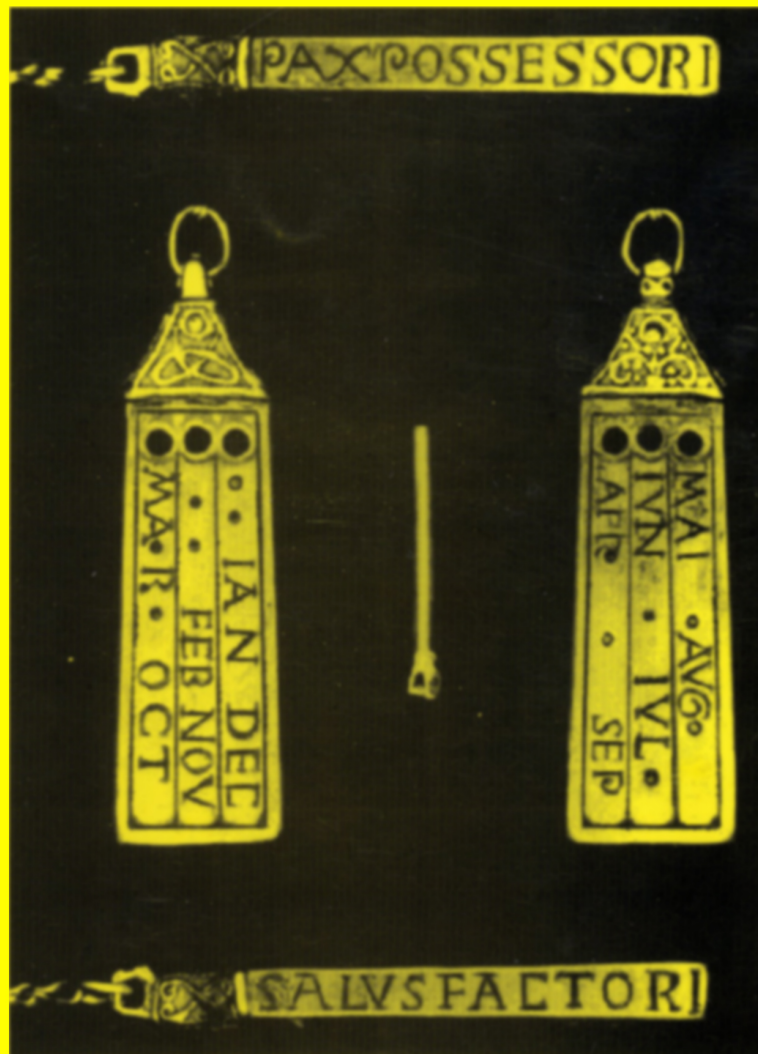


The British Sundial Society



BULLETIN

No. 95.2

JUNE 1995



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HONORARY OFFICIALS OF THE BRITISH SUNDIAL SOCIETY

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Cover Illustration - A composite view of all the faces of the Canterbury Pendant, with the gold pin gnomon in the centre, see pages 39-44. Please note that the letters have been emboldened for this illustration.

FROM THE PATRON
THE RT. HON. EARL OF PERTH, PC

It was sad news to learn of the death of George Higgs, our oldest member at the age of 94, but it was good to know that he had his family around him when he died.

The loss to the Society will be the loss of his skill, knowledge and experience in the art of constructing sundials, as well as the loss of his good company. The loss will be the greater for all those who were lucky enough to know him as a friend. Indeed, he had many friends, who enjoyed and wondered at his youthfulness, and his sense of fun, especially where it had anything to do with sundials.

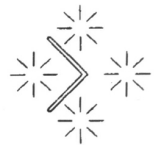
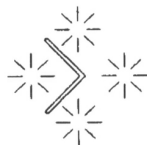
George was one of the Society's earliest members (number 007, I believe!), and he played an important part in its astounding growth. Many from all over Britain and from overseas have shown their great interest in an art form which might have been superseded centuries ago with the invention of the mechanical timekeeper. The sundial is an anachronism, but its appeal remains very strong. To be able to harness the rays of the Sun (or even the Moon) in countless fascinating, ingenious and artistic forms to tell the time goes back thousands of years.

George was one of the foremost latter-day exponents of this mathematical art. For example, he often collaborated with David Gulland in the making of the most beautiful window-pane dials, and he spent much time painstakingly restoring historic Scottish sundials. I owe him much: I inherited two fine old sundials and I now have

others, great and small, which are a delight to me, thanks to his enthusiasm and to his meticulous care in aligning them. I am sure that many would agree with me that George added to life!

Whilst I realise that there is a memorial fund to provide a special prize within the inaugural Award Scheme, I, for one, would like to pay tribute to George Higgs with a permanent memorial, which I believe should be a sundial of unusual form, say a glass window dial set up in a prominent or appropriate building in Kircudbright, his home for so many years. George, while deprecating such a tribute from his friends, would secretly have enjoyed the challenge, and would no doubt have approved, at least in principle. It seems to me that, whilst it must be up to George's friends to rise to the occasion, since he held no official post within the Society, it would be nice if the membership could have the opportunity to contribute to this proposed memorial sundial. Furthermore, as George was an elder of the Society (if not an elder 'statesman') and a prominent British diallist, it would seem to me to be entirely appropriate for the British Sundial Society to be associated with this proposal.

EDITORS NOTE: Those wishing to contribute to this worthy appeal are requested to make their cheques out to the "British Sundial Society", clearly marked for the "George Higgs Memorial Sundial Appeal", and forward these to the BSS Treasurer - Mr. R.A. Nicholls, 45 Hound Street, SHERBORNE, Dorset DT9 3AB.



DIALOGUE

COMPENDIUM

Volume 1 No 4 of the Journal of the North American Sundial Society has expanded into a 28 page issue plus a double page card printed with a working scale model of the Lyman Briggs Sundial and instructions of how to make it. This dial is covered in three separate articles - "The Briggs Dial - A Personal Encounter" by Ross McCluney, another on the error in relocating the Briggs sundial by Fred Sawyer, and "Implications of Moving the Briggs Dial" by Robert Terwilliger.

The first 2½ pages cover the generalities associated with the running of NASS (North American Sundial Society).

An excellent illustration of the Briggs dial, plus close-ups of the dial and furniture are given in an article reproducing the booklet issued August 1949. It was intended to commemorate the first three Directors of the National Bureau of Standards.

Robert Terwilliger, in the section "Design and Construction Forum - III", discusses the construction of a Polar Dial. It includes a short Basic Program with Microsoft QuickBASIC but can be run in other Basic environments.

Fred Sawyer also contributes "Reducing a Plane to the Horizontal". The Digital Compendium (the disc equivalent of the journal) contains a program to implement the mathematical procedures outlined in the article.

The final article is by Allan Pratt - "Digital Dials: Old Power, New Technologies" and ends on the Holographic Sundials of Michael Korn. Book reviews by F. W. Sawyer are given on pages 24-26.

The foundation of a new Sundial Society in Quebec, Canada is reported. The newsletter will be in French. Allan Pratt reports on the great success of NASS in the first year of its existence, growing to over one hundred members. On the final page is news of the Annual Meeting at the Smithsonian Institution in Washington DC and the archival files in the Compendium disc. Separate insert sheets cover the details of the ambitious program of events.

The British Sundial Society extends fraternal greetings to NASS and congratulates NASS for its successful year of consolidation and dialling contributions. Well done!

* * * * *

DE ZONNEWIJZERKRING

In issue 95.1 it is reported that at the September 1994 meeting a number of members showed apparatus of their making, showing that there is great deal of continuing interest in dialling. The North American Sundial Society is exchanging Bulletins with the Dutch Society.

It is believed that the Pole Star is slowly dying. Programs for setting-out sundials are offered by a member.

A translation of a French article (into Dutch) gives a description of a very large sundial on the French motorway A9 between Orange and Nîmes. It is 17 metres high, based on a model only 30 cm high made by a lady sculptor. Experiments began in 1988 and the dial completed in 1993. Full details are given of the various components, with dimensions and angles, together with photographs and drawings.

An article is included on the Meridian Line marked by Arago in Paris, and the monument to Arago which was unveiled on 14th November 1994, written by M. J. Hagen. It is followed by an article showing parts of a document dated July 1836 about the introduction of mean time to Nijmegen, and the use of sundials and regulator clocks. An illustration of the dial to indicate midday is given, and a drawing of the dial in use.

An azimuth projector is described, with the principle of finding the North-South meridian, commencing with a weight hanging on a string suspended from a stepladder. The basic idea is elaborated and a simple instrument described.

Details of times of sunrise, highest point and sunset is given by teletext in the Netherlands, plus a note on modifications.

A universal sundial model is described and illustrated, a full size drawing of the dial scale being given. The four dials of a sundial in the cemetery Deventer are shown in diagrammatical form, with descriptions. A method of making a horizontal dial furnished with date lines and using the shadow indicated by a cord is described, the same author also describing a table by Cruquius, dated 1726, which shows the rising and setting times of the sun which is surprisingly accurate.

Listing of Netherlands sundials continues, with a brief history of how they became to be recorded in the first place. There are six pages of reports on sundial societies bulletins and two book reviews - *The Portable Universe: Two Astrolabes of the Boerhaave Museum*; and *An Exhibition of Globes and Planetaria*, from the collection of Rudolf Schmidt. Issue 94.3 of the BSS Bulletin has almost two full pages devoted to comments on the contents, a most comprehensive analysis of the material.

On the last page is an illustration of a book by H. W. van der Wyck *Het A B C van de Zonnewijzer* (The ABC of Sundials). This gives the fundamental principles of dialling and the construction of sundials from simple materials. The text is Dutch.

This issue is another compilation of excellent and informative articles.

E. J. TYLER

* * * * *

NEW TREATISE

A new dialling treatise has been issued in Germany which contains details of about 8 000 sundials, the following is a foreword to the book written by our Vice-President, René R.-J. Rohr. A review of the book will be given when a copy has been obtained.

FOREWORD:

Time, omnipresent to all men, has up to now, not been defined. Undetectable to all our senses, it remains an image in the mind which is only thinkable in terms of motion. In mathematical fiction or in cinematography it plays the role of a fourth dimension, and then perhaps approaches nearer a meaningful definition.

It must have been movement that brought to humanity, even in Neolithic times, nearer to a concept of Time; and the measuring of its passage by the most primitive means -

such as the shadows of trees or a stick, finally with stones set out for easier observation. It would not be unfair to consider these forerunners as the origin of time measurement and the beginning of sundial science.

One can accept that the use of this kind of time measurement continued to grow, for in China 5000 years ago this led to the start of astronomy and the application of the shadow of gnomons to time determination.

An early mention of primitive time measurement is that in the Bible where it is mentioned in the Book of Kings about the sundial of King Ahaz in 800 BC at Damascus, and had long existed in Chaldea. Following this was the hollowed-out hemisphere, also of Chaldean origin, the use of which spreading westwards, was used for a millenium in the Roman Empire for showing temporal hours. In the same period, sundials were found occasionally on walls in Rome and Egypt. These were later mentioned by the Venerable Bede at the beginning of the seventh century and were to be seen on churches and monasteries until the late Middle Ages. Finally, in the last years before the Renaissance, came the invention of the Polar dial, known in Europe at the beginning of the 15th century and which by the 18th century had reached an unbelievable height of development.

In the meantime, mechanical timekeeping had also reached a state of development which threatened the existence of sundials. Many valuable dials were then lost.

It is true that a sundial draws attention from an indifferent observer by some secret influence, making him think of the passage of Time, about existence and death, the finite and infinity, then and now. Their quotations arouse deep feelings in the friends of Nature.

In thinking of the origins of sundials, the more enthusiastic students made lists of sundials in their neighbourhood. Later there appeared societies which sought these relics and valuable artefacts, not only in their own areas but in whole countries, and who sought to protect them from destruction.

The present work has collated the listing of 8000 examples by the D.G.C. The efforts of its members have brought about the renovation of countless sundials, and the continued existence of others.

The old custom of giving a sundial a motto continues to this day. A verse from Heinrich Heine's "Atta Troll" about a neglected sundial is particularly apt:

No, I am not yet dead
Nor extinct, for in my soul
The flame of life
Rejoices and blazes.

To all the friends of sundials, who have put their heart and soul into this collection of dials, our acknowledgements and grateful thanks.

RENÉ R. R.-J. ROHR
BSS Vice-President

* * * * *

EPIGRAMS


The following mottoes have been extracted from Hillaire Belloc's *Epigrams* by our member J. P. Lester:

XLVII In soft deluding lines let fools delight.
A shadow marks our days; which end in night.

- XLVIII How slow the shadow creeps: but when t'is past
How fast the shadows fall. How fast! How fast!
- XLIX Loss and Possession, Death and Life are one.
There falls no shadow where there shines no sun.
- L Stealthy the silent hours advance, and still;
And each may wound you, and the last shall kill.
- LI Here in a lonely glade, forgotten, I
Mark the tremendous process of the sky.
So does your inmost soul, forgotten, mark
The Dawn, the Noon, the coming of the Dark.
- LII I that still point to one enduring star
Abandoned am, as all the constant are.
- LIII Save on the rare occasions when the Sun
Is shining, I am only here for fun.
- LIV I am a sundial, and I make a botch
Of what is done far better by a watch.
- LV I am a sundial, turned the wrong way round
I cost my mistress fifty pound.

* * * * *

IN MEMORIAM



Wir sind traurig,
daß Du von uns gingst,
aber dankbar,
daß es Dich gab.

Gott der Herr nahm heute abend nach kurzer, schwerer Krankheit
meinen lieben Mann und unseren guten Vater

Dr.-Ing. Hugo Philipp

Vorsitzender des deutschen Arbeitskreises "Sonnenuhren"

im Alter von 69 Jahren zu sich in sein Reich.

In stiller Trauer, aber auch in Dankbarkeit für all seine Liebe,
die er uns geschenkt hat, nehmen wir Abschied.

Doris Philipp
Markus Philipp
Stefan Philipp
Doerthe Philipp

40721 Hilden, den 29. Januar 1995
Düsseldorfer Str. 73

Das Seelenamt wird am Montag, dem 6. Februar 1995, um 9.30 Uhr in der
Pfarrkirche St. Johannes Evangelist, Düsseldorfer Straße, Hilden gehalten.

Die Beerdigung findet im Anschluß daran um 11.00 Uhr auf dem
Hauptfriedhof statt.

Dr.-Ing. Hugo Philipp, Chairman of the German Sundial Society, died on 29th January 1995, aged 69 years. The BSS Council, on behalf of the members of the British Sundial Society, extends sincere condolences to his family. A further appreciation will be included in the next issue of the BSS Bulletin.

PORTABLE DIALS - ART AND DECORATION

JOHN MOORE

Portable dials were made primarily as functional items, but many of their makers also made them attractive by various means such as ornate engraving, coloration and even by adding pictures. Many dials were highly decorative and were fine examples of the craftsman's art.

In general, French dials are the most elaborately decorated, and with many, their decorative features are of greater importance than their function. The early French makers used only the finest materials such as silver, often with gilding, for many of their dials, because they were made for an elite clientele. Silver is not the easiest material, especially when well polished, on which to see a shadow. The ideal material should have a plain matt white surface. This was achieved by many of the English and German dialmakers by silvering the brass scales on their dials. It was also provided naturally by the ivory of many diptych dials.

The portable dial is frequently a platform for the artist, an object of beauty or jewellery for the pocket and frequently shows many different styles of embellishment.

ENGRAVED DECORATION

One of the simplest means of 'improving' a dull but functional sundial, was to add fine engraved patterns to the plainer areas that were devoid of scales. Often, this would be little more than a simple pattern around the dial edge or on the underside of the compass bowl. In particular, English makers favoured this simple and more restrained style of decoration. On early English dials the wheatear pattern is one of the best known. It appears on many English dials and other scientific and mathematical instruments from the more important makers. The English Rose was also popular and is a most attractive feature on an instrument. An inclining dial by Culpeper¹, has the rose prominently placed in the centre of its compass bowl and wheatear patterns around it. (Fig. 1) A more elaborate rose

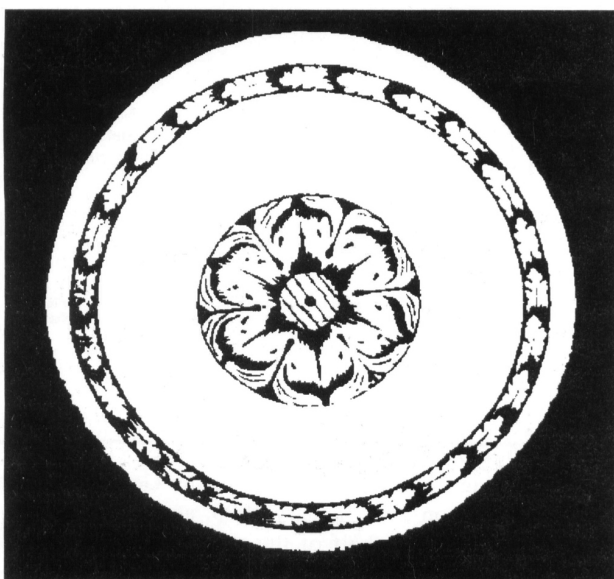


FIGURE 1: English Rose and Wheatear Patterns from a Culpeper Inclining Dial

is used by Richard Whitehead on a 'Butterfield' type dial in silver made around 1675. (Fig. 2). On this dial, he also engraves some attractive flowers on the gnomon erecting spring. Note also that the compass bowl has a transit clamp for the compass needle. This was an English feature seldom, if ever found on their French counterparts.

Similar patterns were used by French dialmakers. These were generally much more elaborate as may be seen on the compass bowl of a silver inclining dial by Chapotot of Paris. (Fig. 3) This is not a rose but a bold foliate swirl. Another interesting fact about this dial is that Chapotot in nationalistic fashion, reserves the top plate for French towns and places the foreign ones underneath.

The prominent and well-known decorative feature of the so called 'Butterfield' dials is the bird supporting the gnomon with its beak pointing at the latitude scale.² This is a very particular form of decoration, and quite a charming one. It was widely copied by French makers from around 1680 and persisted right into the 19th Century. A similar bird was also used by a number of English 'Butterfield' dial makers.

The dialmaker's signature was often ornately applied and showed great artistry with its elaborate squirls. English and German dials were less flamboyant in this respect than the French.

Engraved patterns, either foliate or floral are sometimes used to excess, especially on French dials. Fig. 4. shows an unsigned French brass octagonal dial that is decorated all over with ornate foliate scrolls, leaving no space between them. This dial is unique in having a Butterfield style dial on its lid, and an Augsburg style dial between its plates. There seems to be no logical reason for the two dials being combined in one instrument as both do essentially the same job. It was probably commissioned by the purchaser who asked for it to be 'the best and most complicated dial possible', in order to impress his friends. He also had his



FIGURE 2: 'Butterfield' dial by Richard Whitehead of London showing an elaborate English Rose design



FIGURE 3: Inclining dial by Chapotot of Paris showing a typical French floral design.



FIGURE 4: Excessive decorative engraving on an unsigned French dial

motto, “Candor et Odor”, surrounded by elaborate leafy scrolls on the underside, not just in its centre or out of the way, but the full size of the plate. A small list of towns and their latitudes are then squeezed around the underside edge. It seems rather strange that this very ornate dial is made in brass and not in silver, and that it remained unsigned. Perhaps, at one time the surface of the brass had been finely gilt?

Flowers, which were more common on the lantern clocks of the mid 17th Century, were sometimes used as decoration. A quadrant by Walter Hayes, c1680, is finely adorned with tulips. This is the quadrant already described,³ with the hidden engraving beneath its volvelle.

A rare Analemmatic dial by Gabriel Stoakes (Stokes) of Dublin, has an ornate engraved area around its analemmatic gnomon. (Fig. 5.) This is a very formal pattern, typical of those found north of the English channel and unlike any that would have emanated from Continental makers. Apart from this patterning, the dial is relatively plain except that the main dial plate is silvered and its gnomons are gilt. Dials by Irish makers are quite rare and are generally well executed. The work of Dublin craftsmen, not only of instruments but also of silver and other metalwork, was similar and equal in most respects to those from London. The only real difference to be found, is that their work is slightly heavier and more substantially made than similar London items.

PICTURES

Dials with pictures on them are relatively rare and as such are much prized by museums and collectors. Fig. 6. shows the back of a silvered brass ‘Butterfield’ dial by Hays of Paris. On the compass bowl, he depicts a monk, kneeling down in prayer, his face being illuminated by an ethereal beam of light from the sky. It carries the inscription in Latin, “Fuge tace quiesce”. On the top side of the dial plate, inside its three chapter rings and partly covered by its gnomon, is engraved a scene showing a bridge over a

flowing stream, leading to a castle. The dial has the unusual latitude of ‘Grand Chartreuse, 45°’ in its list of towns and a 45° chapter ring. The words, Grand Chartreuse extend prominently both sides of the gnomon spring. It is therefore quite probable that the dial was made for the Abbot at Grand Chartreuse monastery.

Several Ivory diptych dials are known with engraved pictures.^{4,5} Some carry a biblical scene, an angel or flowers, but on one dial, (Fig. 7.), there is an impressive view of the town of Nuremberg. This is the only known dial so decorated. A town layout of this nature could also

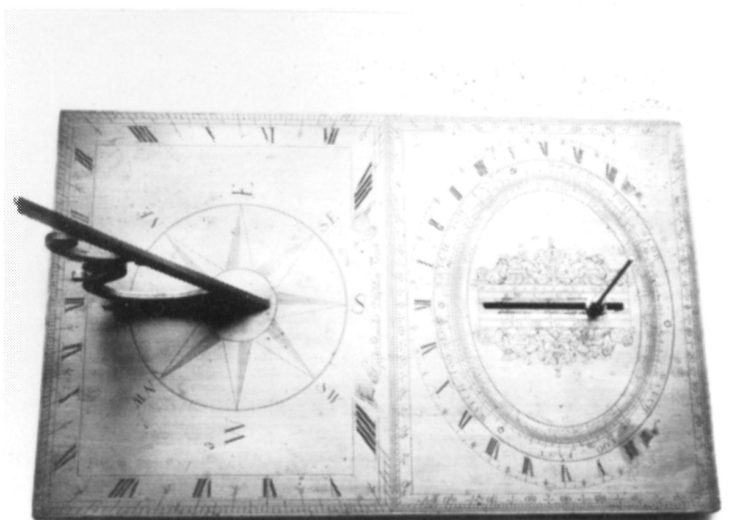


FIGURE 5: Formal patterns on an Analemmatic dial by Gabriel Stokes of Dublin



FIGURE 6: Delightful engraving of a monk on the compass bowl of a dial by Haye of Paris

serve as a simple map, showing the position of churches and town gates. Some of the earliest French diptych dials, particularly those from Paris, carried painted scenes on them.⁵

Many makers just could not resist the temptation to try out and test their engraving skills. Hidden engraving on a diptych dial by Jacques Senecal of Dieppe shows a galleon in full sail.⁶ Fig. 8, shows a fish or eel that was engraved on a 17th Century unsigned English boxwood horary quadrant.⁷ It is positioned between two arcs in an area that



FIGURE 7: A view of the city of Nuremberg on the lid of an ivory diptych sundial

would otherwise be blank. On the same quadrant, there are some very fine complex patterns reminiscent of Indian decoration, possibly influenced by Arabic instruments of the time.

CRESTS AND ARMS

Dials were often made to order, and these would sometimes carry the customer's coat of arms or motto. Where these were shown, they were usually prominent and a major part of the decoration of the piece. An ivory magnetic azimuth dial by the otherwise unknown Dieppe maker, Nicholas Crucifix, carries a bold armorial showing a shield beneath a rather ferocious but delightful monster. (Fig. 9) This dial has already been described,⁶ and is otherwise finely decorated with orange or brown mottled patterns.

PRECIOUS DIALS

These are the dials that were made, not so much as sundials, but more as precious objects. They equate to jewellery in modern times. Some were made of gold, some of silver with local gilding, some with precious stones or tortoiseshell, and others just in the finest quality imaginable.

A particularly fine silver and gilt dial, (Fig.10), is signed by Timotheé Collet of Paris and is dated 1663. This early octagonal dial is in the general form adopted by later French makers such as Butterfield. Instead of a bird, this dial uses a graceful gilt arc supporting its gilt gnomon. Its decoration is both simple and graceful. An unusual feature, is the **XII** noon marking, which is on an extended section of the dial plate. On most dials the **XII** was frequently hidden by the gnomon. This dial is further embellished with an ornate makers signature. Its reverse side, (Fig. 11), is ornamented by a gilt spring for the gnomon. It has finely fretted ends of flowers and fruits being held by serpents heads. The matching spring on the opposite side is non functional and placed there purely for symmetry. In its centre, is a gilt lunar volvelle showing the phase of the

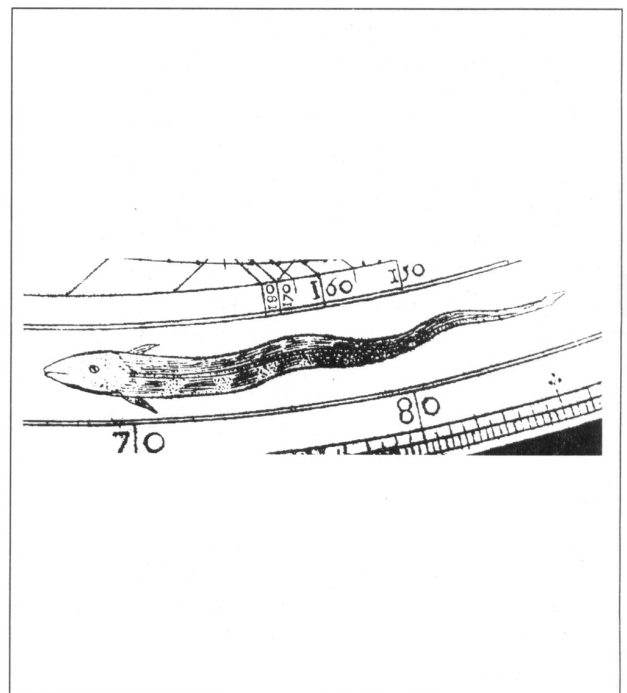


FIGURE 8: Fish or eel taken from an early English boxwood quadrant



FIGURE 9: Decoration on the top of a Dieppe ivory diptych dial by Nicolas Crucifix

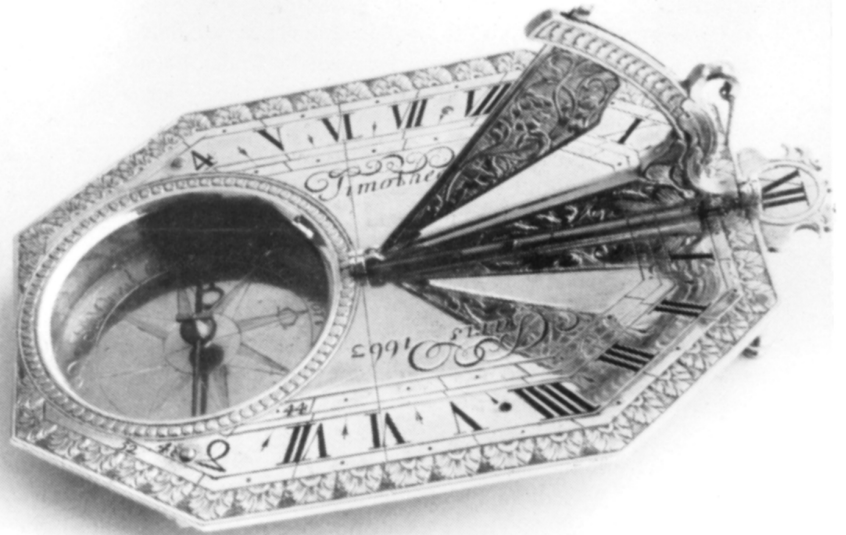


FIGURE 10: Silver and gilt dial by Timotheé Collett of Paris, 1663

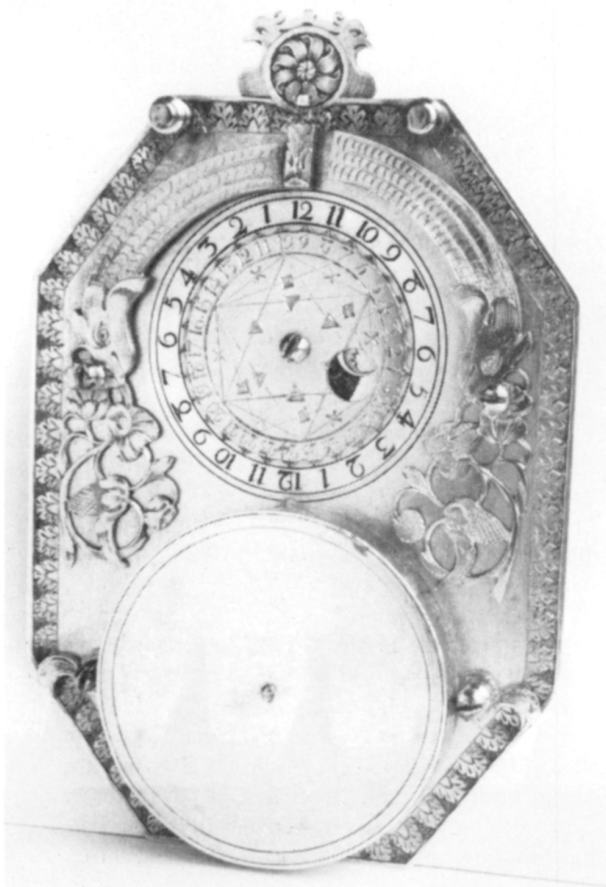


FIGURE 11: Underside of Collett dial



FIGURE 12: Early silver and gilt diptych dial

moon in its round aperture. This enabled the dial to be used at night as a moon dial, the hour shown by its shadow being converted by this volvelle. The shadow on a bright silver surface would be difficult enough to read in sunlight and must have been impossible by moonlight. Its useful function is therefore to be questioned. In the centre of the volvelle are depicted the astrological aspects.⁷ This feature is somewhat uncommon on French made dials, and is an early feature seldom found at this late date. There are only four dials of this style known that are made by Collet. Each is of the same fantastic quality although they vary somewhat in size.

Fig. 12 is a very small dial of unknown origin. It is possibly 16th or 17th Century, Italian or Spanish, made of silver with some parts gilt. Its compass bowl is fashioned from rock crystal, a pure type of quartz that looks similar to glass. The ornately patterned gilt lid is surmounted by a large square ruby. The dial itself is of the string gnomon diptych type, with both vertical and horizontal hour markings. The hour divisions are somewhat inaccurately engraved, showing that it was prized more as a valuable object than as a sundial. On its vertical silver dial is engraved a smiling sun's face, which has been charmingly enhanced by the addition of local gilding. The dial still has its original tooled leather case that has afforded it

protection over the centuries. The tooling on the case is continued all over including its underside. Internally it is lined with purple velvet and there are areas lined with paper carrying traces of green printed patterns, probably from an early religious book.

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ACKNOWLEDGEMENTS

The author would like to thank Harriet Wynter for the photograph of the Nuremberg dial, Fig. 7.

GIVE US BACK OUR ELEVEN DAYS

DOUGLAS WOODRUFF

THE GREAT DISAPPEARING TRICK OF SEPTEMBER 2-14, 1752

The interesting article on the reformation of the Julian Calendar by Girolamo Fantoni in BSS Bulletin 94.3 can be supplemented by the following article published in September 1952 (the source is not known).

Two hundred years ago England adopted the Gregorian reform of the Julian Calendar, which was by then 11 days out.

There is hardly a schoolboy so low down in a low form that he cannot participate in a derisory titter of superiority when he hears of those Englishmen who, resentful and perplexed at the change in the Calendar, when in 1752 September 2 was suddenly succeeded by September 14, cried "Give us back our eleven days"!

An election cartoon of William Hogarth, at the height of his powers, helped the phrase to that rare and lasting fame, a place in the textbooks used in lower and middle forms of English schools.

