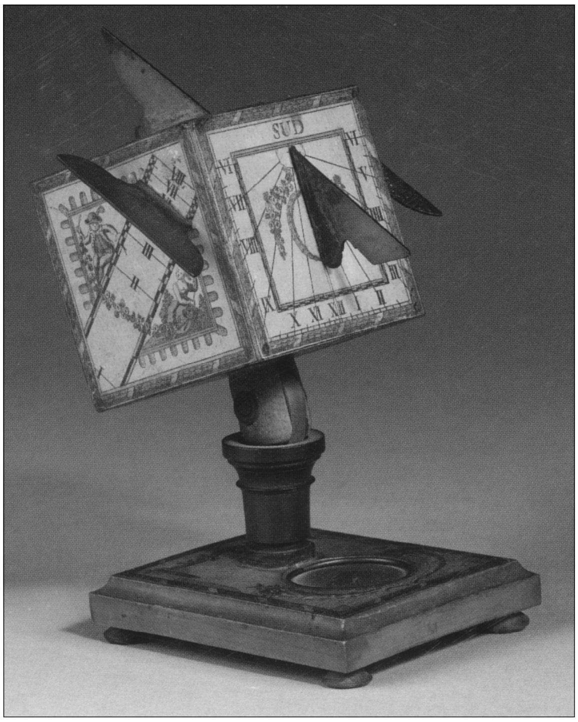



*Fig. 1. Cube dial by David Beringer.*

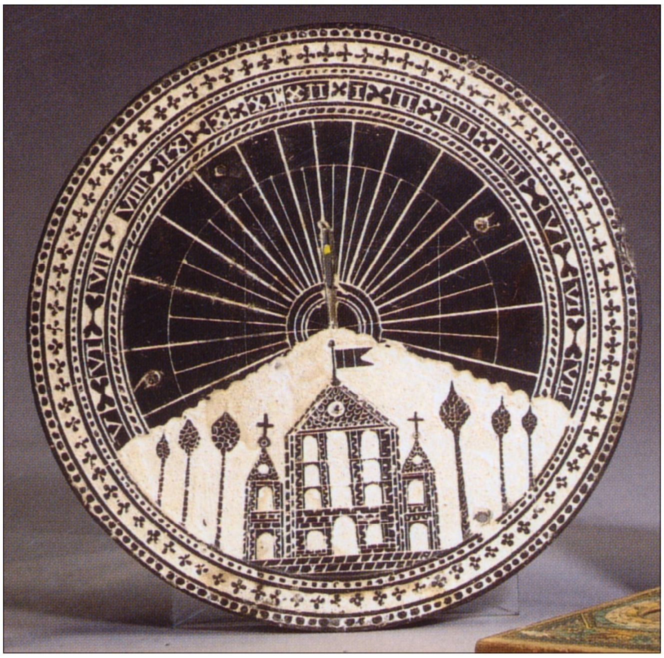


*Fig. 2. Polish slate dial.*

A rather unusual horizontal slate dial from Poland, just 7" diameter and thought to be 17th or 18th century, was sold for £576. It is attractively engraved with a church surrounded by trees. Its gnomon is missing.

The real star of the sale, and my choice for the most interesting dial sold during 2007, was a medieval astrolabe

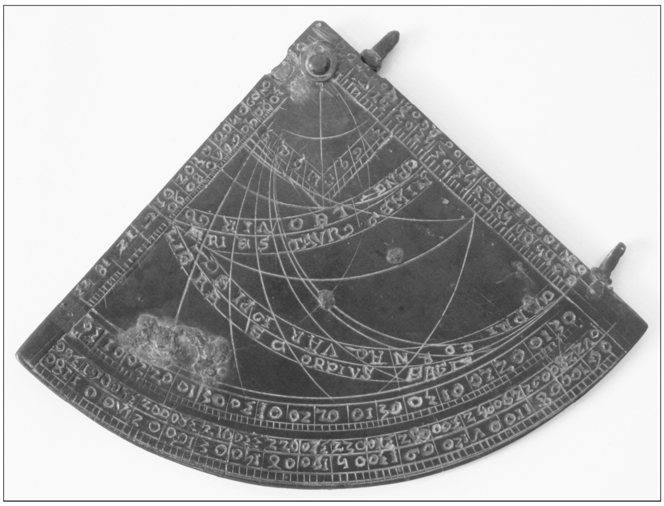


*Fig. 3. Medieval quadrant excavated in Canterbury.*

*Fig. 4. The reverse of the medieval quadrant with an eagle*

quadrant found during excavations in St Dunstan's Street, Canterbury, in 2005. This 14th century quadrant dates from around the time of Chaucer and it is possible that its Chaucerian links may have helped push up its price. It was eventually sold for a staggering £138,000, somewhat above its original estimate. The quadrant is of the type known as Quadrans Novus, first described by Jacob ben Mahir ibn Tibbon of Montpellier (*Fr.* Don Profiat, *Lat.* Prophatius Judaeus) c.1236–1305. Only eight of these quadrants are known, with only three in Britain. It tells the time in unequal hours, the day being divided into 12 'hours' and the night another 12. Sunrise is the start of the first hour with noon at the start of the sixth. Being an altitude dial, the hours from noon retrace their earlier counterparts until the end of the eleventh hour. On the reverse of the quadrant is the figure of an eagle pointing with its wings and tail to an Easter calendar. Unlike more modern calendars, this one uses Roman dates such as Ides, Nones etc. When found, the quadrant was heavily corroded but these deposits have been carefully removed leaving just the eagle fixed and no longer able to rotate.

