The British Sundial Society

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Cover Illustration - The Isaac Newton Sundial in Colsterworth Church, Lincolnshire. It is difficult to photograph since it is partly hidden away behind the organ loft insensitively installed in 1897. The caption under the dial reads: "NEWTON AGED 9 YEARS CUT WITH HIS PENKNIFE THIS DIAL. THE STONE WAS GIVEN BY C. TURNOR ESQRE AND PLACED HERE AT THE COST OF THE RT. HON. SIR WILLIAM ERLE, A COLLATERAL OF NEWTON, 1877".

DIALOGUE

DE ZONNEWIJZERKRING
BULLETIN 93.2 No. 50

The Dutch Society is celebrating its 15th anniversary. An Exhibition of Sundials was held in Amersfoort; Museum "Flehite" from the 4th July to the end of September. Tues - Fri 10th - 17th, Sat, Sun 14th - 17th.

The January meeting included a number of slide shows and the announcement was made of plans for a meridian line in Utrecht. Unfortunately the plans for BSS members to visit Holland in September 1993 had to be cancelled.

A description is given of a dial to overcome the disadvantage of an analemma by using a broad gnomon giving a wide shadow and graduating the dial plate showing various times of the year at which the time is read accordingly. The Editor complements this by another diagram resembling a spider's web.

In the year, the sun in the Netherlands stands above the horizon for 4,000 hours but for only about 1/3 of this time is there sunshine ie. about 4 hours per day. The question then arises why are the members bothering about sundials?!

There follows a discussion on the track of the sun which is complicated by the difference between the horizon and the equator.

An 18th century dial in Zwolle is described and illustrated which has unusual divisions and two gnomons.

The introduction of railways and telegraphs created a need for more precise timekeeping, and as many public clocks differed from each other. H. van der Kraan designed a sundial to overcome this, and an illustration and description of the instrument is given together with literary references. Another writer comments on the instrument and points out a disadvantage.

A discussion is included on the slight corrections necessary to allow for the slowing down of the earth's rotation. Various authorities are quoted, and the author invites readers to comment on the subject.

The desire to determine the position of planets and stars in the sky gave rise to the "Torquetum", the earliest being that of Cusanus in Bernkal 1434 with later examples coming in the 15th and 16th centuries. The theory of the instrument is explained and diagrams and views of the instrument of 1577 and 1540 are included.

The equation of time is described in great detail beginning with an earth that has a vertical pole and moves in a circular orbit and then modifying the idea with all the variations that occur.

Instructions are given for making a cup dial based on a design of Georg Brentel 1573 - 1619, and a member in South Africa describes a dial on his house which is 34° S.

Our Vice President M.J. Hagen has produced a book on Analemmic sundials 40pp A4 F. 10.00.

There is a description of an ingenious device for demonstrating the ecliptic and of a pocket dial by Jan Roelas van Vries of Amsterdam made in 1642.

The list of sundials in the Netherlands is continued and various references to articles in periodicals are given. The Bulletin concludes with a design for a sundial with three gnomons one for the time, one for the azimuth and one for the signs of the Zodiac.

BULLETIN 93.3 No. 51 opens with an account of a mechanical sundial by A.J.M. van den Beld. Full details are given with a number of illustrations which include an engineering drawing of the device. Jan Kragten gives some comment upon the Venetian Ship sundial sold at Sotherby's on 25th February 1993 for £37,000, once the property of John Wilson (1719-1783), an antiquarian and historian of Broomhead Hall, near Sheffield. The dial was placed in auction by David C. Wilson, to whom it had come by descent from the original owner. There are only seven examples of this type of dial known, the Science Museum. London, had one but has "lost" it. There are some dubious features in respect of the latest dials found.

F.J. de Vries subscribes an article on sundials with cylindrical faces, and illustrates a modern example in Berne. A developed drawing of the Quirinale sundial faces is shown, see BSS Bulletin 92.2, pages 10-16.