SO STRONG IS CUSTOM

Undoubtedly there was a good deal of feeling, mainly in the countryside.

In seventeen hundred and fifty-three
The style it was changed to Popery,
But that it is liked we don't all agree,
Which nobody can deny.

When the countryfolk first heard of the Act,
That Old Father Time was condemned to be
racked,
And robb'd of his style, which appears to be fact
Which nobody can deny.

This poem goes on further to be sung to the tune of "The Jews Triumph", linking the measure, quite unjustifiably, to an even more unpopular Act, hastily repealed, to allow Jews to be naturalized.

Immemorial usage, the memory of man not going back to the contrary, had made the Calendar seem part of the eternal framework of Nature; so strong in custom that it seemed presumptuous for an English Parliament to alter what Julius Caesar had done.

YEAR WITH 281 DAYS

For as long Englishmen had lived contentedly inside the acts of that distant Roman, just as to this day every child who stumbles and gets confused in learning "30 days hath September" is paying involuntarily for the petty vanity of Augustus and his courtiers, who could not bear that the month named after him should not have 31 days if other months had; especially if the month named after Julius had. So he upset the logical alternations of thirties and thirties-ones (days in the months).

But the man-made character of the Calendar was not present in the minds of ordinary Englishmen when out of

the blue, these changes were announced. The language of the Act, which received the Royal Assent, in May 1751, was none too clear. It began with a provision to start the year on January 1, as the Scots had done since 1600. It meant that the 1751 ended abruptly after nine months or 281 days, but there was, rather illogically, no parallel outcry about that truncation.

The Act went on to talk about the Council of Nicaea and the computing of Easter, and how the Vernal Equinox instead of occurring around March 25 had developed the bad habit of coming too early, around the 9th or 10th; and it was to correct this that September 3 was advanced to become September 14, so that March 9 might become March 21.

The practical consequences were not uniform. The Act said a great deal to the effect that no one was to come of age 11 days sooner, or finish their apprenticeships "until the full number of years and days shall have elapsed". Man's estate would be reached 11 days after the 21st birthday. (Some people, of course, lost their birthdays altogether in 1752).

All rents and payments were to be for the same number of days, ie payable 11 days later "as the same should and ought to have been payable in case this Act had not been made". Interest was to be made for the "true number of natural days". That is why the financial year begins and the income-tax assessments go out on April 5. (Previously 25th March).

But then exceptions were made for courts held with fairs and marts. These were to begin 11 days sooner, because the fairs and marts were tied to seasonal agricultural activities. It was a conscientious attempt to reconcile legal justice with agricultural convenience, but it confused the countryside.

A LORDS MEASURE

All this rural perturbation, however, was below the attention of the three men who carried the reform. It was a Lords Measure, an achievement of enlightened aristocracy.

Lord Chesterfield, the polished man of the world, moved the Bill in the Lords, and afterwards claimed chief credit for its easy uncontested passage because he had avoided any over-elaboration of an involved subject. He wrote: "It was not in my opinion very honourable to England to remain in gross and avowed error, especially in such company (meaning Russia and Sweden, who alone kept the Old Style).

But the brains of the enterprise were the scientific Earl of Macclesfield, the son of the impeached and convicted Lord Chancellor of George I, who had found consolation in astronomy at Shireburn Castle in Oxfordshire, and Dr. Bradley, the Astronomer Royal.

To these men it seemed inadvisable to state plainly what they were doing, and their Act merely remarked guardedly that "a method of correcting the Calendar so that the Equinoxes and Solstices may in the future fall nearly on the same nominal days on which the same happened at the time of the said General Council (Nicaea), has been received and established, and is now generally practised by almost all other nations of Europe".

In fact John Bull was belatedly coming into line and, 170 years later, setting his days by the Calendar Pope

Gregory XIII made in 1582.

That was the very height of the conflict of the Elizabethan Government and the Roman See, and Elizabeth, although her clear mind was impressed by the advantages of the reform, did not care to adopt a new style announced in a Papal Bull lest the Bishop of Rome might seem after all to have some jurisdiction in her realm.

OLD PRIESTLY FUNCTION

For calendars and chronologies, the observance of the sun and the moon had been immemorially part of the authority of priests, and the Pontifex Maximus was exercising functions stretching back far beyond the Roman Republic, to Chaldea and Egypt.

The errors of the Julian Calendar had been known in the 15th century and the reform had long been agitated for in Rome. It was an activity wholly appropriate for the Renaissance and the age of maritime exploration, when the Vatican was becoming map-minded because mission-minded.

But for the contentedly slow tempo of Rome, it might well have come 50 or more years before and then it would presumably have been adopted in England as it was through the rest of the Catholic world.

* * * * *

CORRIGENDA

On page 30 of the article by G. Fantoni, a printer's error has resulted in the 2nd September 1752 being shown as 2nd October 1752. Also in the chronogram on page 30, some of the required underlining of the letters has been omitted, it should read:

"IACOBVS III D.G. MAGNAE BRITANNIAE ETC REX.

The result is:

$$I C V I I I D M I I C X = M + D + CC + X + V + IIIII \\ = 1000 + 500 + 200 + 10 + 5 + 6 = \underline{1721}$$

as stated in the article.

* * * * *

NOTE:

It is an apparent paradox that the Calendar date had to be advanced when the Vernal Equinox was already arriving too early, and that the addition of eleven days to the year in 1752 actually reduced the length of that year by that amount, which is precisely that which caused the *hoi poloi* to be so disturbed about going to join their Maker rather earlier than anticipated. Evidently their lives were not as miserable as history books would have us believe in the accounts of the Middle Ages.

The ingenuity of those who devised the necessary changes to the Calendar is manifest when the error today, over four hundred years of the Gregorian Calendar later, is so small. This is a very great tribute to the ingenuity they exercised at the time when the Roman Catholic Church was still making the *Primum Mobile* turn around the earth once in every twenty-four hours.

BEWCASTLE CROSS (PART II)

CHARLES K. AKED

There are many early Saxon sundials in the north of England, but none have runic characters. The Kirkdale example does have letters which are intermediate between the runes of Bewcastle, see Figures 9 and 10, and the later Anglo-Saxon letters which became adopted. Hence Bewcastle Cross was executed long before the eleventh century, whereas the basic sundial design is much like that of Kirkdale.

All Anglo-Saxon dials are similar in their essential details, dividing the day into four main periods, the inscribed line indicating the end of the last period and the commencement of the next. It would be true to say that these dials form a distinct group preceding the ubiquitous Mass dial which was a retrograde step in English dialling introduced by the Normans and before the "scientific" sundial using a polar gnomon was introduced from Europe.

The actual time system used by the Anglo-Saxons is little understood although the Reverend Daniel Haigh gave what appeared to be a full account of their timekeeping system in his detailed paper in *The Yorkshire Archaeological and Topographical Journal*, parts XVIII and XVIII. In my article of December 1973 which appeared in *Antiquarian Horology*, I assumed this had been accepted as correct since I could find no criticism of Haigh in later horological papers. Now it seems that much of what Haigh stated was mere conjecture.

The early Roman church became the depository of timekeeping methods, merely because it was deemed essential to have prayers said at the correct times. The Church authorities ordered that some means be used to determine the times for these, hence the dials on churches. Since the design of these originated in the Mediterranean area, it meant the use of a horizontal gnomon and the indication of seasonal hours. There were supposed alternative means of time telling in Saxon times through the use of sinking bowls which meted out a fixed amount of time, and also tallow dip candles which meted out equal periods of time. Such methods could not fit in with the seasonal hour indication of the sundial except perhaps at the time of the equinoxes when seasonal and clock hours are equal in duration. King Alfred is supposed to have used candles in a horn lantern, dividing his day and night into three periods, two for work and one for sleep. It is hardly likely that the tallow candles of his day were consistent enough for measuring time.

The Venerable Bede in his writings mentions that the hours were longer in summer than in winter, ie seasonal hours. We must assume that, in the absence of any known mechanical timekeeper to measure out uniform hours, temporal hours were indicated by the early Anglo-Saxon sundials. The great disadvantage was that the dial design which was reasonable for use in the Mediterranean area, completely failed in its winter indications when used so far north. There was absolutely no need to indicate twelve equal hours in the day since there was no standard by which this could have been measured at the time.

Before the Bewcastle Cross sundial reached its present position of almost total obliteration, it seems likely that at some time the original dial was altered to show twelve divisions of the day by adding two extra lines in each quarter of the dial. At such a height and with such a small

dial (ten inches across and seven inches high), the provision of twelve lines did not do much to add to the utility of the dial indications. These added lines were cut to a much shallower depth than the original lines and have now almost vanished. The short cross lines too were either cut later or recut at some stage since their delineation was clearer than the rest of the lines. The sundial at Kirkdale also has subdivisions of the periods but these divide the main quarter day periods into two parts, giving eight parts to the daylight period. This dial too may have been modified since three of these half-tide lines are quite different in character to the main lines. Bewcastle Cross could never have had this kind of division originally since it would have prevented later division into twelve parts.

It seems to the writer that the Bewcastle dial is earlier than that at Kirkdale but is one which belongs to the group of dials which are peculiarly Anglo-Saxon and mainly located in Northern England. See Appendix II and Fig 11. Of course we must remember that they may well have been much more widespread but were destroyed by the Normans after the Conquest. The Normans despised the Anglo-Saxons as ignorant peasants and commenced a huge ecclesiastical building programme which annihilated much Anglo-Saxon work.

The obvious difference in workmanship between sundial and monument seems to indicate to the writer that the dial is a later added feature where advantage was taken of a part of the panel for its delineation.

At some indeterminate time later the dial was altered to give twelve divisions and these extra lines have almost disappeared. They were still quite clear when the writer visited the site, so the last twenty years or so have done enormous damage. To see what the dial was like in earlier times one has to visit the Plaster Court at the Victoria and Albert Museum, London, where there a plaster replica of Bewcastle Cross. A better plaster replica is to be found in the small museum at Durham Cathedral where a plaster copy is also on display. There is a plaster cast of the dial at the Science Museum, this is a cast of the cast at the Royal Scottish Museum, Edinburgh, and is misleading, see Fig 12. For years the writer could not understand the huge cavity at the site of the gnomon planting when looking at the Science Museum example, but as may be seen by a comparison of Figs 6 and 12, the hole in the actual dial is quite different. The vertical rutted line on the right seems to be the result of rainwater dripping fortuitously from the upper part of the cross. It has always been shown in illustration, possibly it commenced a flaw in the stone itself.

Incidentally, the shrine of St. Cuthbert is in Durham Cathedral, it may be recalled that the little church at Bewcastle (Fig 2) is dedicated to him. His likeness may be seen as a carved wooden figure in the cloisters to the north of the cathedral. The Venerable Bede also is enshrined here in the Galilee Chapel to the west in a modest marble chest tomb. In the monks dormitory is a large collection of relics, plus a plaster cast of Bewcastle Cross.

Since Bede (672-735) does not mention the Bewcastle sundial, it seems fairly reasonable to suppose it was delineated after his time or that it was unknown to him. His great work *Historia Ecclesiastica Gentis Anglorum* was

published in 731 AD after his death. His scholastic work was eventually taken over by the learned scholar Alcuin who died in 804 AD.

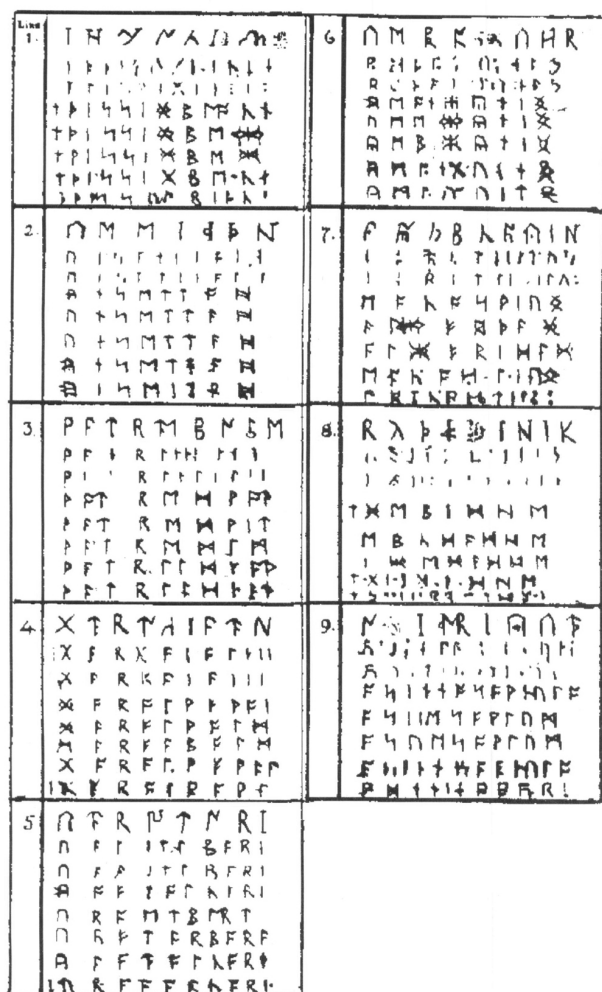


FIGURE 9: The nine lines of runes (numbered 1-9) in the main inscription as drawn by various researchers, reading from top to bottom: George Smith 1741, Henry Howard 1801, Samuel Lysons 1816, John Maughan 1857, Daniel H. Haigh 1857, Isaac Taylor 1892, W.G. Collingwood 1899, James King Hewison 1913 (from a photograph).

SUMMARY

1 The solution of the actual date and purpose of the monument lies with archaeologists and historians. Without knowledge of the practices and languages of the people at the time, the average diallist would make little progress in wading through the masses of material available. Much of this was written by biased people. The use of runes for the inscriptions signifies a period some considerable time before the end of the first Millenium. If the phrase "In the first year of the King of this realm Ecgrith" is correct, the cross must have been produced with extraordinary speed, and it would

be a very complex project to produce such a magnificent cross within a year. It would be quite a feat to find a piece of stone in the first place, to move it, and have someone capable of carving to such a high standard. A Continental craftsman must have been commissioned to do the work, it is unlikely that a skilled British craftsman was available.

- 2 By comparison with other early Anglo-Saxon dials, Bewcastle Cross sundial would appear to be contemporary with Irish dialling practice which commenced much earlier than in England. The standard of execution of the original dial lines was primitive compared with that of the actual cross. The cross should have carried some mention of the use of what would be a very strange device to most of the native population. The difference in lines is such that the dial appears to have been modified later to allow the duodecimal division of the daylight hours. Such an arrangement is quite useless for this purpose except around the equinoxes. A discussion of the principles involved is beyond the scope of this article. The height of the dial makes indication by duodecimal division of rather doubtful utility. The only advantage of being at such a height would be to place the iron gnomon out of reach of people. Such a piece of metal would have been of great value.
- 3 Much of what has been written here is in the nature of an epitaph because the sundial on Bewcastle Cross has almost been extinguished in a mere twenty years by the accelerated decay of stone in the last few decades. It is no longer of any use to visit the actual dial to make a critical examination of the lines. Only the mid-morning and midday lines sensibly remain. Future researchers will have to look at the plaster replica at Durham to see how the dial appeared in the nineteenth century. There are some notes preserved there by one of the priests of Durham Cathedral who took an interest in Bewcastle Cross and other old monuments, which extended to having plaster casts made. These need to be studied further.
- 4 The present writer was the first to deal with the sundial at Bewcastle in a horological context - see the list of references. No one seems to have taken up the challenge since, but for someone looking for a dialling thesis this seems to be an area well worth investigating.
- 5 Bewcastle Cross should be given protection from the weather, even if it is only a large cylindrical plastic shield placed over in winter. It needs to be placed indoors to preserve what remains from further destruction. It is one of the greatest masterpieces extant from the Anglo-Saxon period.

APPENDIX I

A description of the plaster cast of the Bewcastle Cross sundial on display in the Science Museum, London, is given in the descriptive catalogue of the Time Measurement collection written by Dr. F.A.B. Ward, published in 1966. For the convenience of present readers, the brief description is given here:

A plaster cast of the stone sundial in the south face of Bewcastle Cross, Cumberland, prepared from a similar cast in the Royal Scottish Museum, Edinburgh. The dial markings are cut on the actual stone of the cross, which



FIGURE 10: The runes drawn by the Rev. John Maughan, left to right 1854, 1854, 1857.

bears various inscriptions. One of these can be transcribed as “First year of the king of this realm Ecgrith” and this inscription enables the cross to be dated at approximately AD 670.

At this period it was customary in England to divide the day from sunrise to sunset into four “tides”, and corresponding to this division the dial possesses four main hour lines - a horizontal one for midday and two intermediate lines, which are drawn at 45°. Each of these main lines is marked with a cross stroke, and there are in addition two intermediate lines between each of the main lines. These correspond to a division of the day into 12 parts, but it is possible that they were cut at a later date. To see the difference in the lines turn the photographs upside down (Figs 6 and 12).

The gnomon is missing, but it is conjectured that it stood out horizontally. Such a gnomon would divide the daylight hours into only approximately equal parts and dials of this type would thus give only a rough subdivision of the day.

This confirms the earlier mention of the Science Museum being only a second-hand version of the dial and perhaps accounts for the apparent unnaturally large hole for the gnomon. By assuming the inscription had been transliterated correctly, a close approximation for the date of erection was possible.

The comments about the division of the day into tides are misleading since “tide” in old Anglo-Saxon merely means “time”. Bede writes of seasonal hours at this time. The horizontal line was never marked with short cross strokes, although that at Kirkdale does possess these. Dr. Ward informed the writer that he had never visited Bewcastle to view the cross, nor Kirkdale.

Another piece of misinformation is that the horizontal line marks sunrise and sunset, it can do this only between the autumnal and spring equinoxes, and only if the line of sight from the dial to the horizon is unimpeded. A vertical dial is very limited in indicating the hours in midsummer as the sun has to rise well into the sky before it illuminates the south face at all. For some time the rising sun merely illuminates the eastern side, similarly in the evening the sun illuminates the west side only. But who needs a sundial to inform him that the sun is rising or setting? All the sunlit hours are shown fully in winter.

The statement that the Bewcastle dial can only give a rough division of the day is a classic understatement. The dial at Bewcastle is quite useless in winter for giving any significant indication except for midday when it does not matter if the gnomon is horizontal from the face of the dial or polar, the noon indication is accurate. In an age when those who worked did so as long as daylight persisted, the division of the day into two would be sufficient to know when a break for a meal or rest was permissible or possible.

For further details of the discussions between Dr. Ward and myself on the aspects of Bewcastle Cross, consult references marked * in the following list.

The views on the sundial are personal to the author and he has no scientific basis or data to confirm his conclusions. There is very little evidence of the use of sundials in Britain after the Romans left until the Anglo-Saxon dials appeared. The Romans introduced the hemicyclium to Britain and there is at least one example preserved in a museum. They cannot have been impressed by the use of the sun for time indication since many of the Roman soldiers when writing home grumble about the cold and wet climate in comparison to the sun in Rome.

APPENDIX II

WEAVERTHORPE

The Anglo-Saxon sundial at St. Andrew’s Church, Weavertorpe, Yorkshire is a late example in classic form, cut long after the Norman invasion (see Fig 11). Perhaps its remoteness enabled this to be executed without opposition. When the Domesday Book was compiled it was recorded that the Manor of Weavertorpe was laid waste and the church had been left a ruin, probably by the Vikings. The present church was built between AD 1110 and 1120. Mrs. Gatty puts the date of this dial before AD 944 but her information is wrong. The duodecimal system could not have been adopted at that time, and this dial is not a case of the four-tide day period being further divided later. The dial inscription also demonstrates the Latin language rendered in an Anglo-Saxon style. The Weavertorpe sundial demonstrates that the basic Anglo-Saxon sundial underwent little real change in form from the beginning until its final demise.

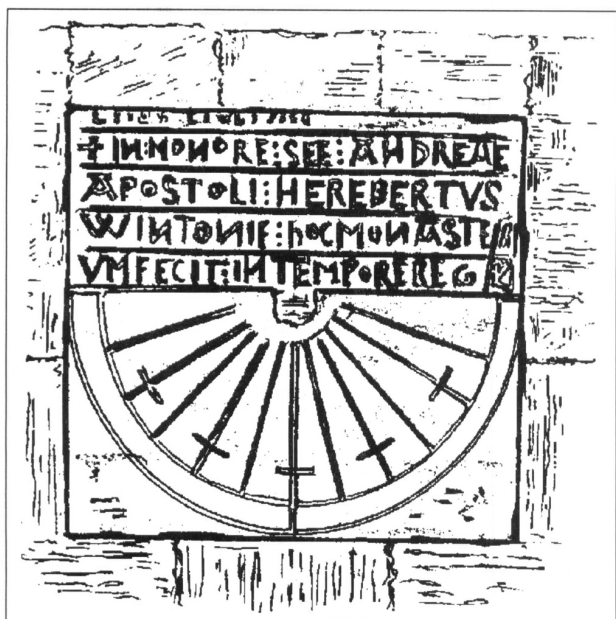


FIGURE 11: The late Anglo-Saxon dial in the porch at Weaverthorpe church in Yorkshire.

The Weaverthorpe sundial now lies within the protection of a porch and it may have been moved at some time because part of the inscription has been cut away, see Fig 11. The top part bears the lower half of the letters of two or possibly three words. Nearly all the delineators of these dials ran out of space, just like the young pupil who commences with a great flourish and has to cramp his words into a rapidly shrinking space. The porch was added in the year 1300, which accounts for the sundial and inscription being in such a fine state of preservation. This dial does not appear to have ever been modified.

Herbert's son, William Fitz-Herbert, probably moved from his Winchester home to the north to supervise the

building of his father's church. He was ordained priest, became Treasurer of York Minster and Archdeacon of the East Riding of Yorkshire. He was consecrated Archbishop of York in 1143 but his tenure of the Archiepiscopate was precarious and he spent much time in exile until his death in 1154. He was canonised in 1226 and became Saint William of York. During his tenure of the See of York, his family gave the church at Weaverthorpe to the monks at Nostell Priory, near Wakefield. In 1268 the church and living of Weaverthorpe was given to the Dean and Chapter of York Minster, and these officers are still the Patrons of the Weaverthorpe living.

The Weaverthorpe sundial, in similar fashion to that at St. Gregory's Minster, has had the good fortune to be protected by an entrance porch built in 1300. The church stands on an exposed hillside and no doubt the elements caused trouble to both those coming to pray and the building itself, hence the porch. So for the last seven hundred years, the sundial has been denied the opportunity of measuring time by the sun, at the same time it has been preserved in a good state.

The main interest in this dial is that it is a dated example of a Saxon sundial made in the time of the occupation of England by the Normans, but it has developed from the Anglo-Saxon octaval tide indication to the duodecimal indication of today, it is not a conversion of an Anglo-Saxon dial to duodecimal indication. It retains the Anglo-Saxon feature of short cross lines but these are now mere decorative features instead of marking important times of the day like sunrise and mid-morning.

At the time this dial was cut, there were no mechanical clocks in the world, therefore this dial has not been cut into twelve divisions to simulate clock time. The equiangular division of the "hour" lines also shows that the gnomon originally fitted was a horizontal type since the use of a polar gnomon also indicates the designer knows something of the principles of dialling. Such knowledge is not indicated here.

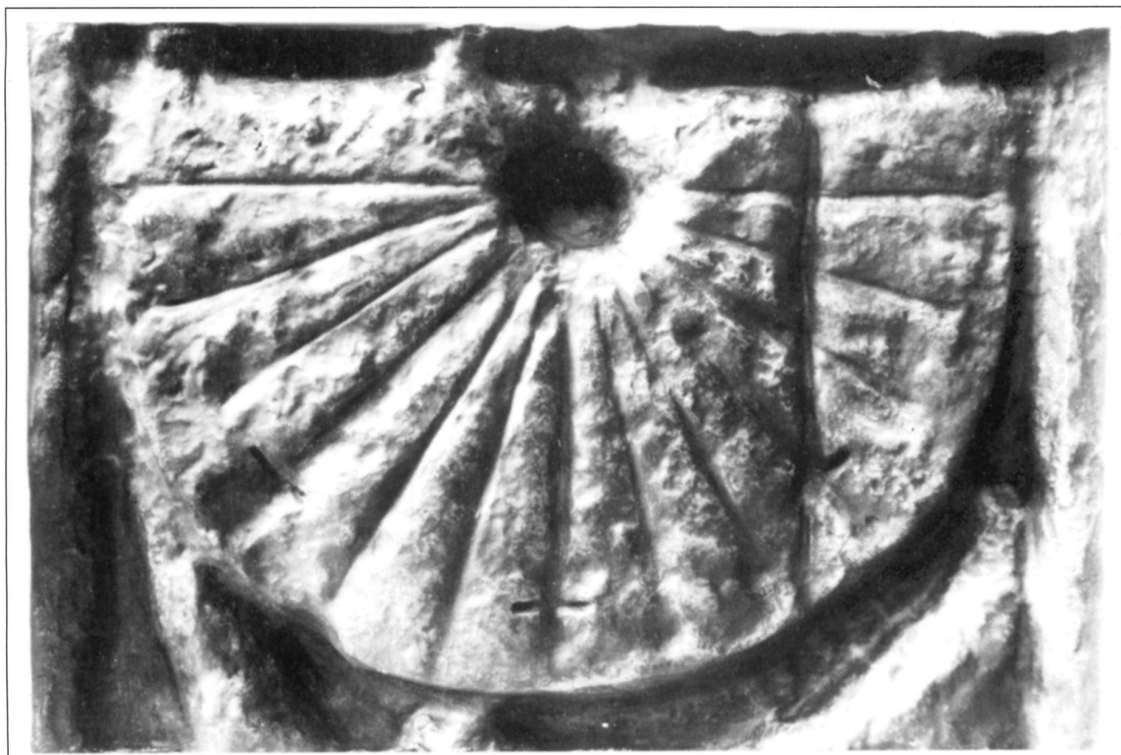


FIGURE 12: A second generation plaster cast of the Bewcastle Cross sundial at the Science Museum. The centre hole is completely wrong and the cross lines have been artificially "improved".

It seems, therefore, that the Normans introduced the twelve divisions of the day to England, and the oft quoted conjecture that sundials adopted this division to comply with mechanical clock indications is not correct. In fact the early clocks did not indicate the time on a dial but did so by strokes upon a bell, hence the name "clock" derived from the French word *cloche* which means "bell". Mechanical clocks adopted the sundial method of indication much later, hence the term dial for a clock face. However the first clocks using dials to indicate the time employed a fixed pointer to simulate the shadow line and the dial itself rotated. Today most clock dials are fixed and the pointers (or hands) turn over the dial like the original shadow of the gnomon.

APPENDIX III

DURHAM CATHEDRAL ST. CUTHBERT

To whom Bewcastle Parish church is dedicated, the greatest saint in the north country. He died in his cell on the island of Lindisfarne in AD 687 after serving only two years as Bishop. He was first buried on Lindisfarne but when the Viking raids commenced in the ninth century, the monks of Lindisfarne began a journey through the north of England searching for a place to settle. During their travels they transported the body of St. Cuthbert with them, for on his deathbed he had charged the monks to take his body with them if they should have to leave the sanctuary. After seven years of wandering, by AD 883 the monks reached Chester-le-Street and settled there, where a shrine to St. Cuthbert was built in the Saxon church. In AD 1093 the Saxon church was torn down by the Normans and a great cathedral was put in its place, the marvellous building that stands there to this day. St. Cuthbert's shrine was erected on a temporary basis in the Cloister Yard and remained there until it was translated to the new Cathedral, behind the High Altar, in AD 1104.

At the time of the transfer of St. Cuthbert's body in 1104, it was still in a good state of preservation. This, and the legend of the saint's great holiness, brought great numbers of pilgrims to visit his shrine. These visitors greatly helped in the income of the cathedral, and in turn many miracles took place at the shrine. At the Reformation, following King Henry VIII's break with Rome; the shrine was despoiled by orders of the King's Commissioners in 1540. The Saint's body, still in its original coffin of AD 687, was buried under the place where the shrine had stood.

In 1827 the tomb was opened and a series of coffins were revealed, containing a skeleton swathed in silk. The earliest of the coffins, together with St. Cuthbert's pectoral cross and several embroidered stoles were taken from the tomb and are now to be seen in the Cathedral Treasury. St. Cuthbert's bones were replaced in the tomb, the surrounding stones being part of the medieval shrine. The place of the shrine is now surrounded by a woodwork screen and is referred to as the feretory. In the corner of the feretory is a statue of St. Cuthbert holding the head of St. Oswald, the King of Northumbria, who had founded the See of Lindisfarne in AD 635 and was martyred in AD 642. His head was placed in the coffin with St. Cuthbert by the Lindisfarne monks, thus any representation of St. Cuthbert always includes the head of St. Oswald.

The tall candlesticks around the tomb were designed by Sir Ninian Comper in 1950, also the overhead tester which

is suspended from the same holes in the vault as was the gilded and painted cover of the medieval shrine. This tester represents Our Lord in Glory surrounded by symbols of four of the Evangelists.

On the north side of the cloisters is a modern wooden statue of St. Cuthbert, he is depicted seated in a pensive mood, with his hands clasped.

THE VENERABLE BEDE

To the west of the great body of the cathedral is the Galilee Chapel added by the Bishop of Durham, Hugh de Puiset (Pudsey) in 1153-1195. In this chapel is the modest black marble chest tomb of The Venerable Bede. Regarded as the greatest scholar in the early English Church, he spent his life in the monasteries of St. Peter, Monkwearmouth, and St. Paul, Jarrow. His most famous work is the *Ecclesiastical History of the English People*. Bede died at Jarrow on 25th May 735, his bones were brought to Durham Cathedral in AD 1022 and first buried with St. Cuthbert. In 1370 his bones were placed in a splendid shrine in the Galilee Chapel. The shrine was destroyed in the Reformation and his bones were buried in the same spot. In 1831 the tomb was opened and his bones placed in the present shrine which bears the words in Latin "In this tomb are the bones of the Venerable Bede". The second window in the north wall is dedicated to The Venerable Bede, it was erected in 1973, the work of Alan Younger to commemorate the thirteenth centenary of the birth of Bede in AD 673.

THE MERIDIAN LINE

A meridian line was installed in Durham Cathedral cloister in 1829 by Mr. Wm. Lloyd Wharton, of Dryburn, and Mr. Carr, then Headmaster of Durham School. It was described by the Reverend William Chevallier much later thus:

"In the upper part of one of the unglazed windows of the cloister, about ten feet from the floor, a piece of stone is inserted, in which is a circular aperture, about an inch in diameter, with a thin edge. When the sun is near noon, and thus almost directly opposite to this aperture, the light which streams through the aperture forms a luminous image which, when the sun is low, as near the winter solstice, falls upon the opposite wall. By observing the first contact of the circular spot of light with the meridian line, and also the time of the last contact, and taking the mean, I have found that the instant of apparent noon can be ascertained within a second of time".

The meridian line is almost derelict today because of the decay of the stone pavement and the wall up to a height of about three feet.

On 19th September 1991, the writer paid his third visit to photograph the meridian line. Arriving there in broad sunlight he was sanguine of achieving this modest aim, alas, as the morning wore on, the sky became overcast and gloomy. About a quarter of an hour before solar noon, he prepared the scene by removing a large wooden bench completely hiding the meridian line, but it seemed that it was all in vain because of the missing sun. At this point the writer thought of St. Cuthbert as he was known in medieval times as a worker of miracles, and requested that a minor miracle might be performed so that the sun might appear for the purposes of taking photographs. He had no real conviction that this request might be answered, nevertheless the clouds parted from a thick blanket of grey and the sun shone through. All the necessary pictures were

secured, with the sun immediately before, on, and after the meridian line. By this time a crowd of interested people had gathered, an impromptu lecture was given on the subject of meridian lines, during which the sun began to fade and the clouds closed in once more, leaving the scene in the previous gloom. The sun never shone again during his short stay in Durham. Although it may be a complete coincidence, the writer was quite convinced that St. Cuthbert had performed this miracle, if only to convince a sceptic.