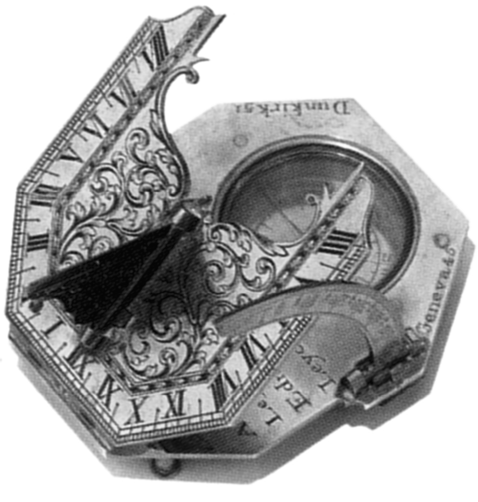


*Fig. 5. Gilt brass inclining dial by Edm. Culpeper.*

Christie's final sale of instruments was on 17 May 2007. It included a selection of portable dials. An inclining dial by Edm. Culpeper in gilt brass from around 1700 made an exceptional figure for this type of £9600. Several of these inclining dials by Culpeper are known. They are delineated for a latitude of 60° north but by inclining the plate with its gnomon they may be used at any latitude between 0° and 60°.

*Fig. 6. Double crescent dial by Johann Martin.*

A good double crescent dial by Johann Martin of Augsburg from around 1700 sold for £4800. From the photograph it appears that its horn-shaped gnomon is missing. The dial uses the horn tips to throw a shadow on one of the two crescent hour scales, fitted to the east and west sides. These dials are not commonly found and most tend to be in museum collections.

A silver 'Butterfield' dial by John Coggs made a respectable £4560, about twice its estimate. English Butterfield dials are not found so often as those from France and are usually made in brass. This silver dial dates from the mid-18th century and is attractively engraved with

*Fig. 7. Butterfield dial by John Coggs.*

*Fig. 8. Model of Greenwich 'Dolphin Dial'.*

foliate patterns. The gnomon is supported, as usual with these dials, by a bird using its beak to indicate the latitude.

A model of the Greenwich 'Dolphin Dial', sculpted by Edwin Russell, was produced by Brookbrae in 1977. It is one of a small batch of 25 commisioned by the National Maritime Museum, Greenwich. It sold for a disappointing £336 against its estimate of £2000–£3000.

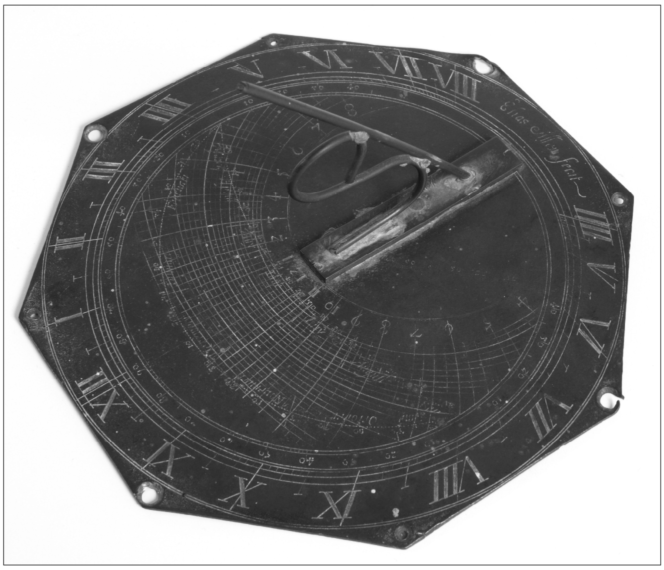


*Fig. 9. Double horizontal dial by Elias Allen.*

In Bonhams Science and Marine sale, 28 November 2007, there was a hitherto unrecorded octagonal double horizontal dial (1635–1645) signed by Elias Allen. Unfortunately the dial's gnomon, always prone to damage on these dials, had been replaced with one of the wrong type.  However, the dial was otherwise in good condition and it sold for £1800.

**ACKNOWLEDGEMENTS**

I would like to thank the following for allowing me to use their photographs. Bonhams, London for Figs. 1 & 2. Christie's South Kensington for Figs. 5, 6, 7 & 8. These pictures remain their copyright and may not be reproduced without their permission.


It was John Carmichael who reminded me about this cartoon. Tim Hunkin, who presented the tremendous TV series *The Secret Life of Machines* a few years ago, drew these Rudiments of Wisdom pages for publication in the Observer newspaper between 1973 and 1987.  Tim, who is now busy making ingeneous and humorous mechanical models and has made several sundials of his own, says that being paid to research any subject that took his fancy was an ideal job.

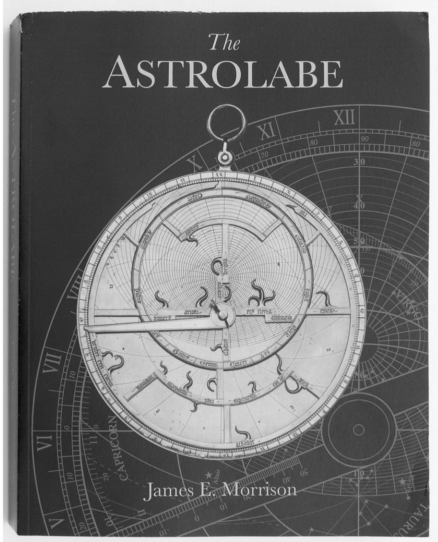
The strip is a good introduction to sundials but does contain a couple of errors. Current scholars don't believe that the Egyptians used their obelisks as gnomons of sundials, though they were set up to honour the sun-god Ra.  It was the Romans who used them for this purpose when they took them to Rome.  And Charles Wheatstone's polarised light sundial needs to be pointed at a region of clear blue sky.  The sun itself can be clouded over but it is the direct skylight that is polarised, not the diffracted light through a cloud. (see Allan Mills' article 'The Sellotape Sundial', *BSS Bull* 98(1), pp.3-9.)