The reactions to a discussion in the Bulletin (it states 99.2.21 but there are almost six years before this is published) about the leap second. A graph shows the daily error in the rate of rotation of the earth over the centuries from 1600-2000. According to this the earth is gaining about 1.5 milliseconds a century so no one need lose too much sleep over this.

There is a long paper on Stonehenge. Based upon Gerald Hawkins' article in Nature some thirty years ago - "Stonehenge Decoded", the accent is on "Squaring the Circle". This article is presented only in English and the author's name is not given.

Next comes the continuing list of sundials by M.J. Hagen which in this issue covers eight pages and is growing in a monumental coverage of the Netherlands sundials. Unfortunately the photocopied reproduction of De Zonnewijzerkring does not do justice to the illustrations of the dials themselves.

Again there is a large section covering dialling literature and articles in various publications. Included is a catalogue of sundials in Austria, *Cadrans de Solares de Paris* by Andrée Gotteland and George Camus, an article on Grandjean de Fouchy, inventor of the mean time meridian in *Horlogerie Ancienne* No 27, also by A. Gotteland. The BSS Bulletin is more than fully quoted plus the BSS Chairman's contribution to *Clocks*.

ANALEMMA

No's 5 and 6 (covering May-December 1992) of the Bulletin for the Association of Friends of Sundials based in Madrid were received some time ago. English abstracts are given of the articles which are presented in Spanish. The Bulletins are attractively printed in A4 size. No 5 contains articles on Almucanters (circles on the celestial sphere parallel to the horizon), Joan de Arphe's treatise *De Varia Commessuraction* which contains a section on sundials; dial hunting by J. L. Lorente, Gnomonics and Literature, setting out a vertical declining dial, a problem in moving a sundial from Munich to Madrid and Canonic sundials based on a study of the Orchomenos sundial.

No 6 contains many interesting articles, commencing with the "Sun Dial Book" published by Pedro Roiz in 1576 and written in Spanish instead of the usual Latin text. The huge sundial designed by R. Soler Gayà now erected at the Palma de Mallorca Nautical and Fishing School is fully described. A method of finding the equivalent dial of a declining and inclining dial to be placed in a new geographical position is given by A. De Vincente. A publication report outlines the illustrated book of Majorcan sundials by R. Soler Gayà and describes it as a "beautiful" book. A Basic computer program is given by J. de la Calle to find wall declinations. The well produced magazine ends with "Notes and Comments" a continuation of a table for the Equation of Time for 1993, and a delightful glimpse of the Tower of the Winds in Athens on the rear cover.

THE SUNDIAL OF THE OLD FRANCISCAN CHURCH IN ROUFFACH

BY RENÉ R-J. ROHR (FRANCE)

A UNIQUE ASTRONOMICAL CHRONOGRAM

Rouffach is an old Alsatian market town situated amidst a golden vineyard countryside some 15km southwards of Colmar, its district-town. When crossing the main thoroughfare of Rouffach, travellers have their attention drawn to the western side by the slightly protruding apse of a former church with an open-air pulpit, the last remaining in the province. The church dates from the thirteenth century and was part of a renowned Franciscan Abbey, of which the church is now the only remaining part after the destructive furies of the great French Revolution of 1789.

It is no longer possible to discover the reasons why the church alone was spared from destruction, possibly the existence on its southern side of a huge sundial completely filling the 3.50 metres space between two high Gothic windows, surrounded by a very special fresco, may have had some special significance for the ignorant and superstitious assailants.

This fresco consists of an octagonal frieze of green foliage ending in volutes and framing the hour-numbers of a sundial that surround a circular picture of the heavens in the form of the presentation drawn and taught by Ptolemy but partly modernised by Tycho Brahe.

It is many years since I saw this dial for the first time, the whole of the painting was then already in a condition of almost hopeless deterioration. The representation of a lunar eclipse was unmistakable, as was the position of Mercury at its point of inner conjection on its orbit drawn around the sun. The conjunction of these two astronomical events suggested to me the possibility of discovering the date if some more planets were visible; but I could not see any depicted. However my interest was aroused in this interpretation and never subsequently waned.