Over the Dean's kitchen there was a sundial which was badly decayed as long ago as 1888. It bore the motto "Soles pereunt et imputantur" - Suns depart and are reckoned. This motto was derived from Martials Epigrams.

Neither of these dialling artifacts are mentioned in the guides to Durham Cathedral. Of course there are so many wonders to see that sundials are of little interest to most visitors unless they see someone taking photographs of what seem to be blank walls.

On the west side of the cloisters is the entrance to the monastic dormitory which is now a museum and library. Here may be found a plaster replica of the Cross at Bewcastle, invaluable as a record of its condition in the nineteenth century. There are also manuscript notes in a book held in the library in respect of this and other crosses in northern England.

REFERENCES

A walk round Durham Cathedral, C. J. Stranks.

A short guide to Durham Cathedral, John Wild, Dean Emeritus.

APPENDIX IV

Typical comments by archaeological writers on Bewcastle Cross sundial:

Extracts from Baldwin Brown, *The Arts in Early England*, Volume 5, 1921.

Page 146: The upper foliage panel on the south face contains a sundial very tastefully placed in relation to its surroundings. There is the hole for the gnomon and an incised horizontal line drawn through it marks the semicircle of the dial. The semicircle below is divided into four equal spaces by lines radiating from this centre each of which is distinguished by a short cross-piece near its end. Each of the four spaces again is divided into three by two plain incised lines. Comment on the dial is reserved.

Page 173: A Roman sundial from the station of Borcovicium on the Roman wall within a walk of Bewcastle is preserved in the Museum at Chesters on the North Tyne. In the Irish life of St. Moling, who lived in the VIIth century, we are told of a large stone which he preserved from the of a horologium, no doubt a dial.

From *The date of the Ruthwell and Bewcastle Crosses* by Albert S. Cook, 1912.

Page 301: The sundial on the South face of Bewcastle Cross is by common consent as old as the rest of the carving.

Collingwood, *Chambers's Encyclopaedia*, 1892.

This dial is a semicircle with hole for the gnomon now lost, and rays numbering twelve divisions between sunrise and sunset. It certainly is part of the original monument.

Collingwood did not believe that any sundials were sculpted in Cumberland before the Norman period, ie AD 1066.

Gatty, *The Book of Sundials*, 1900. Under "Notes" on



FIGURE 13: The engraving of Bewcastle Cross in Mrs. Gatty's book, 1900 edition. Note that the delineation of the decorative features is a mere travesty, compare these with those shown in Figures 4 and 5.

page 504. (See Fig 13.)

DIAL ON THE CROSS AT BEWCASTLE.

The Cumberland and Westmoreland Antiquarian and Archæological Society has recently published the late Reverend W. S. Calverley's "Notes on the Early Sculptured Stones and Monuments in the Diocese of Carlisle", and among his illustrations there is one of the Bewcastle dial. The photograph was taken from the top of a stepladder, and consequently gives a much larger and more distinct view of

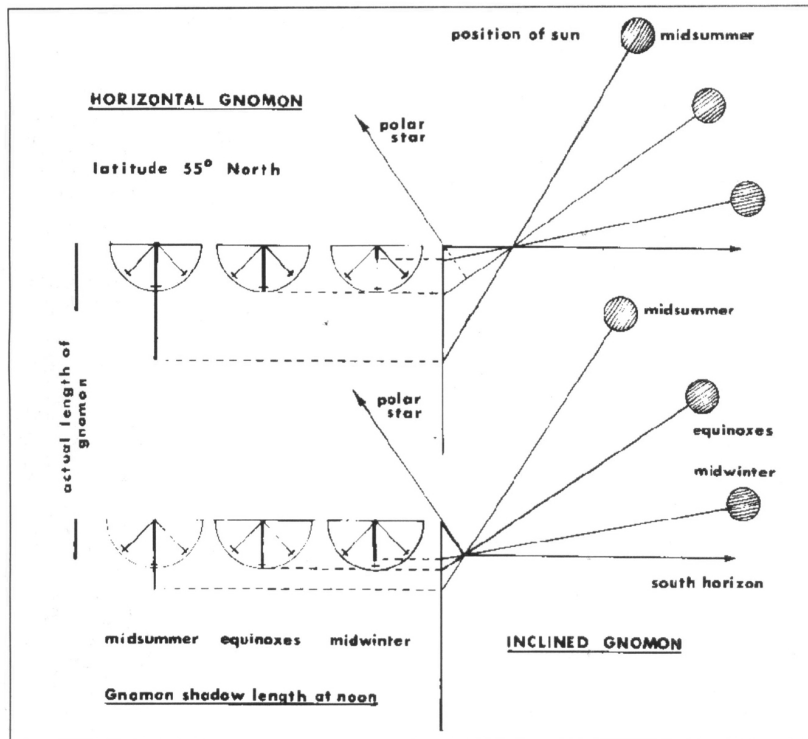


FIGURE 14: Seasonal variation of shadow length at noon for a vertical south-facing sundial situated at latitude 55° North. The noon shadow is the only accurate daily indication with an horizontal gnomon, dividing the daylight period into two equal parts. The Bewcastle Cross Sundial cannot indicate the entire day period from the Vernal Equinox until the Autumnal Equinox.

the dial than any previous view had done. The principal hour-lines appear very plainly, but those for 4 pm and 5 pm are almost effaced, and the cross marks on the 9 am and noonday lines, noticed by Dr. Haigh and Professor Stephens, are not discernible. The vertical line to the east is only faintly seen. Probably these changes are due to the effect of time and weather on the stone. The editor of the "Notes", Mr. W. G. Collingwood, writes that "the dial is part of the original design and construction of the monument; for there has been no patching or piecing of the stone. The dial is in high relief, and the substance of it has been left unremoved in the first carvings. The flow of lines and harmony of composition show that it was intended by the artist to fit in among the patterns of the cross".

There is a more detailed account of the Bewcastle Cross sundial to be found on page 49-51.

The 1872 edition of Mrs. Gatty's book does not contain any mention of the Bewcastle Cross sundial, it was then unknown to her. In all probability she was never able to see Bewcastle Cross for herself.

APPENDIX V

BEWCASTLE CROSS SUNDIAL

The ending of the author's article in *Antiquarian Horology* of December 1973 is repeated here in main outline since many British Sundial Society members may not have easy access to such early copies of this journal.

Figure 14 shows the seasonal variation in the gnomon shadow length throughout the year for a vertical sundial situated at latitude 55° North. All writers state that a

horizontal rod gnomon was employed, and there is no real reason to doubt this if the dial is as early as is supposed. The importation of this type of dial from Mediterranean areas, where it could cope with the indication of temporary hours throughout the year, to such a northern latitude, indicates a lack of knowledge of dialling principles. Nevertheless from some time before the Spring Equinox, until some time after the Autumnal Equinox; the use of a horizontal rod gnomon will divide the daylight period into a reasonably satisfactory indication of temporary hours. The sundial on the South wall of the Tower of the Winds is one of the earliest examples of this type of dial but the present horizontal rod gnomon has a ball tip.

In the middle of winter, however, the shadow of a horizontal rod becomes very short. For a period of about six weeks whilst the Sun was approaching and receding from the Tropic of Capricorn, the Bewcastle Cross sundial would have been almost useless. If the sun was at all hazy, the indications would have been quite useless, for in midwinter it would be extremely difficult to see any shadow clearly at such a height from the observer, let alone distinguish its orientation. One must suppose that the viewers in those far-off days suffered from the same problems with eyesight as we ourselves do today.

The daylight hours in our system at Bewcastle in midwinter are very roughly from daybreak around 08.30 and nightfall at 15.30, rather less than 7 hours. In contrast the daylight period in midsummer is from about 04.00 to 20.00, about 16 hours, making the ratio of temporary hours summer/winter more than 2:1. Such a system is manifestly useless to divide the daylight meaningfully, and the later

lines would not improve the utility of the sundial.

Some writers have suggested that this further subdivision was done to bring the sundial into line with the indications of a mechanical clock and the twenty-four division of the complete day. This would be meaningless unless a polar gnomon was employed. No public mechanical clock has ever been erected near Bewcastle Cross, and our division of time would have meant nothing to the local inhabitants until the fourteenth or fifteenth centuries (but see the comments on the Weaverthorpe sundial. Much still remains to be researched.

* * * * *

FURTHER READING

Many of the sources are mentioned in the text and are not repeated in the listing here. The following is a brief collation only. Most of the information on Bewcastle Cross is necessarily to be found in archaeological journals and papers.

Liber St Isidori. (Book of Saint Isidore [Circa 530-636], Archbishop of Seville in 594). Anonymous author. A drawing of a sundial appears in this Irish manuscript kept in the library at Basle, Switzerland, and it bears an inscription 'Orologium Viatorum' - Traveller's Clock. The remains of the same inscription may be found on the dial at Great Edstone, near Kirkby Moorside. Date of manuscript not found.

Historia Ecclesiastica Gentis Anglorum. Baedae - The Venerable Bede c. 672-735. (A History of the English Church and People). Bede makes references to timekeeping and methods in his writings, for example in *De Temporum Ratione*, Cap V; and *de Temporibus* Cap II, *Dies vulgaris est solis praesentia super terram, qui proprie XXIV horis adimpletur*. (Time Reckoning, and of Time - Common Days, wherefore in the strict sense 24 hours ...). A standard edition of Bede's work is that edited by C W Jones, *Baedae: Opera de Temporibus*. Publications of the Medieval Academy of America. Cambridge, Massachusetts.

"Ancient Sundials, especially certain Irish examples of ecclesiastical use". Du Noyer. *Archaeological Journal*, Volume 25, pages 207-223. London, 1868.

"Yorkshire Dials", Reverend Daniel Henry Haigh. *The Yorkshire Archaeological and Topographical Journal*. Volume 5, Parts XVIII and XVIII, pages 134-222, plus diagrams. This was long regarded as the definitive treatment on the sundials of Yorkshire, it must now be regarded as being permeated with conjecture. York, 1879.

The Conversion of the Heptarchy. Bishop G.F. Browne. London, 1896. In this work the style of the ornamental sculpture decorating the pillar of the Bewcastle Cross is discussed, Browne considered this to be the work of a Byzantine craftsman. This is not at all certain, these designs also have traces of Celtic influence and the English Church was long dominated by the Celts. Both the Reverend Browne and his collaborator, the Reverend D. H. Haigh, were not averse to the use of imagination.

The Book of Sun-Dials. Originally compiled by Mrs. Alfred Gatty. Enlarged and re-edited by H.K.F. Eden and Eleanor Lloyd, pp 49-51. Fourth Edition 1900.

"Dialling", *Encyclopaedia Britannica*. All the old editions carry sections on dialling, ie from 1768 onwards. The oldest editions treat the subject more thoroughly, "The Art of Dialling", in the 1768 edition being 22 pages in length. In the 11th Edition dialling is treated on pages 149-155 of Volume VIII, the author being Hugh Godfray, Fellow of St John's College, Cambridge the treatment of which is complete but fairly simple. New York, 1911

Primitive Sun Dials or Scratch Dials, Dom Ethelbert Horne. Taunton, 1917.

The Arts in Early England. Gerald Baldwin Brown. Vol 5. 1921.

Sundials. T. Geoffrey W. Henslow. London, 1935.

Scratch-dials and Medieval Church Sundials. T. W. Cole. Saxmundham, 1938.

Sundials. R. Newton Mayall and Margaret L. Mayall. Boston 1938.

"The Bewcastle Cross". R.I. Page. *Nottingham Medieval Studies*. Vol IV, pp 36-57, 1960.

"Bewcastle Cross". Charles K. Aked. *Antiquarian Horology*, Vol 8, No 5, pp 497-505, December 1973. Two of the dial illustrations were printed upside down in this article.

* "Bewcastle Cross". Letter from Dr. John B. Penfold about the sundial and missing cross, also letter from Dr. F.A.B. Ward in criticism of the article in the previous issue. *Antiquarian Horology*, Vol 8, No 6, p 648, March 1974. In this several incorrect statements are made.

* "Bewcastle Cross". Three letters under this heading from Myron Pleasure, G.D.M. Wharton, Charles K. Aked and Dr. F.A.B. Ward respectively, *Antiquarian Horology*, Vol 8, No 7, pp 776-779, June 1974. Dr. Ward agreed that the professed differences had been narrowed down "almost to vanishing point".

"The Sundial of Bewcastle Cross". Charles K. Aked. *Clocks*, Vol 9, No 2, pp 21-25, August 1986.

"Whilst time stood still ... centuries passed". Charles K. Aked. *Clocks*, Vol 10, No 6, pp 37-41, December 1987. This deals with the sundial at Kirkdale and its history.

"Destruction by Decay". Charles K. Aked. *British Sundial Society Bulletin* 93.3, pp 32-4. Brief outline of the accelerated decay of Bewcastle Cross sundial since 1972.

"Anglo-Saxon Sun-Dials and the 'Tidal' or 'Octaval' System of Time Measurement". A.J. Turner. *Antiquarian Horology*, XV, no 1, 76-7, September 1984. An interesting discussion on the time systems in use in Anglo-Saxon England. A very scholastic essay into the subject but using negative proofs.

ACKNOWLEDGEMENTS

The photographs of Bewcastle sundial shown in Figs 5 and 6 were supplied by Mr. Robert Sylvester, to whom I am greatly indebted.

Most of the text on Bewcastle Cross has been written after a study of the books and references listed here. The author himself has no first hand experience of the study of ancient monuments apart from looking at them.

BEWCASTLE CROSS

The weathers of a thousand years
Have not confused this shape,
Nor biting frost nor Nature's tears,
Nor hailstones on its mossy drape.
Time has gently softened traces,
Enhanced shape and subtle line,
On these four columnar faces,
As much by chance as by design.

Divine in thought, idealised,
Tall token of creative art,
Inspiration crystallized
In hard stone pleasing to the heart.
What force moved the carving hand;
To shape this treasure standing here,
A column planted in the land,
Carved monument of yesteryear.

Half a million days ago,
Freed from a rocky bed,
New and slender, plainly so,
No ornament or line, instead,
Product of an ancient clime,
With latent charm within,
Waiting from the start of time,
For existence to begin.

Whose was the thought inspired?
In whose mind was this conceived?
What event or deed conspired?
What message was received?
What hours spent in contemplation
On these features here today?
What inspired such application?
No one on earth can really say.

Once this pillar standing here,
Held high a mighty cross,
A symbol of a faith so dear -
Of mankind's greatest loss;
Now vanished from the sight of man
Cloaked from mortals it is true,
Part of creation's master plan
To hide the past from human view.

Seek you the dial? It plays no part,
With gnomon gone no shadows play
On time-worn lines which lack the heart,
To indicate the passing day.
Yet countless days are written here
In details softened by decay,
The inscribed runes on longer clear,
With meaning lost along the way.

Through puzzling in the distant view,
These runes no clearer stand,
More enigmatic it is true,
When standing close at hand,
Could we but cast a magic spell
To recall these signs below,
Writ so deeply just to tell,
Of words of praise from long ago.

What mysteries, what tales to tell,
Could this cross be tongue allowed,
Conjectures you could swiftly quell
By the truth which made you proud
To hold your head above all men,
Proclaim the hero and event,
To all who came within your ken,
To gaze upon your testament.

The fathers of the English race,
Caused this blade of stone to rise,
Where it has stood in awesome grace,
A runic message for the wise.
Against all elemental furies,
These ancient shapes beguile;
Unsullied through the centuries,
Except for head and epistyle.

Like Oswald, king, whose saintly head,
At his death, from body taken,
The cross which once stood overhead,
Was removed by deed mistaken;
Safe in Cuthbert's holy shrine;
Oswald's head has been conserved,
The body of this shaft is fine,
Its head is lost and unpreserved.

By Saint Cuthbert's little church,
Sheltered from chill northern blast,
On rocky base which serves as perch,
This pillar from an age long past,
Icon of deeds, for fearless men,
Who civilised these ancient lands,
Though time-worn, and slightly broken,
Proud and erect still stands.

This Christian symbol standing here,
Witness of so many passing years,
Enigmatic yet with message clear,
Once cleansed by Nature's gentle tears,
Assailed now by the present tainted air,
Will no one help preserve the dial's face?
All these runes and carvings fair?
Or must it perish in decayed disgrace?

LA TORRE DEI VENTI IN VATICANO

GIOVANNI PALTRINIERI (ITALY)

INTRODUCTION

Among the great numbers of astronomers of the past who have occupied themselves in measurements using gnomons, a position of honour is surely due to Egnazio Danti.

He was born in Perugia in 1536 into the family Rainaldi, which later changed its surname to Danti because of the intense literary activities of his grandfather and father, the son also changed his name from Pellegrino to Egnazio on entering the religious Order of San Domenico (Dominicans).

Because of the outstanding qualities of his mathematical and philosophical abilities (favoured by the powerful and exceptional Florentine culture of that period), he came to the notice of the Grand Duke Cosimo I de Medici, who invited him to court as his cosmographer, and charged him with the preparation of maps as well as a great terrestrial globe.

But the aspirations of the Duke were growing and his religious protégé soon showed himself to be particularly adapted to carrying out the ideas of his patron, who intended to raise the city of Florence to the peak of European culture, and who promoted any prestigious initiative.

Among these, the most desirable was certainly the creation of a new Calendar to replace the imperfect Julian calendar then in use, and with this being achieved, would always be associated with his name. This would-be “new Caesar” - the Grand Duke, charged Danti with the extension of his studies and agreed to finance the construction of a series of solar instruments on the facade of the church of Santa Maria Novella of Florence, and a horizontal meridian line inside the church; these constructions would enable the determination of the solstices, equinoxes, also the duration of the year (1).

The death of Cosimo I in 1574 unfortunately brought the research to an abrupt end and although Danti had the means to finish the solar instruments fitted on the facade of Santa Maria Novella, he could only execute the gnomon aperture for the meridian line. Because of the scientific jealousy he aroused in Florence, he was obliged to depart at twenty-four hours notice to Bologna, being persuaded to go by the Grand Duchy. Here he took lodgings in the Casa Madre of the Dominican Order, and constructed not only a meridian line but also anemoscopes (indicators of the direction of the prevailing wind).

THE ANEMOSCOPE

The anemoscope was a mechanism invented by Danti himself, which consisted of a pointer arranged on a wall or ceiling, moved by a shaft connected to a wind vane on the roof. By this means it was possible to indicate the direction of the wind and in consequence predict the weather. Both the meridian and the anemoscope have the common need for cardinal points, and therefore one instrument can be superposed on the other without any undue confusion, later we will see that Danti made use of this in the Vatican.

Very little remains today of the work executed by Danti in Bologna. The meridian he traced on the floor of the Basilica of San Petronio disappeared with the installation of later ones (the present is that of Cassini 1655) (2).

There is part of a meridian traced on a wall in the Convent of the Dominican Order which the author of this article has discovered under the plaster. A trace of a quadrant survives on the external wall of the Convent Library.

Meanwhile the scientific fame of Egnazio Danti was extending far beyond the limited confines of Bologna, so it was natural that his fame should reach as far as Rome. Everyone knew of his researches, conducted first at Florence, and then at Bologna; and of the instruments that he had constructed there. The time was now ripe for a revision of the Calendar and this was subjected to a close examination according to a master plan containing the aims which the protagonists of this exceptional event wished to achieve.

At this time the Bolognese Gregory XIII (Ugo Boncompagni) was installed as Pope in the Basilica of St. Peter. Originally his family name was Dragoni: a dragon is therefore incorporated in the Coat of Arms of the family, and this appears on many works achieved under his pontificate.

TORRE DEI VENTI

This period was a golden age for the Arts, with new constructions everywhere and modifications to existing works, whilst the Vatican was an immense building site, see Fig 1. The open gallery of the third floor was constructed, which goes from the apartments of Pope Pius V up to the Belvedere, above the centre of which the “Torre dei Venti” (Tower of the Winds) was built.

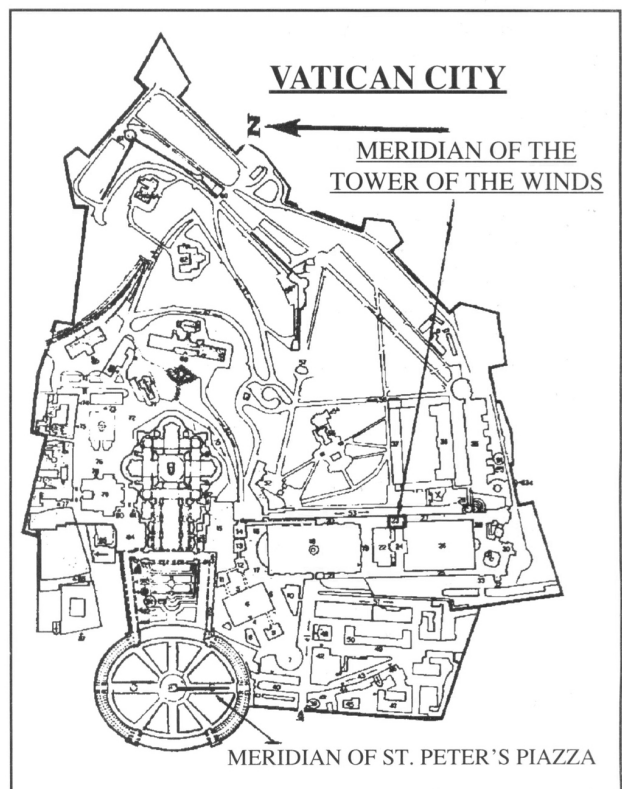


FIGURE 1: Plan of Vatican City showing the Tower of the Winds.

By 1580 the gallery had just been completed, the walls were decorated with geographical maps depicting the numerous regions of Italy, the design of which was due to Egnazio Danti, who had been recently nominated as Cosmografo Pontificio (Geographer to the Pope).

At the centre of this new construction, sponsored by Gregory XIII, the Bolognese architect Ottaviano Mascherino created the “Torre dei Venti”, 73 metres in height with shuttered terraces covered in such a way as to allow meteorological observations, it is assumed that the present arrangements are attributable to Danti, who created the Hall of the Meridian within which is included a wonderful allegory of the wind.

The paintings, begun in 1580, were completed in the following year. These include the decoration by Nicolo Circignani (called Pomarancio), the landscapes to the Flemish painter Matteo Bril; whilst the medallions which represent the four seasons, are from the hand of Matteino da Siena.

The tower, aptly named, is erected two floors above the surrounding buildings, and is easily visible from the Courtyard of the Pigna, the Belvedere, and from the Library. It is possible to obtain a good view similarly by climbing the Dome of Saint Peter, whilst outside the Vatican walls the tower can be seen in the distance.

We now pass on to details of this singular work which unites Science and Art which from 1579 was the Vatican Observatory and for three more centuries was maintained as an important centre of astronomical and meteorological research.

If one wishes to visit the “Torre dei Venti”, one must pass through the secret Vatican Archives where one has to pay a small entry fee and enters into the “Sala della Meridiana” situated on the first floor, passing through a door of limited height which obliges the visitor to bow his head. It is probable that this was deliberately arranged by

intelligent design, for a person on entering the hall automatically stands upright after passing through the doorway and spontaneously raises his eyes, to be enchanted by the spectacle presented to his gaze.

The ceiling has a blue background, at the centre of which is positioned a large metal pointer. Along the circumferential ring over which the pointer passes are the Italian names of the eight winds: Tramontana - North, Greco - North-East, Levante - East, Scirocco - South-East, Ostro - South, Libeccio - South-West, Ponente - West, Maestro - North-West.

From this circumferential ring project twelve rays which are identified with the Greek and Latin names of a number of the winds: Septentrio - N, Aquilo - NNE, Hellespontius - ENE, Subsolanus - E, Vulturnus - ESE, Euroauster - SSE, Auster - S, Austeraficus - SSW, Africus - WSW, Favonius - WNW, Circius - NNW. In a second and larger annulus are written the eight principal winds according to nomenclature of Girolamo Cardano, Septentrio - N, Borrhapeliotes- NE, Subsolanus - E, Notapeliotes - SE, Notus - S, Notalybicus - SW, Zephyrus - W. and Borrolybicus - NW.

The metal indicator, mentioned previously, is the terminal part of the anemoscope which Danti installed on the tower. He incorporated some improvements into his invention, in this installation the idea was notably extended.

The instrument in principle is very simple, a freely rotating spindle passes through the hole in the roof, on the upper extremity of which is mounted the wind vane, the lower end carries the pointer and indicates the direction of the wind. Obviously the shaft must be supported by a series of bearings to maintain it in the vertical position and allow it to turn with the minimum amount of friction. However in the Sala Meridiana, the space below the vault is not available and in consequence the axis of the pointer is displaced in respect to that of the wind vane. The shaft of the wind vane is connected to the shaft carrying the pointer by a horizontal shaft which transmits the motion via bevel gears, see Fig 3.

In the Vatican archives is preserved a precious manuscript of Danti's with the title of “In Anemographia F. Egnatii Dantis O.S.D.”, see Fig 2. The subtitle continues: “In Anemoscopium Vaticanum Horizontale Ac Verticale Instrumentum Ostensorem Ventorum - ad Sanctiss. Ac Beatiss. Patrem D.N. Gregorium XIII POM”.

The manuscript consists of two parts. In the first part the author describes the number, names, and order of the winds from the Greek and Latin, the order and divisions used in hydrography, the properties of each wind, and the season in which it appears.

In the second part is a minute description of the anemoscope (there is also a sketch of it, see Fig 3) which precedes an introduction of a scientific and philosophical nature. The tone of the discourse is more or less as follows: “In the beginning, the Creator made the wind to moderate the air, the water and the earth, and from this the seasonal variations of temperature. Moreover the winds were created to purify the air, to drive away the pestilence and other ills originating from the malignant vapours of the earth”.

As he states expressively in his book Anemographia in 1578, written on the invention of the anemoscope, he had “taken observations from the marble tower which Andronicus Cirreste erected in Athens”. Each wind commonly known to the ancient mariners is linked to a precise atmospheric manifestation, and from the direction

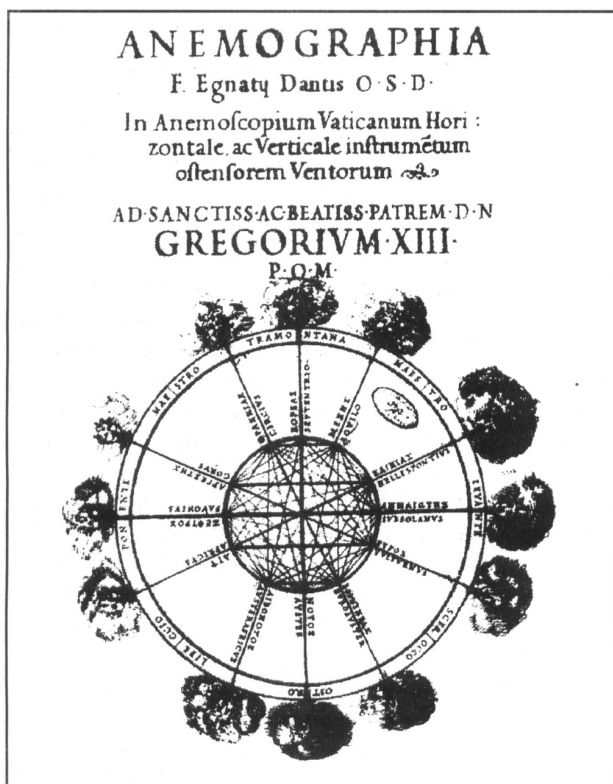


FIGURE 2: Frontispiece of Egnazio Danti's manuscript - Anemographia.

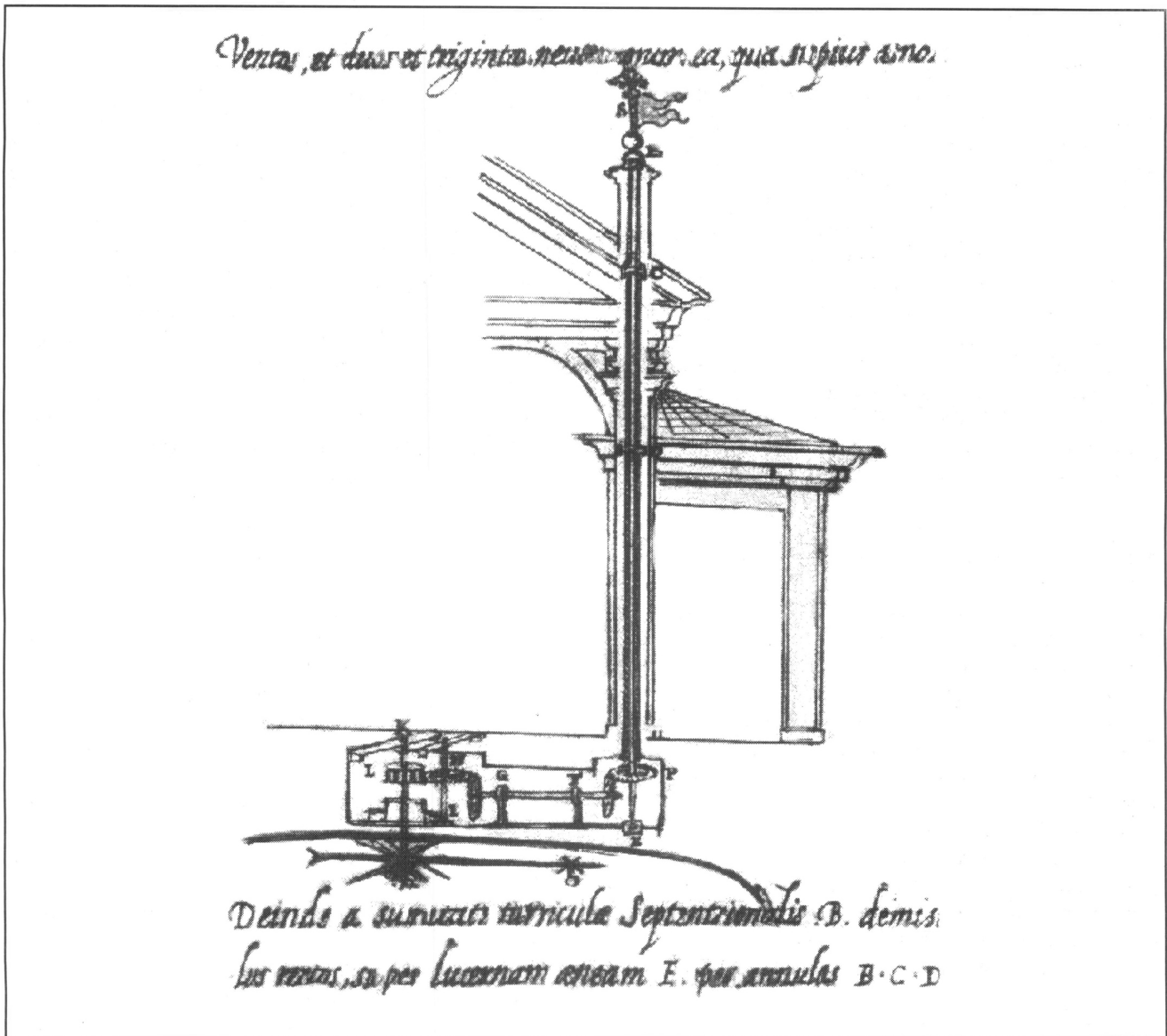


FIGURE 3: Design of the mechanism of the Anemoscope installed in the Tower of the Winds, Vatican City.

of wind shown by the wind vane it was possible to forecast what the approaching weather would be. Today, at the Vatican, the only remaining part is the immobile pointer below a sky of blue: the external weathervane disappeared in the middle of 1700 to make way for more modern meteorological instruments.

The concavity of the ceiling beyond the outer circle of inscriptions is entirely occupied by a fresco containing numerous figures which range from babies to decrepit old men, all are occupied in the act of blowing with the mouth towards the centre point. One figure has the wings of a dragon which recalls the family name of Pope Gregory XIII. These figures illustrate the character of the winds, bringing into prominence the double action of these, beneficial or destructive. The wind, if of modest nature, can be of very great use to man, but can be very harmful when it becomes an uncontrollable force.