*JD*

Reproduced by courtesy of Tim Hunkin.

# BOOK REVIEWS (cont)

**The Astrolabe** by James E. Morrison. Published by Janus, Rehoboth Beach, DE, USA 19971, November 2007, pp xvi+438, 11"× 8½", approximately 250 b&w illustrations and photographs. ISBN 978-0-939320-30-1. Price $60 US plus p&p.




This is a book which has long been needed. For anyone wanting more than a cursory introduction to the technicalities of the astrolabe they would, until now, have had to search through a diverse collection of sources in a range of languages and mostly out of print. There are available a range of books containing many photographs of the instruments accompanied by descriptions and details, sometimes, of their date, places of origin, their makers and the scales to be seen on them. As the author, James (Jim) Morrison, says at the start of his preface, *"This is not a book about astrolabes* [in general]. *Rather it is about THE astrolabe … and astrolabe related instruments"*. This is a comprehensive book explaining the principles of the design of astrolabes, the parts of the instruments, descriptions and uses of the scales to be found on them, how they function and are used and, not least, how to make them.

The first of the 27 chapters gives an introduction to the astrolabe, the general principle, parts and types whilst the second, headed *A Concise History of the Astrolabe*, gives exactly that from the foundations of the instrument, its development and refinement to its decline.

The following 14 chapters cover, in much detail, the various types of astrolabes, the different projections, the large variety of scales to be found covering time-related and astronomical aspects through to surveying and some astrological uses. These chapters include the necessary mathematical and graphical methods and techniques which enable anyone desirous of designing and making astrolabes for themselves to be able to do so. This is written from experience since Jim has himself made examples of all the types he describes. His guidance and advice on this is straightforward and easy to follow. No extensive knowledge of mathematics is required beyond ordinary secondary school level and the use of the simple trigonometrical functions found on a standard pocket calculator. The graphical methods are within the scope of a person able to use a rule, set square, dividers and compasses. Included in these chapters is a short one of three pages to cater for those living south of the equator and who wish to make one for southern latitudes.

Following the astrolabe chapters there are seven chapters covering the similar topics of description, principles, uses and the making of various quadrants – Astrolabic, Prophatius, Gunter's and Sutton's – related to the astrolabe. As with the astrolabe chapters, these also include a good number of sample problems to elucidate the use of the instruments described. In addition there is a chapter, of particular interest to sundiallists, about horizontal instruments including using and making Oughtred's double horizontal dial.

The general heading of *Supplementary Material* is given to the final part of the book and chapters are titled *Astronomical Background, Astronomical Calculations, Computers and Astrolabes* and finally *Design, Layout and Fabrication.* This last will be especially helpful to those readers making their own instruments, giving much useful advice whether making a paper item mounted on card or board or intending to progress to a metal astrolabe or quadrant. The 'computers' section provides a number of programs and routines in BASIC and $C/C^{++}$ and also a simple introduction to Adobe PostScript.

This book includes two appendices giving star positions and, for 2006, solar data, a glossary, an extensive bibliography – nearly all in English – and an index. There is a selection of drawings intended to be copied for cutting out and assembled into a working astrolabe.

This is a big, heavy book so it is wise to be sitting comfortably if using it hand held! It is not one to read as a narrative but to delve into as necessary for particular topics and research. The copious drawings throughout are very clear and of high quality. The text has been computer generated but it is properly justified, like a traditional book, and is in a very clear and easily read font. The many notes are all placed at the bottom of the page, avoiding the disturbance of having to flip back and forth to other pages.

All in all this book is most highly recommended whatever the level of one's interest in these instruments, or in astronomical instruments in general. It will be many years, if ever, before it will really be superseded.

*The review copy has a softcover but the latest printing has an OTABind layflat binding which will improve its handling considerably.*

*Tony Ashmore*, *Didcot*

# Postcard Potpourri 7 – Polam Hall, Darlington

## Peter Ransom

Polam Hall is an independent girls school at Darlington, Co Durham. It was founded in 1854. This postcard, thought to be c.1920 (based on a previous picture of c.1910 when the trees surrounding the pergola were not so large) features two of the scholars making their way down to the dial.

This is clearly a large horizontal dial, possibly of slate. I am unaware whether the dial is still there since I am still awaiting a reply from Polam Hall School.

*pransom@btinternet.com*

# Then and Now

This picture of a Pilkington & Gibbs heliochronometer Type 2 (serial number 536) was taken when the then Prime Minister, Herbert Asquith, visited Port Sunlight on 20 July 1912. It was clearly an event of some importance locally with everyone dressed for the occasion: there was even a guard of honour for the motorcade provided by the Boys' Brigade.

J G Davies

The dial was originally purchased by the First Lord Leverhulme and installed at his home, Thornton Manor, Thornton Hough, Wirral, Cheshire. It passed down through his family until the death of the third Lord Leverhulme in July 2000, when the Manor was sold. The Manor is now private though it can be hired for functions.