I tried, without success, searching through the archival sources and records referring to the Abbey, however no detail was left behind. Of course sundials in monasteries have been familiar items for centuries, but what about this unusual example of an astronomical display, historical and perhaps unique?

The hour numbers going from X am to VII pm were well preserved but appeared to be mere accessories to the display rather than a pretext for it. Neither date nor the name of its designer could be detected. But the fact that the sun was surrounded by two orbits is an important hint to the former, somewhere between Copernicus and Tycho Brahe, and thus belonging to the earlier part of the seventeenth century. The earth in the centre is in accordance with the monasterial doctrines of the time. Around the earth are the orbits of the moon and sun, further off, along the outer circle of the astronomical area are three more orbits duly annotated with the names of Mars, Jupiter, and Saturn. Except for Jupiter, which I found later, the orbits lacked the planets themselves. Jupiter was in the shadow of the moon and scarcely visible, but was in opposition and correctly positioned on its own orbit. The outer circle is properly graduated in 360 degrees, divided into four quadrants, two of which being sub-divided in 5 degree steps, one commencing at the equator, the other at the North pole. The circular space between the orbits of the moon and Mars contains names of some of the 42 stars placed in irregular disposition along the outer circle in the external narrow annulus of space (Fig. 1).

No planet was visible on the orbit of Venus, I was correct, as will be seen later, to suppose that it was depicted in an area where at some unknown time in the past, important repair work to the masonry had been carried out. But the fact alone of the chance coincidence of the two special positions of Mercury and Jupiter, together with a

FIGURE 1: The Astronomical Dial as it appeared in 1976.

lunar eclipse, must have had quite an astrological significance.

The style had remained correctly set pointing to the celestial pole. Straight lines marked the positions of the Equator and Ecliptic, as well as their axes, also the limits of the umbra, but with a curious curve in the region of the earth, also and those of the Tropics. Except for the Ecliptic, all these lines were indicated with their Latin names but even with the use of a telescope, most of the inscriptions had become illegible. Letters from previous restorations had bled through in places and added to the general muddle. In the cone of the lunar umbra, three lines of an inscription seemed to be hopelessly lost. Beyond doubt, the last restoration had taken place before the events of the great Revolution, and is seemed that from that time no thought had been given to keeping the sundial in good repair. Sections of the masonry had been replaced without any thought for the dial. An important part of the sun and the two orbits of the innermost planets, along with the position of Venus, had been destroyed in this careless way.

For years I had visited the dial, anxiously observing its slowly progressing deterioration. Even in its desperate condition, and in spite of the loss of most of the planetary indications, it held too much astronomical information as not to suggest the idea of some hidden date. A few more years of neglect however, and perhaps the most interesting memento of our local history would disappear for ever.

For years I published articles and gave lectures on this dial, finally this resulted in a letter from the State Secretary for Culture requesting me to make contact with the Regional Director for Cultural Affairs in Strasbourg with a view to making a detailed examination and restoration of the dial. Naturally I agreed immediately, but did not, at the time, envisage the difficulties I was about to encounter and shoulder.

Neither in Colmar, Rouffach or anywhere else could any paper concerning the abbey or its church be located. All the documents concerned with the abbey had been destroyed by the raging mob of 1789. The only facts I could uncover were that the Franciscans were living in Rouffach about 1250 in an old farmhouse; about 1280 their first church had been built, of which some buttresses and the open-air pulpit remain; the rest of the church having undergone various alterations which were completed around 1490 to 1510 in the present edifice. After the Revolution and the disappearance of the other buildings, the church was cared for by some of the monks, assisted by the people of Rouffach and former students of the abolished Latin School.