The fresco consequently has other designs than the purely artistic, inasmuch as the theme is developed according to a precise logic: Danti compares the winds with historical events which in some measure disturbed the stability of Saint Peter's boat; this is given a broad treatment in the paintings on the walls.

From the ceiling, passing to the floor, it is seen that this

is executed as an analogue of the ceiling. Vertically under the anemoscope is a circle of white marble 1330 mm in diameter. On its circumference the winds described previously are indicated. Each wind is connected with each of the others by a series of engraved straight lines which are basically traced to coincide with their Cardinal Points. The north wind and the south wind are in fact on a line coinciding with the meridian line traced upon the floor, which passes exactly through the centre of the marble disc. On the surrounding pavement in terracotta is engraved the same nomenclature of the winds shown above on the ceiling.

The Meridian Hall is not perfectly orientated: looking from the north the east and west walls deviate about two degrees towards the west. the north and south walls are approximately 770 cm in length, that of the east and west walls, also the floor on which the meridian is traced, is 842.5 cm.

The decorations of the walls not only underline the direction of the Cardinal Points and the allegories of the winds but have a theological theme which is intelligently expressed. At the centre under the dome, on each wall are found representations of the four seasons. The representation of summer is obviously on the south wall,

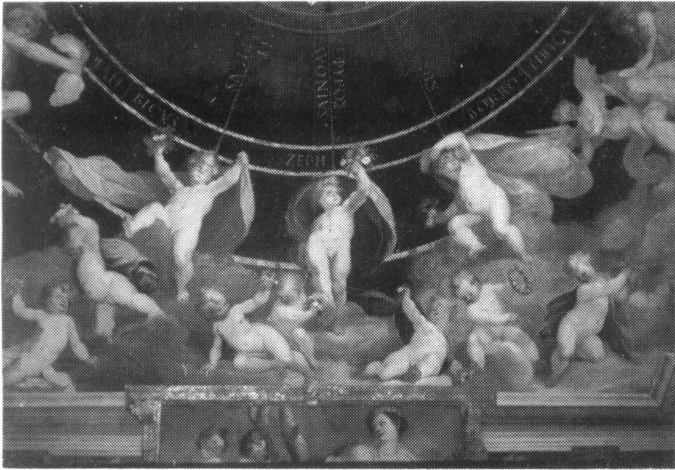


FIGURE 4: Part of the fresco showing the allegory of the Winds.

that of winter, on the north wall. Figure 4 shows part of the depiction of Spring.

The four walls convey significant messages which are to be read in the light of the counter-reformation: an obligatory treatment in the historical period to which these pictorial works are ascribed.

On the north wall the north wind is depicted in representation of the protestants of the earth. The wind strikes some cliffs which releases other winds intended to scourge the ship of Rome: but this crosses the tempest safely thanks to the Presence of the Saviour.

When in 1655 the meridian hall extended hospitality to Queen Cristina of Sweden for a certain time, she had only recently been converted to Catholicism. The authorities had the delicacy to remove the inscription “Ab Aquilone omne malum” which gave a clear allusion to Nordic origins. [Roughly meaning - ‘from the north wind comes all bad things’].

Paintings on the west wall show the shipwreck of Saint Paul to demonstrate that misfortune for the church of Rome can come in other directions apart from the north. But the most spectacular of all the walls is that of the south, on which is depicted the well-known extract from the “Tempesta Sedata”, (Calming the Storm) see Fig 5, where Christ is on the ship with the Apostles in a stormy sea; his ordering of the wind to cease saves the occupants of this fragile vessel from certain death by drowning. The significance of the presence of the Saviour, who will always sustain the Church of Rome is thus easily inferred, and the spiritual effect is secured by this pictorial depiction of the event.

THE MERIDIAN

The gnomon aperture is positioned at the summit of the painting and coincides with the mouth of Austro, the south wind from which the scene is derived. This hole has a diameter of 14mm at a height of 5190 mm from floor level, and is set back in respect of the plane of the fresco by 20 mm.

Figure 6 gives the details of this singular Vatican meridian, drawn from the measurements taken by the author of this article. Under the vertical point from the



FIGURE 5: “Christ calming the tempest”, fresco on the north wall of the Meridian Hall.

gnomon aperture, near the south wall, is the start of the meridian line, a simple marble strip crossing the entire room and dividing it exactly into two, with engraved longitudinal markings. The surrounding pavement has been described previously. With this instrument it is still possible today to capture the instant of midday by simply observing the moment at which the luminous projection of the sun straddles the meridian line. This instant is not absolutely correct because the meridian line deviates towards the east by $1^{\circ} 10'$, leading to a slight error in the noon observation.

On the strip of marble are engraved the positions of the sun’s image as it enters in turn the signs of the Zodiac. The enlarged sign of Cancer is engraved within an ellipse which has a bar across its centre, in Gemini-Leo there is a simple transverse notch.

The signs Virgo-Taurus, Libra-Aries, Scorpio-Pisces, are surrounded by ellipses without transverse marks. The signs Sagittarius-Aquarius, and Capricorn are lacking because of the limited length of the floor in relation to the gnomon height. These may exist on the north wall under a thin layer of paint (as has been found with Danti’s meridian at Bologna by the author). This conjecture could be easily verified without affecting the area of the actual frescoes.

The actual Zodiacal signs engraved on the marble line are, however, somewhat imprecise. The Torre dei Venti is at latitude $41^{\circ} 54.1'$: the obliquity of the ecliptic in 1580 was $23^{\circ} 29.6'$, and the gnomon aperture 5190 mm above the meridian line. Using these figures in calculations results in finding significant differences in the actual positions of the Zodiacal signs. The greatest is found in Virgo-Taurus, with 108mm error. The dimensions of the ellipses also are very approximate and do not increase with increase of Zenith angle; the image of the summer solstice sun, for example, is larger than that of Virgo-Taurus.

It could be argued that the indications engraved on the meridian line are not those of Danti, but from some other later astronomer. However it is certain that Danti was able to demonstrate to the Pope the practical necessity to add ten days to the calendar indication resulting from the accumulated errors of the Julian calendar, and evident from the deviation between the calculated equinox and the true

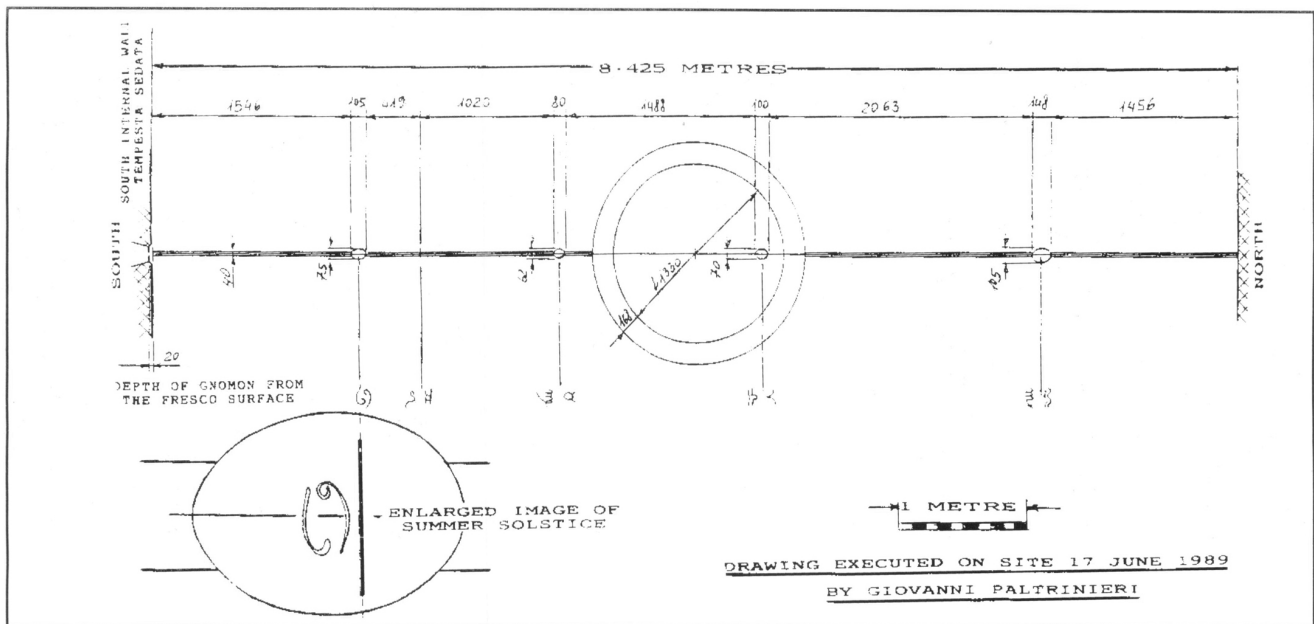


FIGURE 6: The Meridian of Egnazio Danti in the Tower of the Wind, Vatican City. This is drawn from measurements taken by the author 17th June 1989.

equinox indicated by the meridian line. [This caused an error in calculating Easter day, the main ecclesiastical reason for correcting the calendar, the ordinary person was not aware of any such need].

The necessity of the correction required to the Julian calendar was thus first demonstrated by the erection of the "Torre dei Venti", which coincided with the brief magic period of the scientific and cultural renaissance in which Danti found himself happily immersed. From this time the "Torre dei Venti" had a major dedication, and in it was held the sittings of the Commission assembled to examine the proposal to reform the Calendar, which in 1582 was officially promulgated as the "Gregorian Calendar" and adopted throughout the Catholic world, and later by most of the civilised world.

The astronomical use of the building continued long after the exceptional achievements of Egnazio Danti. In 1797, on the floor of the second storey of the "Torre dei Venti", Mons Filippo Gili traced a second meridian, a modern and indispensable instrument which was put to use as soon as it was installed in place. This second meridian is still in existence: with a gnomon height of 3877 mm it is not, however, exceptional, although it is aesthetically pleasing and interesting. The tower was then furnished with an astronomical dome when Pope Leo XIII created a Vatican Observatory in 1891, it remained there until 1906, when it was transferred to the large tower in the Vatican Gardens. In 1932, the increasing stray light in the Roman sky, caused the observatory to be moved to Castel Gandolfo, where it is situated still, thus bringing to an end an observatory in the shadow of St. Peter's Dome.

THE OBELISK IN ST. PETER'S SQUARE

At the centre of Saint Peter's Square in Vatican City stands one of the most famous obelisks in the world. It is 25 metres in height and does not have the customary hieroglyphics normally decorating the four faces, in the Middle Ages it was believed that the ashes of Julius Caesar were contained in the urn at the top of the column.

Originating from Eliopoli (Heliopolis), Caligula had it brought to Rome in AD 37 and placed in the Vatican Circus. It was moved from here, in 1586, on the orders of Pope Sixto V, by Domenico Fontana, with the assistance of Egnazio Danti who devised the means for the erection of the column. For this, 800 men, 60 horses, and 40 capstans were employed, with an intelligent state employee to coordinate the various operations. The presence of Danti at the erection of the obelisk was associated with the proposal to use the monolith as a gigantic gnomon to furnish an indication of time in the ample area of the square. The unexpected death of Danti, the expert initiator of such schemes, and other obstacles, brought this proposal to an end.

It was not until 1817 that the Vatican astronomer Mos. Filippo Luigi Gili (the creator of the second meridian line in the "Torre dei Venti") succeeded in tracing the meridian line which still exists. It is a simple track which starts from the projection of the Summer Solstice, ending in that of the Winter Solstice; a series of circular marble slabs indicate the entering of the sun into the various signs of the Zodiac.

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ANEMOSCOPE AND MERIDIAN IN THE TOWER OF THE WINDS

COLIN MCVEAN

EDITOR'S NOTE: The following extract is a translation from the Italian text of an article by Juan Casanovas S.J in the The Vatican Observatory. It was translated by John Cowtan. Lt. Colonel McVean has very kindly placed the material and the photographs (which he obtained direct from the Vatican) at the disposal of the Editor. By good fortune it arrived at the same time as the article by Giovanni Paltrinieri on the Meridian in the Tower of the Winds in Vatican City, and is included here to give some supplementary information.

THE TORRE DEI VENTI

The Tower of the Winds will always be linked with the personality of Egnazio Danti. This eminent Dominican Priest had the remarkable quality of being able to combine a rare artistic taste with a profound understanding of astronomy, cosmography and of engineering. In Florence, where he was Professor of Mathematics and Cosmography at the Court of the Grand Duke Cosimi de' Medici, he had already gained fame for his publications on astronomy, and for his celebrated maps which could be seen and admired in the Palazzo Vecchio, and which were depicted under his guidance. Later on, when he had moved to Bologna, he constructed the first of his famous meridians in the Basilica of San Petronio. Called to Rome in 1580 as Papal Cosmographer and member of the Commission for reforming the Calendar, he was able to develop, with renewed dedication, the scientific and artistic activities that had already made him famous. Circumstances were then particularly favourable because the imminent reform of the Calendar encouraged astronomers and others of the best minds in Europe to take a lively interest in the problem.

On his arrival in Rome, Danti was immediately charged with furnishing the designs and superintending the decoration of the gallery reserved for maps, and following that to commission and decorate the tower recently built by Mascherino, destined to become the famous Torre dei Venti. Danti found that his apparatus called a "anemoscopio" (windscope) became a very rich fount of artistic inspiration. With it he was able to build on his already great successes in explaining his ideas about natural sciences. The original windscope had been invented and constructed at the Villa della Rose in Florence. Two others were to follow in Bologna, one of these was built for Cardinal Paleotti. The description of these instruments is contained in the book written in Latin called *Anemonographia* that Danti published in 1578 at Bologna, and also in Italian in the same year.

He (Danti) explained in detail that "he had taken as an example the marble tower that Andronicus Cirreste had built in Athens, as the basis of the design he offered. (See BSS Bulletin 92.3, pp 9-16, for an account of this).

The construction of Danti's instrument is extremely simple: if there is sufficient free space above the top of the building, all that one has to do is to fit a vertical pole with a vane attached as high as possible in the open air, connected to an internal arrow indicating the name of the prevailing wind 1.

In the Torre dei Venti, however, because the vane could not be installed at the centre of the tower, it became necessary to provide a system of wheels and a shaft on a

horizontal axis to operate the remote indicating pointer.

After the departure of Danti from Rome, the tower was turned to other uses and if not entirely abandoned, the wind indicator ceased to function. It remained only as a piece of decoration, up to the end of the sixteenth century when more modern instruments were installed.

The room which housed the wind indicator was splendidly decorated with frescoes. The pictorial motifs were studied in the greatest detail and chosen to illustrate the characteristics of the winds and the seasons of the year, serving thus as a background to the apparatus. It has also been suggested that the famous meridian traced on the floor of this room had been conceived as an integral part linked to the wind indicator. The meridian, which was nothing more than a straight line traced on the floor in the direction North-South, became the principal guide to which one referred the readings on the wind compass-card. But above all it served to illustrate the varying height of the sun at midday depending on the season of the year, thus relating a variety of meteorological happenings to prevailing winds. The birth of this supposition became corroborated by the fact that the themes of the pictures around the room were not purely astronomical, and furthermore the meridian traced on the floor was engraved with a large "rose" including the names of all the principal winds. The Torre dei Venti, as its name implies, may then be considered as one of the first buildings ever designed to carry out meteorological observations.

Tradition has it that the Torre dei Venti was a genuine working astronomical observatory, and for twenty years, from 1800 to 1821, Monsignor Filippo Gilio used it for making meteorological, geophysical and astronomical observations using a telescope. Gilio had no successors and the tower was used for other things, and then abandoned. Later, when Pope Leone XIII founded the Vatican Observatory on 14th March 1891, the tower returned to its former use. For some time it was used to house offices, libraries and various astronomical, geophysical and meteorological instruments. But it was not suitable or adaptable to install modern instruments and therefore the Observatory was moved in 1906 to the large tower in the Vatican Gardens which today houses Vatican Radio. Finally, in 1932, because of the much increased level of light in the skies above Rome, the Observatory was transferred to Castel Gondolfo (the Pope's summer residence, south of Rome).

The astronomical activity in the Tower was thus of brief duration. One could say, as has been written before, more than once, the astronomical observations using the meridian were made to ascertain the the number of days between the official Equinox and the date on which the Sun entered the sign of Aries in the Zodiac. But we consider that if Danti contributed to the system of the calendar with proper astronomical observations, these must have been executed very much earlier in Florence or Bologna. The fact is that when masons began the construction of the Tower in 1578, it was already a year after Pope Gregory XIII had, in 1577, sent envoys to the Christian Princes and Universities in Europe, detailing the the project of reforming the Calendar in the form in which it was subsequently approved. The real story about this reform started long before 1578. The

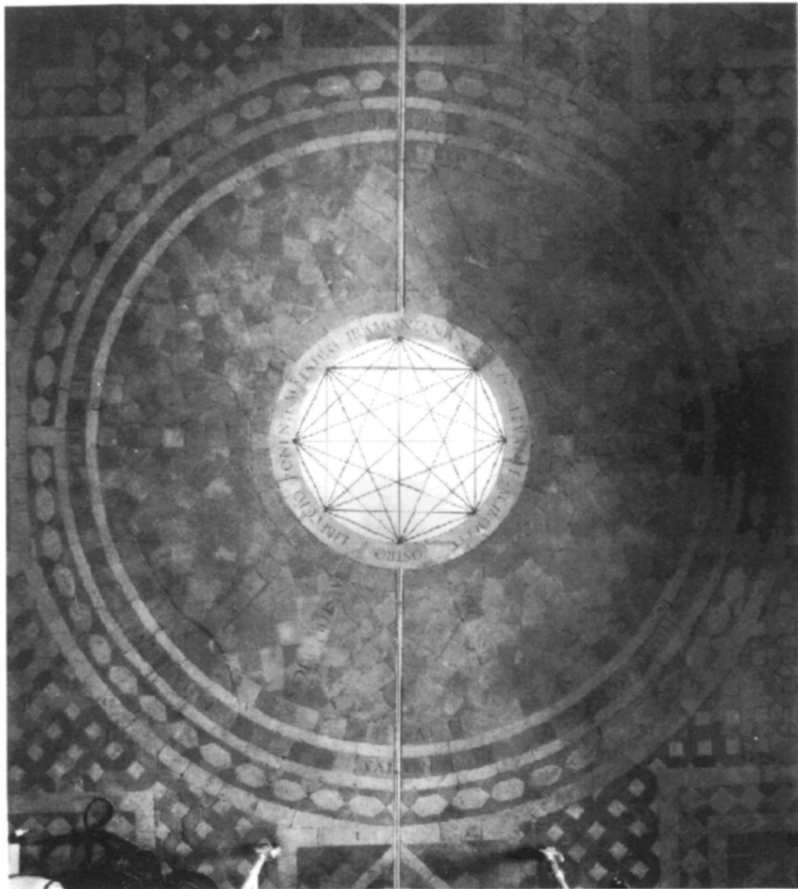


FIGURE 1: The floor of the Meridian Hall, the tubes at the bottom of the photograph are part of the stand from which the picture was taken.

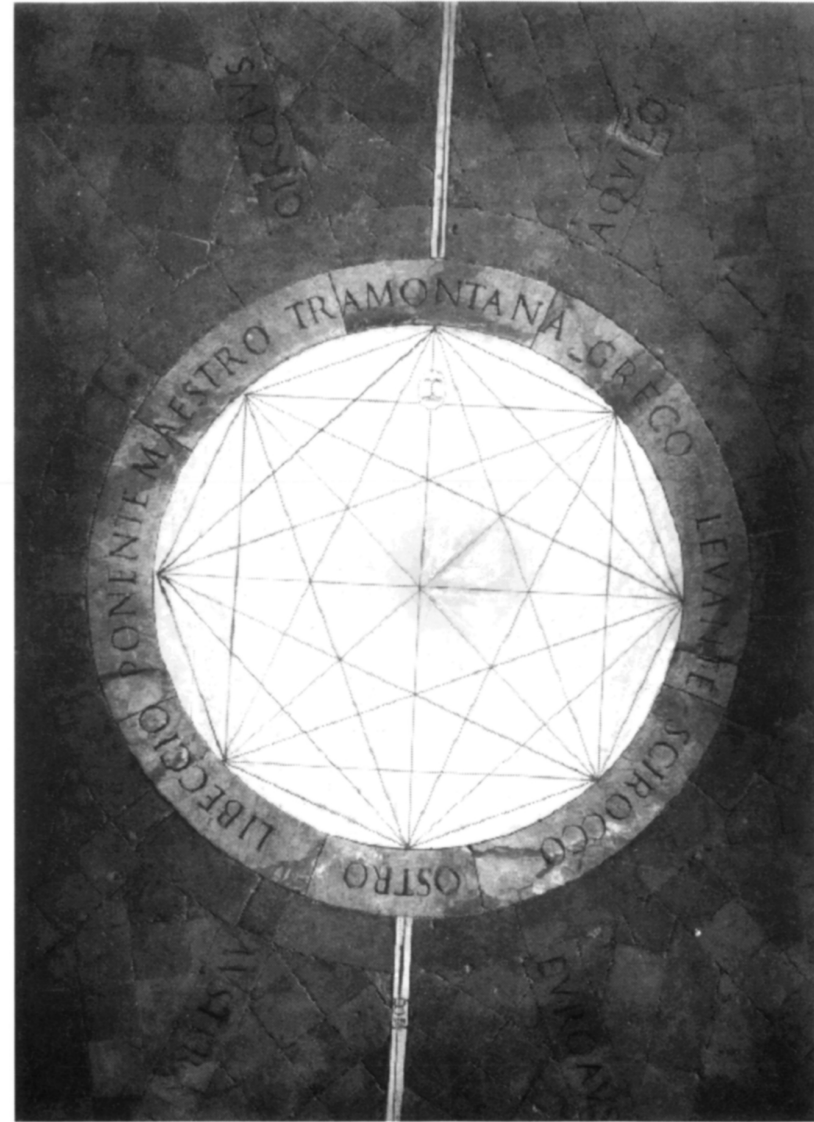


FIGURE 2: Enlarged detail of the central feature showing the eight winds, showing clockwise from the top (north):

TRAMONTANA, GRECO, LEVANTE, SCIROCCO,
OSTRO, LIBECCIO, PONENTE, MAESTRO

Fathers of the various Councils, particularly the Council of Trento, had received from the Papal Summit the task of preparing a project for the reform of the Calendar - a task which revealed itself as not at all easy. The most famous astronomers such as Regiomontanus and Nicolo Copernicus were invited to visit Rome. The calendars then currently being used was the idea of the Puglian doctor Luigi Giglio who had died many years prior to the creation of the Papal Commission for the Reform of the Calendar.

Contrary perhaps to the wishes of Danti, the Torre dei Venti has traditionally been remembered for its meridian and the connected astronomical work,² one of the main contributions to the study of astronomy and development of these instruments, invaluable before the invention of the telescope. Possibly inspired by the very ancient meridian, which can still be seen in the Duomo in Florence, Danti started work to make a new one in the church of Santa Maria Novella in the same city, followed by the first of the famous meridians of San Petronio in Bologna. The meridian in the Torre dei Venti was the most perfect of them, incorporating all the best ideas of those he had previously made.

From remote antiquity, there have been sundials in various forms. The simplest have taken the form of a pole or obelisk in the centre of a square. The length and direction of the shadow thrown on the flat area around provides not only the time of day, but also valuable information on the season, on the length of the year and also on the geographical latitude. The meridians constructed at the time of Egnazio Danti did not require the use of shadows projected by an obelisk, but used the principle of the "Camera Obscura". Rays of light from the sun coming through a small hole made in the south wall of a room threw an elliptical image of the sun on the floor of the room, elliptical because the light forms a cone on the horizontal surface. The thickness of the wall allows the image to appear only when the sun is in the vicinity of the meridian. The elliptical pattern of light moves across the floor (in Spring at a speed of 0.5 mm per second) and crosses the meridian line at precisely midday local time, recorded on the line with a marble strip. The error in the

measurement of midday was one of just a few seconds. The points on the meridian corresponding to the entry of the Sun into the various signs of the Zodiac traced a small ellipse (in Spring 10.0 x 7.1 cm) of the same size as the images of the Sun.

One can readily imagine the admiration shown by all the visitors to the Torre dei Venti during the years of the reform of the Calendar. Added to the beauty of the frescoes, one had a learned dissertation on astronomy admirably illustrated by the passage of sunlight over the meridian. The necessity for reform (of the Calendar) became more than evident when on 21st March 1571, the image of the sun touched the meridian at a point a good 60 cm from that corresponding to the true equinox recorded on the floor. Notwithstanding the small errors in the alignment of the meridian and the collocation of Aries, Danti's efforts had served their purpose. And today, four centuries later, observing midday on the meridian of the Torre dei Venti, is interesting and not lacking in emotion.

Juan Casanova Society of Jesus
Specola Vaticana

* * * * *

NOTES

- 1 Even now people in the Italian countryside refer to the winds by names rather than by compass direction as we tend to do - e.g. *Transmontana*, *Sirocco*, etc.
- 2 Rather than the wind direction instrument (anemoscope) to which Danti attached so much importance himself. The wind vane itself on the Tower of the Winds in Athens was the invention of Andronicus Cyrrestes, a native of Macedonia, almost one hundred years before the birth of Christ and took the form of a bronze Triton at the centre of the tower roof. It is not known if this gave an indication within the tower itself.

* * * * *

ACKNOWLEDGEMENTS

The photographs are reproduced here by kind permission of the Vatican Museums, Vatican City, Rome.

BOOK REVIEWS (continued from page 50)

Section III.7 deals with Analemmatic Sundials and the dial layout for a park, or school playground, but without the Sun's declination points along the Meridian Line necessary for positioning the movable vertical gnomon. These points are readily given by $a \tan \delta \cos \phi$ where a is the semi-major axis of the ellipse, and are correct for showing True Sun time. A figure-of-8 analemma bearing monthly position marks is depicted with the avowed function of showing Local Mean Time (Clock Time) by the shadow of the gnomon. Figure 50 shows this dial in operation with the gnomon on 1st November. On this date the shadow angle from the gnomon will show 7.30 am whether the gnomon be placed on the meridian line according to the declination $14^\circ 12'$ (the Sun's declination on 1st November) OR on the analemma for 1st November. It is evident from the figure, that this does not correctly convert the true Sun Time to Clock time by adding the requisite 16 minutes which is the Equation of Time for November 1st, except at around

midday when the analemmatic correction of 16 minutes is put into operation.

The complexities and inaccuracies of incorporating a figure-of-8 analemma into a playground type of sundial were recently published in BSS Bulletin 95.1, February 1995, by Frederick W. Saywer III. This article supports the view that the horizontal playground type of dial works ideally only if the vertical gnomon is moved along the meridian line to give Local Sun Time, and that Local Clock Time is best arrived at in the time-honoured manner by applying the Equation of Time and Longitude corrections separately. This would make the analemmatic figure-of-8 and the Equation of Time graph welcome *embellishments* on a sundial. (Not to be incorporated in the process of forming shadows to indicate the time.)

It is strongly recommended as a mine of practical and interesting projects.

ROBERT MILLS

A DIAL BY RICHARD MELVILLE IN SALISBURY, WILTS

R.A. NICHOLLS

1. INTRODUCTION

There are two splendid dials in Salisbury, one a vertical, seen from the public road, and one a multi-gnomon horizontal set in a private garden. This latter was visited by members during the 1994 Conference at Urchfont, but access to the dial was limited to a lucky few chosen by lot. Since that visit, and by kind permission of the owner, it has been possible to make a comprehensive record of the dial, by measurement, pencil rubbings and photography.

2. THE DIAL MAKER

The dial, see Photo 1 is attributed to Richard Melville (also known as Melvin), a well known maker from Belfast and Edinburgh who is thought to have worked in England at a later date. His work is well documented by Somerville,¹ and by the National Museums of Scotland.² He made many multi-gnomon horizontal dials of various shapes; square, rectangular, round, and, rarely, octagonal as in this case. Most were cut in slate, usually Welsh slate, as is this dial. Many of the features of this dial occur on other dials, but only a minority have the large amount of information engraved on this one.

Melville's work spanned the years 1840-1871 approximately. Unlike many, this dial has no date. A full

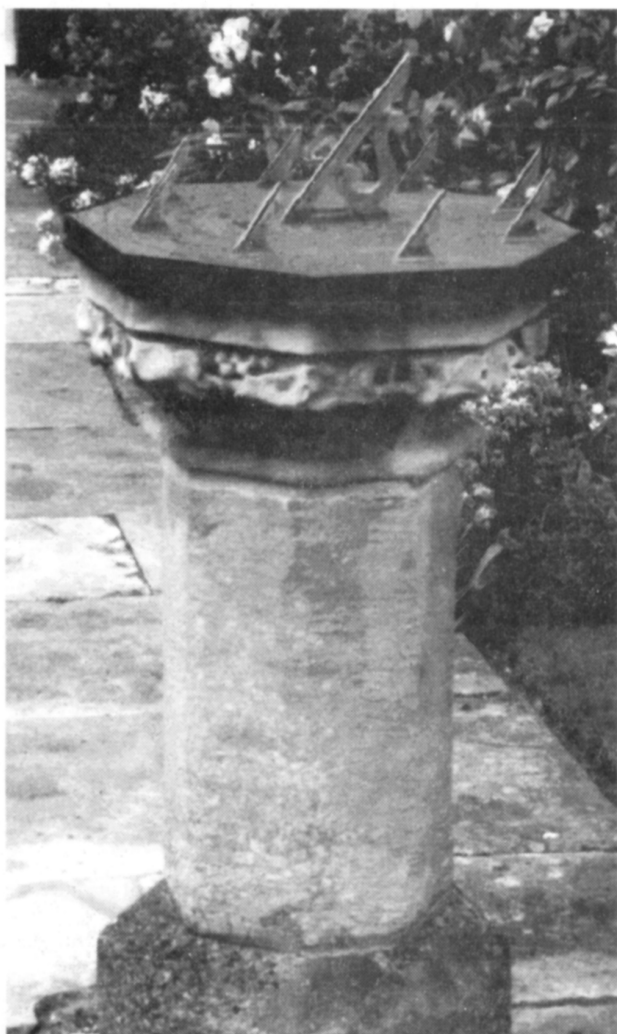


Photo 1: General view of Melville Dial

size drawing of the dial has been made and is reproduced here at reduced scale (Fig 1).

Coincidentally, in 1993 the National Museums of Scotland acquired a paper pattern of a Melville dial,³ rectangular and with fewer gnomons (Acquisition No. MNS T.1993.86). Much of the information on this paper dial is similar to that on the Salisbury dial, and both are discussed here. Fig 2 shows the paper dial. It seems to be drawn for a location somewhere near Canterbury, Kent.

3. CONSTRUCTION OF THE SALISBURY DIAL

The dial is formed by two slate plates, an upper and lower. The thickness of the upper is 13mm, and of the lower 15mm. Both are cut to a regular octagon, measuring 460mm across flats. The two plates are held together by vertical fixings through both, which also penetrate to the underlying stone plinth. The dial has not been recently dismantled, but it seems probable that each of the nine gnomons has horizontal flanges fixed to the lower edge, and the gnomons are held in position by sandwiching these flanges between the two slate plates. One small gnomon is loose and the flanges on this may have broken. The dial is supported on a well carved natural stone plinth at a height of 950mm above ground level.

All nine gnomons are bronze. The main gnomon is 6mm thick and the eight minor ones are 3mm. The vertical height of the large gnomon is 156mm above dial surface and that of the small gnomons varies between 61 and 64mm. The top plate of the dial has slots cut in it to allow the gnomons to pass through. Except for one loose gnomon the dial is in excellent condition. The amount of information on the dial, crammed as it is in a relatively small area, together with the inevitable dulling of the engraving, makes the deciphering of some of the letters and numerals difficult.

4. POSITION AND ORIENTATION OF THE SALISBURY DIAL

The main gnomon is oriented near enough to true north to give reasonable solar time readings, although it is in fact pivoted about 2° to the west of the north-south line on the dial face.