G Hunter

The original photograph was taken by Jonathon George Davies, a photographer from New Ferry & Port Sunlight, who subsequently published it as a postcard. The copy of the postcard is now owned by Gavin Hunter, Unilever historian, who also took the second picture of the dial from virtually the same spot. It shows that the dial is still on its original pedestal which is of a classic design although not one shown in the P&G catalogue. The original glass dome was broken at some stage and has been replaced by a chemistry bell jar with a bung in the neck.

*Mike Shaw*

# PAT BRIGGS' MECCANO MODELS

**John Davis**

One of the most interesting features of the past few Newbury meetings has been the large display of Meccano models brought along by Pat Briggs of Nottingham (Fig. 1). These have ranged from a very simple static model of an equatorial dial (Fig. 2) to very complicated planetaria and orreries.

*Fig. 2. Meccano equatorial & horizontal dials.*

*Fig. 1. Pat Briggs demonstrates his Meccano 'analemmagraph' at Newbury.*

Meccano has a number of applications in dialling. For example, the late Noel Ta'Bois built an interesting machine – effectively a sophisticated trigon – for drawing the hour and declination lines of a dial on any surface.[1] Invented by Frank Hornby in 1901, the original form of Meccano has ceased production but sets are still available from specialist dealers and societies of Meccanomen exist and publish newsletters. Pat has been a Meccano constructor for nearly 75 years and is one of a small band of enthusiasts who concentrate on clocks, orreries and astronomical mechanisms of all kinds. One of the 'rules of the game' is to use only Meccano parts (except for globes) and this introduces the difficulty of the relatively small range of gears available. In particular, there are few gears with a prime number of teeth, key to achieving the complex gear ratios needed for orreries. (Just 2 to 19 can be derived.) The target is always to get the relative orbital speeds accurate to within 1% although any degree of accuracy is possible: see later.

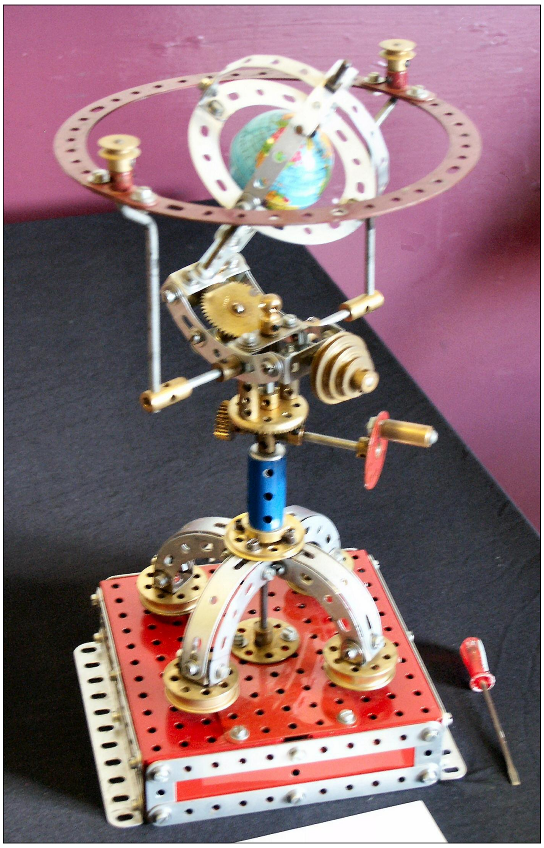


*Fig. 3. A simple Earth model.*

Pat's training as a qualified engineer, including a period as an RAF crash assessor, has evidently provided the background needed for him to devise many ingenious mechanisms. He was introduced to sundials by Noel Ta'Bois and as early as 1986 was writing[2] about how a single universal joint can be used to track exactly the motion of a shadow on a sundial, a subject recently 'rediscovered' in the *Bulletin*.[3] With Noel, they jointly produced an Equation of Time clock mechanism to derive the EoT from the addition of two sine waves, rather than the kidney-shaped cam which Tompion developed (see the inside cover of the last *Bulletin).* It also features in the analemmagraph of Fig. 6.

One of Pat's planetaria has recently been illustrated, together with a list of all its complex epicyclic gear ratios, in an article in our sister publication, the Bulletin of the