The dial is inscribed Latitude 50°51' North, but is at present situated at 51°04' North, some 15 miles north of its original position (possibly near Ringwood?).

The present owners bought the dial with the house some years ago and do not know its original site.

The main gnomon has a style at 51° to the horizontal, but the small gnomons have style angles varying between 53° and 56°. The main style meets the dial face at a point below the geometric centre of the dial, which is a feature of later Melville dials.²

The time lines on the main dial chapter ring are for a latitude of 53° with some inconsistencies around the II to III area. The lines on the smaller dials vary randomly one to another and within each chapter ring, and fit values of latitude varying between 50° to 55°N.

The paper dial also has time lines spaced for latitude 53°N.

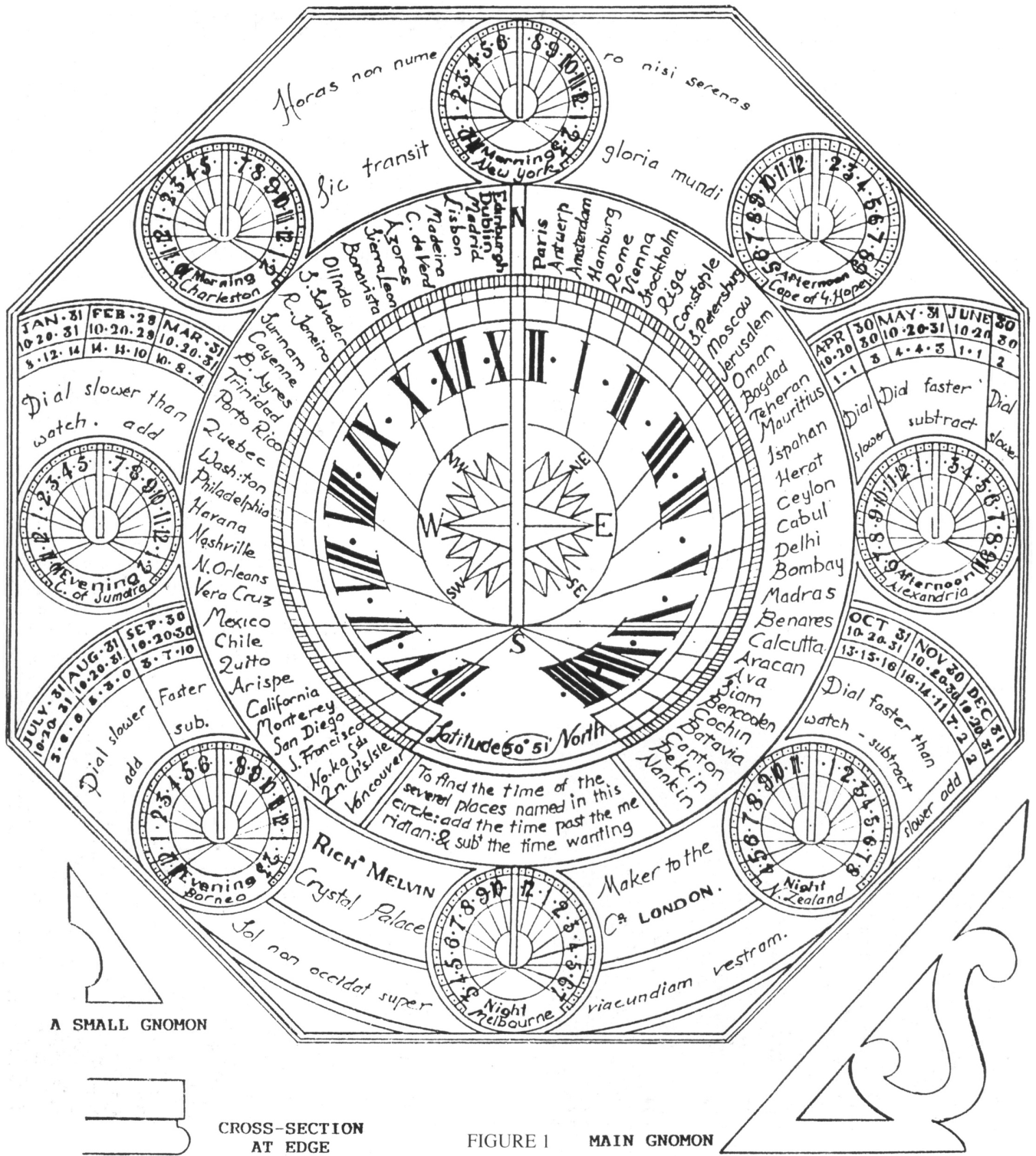


FIGURE 1 MAIN GNOMON

NOTES - THE DRAWING:

1. The drawing is based upon site measurements, pencil rubbings and photographs.
2. The gnomons prevent checking of some dimensions, and weathering of the thin strokes of the lettering etc. make deciphering difficult.
3. Outside dimensions are checked to ± 2 mm.
4. Drawn dimensions are in accordance with the symmetry of the external octagon - this is not checkable on the dial.
5. Neither the letters drawn, nor the numerals are copies of those on the dial, which are copper-plate script. The lettering on this drawing is simpler.

6. A very few Latin words and place-names may be misspelt due to the difficulties noted earlier.

THE DIAL

1. The dial is of slate with bronze gnomons set on a stone pedestal 949 mm above ground level.
2. The dial is inscribed Latitude $50^{\circ} 51' N$ but it at present (1994) situated at $51^{\circ} 04' N$. The main dial gnomon is 51° to the horizontal, and the small gnomons are at 55° .
3. The place names in the circle are not in strict order of increasing longitude, reading top to bottom.
4. The hour lines on the main dial are delineated for Latitude $53^{\circ} N$.

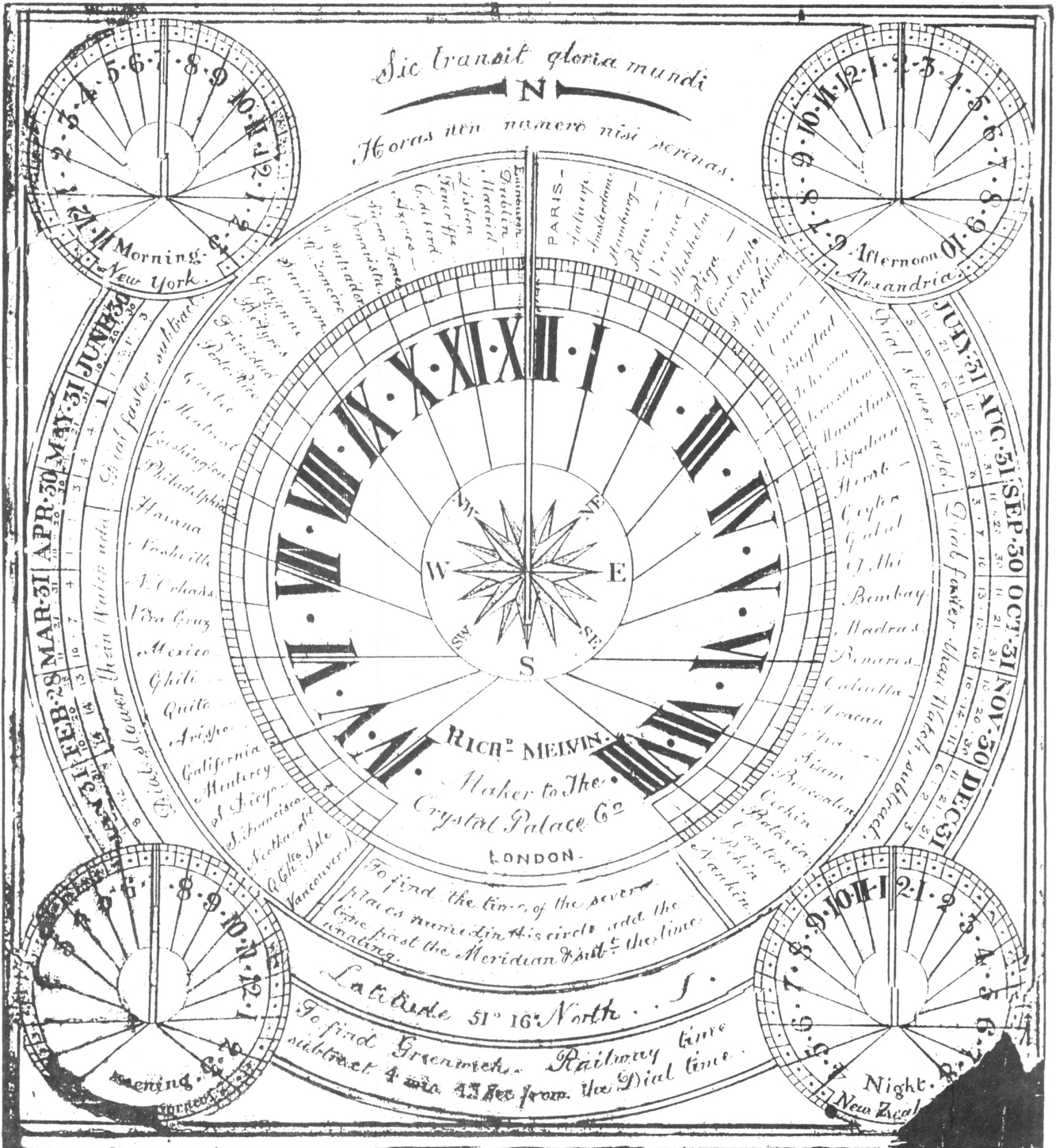


FIGURE 2: Paper scale for Melville dial, courtesy of the National Museums of Scotland

5. A PUZZLING FEATURE OF THE SALISBURY DIAL

The overall colour of the slate dial face is medium blue grey. On this face there are a large number of much darker patches, some roughly circular, some elongated ovals, some approximately rectangular. Dimensions of these patches vary between 5mm and 25mm. At first glance these patches are so apparently regular (e.g. on the main dial chapter ring) as to suggest a decorative pattern, but closer inspection reveals the patches are randomly sized and spaced. None obliterates any essential information on the face however.

The surface of the slate is not physically affected and remains plane and smooth in and across the patches. These resemble wet or oily marks, but do not change colour with air temperature change or exposure to sunlight, nor do they feel wet or oily. No explanation has yet been given for this feature.

Photos 1, 2, 3 and 4 are photographs showing the general construction, gnomons etc. described in 3 to 5 above.

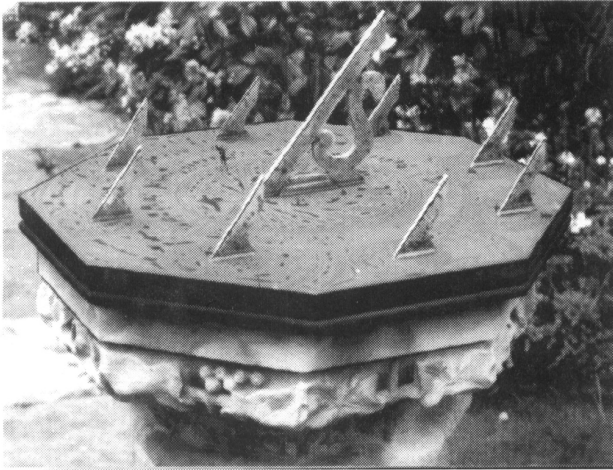


Photo 2

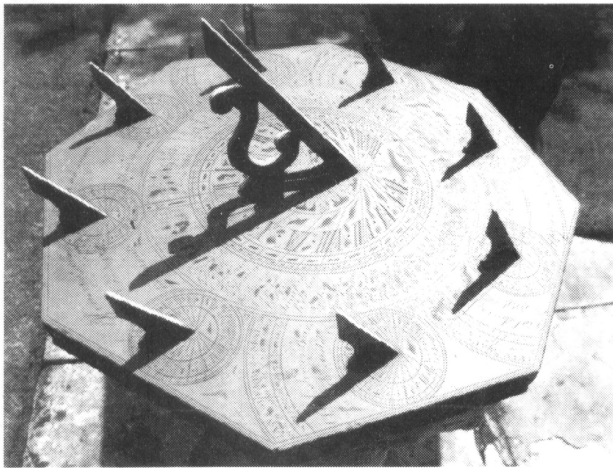


Photo 3

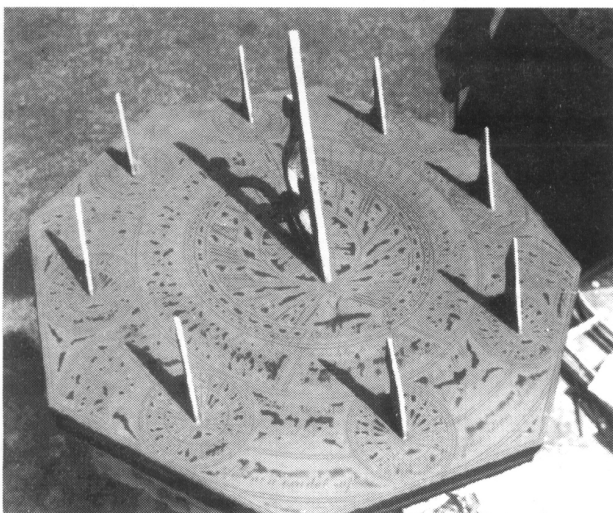


Photo 4

6. INSCRIPTIONS ON THE DIAL FACE

The Salisbury dial is described in detail, with references to the paper dial where relevant. All inscriptions are made to read when facing north.

a) Main Dial

This is inscribed from 3.30 a.m. to 8.30 p.m. in Roman numerals, with lines for the hours, half hours, fifteen and five minutes. Around the base of the gnomon, centred on the geometric centre is a compass rose. The latitude is inscribed in this circle in heavier engraving than the remainder of the face.

b) Small Dials

There are eight of these spaced around the perimeter of the octagon on the Salisbury dial. All numerals are Arabic. Hours and half hours are marked with lines, and dots mark each fifteen minutes. The eight are listed below, starting with the dial on the northern edge and proceeding clockwise.

Inscriptions on each dial			Comparison of dial accuracy	
Place name	Range of hours	Time of day	Reading on small dial when noon on main dial	Actual time at place when noon on main dial
New York	10.45 to 3.15	morning	7 a.m.	7 a.m.
Cape of G. Hope	4.45 to 9.15	afternoon	1 p.m.	1.15 p.m.
Alexandria	5.45 to 10.15	afternoon	2 p.m.	2 p.m.
New Zealand	3.45 to 8.15	night	midnight	11.40p.m.
Melbourne	2.45 to 7.15	night	11 p.m.	9.40 p.m.
Borneo	10.45 to 3.15	evening	7 p.m.	7.35 p.m.
C. of Sumatra	9.45 to 2.15	evening	6 p.m.	6.45 p.m.
Charleston	9.45 to 2.15	morning	6 a.m.	6.40 a.m.

TABLE 1: Detail inscribed on small dials

The paper dial has four dials only those for New York, Alexandria, New Zealand and Borneo, identical with the Salisbury dial except for slightly more ornate chapter rings.

Table 1 shows that the small dials have significant errors in orientation.

c) Equation of Time

This is inscribed on the Salisbury dial in four quarters, next to the Sumatra, Cape of Good Hope, Borneo and New Zealand dials.

The time differences are given for the 10th, 20th and 30th or 31st of each month. Some values differ by one or two minutes from accepted values. Some of the small Arabic numerals were difficult to decipher because the fine lines have been weathered as described in 3 above. Some values may have been incorrectly noted therefore.

The paper dial has similar but not identical values, and these too are sometimes incorrect. The days on which the differences are recorded are the 11th and 21st, and not 10th and 20th. The instructions for adding and subtracting values on this dial are incorrect for the first days of June and the last days of December.

d) Mottoes

There are three on the Salisbury dial, and the first two occur on the paper dial.

- (i) Sic transit gloria mundi

- (ii) Horas non numero nisi serenas
- (iii) Sol non occidat super viacundiam vestram

In the third motto, the word “viacundiam” is incorrect Latin - it should be “iracundiam”. Despite difficulties of interpretation, prolonged examination leaves open the view that the word is incorrectly cut.

e) Maker's name

On both dials there is the following inscription, not recorded on any previous Melville dial:

RICH^D MELVIL Maker to the Crystal Palace Co.
LONDON

The dial owner's name or the date often inscribed on other Melville dials but neither occurs on the two dials considered here.

Research by the National Museums of Scotland shows that the company was formed in 1852 to move the Crystal Palace to Sydenham in 1854. No reference to Melville/Melvin occurs in their 1856 catalogue.

The paper dial refers also to Greenwich Railway time - this was in use from the late 1840s and early 1850s according to the O.E.D.

It seems reasonable to assume therefore that both these dials are later than the mid-1850s.

f) Place Names

A major feature to both dials (and of many other Melville dials) is the list of place names written in a circle around the main dial. These are divided either side of the north-south line and list places in the eastern and western hemispheres respectively. There are 34 names in the eastern hemisphere and 35 in the western. The order of names differs slightly between dials. Other Melville dials have fewer names.

All the place names (with allowances for modern spelling and political changes) can be found in a good gazetteer, with one exception. This is a Bencoolen or Bencoalen. This may be Bengkulu in Indonesia, but other ideas are welcome.

The dial was made for British consumers, and in general the names are of sizable towns or areas likely to be well known in Britain. Certain towns however, especially in the Americas, seem remote and of little importance - in present times at least. The opinion may betray an appalling ignorance of events current in the mid-19th century when the dials were in vogue, but it is possible that the engravers were desperate to fill the lists. For instance, did Nashville loom large in Britain prior to Elvis Presley? And Arispe in Mexico - what is of importance there?

The names were however meant to give instruction to the user. At the bottom of the circle is written:

To find the time of several places named in this circle: add the time past the meridian; and subt. the time wanting.

This inscription is not immediately easy to understand, but if nothing else it must mean that the lists should read from top to bottom in increasing values of longitude in each hemisphere. This is in fact very far from the case. There are major muddles in the western lists in South America and a rather smaller one in the Middle East for the eastern list. These involve errors of up to 20° of longitude in the order of place names. The lists with their actual longitude are not given here for reasons of space but may be had on request to the author.

Another feature of the lists on the Salisbury dial is the heavier engraving of the words “Edinburgh” and “Dublin” in the western list, and “Paris” in the eastern. On the paper dial only Edinburgh and Paris differ from the remainder. No reason for this is immediately obvious.

7. THE ENGRAVING OF THE DIALS

The engraving of the Salisbury dial is in copperplate script. There are some slight variations across the dial but the face viewed as art is remarkably impressive. This is perhaps more obvious on two-dimensional drawings such as Figures 1 and 2, because on site the many gnomons detract from an overall view. The paper dial gives a better impression of the actual script, as no attempt was made in Figure 1 to make a facsimile, letter by letter.

The craftsmanship of the engraver is obvious, and the object of much admiration from those who recorded the Salisbury dial. The engraver was almost certainly right-handed.

8. CONCLUSIONS

Despite the artistic value and craftsmanship of the dial face the Salisbury dial is not an instrument of scientific precision. The National Museums of Scotland (2) suggest that dials of this sort are best classed as luxury items, and that Melville himself, although a specialist sundial maker, was a slate draughtsman.

This seems a fair verdict. The amount of information on the Salisbury dial is almost overwhelming and would have been appreciated by few of those buying or examining it. This allied with the undoubtedly somewhat cavalier approach to accuracy in the style angles, time lines, place names etc. seems to suggest that it was very much for conspicuous consumption. Unfortunately no evidence on costs for these dials is available.

The occurrence of what seems to be random errors in numerals and letters plus the appearance of a large commercial company on the scene and the lack of dates or owners might suggest a production line, with a stock of various shapes and gnomons on the shelf, needing only the addition of a latitude to suit the buyer.

* * * * *

ACKNOWLEDGEMENTS

The Society and the author are very grateful to the owners for allowing access to the Salisbury dial.

The author would like to acknowledge and thank David Brown for his very great help in recording and deciphering the dial.

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ON LUNAR NOMOGRAMS

RÉNE R.-J. ROHR, FRANCE

The name nomography is applied to the mathematical processes which allow the solution of problems by graphical means instead of other possible but more complex means. The word “nomography” is of Greek origin from *Nomos* meaning law, and *Graphos* in the sense of writing. Nomographic diagrams are known as nomograms. In other words, nomograms are the graphical representations of variable quantities of some physical or mathematical formulae.

The invention of nomography as a science is internationally attributed to the French mathematician Maurice d’Ocagne (1862-1938), but it is in fact centuries older since at the early part of the seventeenth century, authors such as Pierre de Sainte Marie-Madeleine, Bonfa, Athanasius Kircher, Ozanam, Bion and others made use of it in most of their works. D’Ocagne never claimed authorship, but he was probably the first writer to employ the Greek name when he published his *Treatise of Nomography* in 1889.¹

The era of change, following almost immediately on the century of the Renaissance, witnessed a sudden increase of interest in spiritual progress which became extended to everything, but especially obvious in the subject of gnomonics following the appearance and rapid propagation of the polar style for sundials. The ensuing teaching of gnomonics in universities made it an object for research and an almost inexhaustible subject for entertainment.

The problems of time measurement, although of little interest to those in daily life, was in the air and gave birth in many minds to the idea of accurately observing the movements of the moon in a new field of investigation not thought of before. It was realized in spite of the greatest practical difficulties and the almost impossible reading of any shadow cast by the moon or the means of transforming these observations into the solar hour system of reckoning. This new dialling occupation must have been purely for the mathematical entertainment of dilettante amateurs, much as it has remained up to the present time.

Their long-forgotten attempts began in two scales placed together like the obsolete slide-rule, one being divided into twenty-four hours, the other, of identical length, into thirty days; i.e. a lunation expressed in a round number. Very soon these graduations appeared on the circumferences of circular plates having a common axis of rotation. It was well known that the true length of a lunar month was approximately $29\frac{1}{2}$ days, each of these days being one number in the age of the moon’s cycle, the thirtieth day being number one in each second successive lunation. The twenty-four hour scale was looked upon as the scale of a horizontal sundial. When in use, the number 30 was set on the shadowline projected by moonlight and the true time was given at the age of the moon.

This method to obtain clock time from the light of the moon gave rise to a great many variants of which Fig 1 illustrates one of the most elementary and yet quite adequate solution. A modern author has mentioned it in his treatise, and another has stated that it is of the most natural simplicity.²

In a table, displayed below and forming part of the well known sundial in the Old Court of Queens’ College, Cambridge (Fig 2); three lines of figures give the solution

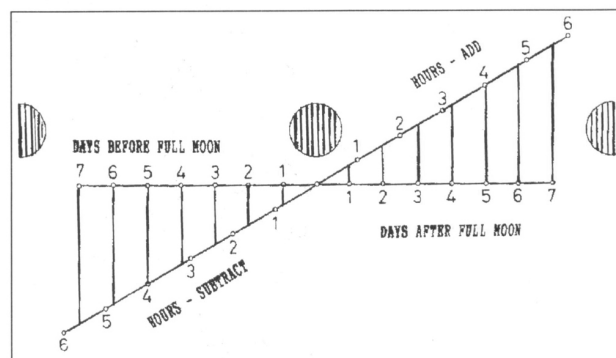


FIGURE 1: Figure taken from *Les Cadran Solaires*, 1986 - page 132. This allows the determination of solar time from a moon observation during the period the moon can give a useful shadow on a dial.

by means of one simple addition in the simplest way:

Lines 1 and 3 give the ages of the moon, and line 2 shows the corresponding time in hours and minutes to be added to the time indicated by the shadow projected on the dial by the moon.

A French engineer, Bion,³ used this same table in nomographic form (Fig 3), which he placed on a rectangular plate pierced by a circular hole. This hole is surrounded by a concentric scale on which the thirty days of the age of the moon is engraved, commencing at the lowest point and proceeding anti-clockwise in equal parts. In the cut-out part of the plate is placed a second pierced disc bearing a scale at its edge divided into twice the 12 hours with the hourlines of a horizontal sundial. In the pierced centre of this plate is a circular plate carrying a style fixed upon the outer plate. The whole instrument may be thought of as a horizontal dial with an added moon-age scale on the outside. The dotted lines visible in the drawing shown in Fig 3 are the constructional lines for constructing the hourlines of the sundial at the latitude of use.

In his treatise on mathematics⁴ Ozanam describes a horizontal sundial with the hour-line numerals, all engraved on a line rectangular to the noon-line and below it, at regular small intervals a succession of 15 parallels bearing from the lowest one upward in two columns the ages of the moon from 1-15 and from 16-29, see Fig 4. Here Ozanam utilizes the fact that on every succeeding day, the moon will be crossing the meridian some 48 minutes later after the passage of the sun, and at each New or Full Moon, the two bodies will cross the meridian simultaneously. Both would mark the same time if the moon possibly could throw a shadow on the dial.

For a better understanding, the fifteen parallels can be regarded as moon-lines. On the day of the New Moon at 12 o’clock, in theory, the two shadow-lines would be superposed on moonline one if the age of the moon is regarded as being there. On the following day the shadow line of the sun will again indicate 12 while the moon will require another 48 minutes to mark the same time on its age line, and so on for each succeeding day its mark on the next moonline will be 48 minutes later. If all the marks on the moonlines are joined, and the same operation performed for all the hours of the day, the result will be as in Ozanam’s

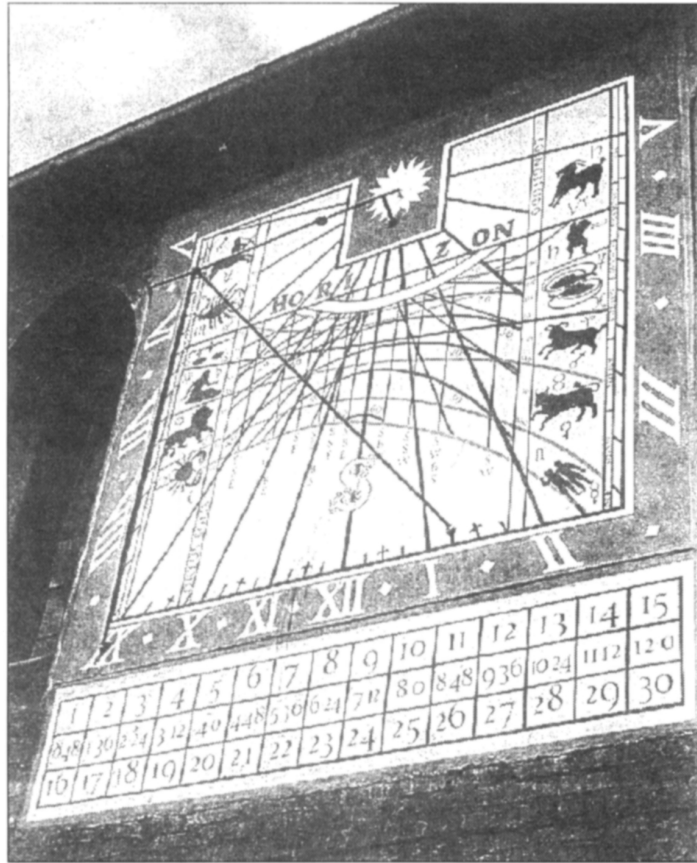


FIGURE 2: The “moon” dial at Queens’ College, Cambridge. This is the frontispiece of *Les Cadrans Solaires*, 1986. It is a normal sundial with a table of the times to *add* throughout the complete lunation period.

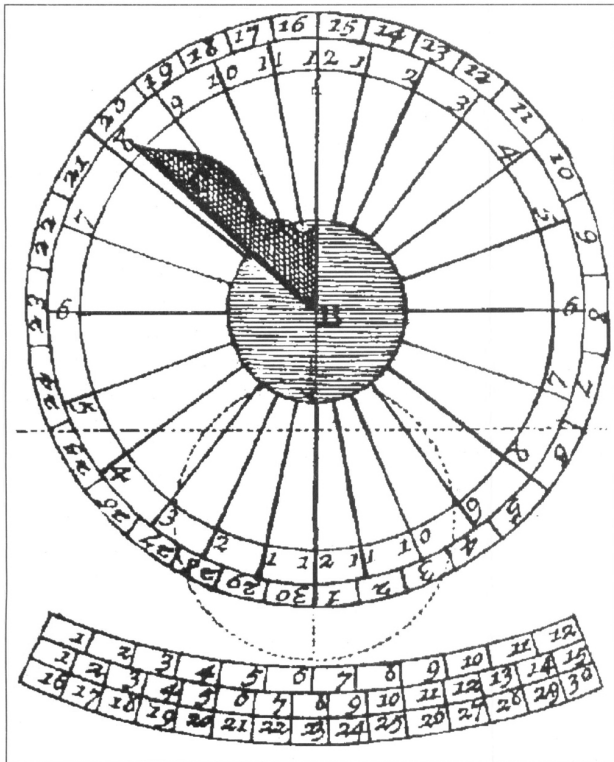


FIGURE 3: The nomogram devised by Bion in the early 18th century.

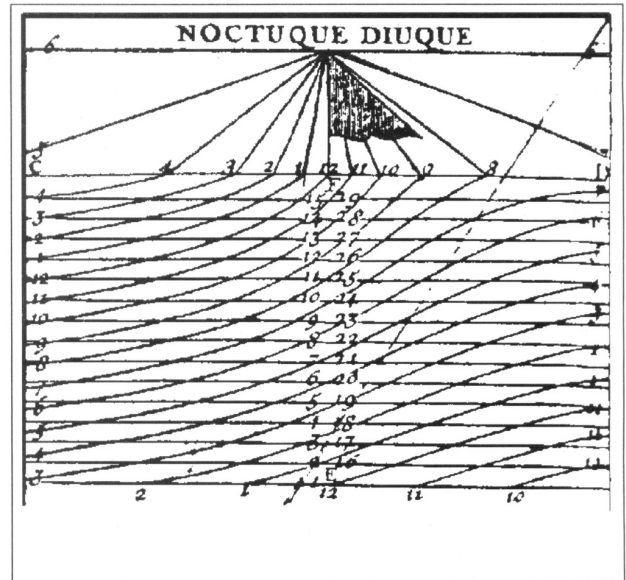


FIGURE 4: Ozanam’s lunar dial for determining the solar time from the moon. Plate 40 from his *Recreations Mathematiques et Physiques*, 1698.

drawing. Each joined curve is to be marked at its ends with the hour of the day, to ascertain the desired time, the observer looks for the crossing of the moon's shadow with the part of the curve which falls in the moon's age ribbon, then follow this curve to the end where the sought-for time is indicated.

But was the moon's age always known?

Father Bonfa, a member of the Jesuit College in Grenoble (today a school for girls), in the years 1672 to 1674 was creating the famous gnomonic installation still to be found there, and he faced the same problem. Throughout the decades his work has been, more or less, tolerably maintained. Margaret Gatty, in her time, called it the most remarkable gnomonic realisation on the Continent.⁵ A few years ago, a plan for a total renovation of the installation had been in view for some time. unhappily the expert in charge, an elderly engineer, died. Since then the situation seems to be slowly deteriorating.

In reference to the previously alluded nomogram by Bonfa (Fig 5), its condition admits to the almost total reading of the letters and numerals. Its title is: *Novum Kalendarium civile lunae*, (New Civil Lunar Calendar). The inscription on the very dark flying ribbon is not visible, but its text is known, in translation it reads:

Add the date of the present month to the epact of the year, take off, if necessary, 30, the sum will be the age of the moon.

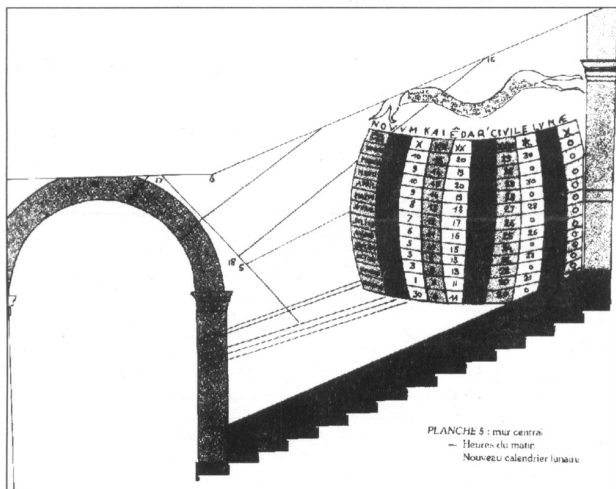


FIGURE 5: Bonfa's NOVVM KALENDAR CIVILE LUNÆ at the Old Jesuit College at Grenoble, France. Delineated 1673.