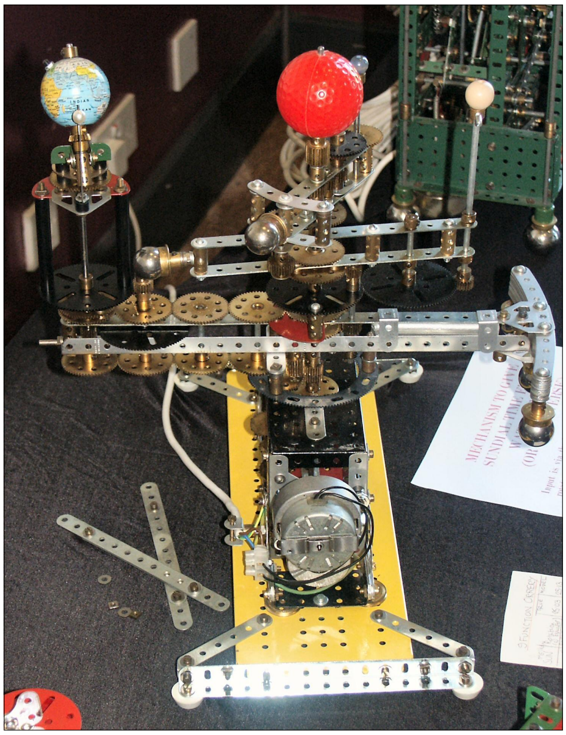


*Fig. 4. A 9-motion orrery.*

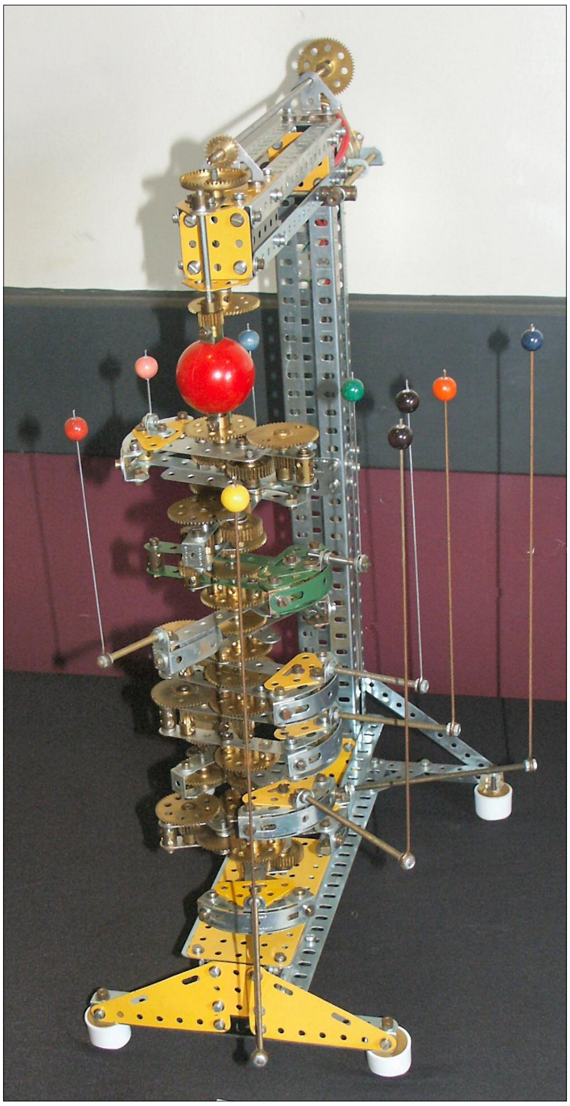


*Fig. 5 (left). A nine planet orrery. The gear ratios are given in Ref. 4.*

*Fig. 8a (right). An astronomical clock.*

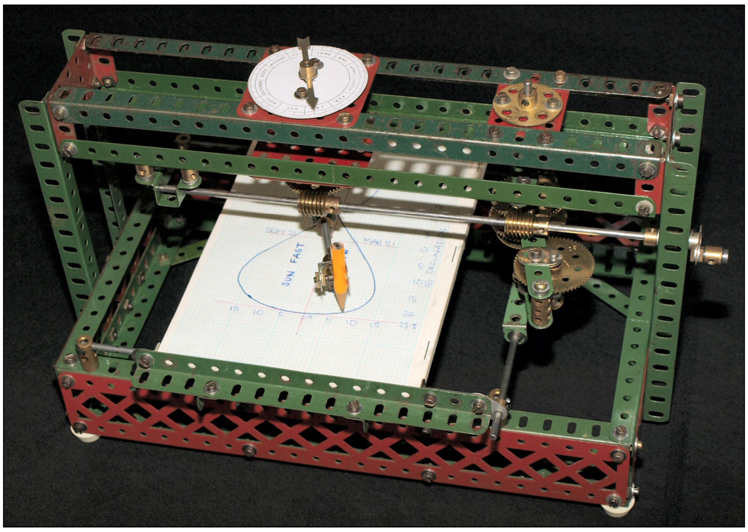



*Fig. 6. A close-up of the Meccano analemmagraph.*

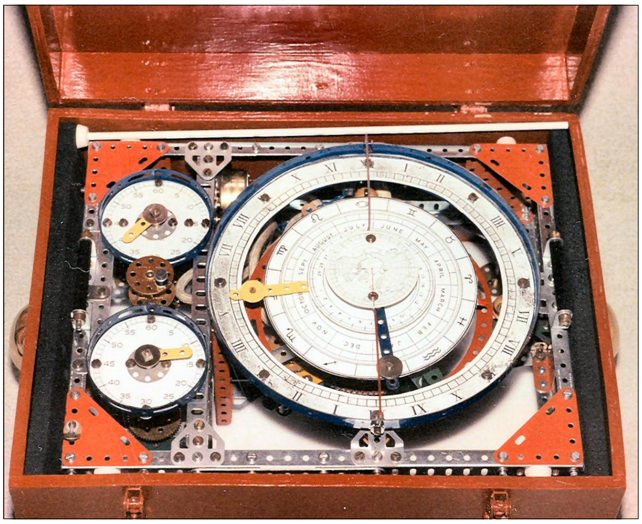
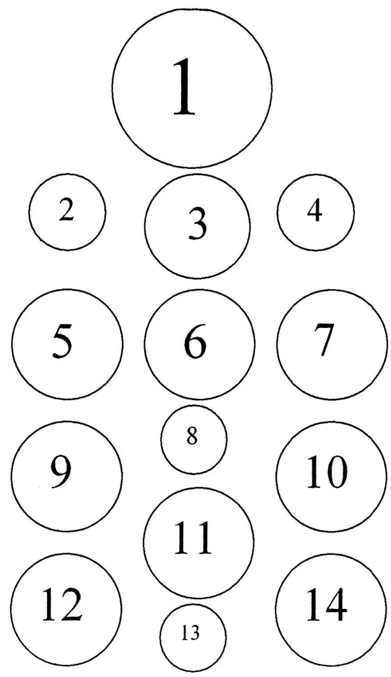


*Fig. 9. A version of James Ferguson's astronomical table clock.*

Scientific Instrument Society.[4] A simple Earth model is shown in Fig. 3. Turning the handle rotates the Earth's axis giving a demonstration of the seasons. It also makes clear the precession of the equinoxes, sometimes called the Plato year (26,000 years). A slightly more complicated 9-movement orrery is seen in Fig. 4 and demonstrates the years for Mercury, Venus and Earth together with their rotations and that of the Sun. The Moon revolves about the Earth in its month with the axis of the Earth maintaining a fixed direction. Even more complicated is the planetarium of Fig 5, showing the motion of all planets (including the re-classified Pluto!) using a sequential epicyclic gear train.