To remind the reader, the observer must remember that "epact" is the name given to the age of the moon on 1st January of each year.

Attempting to simplify, and also to confine his table to reasonable dimensions, Bonfa limited the enumeration of the Roman numerals of lunar ages in line 2 to multiples of five. The numerals shown there are for a year with epact zero. Their separation into parts implies that almost over the range of the table a proportional calculation will be necessary - a detail which makes the present table slightly exceed the notion of a nomogram. The twelve following lines refer to the twelve months of the Gregorian year. Their numbers are the division of the year in parts of 4 or 5 days in conformity with a calendar year of epact zero.

No advice seems to have been given regarding the last three columns on the right, nor to the fact that in leap-years one day has to be taken off the calendar date from 1st

March to 31st December.

Suppose that one requires to know the age of the moon on 8th October of some year with epact 2. In the line for October the date of 8 is in the third column and in this is the Roman numeral XV - when the epact is zero. For an epact of 2, this value must be added to obtain XVII, the required age. If the epact had been 29, the addition would have given $15 + 29 = 44$ and so 30 must be subtracted, since no epact can ever exceed 30 (which will be age one of the next lunation), and so the moon will be aged 14.

But there exists in Bonfa's realisation a better nomographic example (Fig 6) giving in a large rectangle the following translated Latin text:

New clock in which the position of the moon can be found by means of the position of the sun as well as the contrary, and by means of the two stars the age of the moon and the normal hour of the date all over the world.

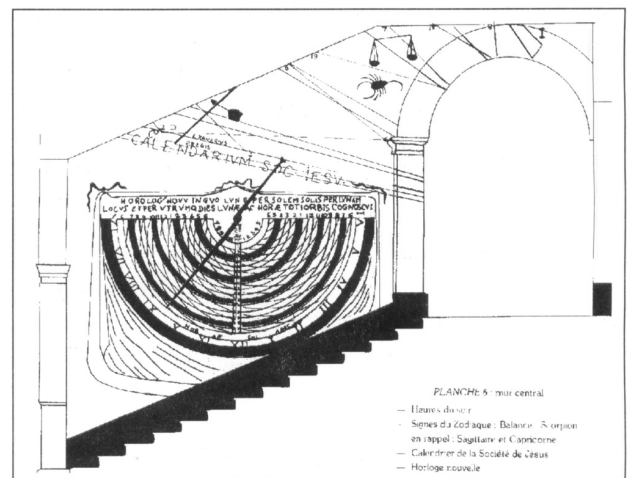


FIGURE 6: Bonfa's HOROLOGIO NOVVM at the Old Jesuit College at Grenoble, France. Delineated 1673.

Below this information, sixteen concentric and equidistant semicircles are drawn, on the vertical radius of which is given from the outermost upwards, the ages of the moon in a lunation, written in two columns from 1 to 15, and 16 to 30 as in Ozanam's diagram shown in Fig 4. The outermost circle forms a ribbon bearing Roman numerals anticlockwise the hours VI pm to VI am. Along the horizontal diameter and the central smallest semicircle, the Arabic numerals cover the same period of time. From each of the Roman numerals a curve leaves tangentially, traversing upwards to the left, joining in the form of an evolute or almost circular arc to the identical Arabic hour numeral.

Let us assign, as we did in the Ozanam diagram with the parallels, the semi-circles the name of moonlines and note that the tangential curves will play the same role as Ozanam's curves in Fig 4. And here, in use, there will be a small rotating pointer with its axis in the centre that will serve the purpose of Ozanam's moon-shadow.

Two very small and now much-faded ribbons follow inside and outside the Roman hour numerals ribbon, the inner bearing the words in Latin: *Hours of the sun*, the other giving the advice: *In the morning use the red hours, the black ones in the evening*. But the colours have disappeared.

The difference in approach of the solution by Ozanam and Bonfa speaks of independent work. Yet a third and

earlier author had years before given a more complete solution and perhaps rather more entertaining and sprightly.

Athanasius Kircher, the well-known German Jesuit, author of the enormous *Ars Magna Lucis et Umbrae* (The Great Art of Light and Shadow) 1646, a manual on gnomonics, had published in this treatise a nomogram on the lines of the preceding solutions Fig 7. It was rather more sophisticated but certainly easier to consult.

Kircher was one of the most learned and productive authors of his time and his works deal with almost all the subjects then taught, and once he had even attempted to interpret the hieroglyphics of ancient Egypt!

In the said figure (Fig 7) he proposes an ellipse surrounded by the 28 phases of the moon in the form of human faces arranged clockwise and commencing with the new moon set at one end of the major axis of the ellipse. In an adjoining external elliptic frame, Roman numerals from I to XXVIII give the corresponding ages of the moon. Each of the 28 moons is provided with a style of suitable size and the moon hour numerals appropriate to its phase. Two similar moons with human faces looking in opposite directions are at the foci of the ellipses and each too is provided with a style for the opposing direction. They are surrounded by the inscriptions *LUNA CRESCENS* and *LUNA DESCRESCENS*. From the first moon spiral ribbons run clockwise; from the second moon ribbons run anticlockwise, these bear radial columns of numerals, the two parts of the drawing being symmetrical disposed about the minor axis of the ellipse.

The columns are, counting from the centre outwards:

First spiral: Ages of the Moon

Second spiral: Phase corresponding to this age

The twelve succeeding spirals: Moon hours marked by the shadow of the moon at each of its ages.

Fifteenth (last) spiral: True Local Time!

When the moon changes between crescent and decrescent, the whole diagram must be rotated through 180° as indicated by the adjoining compasses.

To use the nomogram, the age of the moon, if not known, is looked up in the outer ribbons. The shadow given by the styles, (shown dotted on the central moons) shows the moon's retardation in the corresponding spiral and the time sought for is found on the top spiral in the marked column.

It is more than probable that Kircher's treatise was known all over Europe in the libraries of the Jesuits and in the universities, so Ozanam must have seen it. As to Bonfa, he as well as a number of well known Jesuits interested in gnomonics, are known to have paid visits to Kircher during his time in Avignon.⁶ Kircher must have been one of the first to publish a valuable approximate solution for the measurement of time by means of a moon observation.

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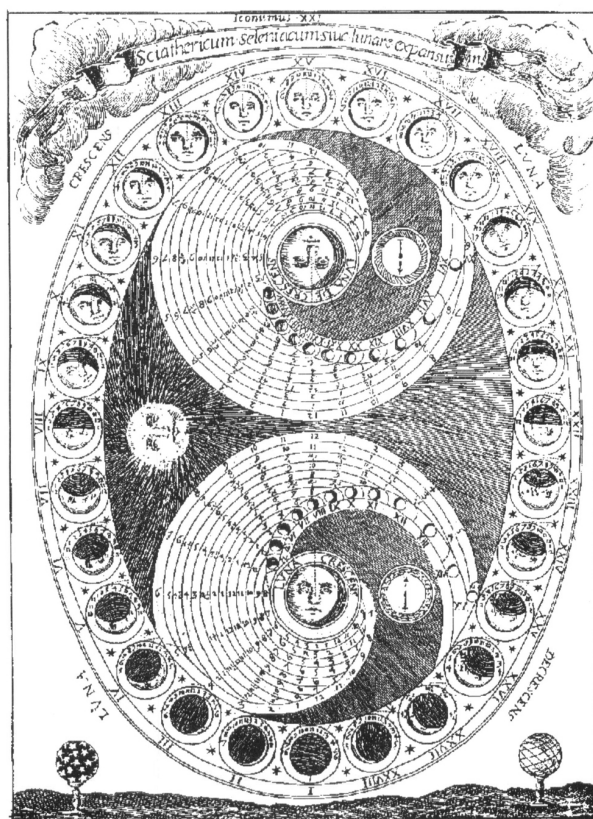


FIGURE 7: Kircher's *SCIATHERICUM SELENIACUM SIUC LUNARE EXPANSUM*

A MODERN REPRODUCTION OF AN 18th CENTURY 'UNIVERSAL' EQUINOCTIAL SUNDIAL

CHRISTOPHER ST. J.H. DANIEL

Thomas Stirrup, in his work on dialling, *'Horemtria Or the Compleat Diallist'*, published in London in 1652, describes the 'Equinoctial Diall' as follows:

"This Diall, though, of all other, he be the simplest, yet is he mother to all the rest, for out of him, as from a root, is derived the projectment of those 24 houre lines on any other great Circle or plane whatsoever".

It is for this reason that the symbol of the British Sundial Society takes the form of a 'universal' *equinoctial* sundial, albeit a portable dial, which, for artistic purposes, is depicted as an hour-ring, viewed in the N/S elevation, with the gnomon set in the vertical, in the equinoctial plane of the instrument.

Despite a common interest in the subject, not everyone is aware that the equinoctial sundial is the fundamental instrument from which all other dials are derived. Apart from the Society's symbol, the *armillary* sundial is of this class, as is the 'dolphin' sundial at the National Maritime Museum at Greenwich. Likewise, spherical dials and hemi-cylindrical scaphe dials, are amongst those which also come into this category.

Portable sundials were once in common use, as watches are today, for checking the time. Nowadays, however, they are rarely seen, except in certain museum collections or in those of private individuals, and in auction sales of scientific instruments. Consequently, whilst the symbol of the Society will be obvious to those who are familiar with portable sundials, it may not be so obvious to others.

Quite by coincidence, within the last three years, the Edenbridge firm of J.B. Developments, specialising in precision optical equipment, such as that used in the construction of the Channel Tunnel, used their subsidiary company, *Culpeper Instruments*, to produce just such a dial as the one symbolised in the logo of the Society. Also, by coincidence, they asked me if I would be prepared to produce an explanatory leaflet to accompany the instrument, with instructions on how to set it up and use it. I was only too pleased to accept this invitation, since it provided an opportunity to bring this fine-looking sundial to the attention of our members.

The firm of Culpeper Instruments takes its name from one of the most celebrated London instrument-makers of his day. Edmund Culpeper (1660-1738), who made various mathematical instruments in silver, brass, ivory and wood, including numerous sundials. From about the year 1706, Culpeper had premises at 'the Sign of the Cross Daggers', next to the 'Pope's Head' Tavern, near the Bethlem Gate in Moorfields. Culpeper Instruments have adopted this famous 'Cross Daggers' sign for their own logo, as a symbol of quality.

In keeping with their name and logo, Culpeper Instruments, make reproductions, in limited editions, of fine historic instruments, including telescopes, microscopes and a variety of other mathematical pieces. Such is their

reputation for excellence, that their different limited editions are much sought after by collectors and seldom appear to reach the open market in the normal way. I cannot recall ever seeing an advertisement for any Culpeper instruments, which, perhaps, gives some indication of the demand for their work.

One reason for this scarcity is the fact that the craftsmen, who produce these beautiful scientific masterpieces, are normally employed in the production of optical equipment for the parent firm, and tend to engage in their historic reproduction work only when there is a lull in normal business. Consequently, their 'limited editions' of historic instruments are indeed limited by other demands on their time.

Their latest limited edition is a portable 'universal' equinoctial sundial, taken from an 18th century design, made in polished brass, that can be set for any latitude in the northern hemisphere. With a little ingenuity, it can also be used equally well in the southern hemisphere, hence its 'universal' qualification. The dial may be orientated by means of a large magnetic compass, set into the base of the instrument, whilst the base-plate may be levelled by means of four levelling screws and a plumb-bob. To operate the instrument, the hour-ring must be clamped to the latitude arc or quadrant for the latitude of the place of observation. The gnomon must be set parallel to the axis of the earth, i.e. in the polar axis, by means of the compass and the dial must be perfectly level. The time may then be read off by observing the centre-line of the shadow of the gnomon on the silvered scale of the hour-ring. The time thus obtained will be Local Apparent (Solar) Time, to which a correction for longitude must be applied to obtain Standard Apparent Time. To obtain Standard Mean Time, i.e. 'Clock' Time, or, in the United Kingdom, Greenwich Mean Time (GMT), a correction for the *equation of time* must also be applied.

Whilst the hour-scale is graduated in divisions of hours, half-hours, quarter-hours and five-minute intervals, whereby the time may be gauged accordingly, the accuracy will depend on the correct setting of the instrument and its alignment in the meridian. In orientating the dial, care must be taken to allow for the local magnetic variation, although it may not be possible to correct for local magnetic anomalies. To steady the compass needle, there is a facility to allow it to be clamped and unclamped, which operation should be carried out very gently, to ensure an exact setting. Assuming that the instrument is correctly and carefully set up, then the dial may be read to an accuracy of within some five minutes.

This new Culpeper reproduction of an 18th century 'universal' equinoctial sundial weighing some 1.2kg (2lbs 10oz) and standing at 162mm in height (O.A.), is a magnificent example of modern craftsmanship and skill. It is also a beautiful example of the simplest of dials, that was in everyday use in the 17th and 18th centuries, the "mother to all the rest", namely the *equinoctial* sundial.

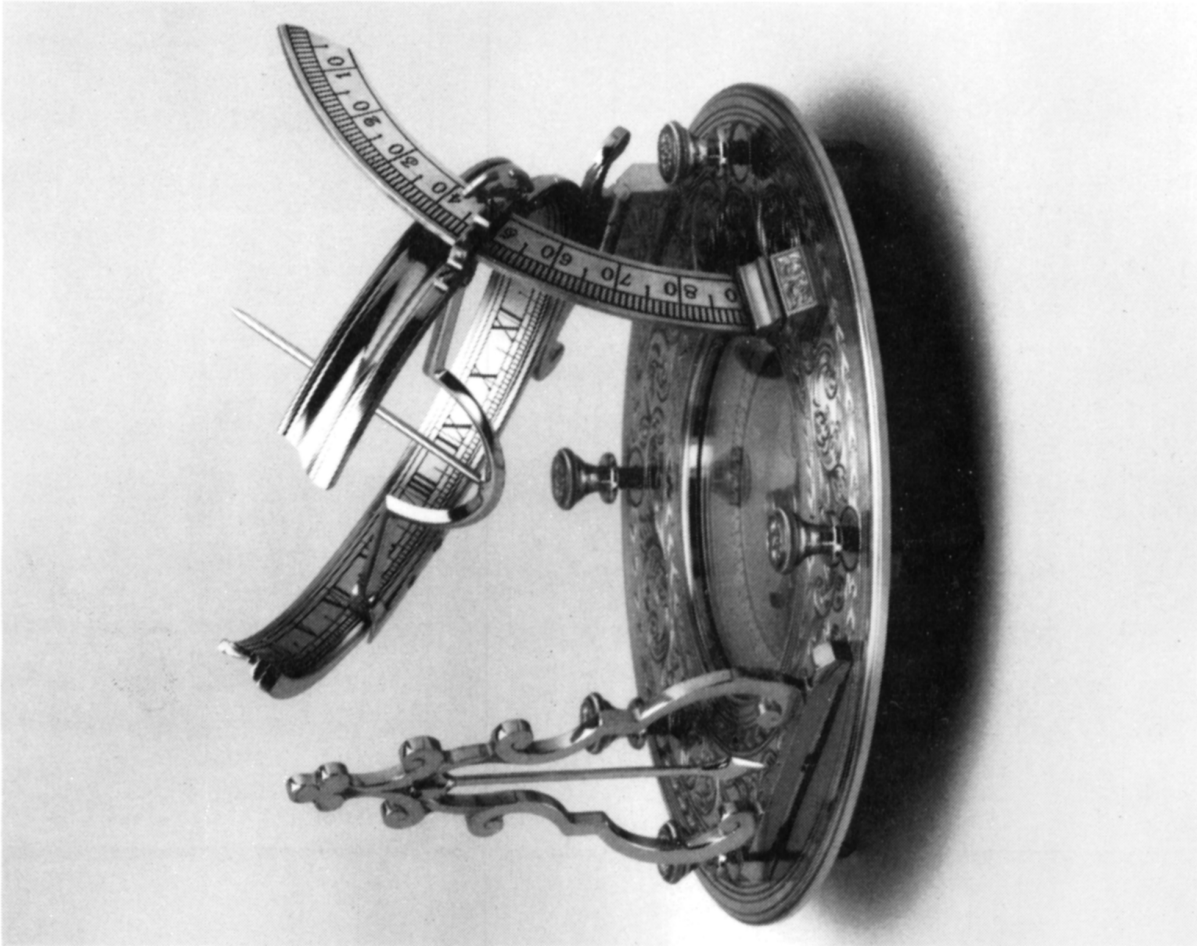


Photo A: "Universal" Equinoctial Sundial by Culpeper Instruments Limited. Taken from an 18th century design, the dial is set for $49\frac{1}{2}^{\circ}$ latitude (North)

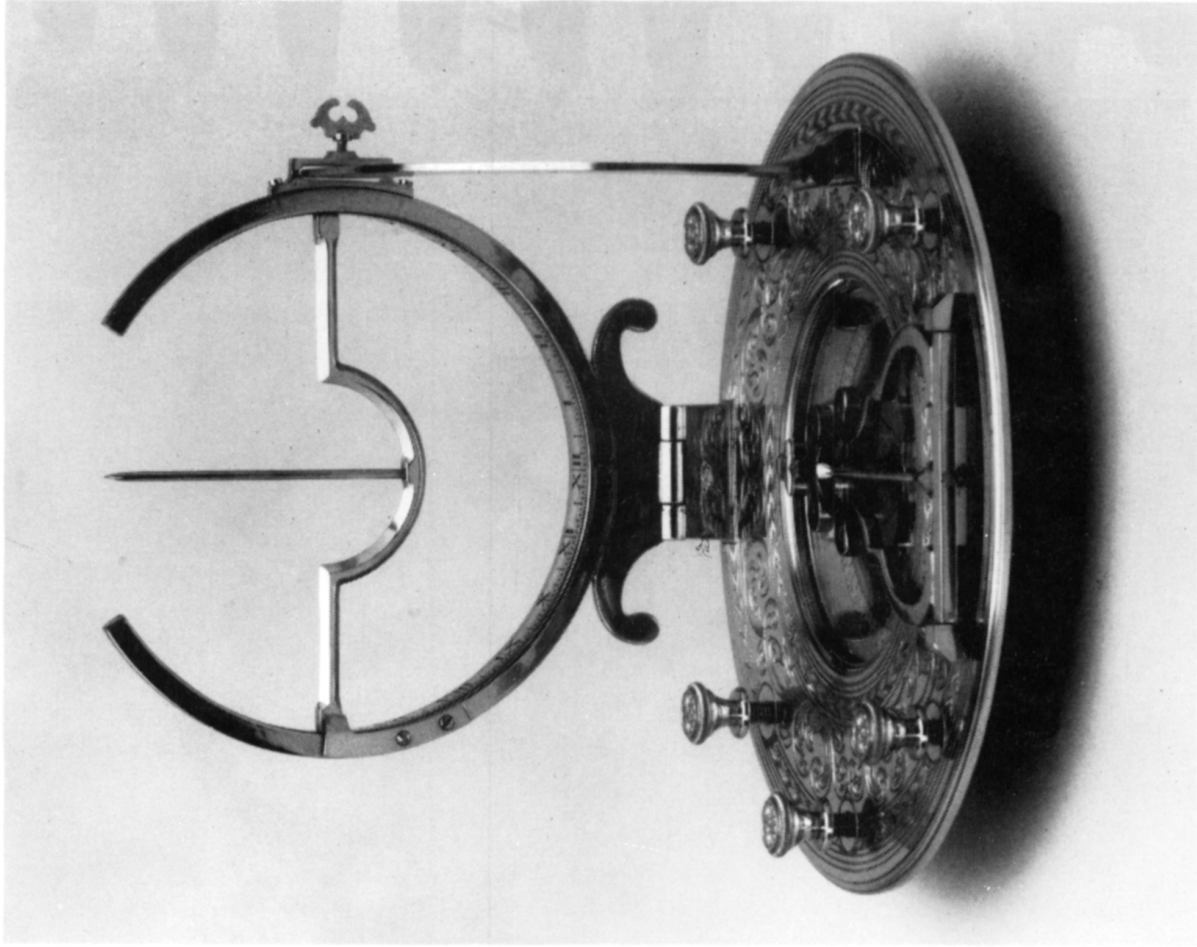


Photo B: The Equinoctial Dial symbol of the British Sundial Society - fundamental to the whole Art of Dialling



Photo C: "Universal" Equinoctial Dial set for Latitude 27° (North)

**THE CANTERBURY PENDANT:
A SAXON SEASONAL-HOUR ALTITUDE DIAL**
ALLAN A MILLS

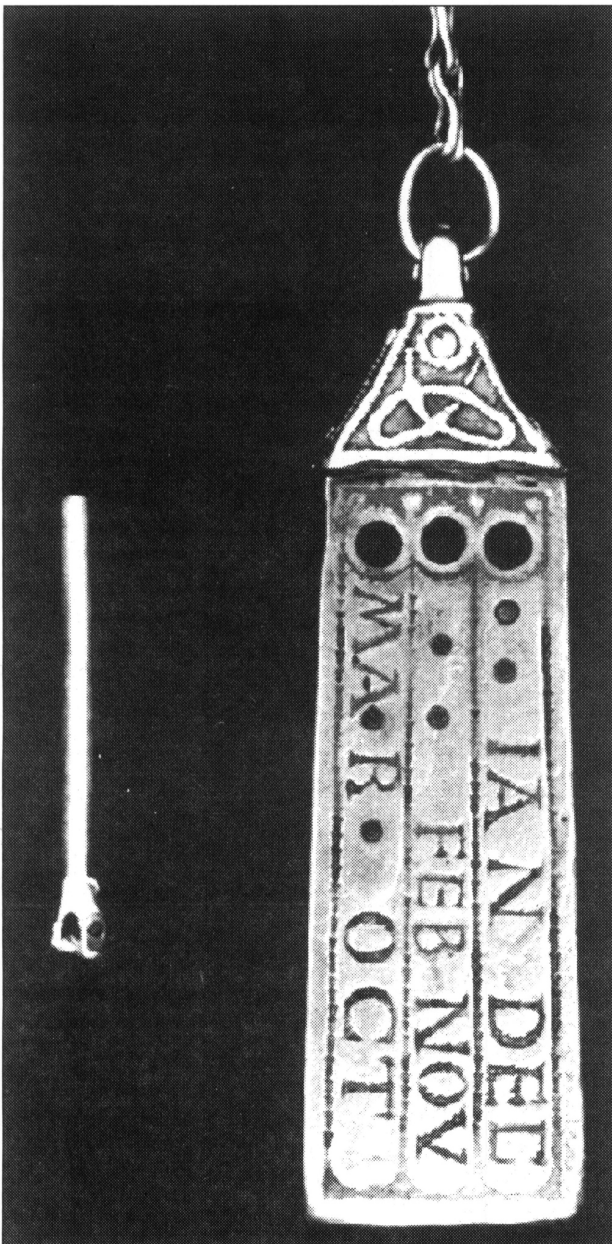


FIGURE 1: One face of the Canterbury dial

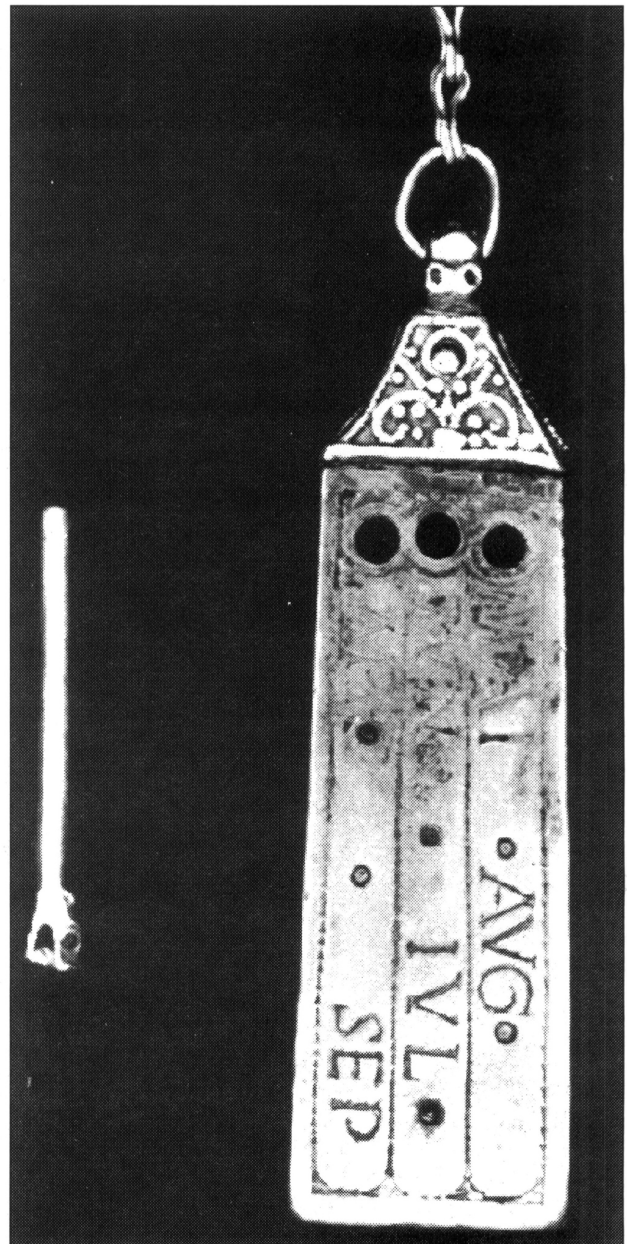


FIGURE 2: The alternate face

Late in 1938, a Saxon pocket sundial was found during alterations to the cloister garth at Canterbury Cathedral.^{1,2,3} The level of the soil had risen due to the number of burials there, and the 18th and 19th century tombstones were out of character with the surrounding architecture. Most of the memorials were therefore removed, the surface reduced to its original level, and the area turfed. It was during this levelling that the pendant was discovered at a depth of two feet, practically at the centre of the garth. It is possible that it had been buried with its original owner.

I am grateful to the Dean and Chapter of Canterbury Cathedral for allowing me to examine and photograph this unique object. Previously, only reproductions of a colour painting by Nowell Edwards have been published.⁴ However, an accurate replica made by Leslie Durbin⁵ in

1950 is on permanent exhibition in the Time Measurement gallery of the Science Museum, London (Inventory no. 1950-10). Other replicas, made in an edition of 750, were offered for sale by the Ransom Gallery, London, in 1975. Finally, a model showing the principle is in the Hullmut Kienzle Uhren-Museum, Schwenningen, Germany.⁶

DESIGN

The pendant takes the form of an approximately rectangular tablet of solid silver with a gold cap and chain, and is of excellent workmanship. Stylistically it has been ascribed to a Saxon origin in the 10th century.

Figure 1 shows one side of the tablet. Three columns bear the names of the months in pairs; Jan - Dec, Feb - Nov, and Mar - Oct, on a face that widens from 16 mm at

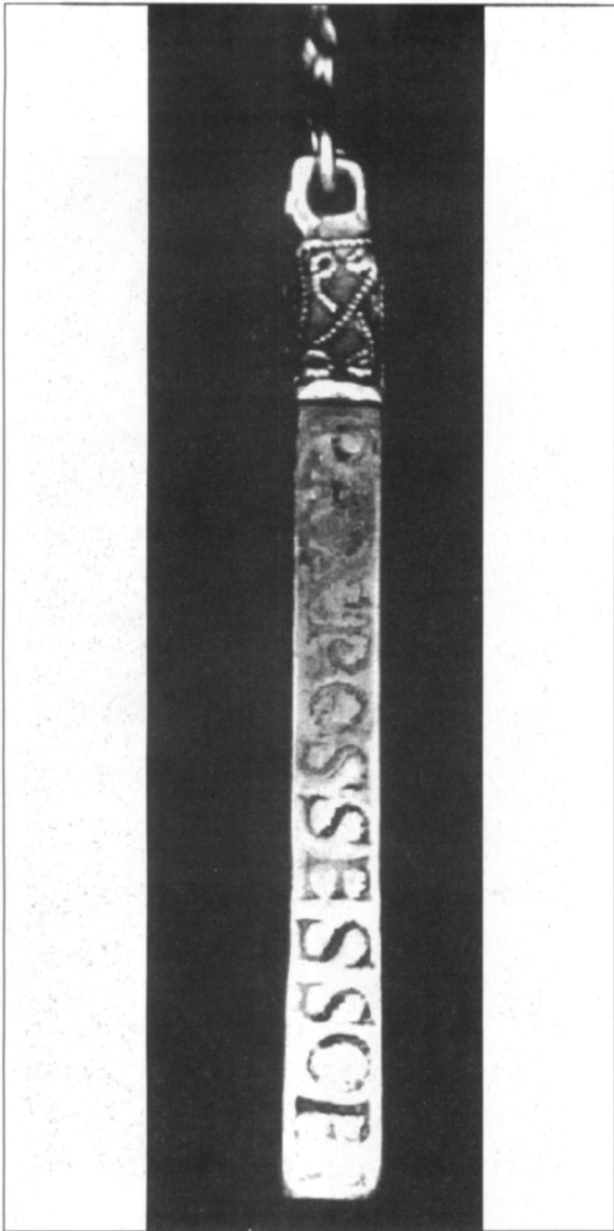


FIGURE 3: The 'Pax Possessori' edge



FIGURE 4: The 'Salus Factori' edge

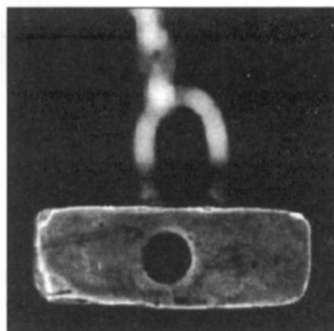


FIGURE 5: The base of the tablet, showing storage hole in which the gnomon was located when the instrument was found

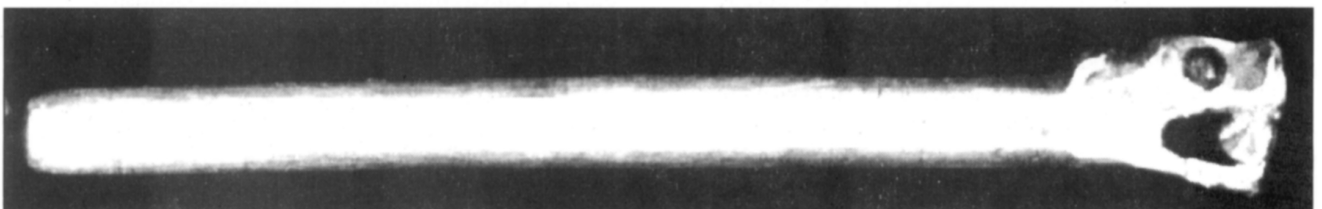


FIGURE 6: The pin gnomon with its decorative animal head. It is 2.3 mm in diameter and 30 mm long overall

the top to 18 mm at the bottom over a length of 49mm. The opposite face is similarly divided into three columns containing the month pairs Apr - Sept, May - Aug, and Jun - Jul, although from Fig. 2 it will be observed that the last two pairs are not in the expected sequence. The edges of the tablet are engraved Pax Possessori ('Peace to my Possessor') and Salus Factori. ('Salvation to my Maker'). These inscriptions are illustrated in Figs. 3 and 4 respectively.

An axial hole drilled upward from the base (Fig. 5) can accommodate the gnomon when not in use. The latter is a gold pin featuring a chased animal head with a ball in its mouth and greenish jewels for eyes (Fig.6). It is remarkable that this component has survived, for it is a very loose fit in the storage hole. The instrument must have been kept in a pouch or bag or some kind.