One of Pat's machines of particular interest to diallists is his ' Meccano Analemmagraph' (Figs. 1 & 6). The analemma is a drawing with the sun's




**Astronomical Clock Faces**

1 Armillary sphere
2 Azimuth of sunrise & sunset
3 Hours of daylight & darkness
  Times of sunrise & sunset
  Equation of Time
4 Simple calendar
5 Solar time (Local apparent time)
6 Greenwich Mean Time & Mean time for 1° West
7 Lunar/solar eclipse prediction & limits
8 Seconds
9 Spring/Neap tide predictor
  Time of lunar meridian crossing
  Age of moon
10 Hours to next High or Low tide
11 Aspect of the circumpolar stars
  Sidereal time
12 Earth globe
13 Moon phase ball
14 Celestial globe

*Fig.8b. Key to the faces of the astronomical clock.*

declination plotted along one axis against the Equation of Time along the other. It is found on some heliochronometers and meridian lines and also on some globes.[5] Pat's design is based on a harmonic analysis of the factors involved and the correct phasing of the resulting components. The construction was simplified by the realisation that two sinusoidal drives of the same period but of different phase can be recalculated to a single drive of revised amplitude and phase. The machine draws out an analemma when the handle (on the right in Fig. 6) is turned. The pen rotates once per year representing the solar longitude, the sine of which gives a good approximation of the Sun's declination to form the vertical axis of the diagram. At the same time, the table carrying the paper moves left and right forming the horizontal (EoT) axis. The circle is reduced to the analemma by the action of a double epicyclic crank driving the table. The primary arm rotates once per year to form an annual ellipse and the secondary arm rotates twice as fast to convert it to the figure-8 analemma visible in Fig. 6 (which includes the correct positioning of the crossover point). The two components are slightly skewed as perihelion and aphelion are some 12 days after the solstices. The mechanism can be modified to adjust for the long term variation of the analemma[6] so that graphs can be drawn for past or future epochs.

The double or 'split-path' epicyclic gear arrangement is a feature which Pat has developed[7,8] to provide precise ratios with a limited number of Meccano gears. For example, the rules of the *Explanatory Supplement to the Astronomical Ephemeris* show that the Tropical Year in 2014 will be 365.24219178 mean solar days. Pat's calculations (all with a 12 figure pocket calculator!) showed that a gear ratio producing the prime number of 6733 would be needed to provide the full accuracy from a one revolution per day input. The deceptively simple gearbox of Fig. 7 achieves the full 11-figure accuracy with only eleven Meccano gears, the split path arrangement delivering the awkward prime number.

A larger machine is the astronomical clock seen in Fig. 8a. This is driven by a single synchronous electric motor and has at its centre a standard 24-hour clock. Then, on other faces, it shows sidereal time, the phases of the moon, the tides, the Equation of Time, the hours of daylight and so on, as shown in Fig. 8b. Each of these outputs requires a very clever mechanism.

Finally, to bring us back to sundialling, Fig. 9 shows an astronomical clock based on that described by one of Pat's heroes, the famous 18th century mathematics and sundial writer James Ferguson.

Those of us who played with Meccano as children will marvel that such fascinating models are possible. Pat's work shows that the British inventiveness is not dead – long may it continue.

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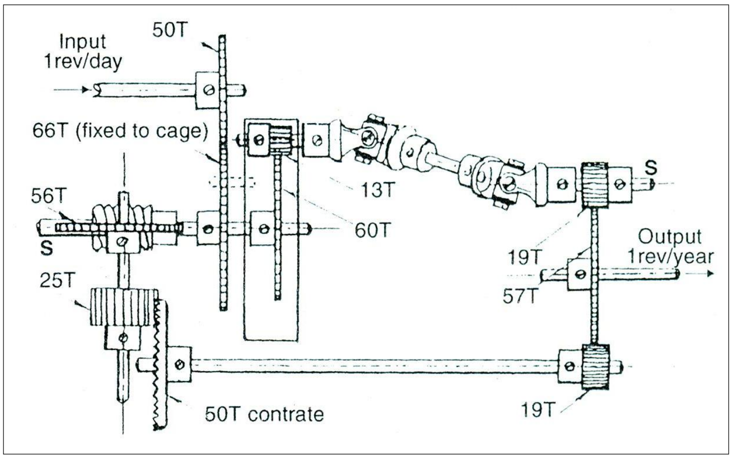


*Fig. 7. A split-path epicyclic gear train for the Tropical year. The two shafts* **S** *must turn in the same direction and the yokes in the intermediate shaft must be aligned as shown. Input to output gear ratio is 365.24219178:1.*

# AN EQUATORIAL MEAN TIME SUNDIAL


## W S MAY


I started making sundials about twelve years ago as a retirement hobby and, after making a fixed equatorial design for a friend, started to think about designing a dial with a mechanism for compensating for the Equation of Time (EoT). One design, based on the reasonable approximation of the EoT as the sum of two out-of-phase sine waves, was described earlier.[1] The more accurate version shown here was originally made with a relatively crude 25" diameter time-ring. Performance in my garden proved very satisfactory so the design and construction method was refined to produce this version.