The suspension chain is terminated by another, very similar, animal head. Could the unusual design offer, in symbolism or heraldry, a clue to the identity of the original owner? Alternatively, a total solar eclipse was traditionally pictured as a dragon eating the Sun, and the design could conceivably commemorate such a dramatic solar event. The only total eclipse around the period in question, with a ground path crossing north Britain and north Germany, occurred on 29 October 878 (Ref. 7). It would have appeared as a partial eclipse at Canterbury.

FUNCTION

Examination of Figs. 1 and 2 will show that each column is surmounted by a hole, with a pair of dots at varying distances vertically below it. It may be deduced that the artefact is an altitude dial, employing the elevation (rather than the more usual azimuth) of the Sun to indicate the time of day. Because of its cyclic variation in declination the altitude of the Sun also varies with the time of year, so the designer of an altitude dial must allow for this by:

- a) Making provision for the entire instrument to be suspended vertically and then turned until its horizontally-projecting gnomon falls in the plane containing the observer and the Sun, thereby casting a shadow vertically downwards. This operation eliminates the effect of the changing azimuth of the Sun.
- b) Incorporating dated scales against which the gnomon must be positioned and the shadow length read. The tip of the gnomon is the time-marking index.

The dial patterns associated with altitude dials calibrated to read in either seasonal or equal hours have recently been derived and prepared for publication⁸.

When the Canterbury dial was examined in 1939 it appears to have been assumed that the blunt point of the gnomon was a push fit in the holes, so that it projected horizontally with the animal head as the shadow-casting index. This is not so: the pin slides easily through the holes until stopped by the decorative head, whereupon it projects 20 mm from the opposite face (Fig. 7). It also appears to have been assumed that the dial was intended to measure time in equal hours, for the reports referenced above mention '9 am' and '3 pm' as well as noon. This is clearly anachronistic: a sundial of this period would have divided the sunlit day into 12 seasonal hours. It is therefore suggested that in the Canterbury pendant dial:

- a) The lowermost dots represent noon. (Reference 3 incorrectly states the uppermost dots.)

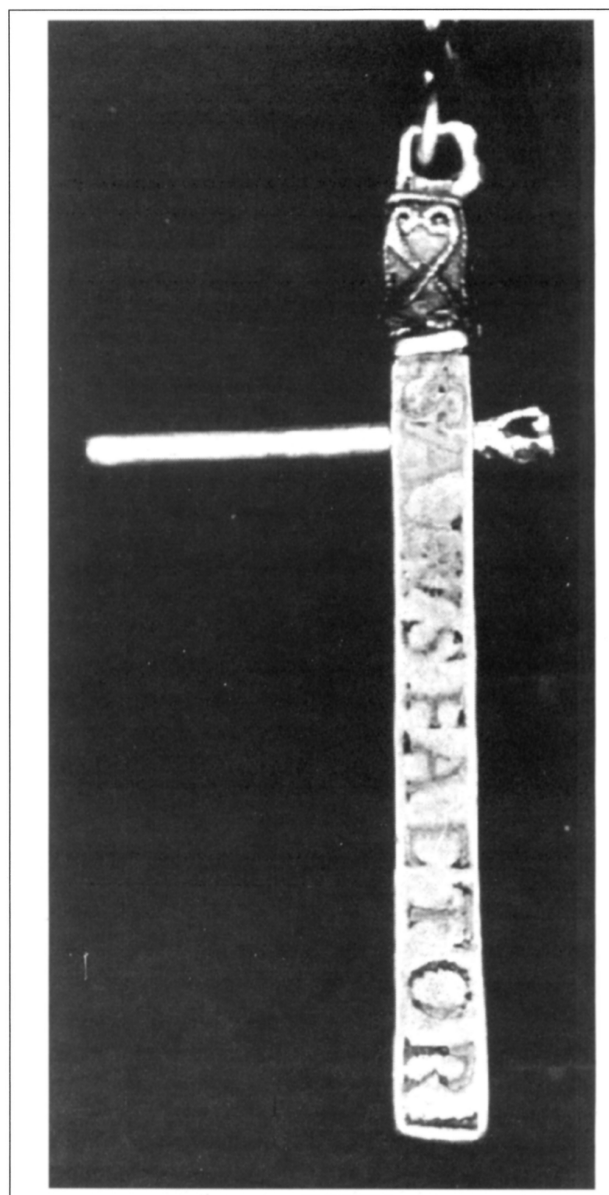


FIGURE 7: The gnomon fitted to the dial plate

- b) The upper dot of each pair was intended to mark the other traditional times for monastic prayer at mid-morning (end of the 3rd hour) and mid-afternoon (end of the 9th hour). The sunrise and sunset prayer times are self-evident.

Saxon dials are frequently stated to be calibrated in 'tides' according to an octaval division of the day, but Turner⁹ has questioned this. He points out that in any case the systems become identical for the 3rd and 9th hours as well as noon.

DIAL PATTERN OF AN ALTITUDE SUNDIAL

Calculation of the altitude dial for a given site requires knowledge of the Sun's altitude and azimuth at the corresponding latitude for specified times of day as the year proceeds. This involves transformation of the universal Right Ascension and Declination astronomical coordinates of the Sun into local altazimuth coordinates. Nowadays this is tedious rather than difficult with spherical trigonometry and an electronic pocket calculator to expedite the numerical work,¹⁰ but the calculation set a formidable problem in the past, particularly for a seasonal hour calibration.

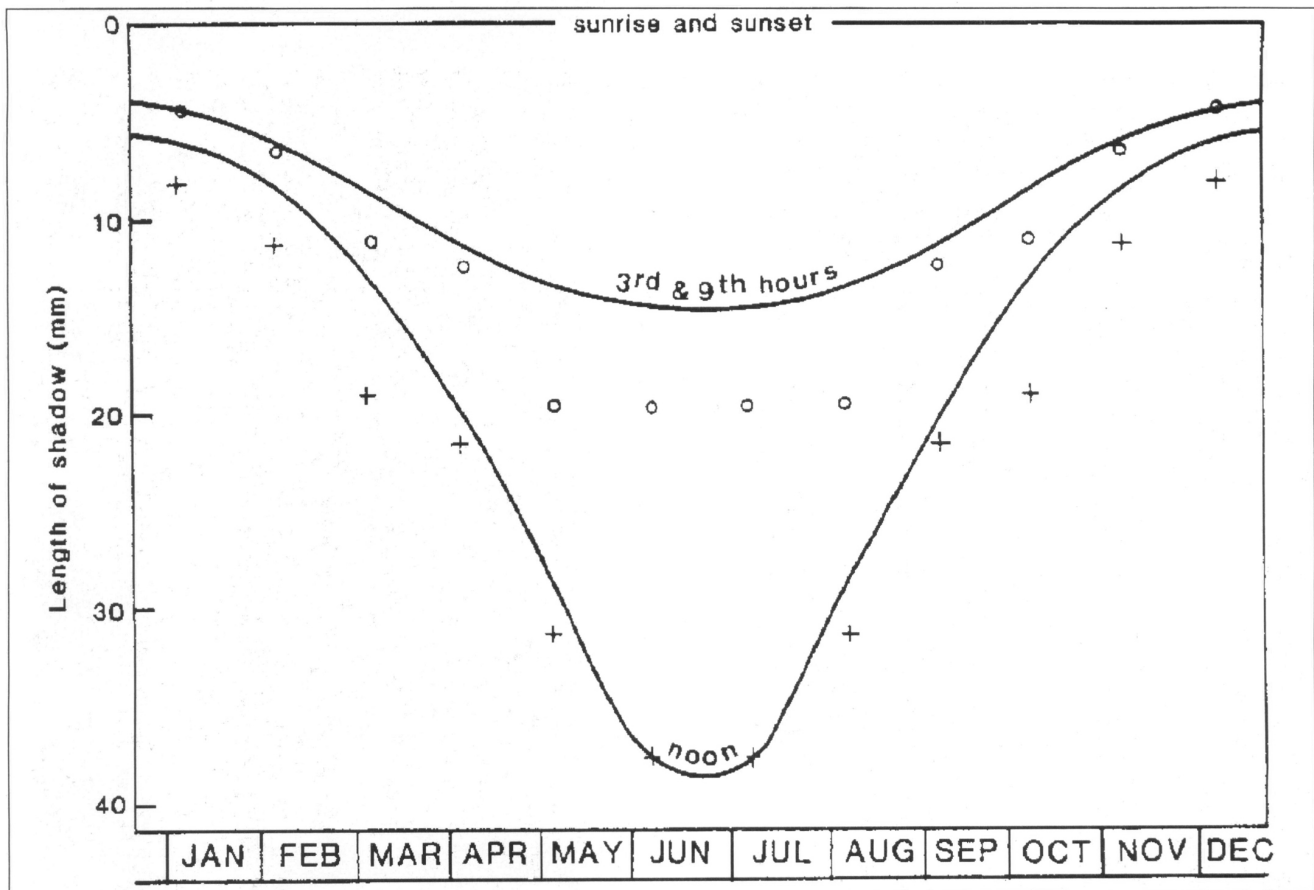


FIGURE 8: The full curves show the theoretical shadow lengths cast by a 20 mm horizontal gnomon during the course of the year. The circles mark the actual lengths to the 3rd/9th hour dots, and the crosses to the noon dots, on the Canterbury dial.

Until logarithm tables became generally available in the second half of the 17th century the best solution was probably the use of a mechanical analogue computer known as a *torquetum*.⁸ Although quite well known in mediaeval times, this apparatus is now commonly misunderstood: it was a computational rather than an observational instrument, and as such invaluable to the practical sundial designer. Thus, a well-made example is to be seen amongst the dialling instruments featured in Holbein's famous painting 'The Ambassadors',¹¹ and it would not be obsolete even today for those who prefer practical derivation to abstract calculation.

The latitude of Canterbury is $51^{\circ}17'$, fortuitously close to the 51° examples worked out in references 8 and 10. Fig. 8 has therefore been plotted from data published in reference 8, and shows on rectangular coordinates the length of shadow at noon, and at the dimensionally equivalent 3rd and 9th hour terminations, thrown by a 20mm horizontal gnomon during the course of the year. The curves are symmetrical, although the vagaries of our calendar for month lengths, leap years etc, do cause difficulties with dates. In particular, it will be noted that the axis of symmetry passes through the summer solstice on June 21st, not through the June/July boundary, reflecting the unequal durations of the seasons.

ACCURACY OF THE CANTERBURY DIAL

The dimensions associated with the Canterbury pendant are shown in Table 1. These points have been marked on Fig. 8. It will be seen that:

- There is good agreement with the noon curve around the summer solstice, when the shadow is at its longest and is changing relatively slowly, so is easiest to mark accurately. It is therefore thought that the instrument was commissioned by a senior cleric resident at Canterbury rather than being brought from some other place of different latitude.
- There is good agreement with the 3rd/9th hour curve at the winter solstice, when the shadow length is minimal and changing slowly. However, as the corresponding distance to the noon mark is much too great, this agreement may be fortuitous.

TABLE 1

Months	Distance from centre of gnomon hole (mm)	
	To upper dot	To lower dot
Jan & Dec	4.2	8.0
Feb & Nov	6.6	11.5
Mar & Oct	11.5	18.7
Apr & Sep	12.7	21.7
May & Aug	19.5	31.5
Jun & Jul	19.5	37.7

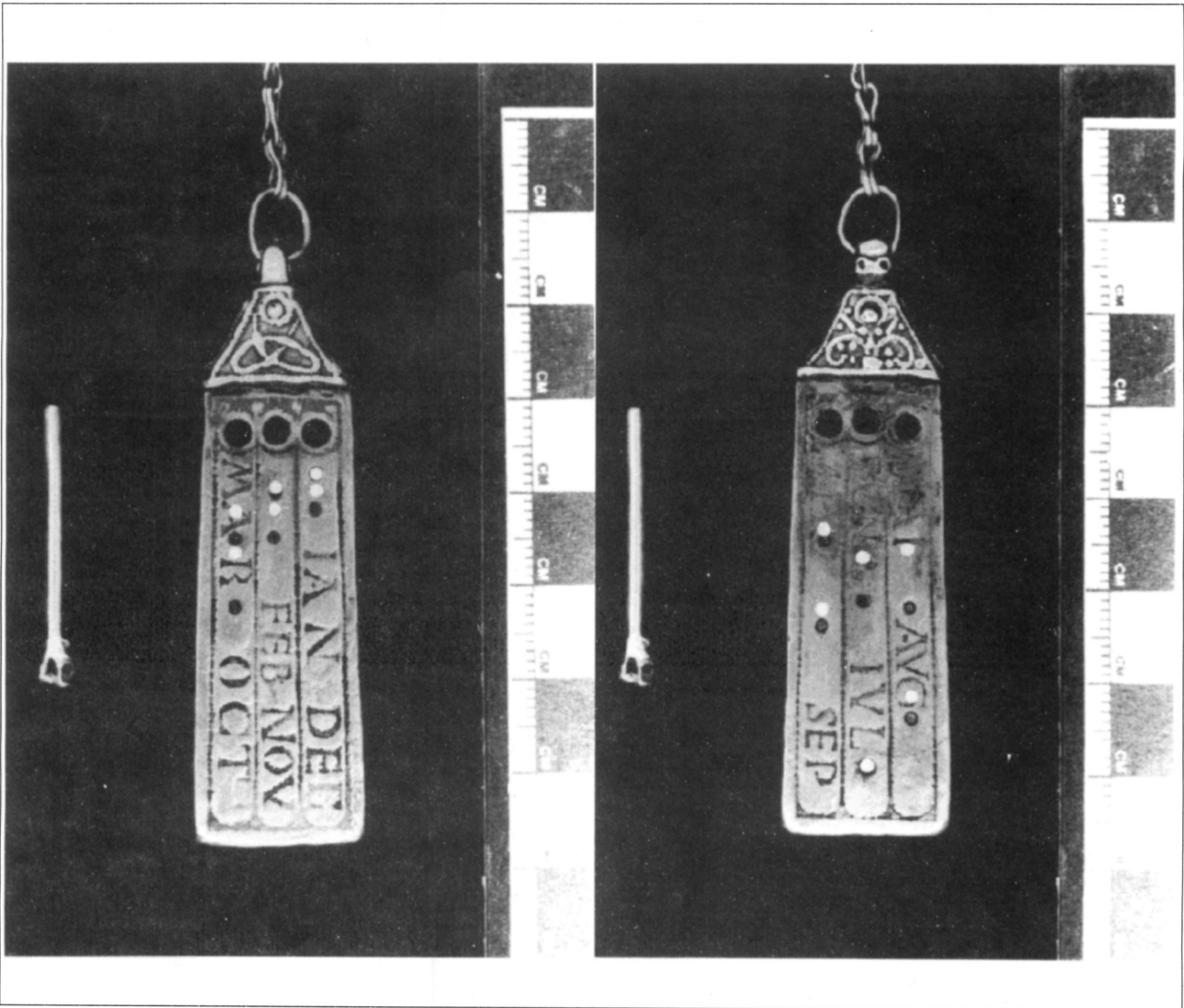


FIGURE 9: An improved calibration: the white spots mark corrected positions for the dots.

FIGURE 10: Alternate face of the recalibrated dial

- c) In general, agreement between theoretical and actual points is poor, the latter tending to be too far from the base of the gnomon. In particular (as noticed long ago by Ward and Chew of the Science Museum) the 3rd and 9th hour dots for May-August should obviously be closer than the June-July positions.
- d) The maker has, however, not simply placed the upper dots halfway between the gnomon and the lower 'noon' dots, which would be the equivalent of the crude '45°' mass dial.¹²

It is concluded that the knowledge of the craftsman (or his adviser) was not quite up to the level of sophistication required to design an accurate seasonal-hour altitude dial. However, it was not long before others demonstrated such an ability.⁸ Of course, in the absence of any other timekeeper errors would not be apparent to the owner of the dial - or to the monks in his charge!

A MORE ACCURATE VERSION

Twelve equal divisions with a mid-point at the summer solstice were marked-out along the time coordinate of Fig.8: their boundaries tended to fall around the end of the

first week in each calendar month. The intersections with the curves then gave the theoretical lengths of the shadow for symmetrically paired dates in the year. The results are entered as white spots on Figs. 9 and 10.

NOTES AND REFERENCES

1. Anon., 'Saxon Pocket Sundial', *13th Annual report of the Friends of Canterbury*, 1938.
2. Anon., 'Saxon Pocket Sundial Found at Canterbury', *The Times* 1939 July 31st, p.9.
3. Anon., 'Saxon Time Measurement', *Nature* **144** (1939) 238-9.
4. In monochrome in references 1 and 2, and in colour as a postcard sold at the cathedral in 1939. An example of the latter is on file at the Science Museum, but unfortunately the original painting can no longer be located.
5. Anon., *Illustrated London News* 1950 June 17th, p.928.
6. A.E. Waugh, *Sundials: Their Theory and Construction*, Dover, N.Y. 1973, pp. 166-7.
7. T.R. von Oppolzer (trans. O. Gingerich), *Canon of Eclipses*, Dover, N.Y. 1962. Eclipse no. 4967, shown on chart 100 and page 200.

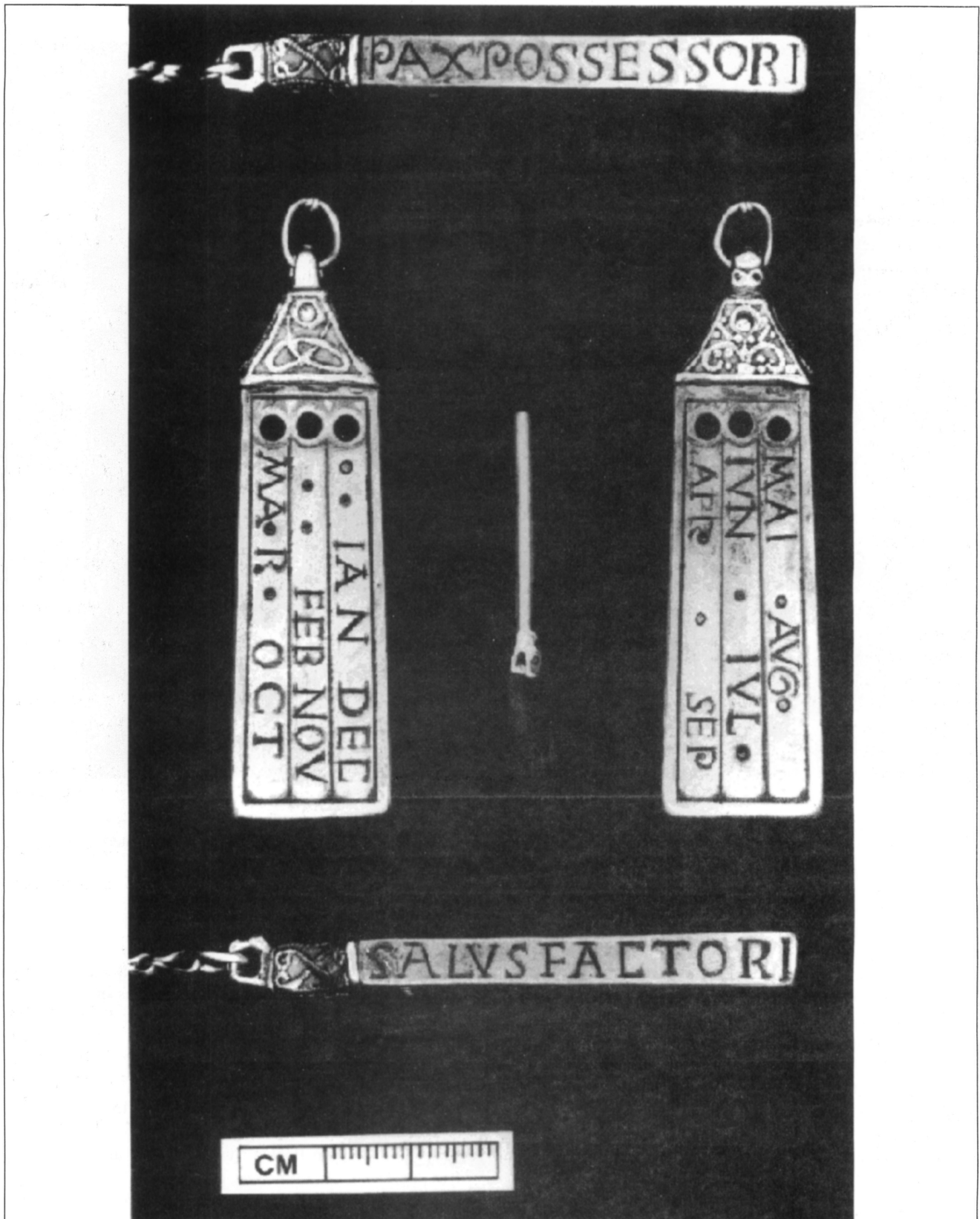


FIGURE 11: COMPOSITE VIEW OF CANTERBURY PENDANT - NOTE - LETTERING HAS BEEN ENHANCED

8. A.A. Mills, 'Altitude sundials for Seasonal and Equal Hours', *Annals of Science* In press.
9. A.J. Turner, 'Anglo-Saxon Sun-Dials and the 'Tidal or 'Octaval' System of Time Measurement', *Antiquarian Horology* **15** (1984) 76-77.
10. H.R. Mills, *Positional Astronomy and Astro-Navigation Made Easy*, Wiley, N.Y. 1978.
11. C.K. Aked, 'Sundials in Illustrations' and P. I.

- Drinkwater, 'The Dialling Instruments Depicted in Holbein's Painting 'The Ambassadors'', both in *Bull. Brit. Sundial Soc.* 1994 Feb pp.12 and 28-29 respectively.
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PLAIN SUNDIALS

STUART R.C. MALIN

Now that they are part of the National Curriculum, there is a renewed interest in sundials. This note presents the mathematical basis for the design of sundials for any orientation and for any location in the world. It should not be difficult to follow if your A-level maths is not too rusty, and even if the equations have to be taken on trust, they can still be used to calculate the hourlines. This can be done with the aid of a pocket calculator, but it is a tedious calculation and it would be much better to write a program for a domestic computer. I have listings in BASIC and FUTURE BASIC which I would be happy to supply.

TERMINOLOGY AND GENERAL CONSIDERATIONS

In this section technical terms, or words that will be used as such, are italicised when they first appear. Since most of them will already be familiar, formal definitions are not generally given.

The garden sundial is the commonest sort, with a horizontal *dial* marked with *hourlines*. On this is mounted a *gnomon* with one edge (the *style*) parallel to the earth's axis of rotation, i.e. pointing towards the pole star. The shadow cast by the style onto the dial indicates the time. But the dial does not have to be horizontal. A *vertical sundial* can be mounted on a south facing wall; if the wall faces any direction other than south, it is said to be a *declining sundial*. Or it can be at an angle between the horizontal and the vertical, when it is a *reclining sundial*. In fact the dial can face in any direction, even north, though the usefulness of such a sundial would be rather limited unless you happened to be in the southern hemisphere. In all cases, the style must be parallel to the earth's axis. This is so that the shadow line will be independent of the sun's declination.

The foregoing refers to *gnomonic sundials*. These tell *apparent solar time*, usually *local time*, though Greenwich or any other meridian time is an option. Apparent solar time was fine until mechanical clocks became sufficiently accurate to make every day and every hour the same length. They indicate *mean solar time* which differs from apparent solar time by the *equation of time*. This varies throughout the year, but can amount to more than 15 minutes. Since mean solar time is now used almost universally (some Islamic countries still use apparent solar time for religious purposes), it would be useful to have a mean-time sundial. This can be done by adding a table of corrections to the information on the dial, but is more elegantly achieved by having an *analemmic sundial* with curved hourlines and a shadow cast by a point rather than an edge. For convenience we will consider this point to be the end of a *prong* which is perpendicular to the dial; more imaginative designs are, of course, possible. An *analemma* is the elongated figure-of-eight curve commonly inscribed on terrestrial globes to show the point of intersection of the Earth with the line joining the Sun to the centre of the Earth at Greenwich mean noon on each day of the year. The north-south extension is from the tropic of Cancer to the tropic of Capricorn as the sun's declination changes between $\pm 23^\circ$, and the east-west displacement is the equation of time, with one hour corresponding to 15 degrees of longitude. (It is often convenient to measure time in angles rather than hours with $1h = 15^\circ$. All angles

used here are in degrees unless stated otherwise.)

The analemma on a globe is effectively the noon hourlines for a sundial with the end of its prong at the centre of the globe. The other hourlines would be similar shapes at intervals of 15 degrees of longitude. Since, however, we are concerned with flat dials rather than a transparent globe (though that is an interesting possibility for a sundial) our hourlines will be distorted analemmas.

To complete the terminology, it would be nice to reintroduce the word *wabe*, coined by Lewis Carroll in "Alice through the looking glass" as the place where slithy toves gyred and gimbled, and subsequently explained to Alice by Humpty Dumpty as being the grass-plot round a sundial.

COORDINATES OF THE SUN

The position of the Sun can be specified by its declination, δ , and its hour angle, h . Declination is measured from the equator, north positive, and hour angle is measured westwards from the meridian in the plane of the equator.

Declination changes only slowly with time, going from -23.4° at the December solstice to $+23.4^\circ$ at the June solstice, and back again during the next six months. To an adequate approximation for sundials

$$\sin \delta = -\sin 23.4 \cos (T + 2 \sin T) \quad (1)$$

where T denotes time increasing from 0° at one December solstice to 360° at the next. From (1) δ and $\cos \delta$ may easily be calculated.

The hour angle changes more rapidly, going through a complete cycle every day. If t denotes the number of hours after 12 noon, then

$$h = 15t + E \quad \text{if you are using local noon,} \quad (2a)$$

$$h = 15t + E + \lambda \quad \text{if you are using Greenwich noon} \quad (2b)$$

and

$$h = 15t + E + \lambda - S \quad \text{if you are using standard meridian noon} \quad (2c)$$

Which of these 3 equations you use will depend on the sort of mean time you want the sundial to tell. For a gnomonic sundial the times are apparent rather than mean, and E is set to zero. In equations (2) E denotes the equation of time, λ denotes the east longitude of the site and S denotes the east longitude of the standard time meridian.

We may approximate E by

$$E = -1.84 \sin(T - 14) - 2.5 \sin 2T \quad (3)$$

DIRECTION COSINES

If we have a three-dimensional right-handed rectangular coordinate system, for example this page with the x -axis to the right, the y -axis towards the top and the z -axis towards you perpendicular to the page, we can specify the direction of any point from the origin of this system by giving the x , y and z coordinates of a line of unit length in the direction of the point. These are the direction cosines, usually denoted l, m, n . Note that $l^2 + m^2 + n^2 = 1$. By a right-handed system we mean that a normal corkscrew, when turned through 90° from the x -axis to the y -axis, would move towards z .

To change from one coordinate system, say x,y,z with O , to another system X,Y,Z with the same origin, we need to know the direction cosines of the new axes in the old system. Let those for the X -axis be l_1, m_1, n_1 ; for Y : l_2, m_2, n_2 , and for Z : l_3, m_3, n_3 . Then the direction cosines of our chosen point in the new system will be

$$L = l_1 l + m_1 m + n_1 n, \quad (4a)$$

$$M = l_2 l + m_2 m + n_2 n, \quad (4b)$$

$$\text{and } N = l_3 l + m_3 m + n_3 n. \quad (4c)$$

The only other requirement will be the equation of a line with direction cosines l,m,n and passing through the point (x_1, y_1, z_1) .

$$\text{This will be } (x-x_1)/l = (y-y_1)/m = (z-z_1)/n. \quad (5)$$

SUNDIAL THEORY

We start with the direction of the Sun in an equatorial coordinate system with origin at the centre of the Earth, x towards the point where the meridian of the sundial intersects the equator, y 90° east of this and z towards the north pole. If the sun's declination is δ and its hour angle h , then it will have direction cosines l,m,n ,

$$\text{where } l = \cos\delta \cos h, \quad m = -\cos\delta \sin h \quad \text{and } n = \sin\delta, \quad (6)$$

(see figure 1).

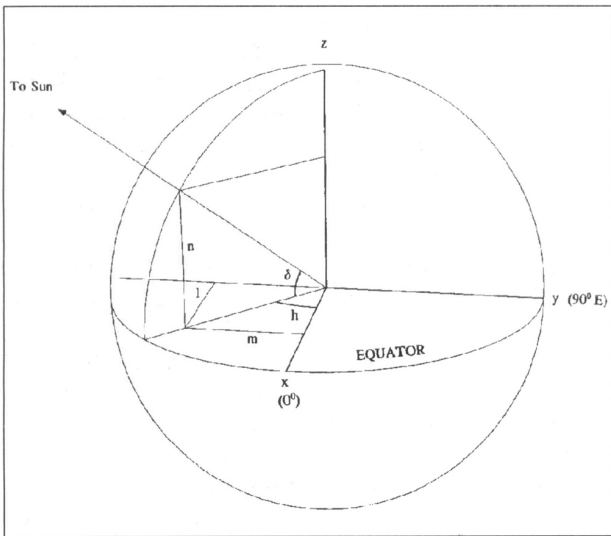


Figure 1: The x, y, z system

Now we rotate to a new (altazimuth) coordinate system based on the site of the sundial, with origin at the sundial, x' towards the south y' to the east and z' towards the zenith. (The change of origin from the centre to the surface of the Earth does not affect the direction of the Sun because it is so remote.) In the x,y,z system, the direction cosines of the x' -axis are

$$l_x = \sin\phi, \quad m_x = 0, \quad n_x = -\cos\phi, \quad (7a)$$

$$\text{those of the } y'\text{-axis are } l_y = 0, \quad m_y = 1, \quad n_y = 0 \quad (7b)$$

and those of the z' -axis are

$$l_z = \cos\phi, \quad m_z = 0, \quad n_z = \sin\phi, \quad (7c)$$

where ϕ denotes the latitude of the sundial (see figure 2).

In the x',y',z' system, the direction cosines of the Sun will be $l'm'n'$, where (using equations 4 and 7)

$$l' = l_x l + m_x m + n_x n = l \sin\phi - n \cos\phi, \quad (8a)$$

$$m' = l_y l + m_y m + n_y n = m \quad (8b)$$

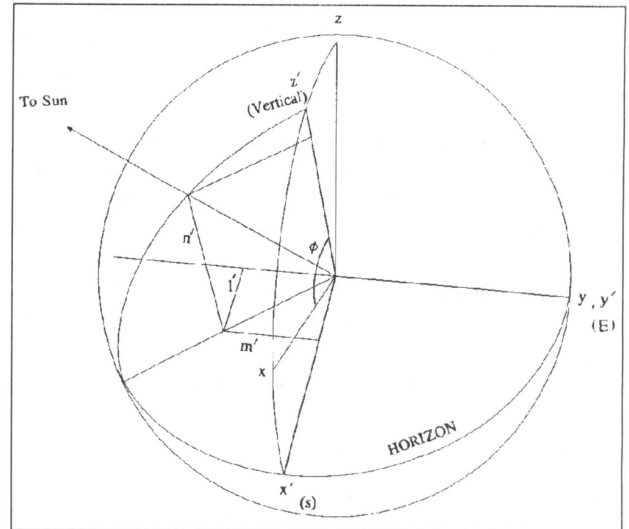


Figure 2: The x', y', z' system

$$\text{and } n' = l_z l + m_z m + n_z n = l \cos\phi + n \sin\phi. \quad (8c)$$

Note that the Sun is below the horizon when n' is negative, so no shadow will be cast. We could also have substituted for l, m and n in terms of δ and h from equation 8, but there is no point in doing so as it complicates the algebra unnecessarily.

The final rotation is to a coordinate system based on the dial itself (if it is horizontal we are already there). We could have gone directly from equatorial to dial coordinates in one rotation, but then we would need to specify the orientation of the dial in equatorial coordinates, which is inconvenient, and it would not have been obvious when the

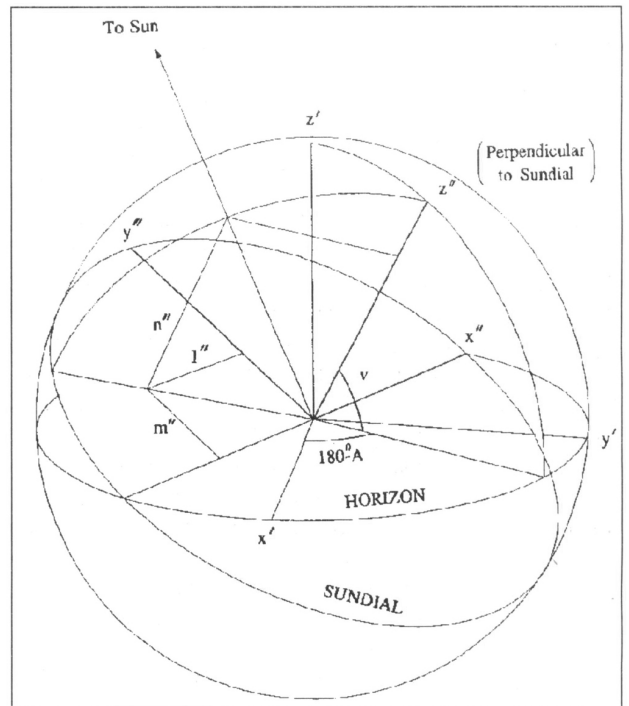


Figure 3: The x'', y'', z'' system

Sun was below the horizon.

Dial coordinates (x'', y'', z'') may be defined with the origin, O , on the dial, the x'' -axis in the plane of the dial, horizontal and to the right. (There will always be a horizontal line on the dial; imagine it submerged in a bowl

of water up to O, then the x'' -axis is the water line. For a horizontal dial, any direction will do.) The y'' -axis is 90° anticlockwise from the x'' -axis (looking from the front of the dial), along the line of greatest slope for all except horizontal dials, and the z'' -axis points perpendicularly out of the dial. The orientation of the dial may be specified by the altitude, v , of the z'' -axis above the horizon and its azimuth, A , measured clockwise from north, i.e. going from north to east to south to west. See figure 3. For a horizontal dial, $v=90^\circ$ and A may be set to 180° to give north at the top.

Following the same procedure as before, in x',y',z' coordinates the direction cosines of the axis are:

$$\text{for } x'' \quad lx' = -\sin A, \quad mx' = -\cos A, \quad nx' = 0, \quad (9a)$$

$$\text{for } y'' \quad ly' = \sin v \cos A, \quad my' = -\sin v \sin A, \quad ny' = \cos v \quad (9b)$$

$$\text{and for } z'' \quad nz' = -\cos v \cos A, \quad mz' = -\cos v \sin A, \quad nz' = \sin v. \quad (9c)$$

So the direction cosines of the Sun in this system are

$$l'' = lx'l' + mx'm' + nx'n', \quad (10a)$$

$$m'' = ly'l' + my'm' + ny'n', \quad (10a)$$

$$n'' = lz'l' + mz'm' + nz'n', \quad (10c)$$

Note that the Sun will be below the dial when n'' is negative, so no shadow will be cast. All the quantities on the right hand sides of equations (10) are available from equations (6), (8) and (9), but again substitution would merely confuse.

The coordinates of a prong of length D pointing out perpendicularly from the origin (i.e. along the z'' -axis) will be $(0,0,D)$ in the x'',y'',z'' system. The equation of a line through the end of the prong and directed towards the Sun will be

$$x''/l'' = y''/m'' = (z''-D)/n'' \quad (\text{c.f. equation 5}).$$

This line intersects the plane of the dial when $z''=0$, i.e. when

$$x'' = -l''D/n'' \quad \text{and} \quad y'' = -m''D/n''. \quad (11)$$

So these values of x'' and y'' are the coordinates of the point on the dial where the shadow of the end of the prong will fall. This completes the requirements for calculating the hourlines on an analemmic sundial.

With a gnomonic sundial the style points towards the pole rather than being perpendicular to the dial. (Or away from the pole, if the pole is below the dial. In that case the signs of its direction cosines all reverse, from here to equation 12c, inclusive. The criterion is that N should be positive.) Going through the same transformations as before, the direction cosines of the style are:

in equatorial coordinates $0,0,1$,

in altazimuth coordinates $-\cos\phi, 0, \sin\phi$

and in dial coordinates L,M,N ,

$$\text{where } L = \sin A \cos\phi, \quad (12a)$$

$$M = -\sin v \cos A \cos\phi + \cos v \sin\phi \quad (12b)$$

$$\text{and } N = \cos v \cos A \cos\phi + \sin v \sin\phi \quad (12c)$$

If the style goes through the origin, the coordinates (L,M,N) represent a point on the style. The line through this point in the direction of the Sun (see equation 7) is

$$(x''-L)/l'' = (y''-M)/m'' = (z''-N)/n'',$$

which intersects the dial when $z''=0$, i.e. when

$$x'' = L - l''N/n'' \quad \text{and} \quad y'' = M - m''N/n''. \quad (13)$$

Since hour lines on a gnomonic dial are straight lines through the point where the style intersects the dial (which

we have chosen to be the origin), a single point on an hourline is all that is needed. If angles anticlockwise from the x'' -axis are preferred, these are given by $\arctan(y''/x'')$.

Although the hourlines on a gnomonic sundial are independent of δ , it is not difficult to set $\delta=0$. This is because, when $\delta=0$, the Sun is above the horizon only between 6am and 6pm local apparent time, whereas it can cast shadows well outside this range in summer (up to 24 hours a day at latitudes greater than $\pm 66.6^\circ$). Also, for certain orientations of the dial, the condition that n'' should be greater than zero for the Sun to be above the plane of the dial is met for only a limited range of δ at some hours. For these reasons it is necessary to use both $\delta=+23.4^\circ$ and $\delta=-23.4^\circ$.

There is a special case when $N=0$. In this case the style would lie flat on the dial and cast no shadow (for example, a vertical declining dial facing east). The solution is to mount the style parallel to the dial at a distance D above it. Then one of the style-Sun lines will pass through the point (L,M,D) and its equation will be $(x''-L)/l'' = (y''-M)/m'' = (z''-D)/n''$. This will intersect the dial at $x'' = L - l''D/n''$ and $y'' = M - m''D/n''$, giving one point on the hourline. Another point on the style is $(0,0,D)$ leading to another point on the hourline at $x'' = -l''D/n''$ and $y'' = -m''D/n''$. The hourline is a straight line through these two points.

This provides the information required for plotting the hourlines, but it would also be useful to know the orientation and angle of the gnomon relative to the dial. Although there are many possible ways of mounting the gnomon, it is convenient to think of it as a triangular lamina with its plane perpendicular to the dial. It can then be specified by the angle θ between the style and the dial, and the line of intersection with the dial. The angle θ is given by

$$\theta = \arcsin N.$$

The line of intersection with the dial passes through the origin and the point (L,M) ; it makes an angle $\arctan(M/L)$ with the x'' -axis.

Finally, for summertime the hour is increased by 1. This is perhaps best allowed for by a note on the dial rather than by additional numbers on the hourlines.

COMPUTATIONAL PROCEDURE

The calculation of the hourlines for a gnomonic sundial is not too laborious by hand, but for an analemmic sundial it would be very tedious and the use of a computer is strongly recommended. This section is intended to facilitate computer programming.

Instructions exclusive to analemmic dials are enclosed in brackets [thus] and those exclusive to gnomonic dials are in braces {thus}. Arabic numerals in parentheses refer to equation numbers, e.g. (9).

- (i) Enter the sundial constants: ϕ, λ (zero for local time), S (zero for Greenwich or local time), $v, A, [D]$.
- (ii) Evaluate $\sin\phi, \cos\phi, \sin v, \cos v, \sin A, \cos A$.
- (iii) Start with the hourline for $t=-12$, i.e. midnight.
- (iv) Start with $T=0$, i.e. the December solstice.
- (v) Evaluate: $\sin\delta$ (1), $\cos\delta$; $[E$ (3)] {set E to zero}; h (2), \sinh, \cosh ; l, m, n (6); l', m', n' (8) if n' is negative go straight to step (vii); l'', m'', n'' (9) and (10) if n'' is negative go straight to step (vii); $[x'', y''$ (11)] $\{L, M, N$ (12); x'', y'' (13)}.
- (vi) Output (print or plot) $x'', y'' \{L, M, \theta$ and t .
- (vii) Unless $T=[360^\circ] \{180^\circ\}$, increase T by $[10^\circ] \{180^\circ\}$ and repeat from (v).

(viii) Unless $t=11$, increase t by 1 and repeat from (iv).

For more detail on an analemmic dial, smaller increments than 10° may be used at step (vii). Similarly, if lines are required at intervals of less than 1 hour, change the increment and terminal value of t at step (viii).

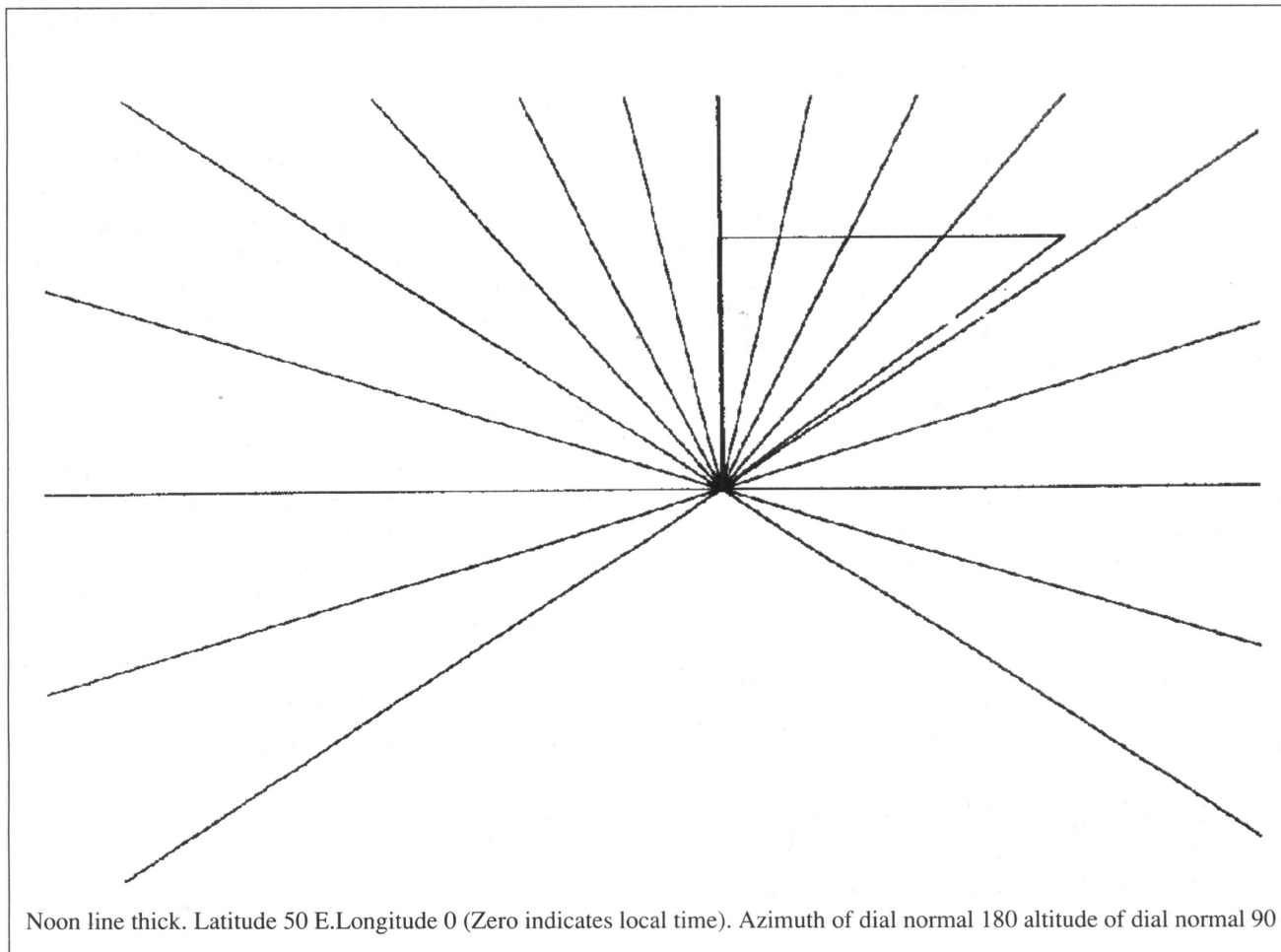
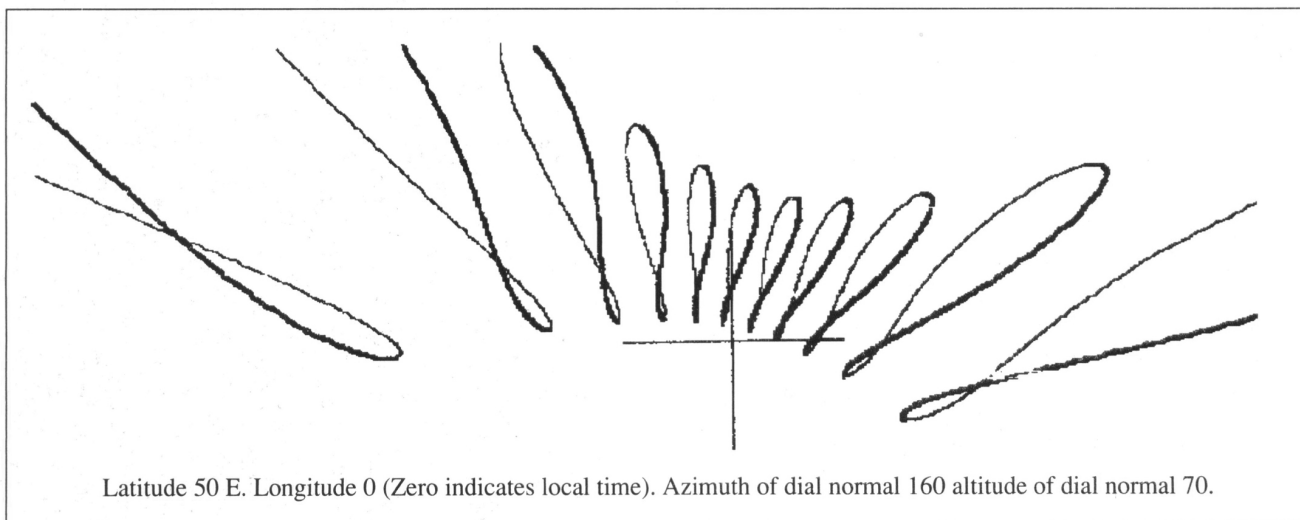
FURTHER POSSIBILITIES

This study has been confined to flat sundials. By relaxing this constraint a vast number of other sundial designs is possible, many with interesting and elegant properties, for example, the transparent spherical sundial alluded to in the "terminology" section. The mathematical approach given here is readily adapted to such cases by replacing the equation of the plane of the dial with the equation of the

shape required, and finding where this intersects with the shadow line. A sphere of radius r , centred on $(0, 0, D)$, would have the equation $x^2 + y^2 + (z - D)^2 = r^2$. I was recently asked to design a sundial to go on a cylindrical chimney; the equation of a vertical cylinder of radius r is $x^2 + y^2 = r^2$. Or why not make a paraboloidal satellite dish into something of practical value by adding hourlines to it?

Altering the shape of the dial by no means exhausts the possibilities. The next modification is to introduce moving parts (see, for example, the illustration to the Collier's Encyclopaedia entry on sundials). But this is beyond the scope of this article.

A listing of a Basic computer program is available from the Editor on request.

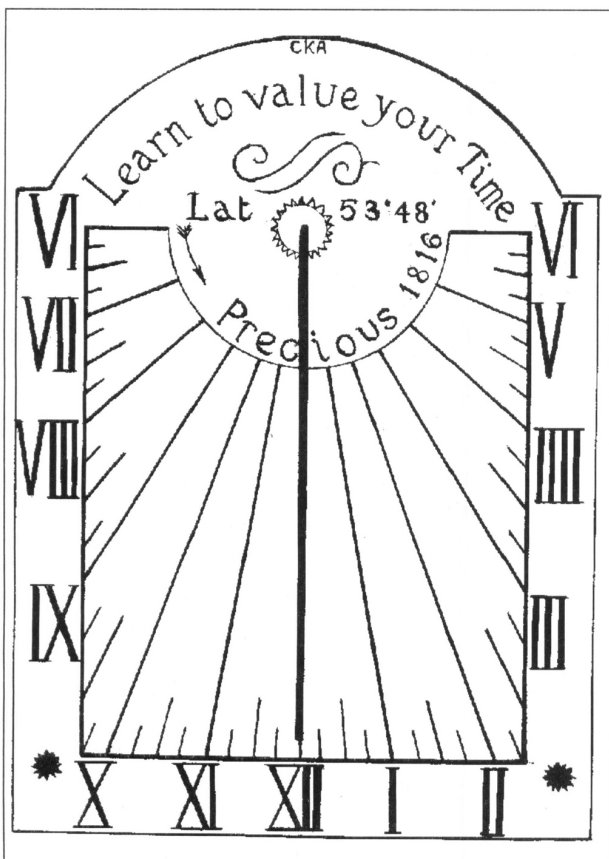


BRACKENTHWAITE FARM DIAL

A previously unrecorded sundial was discovered by our member Mr. David Cook at Brackenthwaite Farm, see Figure 1. It is located on one of the farm buildings which is at Burn Bridge near Harrogate, Yorkshire. This building was not erected until 1953 and is situated at latitude $53^{\circ} 57.2'$ North and $1^{\circ} 33.4'$ West. Obviously the dial is older and the latitude on the dial itself is $53^{\circ} 48'$, which is on a line running through Leeds City centre.

Enquiries by Mr. Cook revealed that the previous owner of the dial had removed it from her father's house at Tadcaster (about halfway between Leeds and York). Her father's house was built in 1816, but again the latitude is not correct for this site since it was made for a more southerly place. The grandfather was a manager for John Smiths (the famous brewers of Magnet Ales) and it is thought he might have obtained the dial whilst going round the public houses which sold John Smiths products. The dial might have had another journey but the present farmer/owner would not sell it as his attitude was - "As it is isn't eating anything, it might as well stay where it is".

The dial is of slate and is painted with a pale blue border with gilt lettering and hourlines, the centre seems to



be the slate only. The condition of the paint can only be described as poor. The dial is 24 inches wide by 33 inches in height, and the gnomon is of iron. The gnomon angle is $36^{\circ} 12'$. Mr. Cook states there appears to be no sign of restoration but it is unlikely the dial could have survived over such a long period without being repainted at some time in the past.

There is a slate dial at Ballakilley, Isle of Man, which carries the same motto in one corner of the dial (it has many mottoes inscribed). It is signed "Rich^d. Watterson's Dial, Kentraigh Mill, in the Isle of Man. Lat. $54^{\circ} 20'$ N, Long. $4^{\circ} 30'$ W. MDCCCXXX" (1830). However this seems to be the only other use of this particular motto, but with the addition of the word "Precious" under the gnomon, the motto as it now stands seems to be incomplete. It would have made much more sense if it read - "Learn to value your Time - Time is precious".

The attached line drawing is only intended to indicate the main details of the dial face, it is not an accurate reconstruction because the measurement details given here were not available at the time it was executed.

BOOK REVIEW

TIME TELLERS. Colin McVean, pp 65, 37 figures plus b & w photographs. A4 format in comb binder with clear plastic covers. Privately published by the author, 1994.

This is not a treatise devoted to sundials, for only the first seventeen pages deal with dialling, and these are intended to introduce children and adults of late development to the concept of telling time by the sun. It also inculcates the reader into using simple materials to construct working models which actually work. Those who have never made a simple model which actually functions accurately, can have no idea of the great satisfaction this can give. No amount of "mind experiments" can do the same. It was a method which the great Lord Kelvin always used, and there was no greater translator of ideas into practice than him. The author declares at the beginning of the book: "This book has been written to encourage children to make things that work".

The rest of the book is devoted to other simple means of time measurement such as Fire Clocks, Sand Clocks, Water Clocks, Escapement Clocks. The significance of these is that over a period of three millennia, these devices were brought into use in an effort to supplement, or supplant, sundials; or to give an increased accuracy. Today Man's time is linked to the modern atomic standards, but as we all know, our lives are still inexorably linked to the Sun. As a result, the sundial refuses to lie down, nay, as a result of the formation of sundial societies, it is at the start of a Renaissance of monumental significance with dialling projects being undertaken all over the world.

It is necessary to know of these competitors to the sundial in order to understand the up and down fortunes of dialling. For example, when mechanical clocks were introduced in the late thirteenth century, it would seem that the death knell of the sundial sounded simultaneously with the hour striking on a bell. Not a bit of it, for once each twenty-four hours the sundial still indicated local solar noon with an accuracy which took several centuries of clockmaking to emulate. So early mechanical clocks were still regulated by the sun and the shadow on a dial. The application of the polar style to the sundial brought the sundial out of temporary hours indication into an equal hours system to stand side by side with the mechanical clock.

In the early nineteenth century, the development of rapid transport created the problem of the differences of local solar time even in a small country like Britain, and this forced the sundial on the defensive again when a uniform time system was forced upon the country. After a long period of stagnation, the sundial is emerging again as one of the major ways in providing a dramatic and sympathetic focus for attention within a large space or on a large plain wall. The sundial one of the few things with motion without moving parts, yet the motion itself is never discovered except by not looking immediately for it.

From a child's point of view, the simplified approach (with a little help from someone who knows the ground rules) of this little work, will allow some understanding of time measurement which has arisen from human beings first noticing the daily movements of the sun.

Some readers may have difficulty in reading the text for

it is handwritten and not typed. The use of a typewritten text would have allowed an expansion of the explanations. For example there is no explanation of why the Equation of Time is required to convert sundial time to clock time.

To sum up, this little book is a microsm of the history of timekeeping up to the end of the ~~end of the~~ eighteenth century, leading a youthful reader from sundials to the mechanical clocks of yesterday, with the accent on model-making.

* * * * *

SUNDIALS AUSTRALIA. Margaret Folkard and John Ward, pp 62, 130 illustrations (the numbering ceases at Fig 66), A4 format, thin card covers. Published by SUNDIALS AUSTRALIA, 3 Bedford Street, Kensington Park, SA 5068, Australia, 1994. ISBN 0 646 222007. Price £7.50 + £1.00 p. & p.

This book has twelve sections: Historical background, Basic facts of earth and Sun, Sundials - Definitions and basic types, Formulae for Sundial Calculations, Relating Sundial Time to Clock Time, Installing your Sundial, Custom Design Sundials, Sundial Mottoes, Sundial Dictionary, References and Index. It is designed to help sundial enthusiasts to make and use various standard sundials for gardens and buildings, and to appreciate the combination of traditional craftsmanship and modern technology necessary.

The concise historical background outlines the important part that the measurement of Time has played in the development of communal life since the dawn of civilisation. It has given us astronomy, navigation and calendars, with the apparent movement of the Sun as a basis of observation and study.

The book explains how the Earth's axis is, for sundial purposes, fixed in space with its North Pole pointing to the North Celestial Pole (near Polaris) and the South Pole of the Earth pointing to the South Celestial Pole, which although not visible, can be located by observers in the Southern Hemisphere using guide lines from the Southern Cross and the two pointers nearby.

The book has been written from the point of view of observers in the Southern hemisphere (the review book sent being the Southern Hemisphere Edition), but it has a strong appeal and relevance to dialists in any latitude, whether North or South of the Equator.

The book will help beginners to appreciate that latitudes (and declinations) are subject to a change of sign with a change of hemisphere. Azimuths are always measured from the North Pole on the horizon in the direction N-E-S-W, but the sundial hour markings in the Southern Hemisphere run anticlockwise, whilst in the Northern Hemisphere, they are marked clockwise. The book is well illustrated by clear photographs and diagrams with clear explanations.

The main types of sundials are described: Horizontal, Reclining, Vertical, Polar, Equatorial, and Analemmatic. Formulae for marking the shadow angles on these dials are given in Section V, thus avoiding the daunting mathematics of spherical triangles.

continued on page 26

READERS LETTERS

THE DIAL OF BONAR

There are several printer's errors in Table 1 of my article on Bonar sundials - BSS Bulletin 91.3, page 14. *Kinaure* Castle should read "Kinmure Castle", *Loudon* Castle should read "Loudoun Castle". At the compass direction SbE location in the last column, *W islands* should read "W ilands", at SW *London* should read "Londn", and at NWbW, last column *Ushant III* should read "Uschant III".

GORDON E. TAYLOR
East Sussex

EDITOR'S NOTE: The corrections sent were mislaid at a time when the Editor was experiencing personal problems because of the death of one of his brothers. He tenders his apologies for the long delay in bringing these errors to the attention of BSS Bulletin readers and hopes that no one has been inconvenienced as a result.

* * * * *

SUNDIAL BOOKS

OXFORD SUNDIALS, price £3.50 post free, available from: The Appeal Office, Somerville College, OXFORD OX2 6HD. Cheques payable to 'Somerville College Appeal'.

CAMBRIDGE SUNDIALS, price £6.00 post free, available from Dr. M. Stanier, 70 High Street, Swaffham Prior, CAMBRIDGE CB5 0LD. Cheques payable to 'Dr. M. Stanier'.

DR. MARGARET STANIER
Swaffham Prior

* * * * *

TIDAL DIAL

You had the kindness to publish my article "A Tidal Dial" in BSS No. 92.2.

The revue "Seine Marine" asked me about the subject and rather than give the French version, I have given him a more adapted text to seamen and also more complete.

I have read with interest your article in BSS Bulletin 94.3 "The Queens' College Dial", particularly about "Longitude" which you translate by the "duration of the day", but in Latin word excuses Mr. Shephard's error.* The design of these hours is so curious (120 for 12) that I believe they were degrees and consequently Longitude of the Sun and not the Right Ascension. I found other corrections than those proposed by Mr. Shephard! May I ask you a Rank Xerox of Scarr's pamphlet?

About your paragraph "The Moon Dial", I suppose we must read at page 5 (right and left) "the same amount must be added" at the place of "deducted". I think it is an error of print or I have nothing understood . . .

Personally, I prefer to add the initial connection and consider that days are those after the New Moon. More simple yet is the M. Rohr's design page 132 in his 1986 edition "Les Cadrans Solaires" and your proposition rejoins it.

Bravo for the BSS and its Bulletin - Thank you for your work.

DENIS SCHNEIDER
France

* Munster wrote "Quantitor diai" in 1531.

EDITOR: I do not possess a copy of Scarr's pamphlet - it has been out of print for many years, does any BSS member have one?

* * * * *

TIME

In collating the Bulletin Index, it struck me that diallist often wax poetic. I dreamed up the first verse of the poem below some time ago, the second and third verses later.

It may (or may not!) fill a corner of a future Bulletin.

TIME IS

Time is a simply a
Convenient way
The distance travelled by the clock
From tick to tock.

Time is simply a
Convenient way
Of measuring
This distance taken by the Sun,
Its shadow 'cross the Dial to run.

Time is simply a
Convenient way
Of measuring
The brief span
Of a man.

COLIN THORNE
Barnstaple

EDITOR'S NOTE: Mr. Thorne has compiled an index of the contents of the British Sundial Bulletin which will be printed and made available to BSS members. The Editor would like to express here his grateful thanks for Mr. Thorne undertaking this arduous task, one which will save much time and trouble for those making future use of the full run of BSS Bulletins.

* * * * *

CAMBRIDGE DIAL

In BSS Bulletin 94.3 there is an interesting article on the Queen's College Dial, Cambridge by Charles K. Aked, in which there is mention of the "moondial" and a pamphlet by M.M. Scarr (a revision of the pamphlet by G.C. Shephard). There is a lot of confusion about the moon table given below the dial and its usage. Some of the confusion is probably due to the description in Shephard's article in which he defines the Moon's hour angle incorrectly.

May I put the matter straight by pointing out that the table is correct, and logically laid out. The user has only to know the date of the previous New Moon, and to deduce the age of the Moon using his knowledge of the current date. He then enters the table with this age as the argument, and takes out the respondent which is to be ADDED to the time read from the dial. Multiples of 24/12 hours are deducted are required, to obtain time in the 24/12 clock.

Greater accuracy in determining local solar time could be obtained if a knowledge of the right ascension were available (daily values are tabulated in Whitaker's Almanac, for example, and could be interpolated mentally

to the approximate time in question):

Where L.A.S.T. = Local Apparent Solar Time
M.T. = Moon Time (read from the dial)
R.A.S. = Right Ascension of the Sun
R.A.M. = Right Ascension of the Moon
Then L.A.S.T. = M.T. + R.A.M. - R.A.S.

In fact the only theoretical inaccuracy in the above method is that it does not allow for the correction due to the Moon's parallax, which is no more than a few minutes.

Of course one could even improve on this calculations by applying the correction for the equation of time and

observer's longitude to determine G.M.T.!

GORDON E. TAYLOR
Hailsham

EDITOR'S NOTE: If Mr. Taylor reads the article in question more carefully, he will note that it is stated that the "moon" table is correctly laid out and that the times indicated are to be added to the moon indication dial time, casting out multiples of twelve hours as necessary. One can obtain several quartz crystal watches for the price of one Whitaker's Almanac.

FOUNDATION OF BELGIAN SUNDIAL SOCIETY

The year 1994 marked the 400th anniversary of Gerard Mercator's death.

Consequently, this commemoration lead to various manifestations and projects in Flanders, e.g. the foundation of a new Sundial Society: "Zonnewijzerkring Vlaanderen".

But let us reflect on the man himself first:

Gerardus Mercator was born in 1512 as Gerard de Cremer in the small flemish fishing-village "Rupelmonde", situated on the banks of the river Scheldt, approximately 15km from Antwerp. "Mercator", in English meaning merchant, is the Latin version of his name.

All his works are signed Gerardus Mercator Rupelmondanus, thus showing his attachment to his native region.

Mercator studied mathematics and philosophy at the University of Louvain and devoted the rest of his life to scientific research. He became famous as: philosopher, theologian, engraver, instrument maker, astronomer, mathematician, land-surveyor and cartographer.

He made a living from making and selling astronomical instruments such as quadrants, astrolabes, armillary spheres and very accurate sundials. This resulted in orders from Emperor Charles V.

His aim was to improve the existing sea charts by studying the earth's magnetism, resulting in the famous Mercator projection, still in use today for navigation.

When he died on December 2nd 1594 all his charts had not yet been completed. Mercator's son, Rumoldus, took over his father's work and published all 105 charts, denominating them "ATLAS", the name Mercator had chosen to call them.

Gerard Mercator is widely recognised as the great innovator of 16th century cartography. His map of Europe, dated 1554, was a masterpiece of critical accuracy and his map of the World dated 1569, introduced a great novelty in navigation: the Mercator projection or cylindrical projection with meridional parts.

It was the award for 30 years of study for the improvement of nautical charts and aid to seaman at

determining their course and position. The Mercator projection is almost universal for marine navigation purposes.

His work put an end to the period of the medieval imaginary approach to geography that populated far off regions with legendary and fantastic creatures.

In the course of the Mercator Year 1994, various sundials were designed and built in Rupelmonde. They can now be admired along a special sundial-route in the parks and on the squares, on buildings and houses of the village.

The village attracts daily many visitors from Belgium and abroad. Hence, the next logical step was the foundation of "Zonnewijzerkring Vlaanderen".

We welcome new members to our society and to our manifestations.

Please contact for further information:

ZONNEWIJZERKRING VLAANDEREN
Oeverstraat 12
B-9150 Rupelmonde
Belgium

Objectives of our Society:

- To provide for the exchange of information about sundial designs between members and with other sundial societies around the world.
- To promote interest in sundials and to encourage and assist in the design and making of sundials.
- To locate and catalogue existing sundials in Flanders and, where necessary, to assist in their restoration.
- To offer special events, publications and other activities related to sundials.

RENE J. VINCK
Belgium

The BSS Council offers its congratulations and good wishes to the newly-founded Belgium Sundial Society - "Zonnewijzerkring Vlaanderen".

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