*Fig. 1. The finished mean time equatorial dial.*

Looking at Fig. 1, the 18" diameter brass time-ring and its supporting brass cage are in turn supported by a semi-circular steel frame which also holds the stainless steel gnomon. The brass cage and time-scale are rotatable about the gnomon axis. The steel frame also holds a rotatable brass drum (Fig. 2) with a groove for the EoT correction machined in its cylindrical surface. The time-ring has a ball-ended pin screwed into it which runs in this groove. The drum is marked at intervals of 10 days.

The EoT data was taken from Waugh[2] and factored in such a way that 1 second was equivalent to 0.7214 thousanths of an inch axially along the drum, to suit the radius of 9.92" described by the ball-ended pin. A year was deemed to have 360 days by February having 28 days, January and July having 31 and all the rest 30 days! This facilitated the machining of the groove in the drum in steps of 1° on a rotary table.

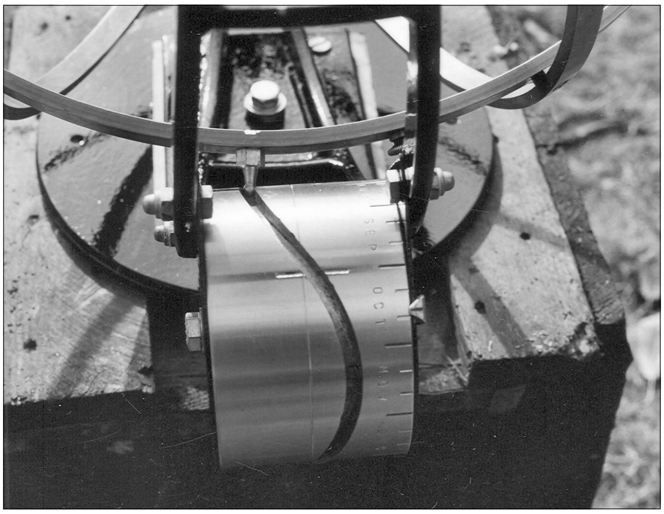

*Fig. 2. The EoT drum.*

Fig. 3 shows the set-up on my Elliott Omnimill. This has a horizontal arbor as well as a vertical one. A ¼" end milling cutter was fitted in the horizontal arbor and plunged to a fixed depth by inward movement of the table (locked against longitudinal movement) at each 1° setting of the rotary table. Before each 'plunge', the vertical height of the table (controlling the EoT value) was set with the aid of a digital vernier clamped to the locked vertical milling frame.

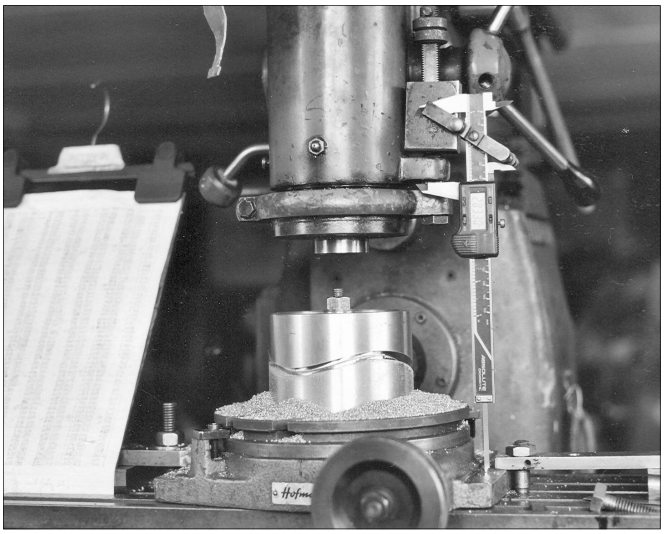

*Fig. 3. Machining the EoT drum, mounted on a rotary table and with a digital vernier used to set the height of the table relative to the cutter in the vertical (EoT) direction.*

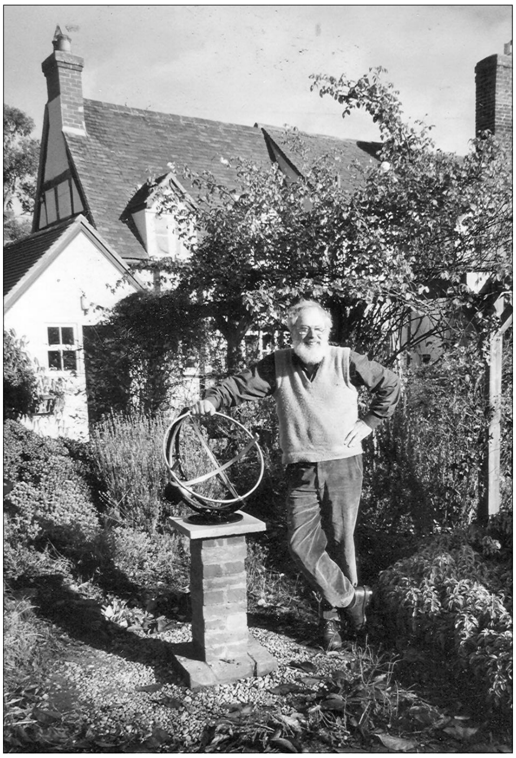

*Fig. 4. The author with the dial on its brick pedestal.*

Having completed the full EoT groove, the 10-day marks were made with a small centre drill in the horizontal arbor cutting short lines by vertical movement of the table. These grooves were in fact displaced by 90° on the rotary table so that the date setting pointer could be put in a good visible position at the top rear. After removing the drum from the rotary table, the sides of the EoT groove were smoothed so that a ¼" diameter steel ball passed freely. The months (JAN, FEB etc.) were stamped by hand.

The time-ring was marked at intervals of 5 minutes when flat and then rolled to circular form (using a set of rolls at the local blacksmith) before mounting in the cage using the gnomon as the centralising axis. The trickiest part of the project was achieving a truly circular time ring of correct radius and then setting it in the frame with the gnomon at its axis and the 6 o'clock marks diametrically opposite. Measurements were made between the ring and the gnomon and the former adjusted in its frame by suitable packing.

The steel frame was welded to its rectangular base plate so that the gnomon lay at 52° to suit the local latitude. This was achieved with the aid of an adjustable set-square marked in degrees. Final adjustment when mounted to the flat circular plate on top of the pillar was done by three brass screws and a central securing bolt with the aid of a plumb line. The dial was arranged to read GMT directly by positioning the ball-ended pin in the time-ring with an off-set of 8.7 minutes from noon for the local longitude of 2° 10' West. Correct alignment to due south was achieved simply by rotating the whole dial to indicate the correct time. All the black steel parts were galvanised before painting and final assembly.

The owner of the dial built a square brick pillar for it (Fig. 4). The dial can easily be read to one minute and is normally accurate to ±1 minute.

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## Mystery Dial

This picture of a high-quality churchyard dial comes from a 3¼″ glass lantern slide. The slide was bought by John Foad on eBay but without any provenance. It seems that it probably dates to before World War I but that is the limit of our knowledge. Does anyone recognise the church? - the cross on the porch is probably the most diagnostic feature, assuming that the dial is no longer in place.

# A GRINLING GIBBONS DIAL

## ROGER BOWLING

Lyme Hall is a National Trust property a few miles south east of Stockport and just within the Peak District National Park boundary. The three fine large vertical dials, (SRN 0145, 6 and 7) which adorn a restored early 18th century hunting lodge, and which were restored in 1998 by Graham Aldred, will be known to some members. He also describes another dial, a horizontal equinoctial dial associated with Lyme, and its discovery, history and reproduction.[1]

There is also another dial in the Hall, a universal equinoctial ring dial of about 1684. This dial though does not work, for it is part of a festoon in limewood by the master of the art of wood carving, Grinling Gibbons (Fig. 1). In the saloon, the room originally designed to be the main reception room, are three of his festoons representing music, the seasons and arts and sciences. The dial of about 12cm diameter is included in the latter, along with a collection of astronomical, surveying and navigation instruments (Fig. 2).

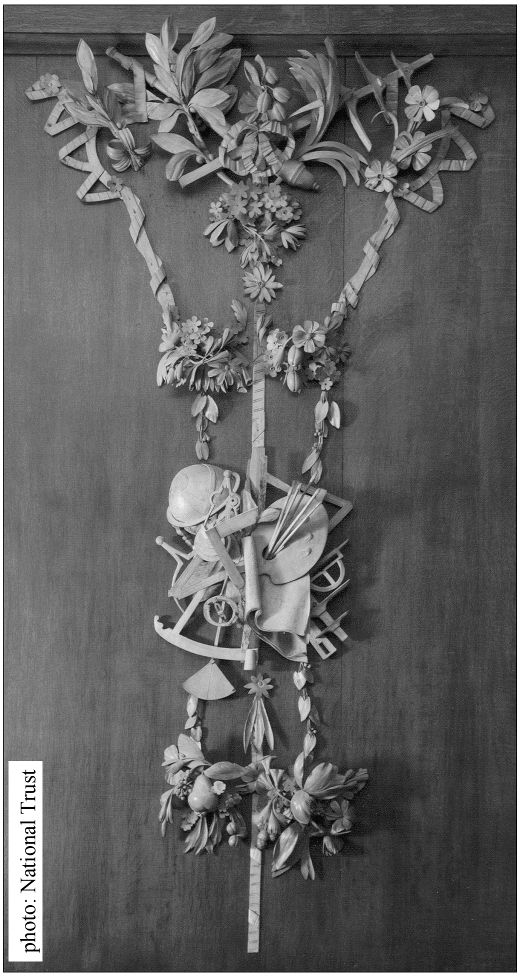

*Fig 1. The Grinling Gibbons carving representing the Arts and Science.*

In November of 1684 Sir John Chicheley on behalf of his brother-in-law Sir Richard Legh (the same Sir Richard of the horizontal equinoctial dial), visited Gibbons concerning "a peece of carved worke". The 'carved worke' in the hall is attributed to the master Gibbons himself, being of the same high quality as that attributed work of his at Petworth.[2] Whether this piece depicting the sciences was selected for or by Sir Richard because of his interest in the sciences, or even commissioned by him, I do not know. It would be of interest to know if Gibbons repeated the design with sundial elsewhere. So, in your visits to the grand houses, take a closer look.

The Sir Francis Legh collection of clocks is also housed in the Hall. It contains examples of all the most famous English makers, automata and musical clocks. Since this year (2007) it is augmented by clocks from the Hugh Vivian collection. Lyme Hall, with its gardens and park, is a good place to visit for BSS members: the clock collection is a bonus.

**ACKNOWLEDGEMENTS**
To Amy Thornborrow, the House and Collections Manager of the National Trust at Lyme Hall, for permission to photograph, and the gift of a copy of the NT photograph.

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*Fig. 2. Detail of the Grinling Gibbons carving showing the universal equinoctial dial.*

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