Commencing in Strasbourg, I arranged with the Government Officers in charge of the project to have a number of detailed slides taken of all the parts of the astronomical part of the dial. These then studied later revealed details of the utmost interest and value. Many inscriptions which previously seemed illegible became clear, and parts of the names of fixed stars, and even Alcor in the Great Bear on the periphery of the destroyed section of the wall, which was imperceptible at a distance, was made visible. As to the previously mentioned text in the umbra, I at length succeeded in deciphering the first words: Linea ecliptica, the remainder seemed to be irrecoverable. Later on this text was to prove of the greatest importance to me, and the time taken to decode it heavily influenced the progress of my investigations.

The combination of legible names and the degrees of declination along the circular graduations ended in the identification of 14 of the fixed stars, some of which were positioned incorrectly; in the case of Capella, this displacement reached 4°. With its inclination of 23.5° above the equator, the diameter going through the centres of the sun and moon is in fact the projection of the ecliptic. But as this is not stated in the inscriptions elsewhere, one could be persuaded to read the degrees of its inclination, as with the fixed stars, as the declinations of the two bodies. This would have placed the position of the sun as close to the summer-solstice, ie near June 21, and this could have been the date of the eclipse[1]. But in addition the position of Mercury had to be found in conjunction![2]. A supplementary aid in my research was the Saros-cycle[3] which could be used backwards from the dates of the eclipses of the present time.

Based on Ptolemy's cosmological system, the fresco was completed by the addition of the two orbits of Mercury and Venus discovered at that time by Tycho Brahe (*who died in* 1601). One may submit that its discovery had taken place only after his arrival in Oranienborg in 1575 where, for the first time, he had suitable instruments at his disposal. However the time was not ripe then for the publication of new ideas, and certainly not to display it on the walls of a monastery before 1600 (these ideas being heretical and would lead to their expounder getting into the hands of the Inquisition). Copernicus, who died in 1573, had laid the foundations of the heliocentric system; Kepler (died in 1630), following him, made further progress.

I therefore decided to begin my research in the first half of the 17th century, an enterprise which met with no success at all. Eclipses visible in Alsace were numerous but none with Mercury in conjunction. Further research was possible in the second half of the century but I did not like the prospect of doing so without first having decoded in the umbra. Once more I looked for information in the archives of Rouffach town hall. I refused to believe that no one had been interested in this unique dial over so many years, with its cabalistic appearance.

This time revealed a primitive pencil sketch, made some fifty years ago by an amateur[4] interested in local history, who seems also to have had some knowledge of Latin. The drawing testified to the fact that at the time it was made, the dial had long been in a bad condition. This drawing, visibly from an unskilled hand, was clumsily executed but it gave the position of Jupiter in opposition, as well as portions of the missing text in the umbra. With the help of a priest I succeeded in restoring it as follows:

LINEA ECLIPTICA
EST IN AQUARIO
TUM ARENIS AQUA AQUARII

This was an undoubted success indeed. On the star maps of the period[5] Aquarius is shown as an old man pouring water in a region poorly starred so as to create a meandering river there: "...the desert watered by Aquarius". The words imply that at the time of the eclipse, the moon was in Aquarius, the sun consequently in Leo, and finally that the line sun-earth-moon was indeed the projection of the ecliptic. The eclipse therefore happened between 21st July and the following 21st August (Gregorian calendar). But once again the position of Mercury failed to be in conjunction. I began to think about giving up searching for the solution as the problem seemed to be intractable.

But one should never desist!

Some time later I recalled my hesitation in putting aside one of the eclipses I thought would be invisible in Alsace. Its maximum obscuration occurred as the moon crossed a location 14° E, somewhere south of the Chacos Group in the Indian Ocean. I suddenly realised that the zenithal reaction was almost parallel with the horizontal plane in Alsace, and at that very moment the moon must have been rising there. The date of the eclipse was 16th August 1617. I hastened to find the location of Mercury on that day; it was almost exactly in inferior conjunction, and with a similar approximation I discovered that Jupiter was in opposition! This eclipse, to be sure, was the one for which I had been searching.

But what of other missing planets? I first thought they must have been in the now missing part of the dial. My investigation did indeed confirm that Venus had been there, but Saturn could not have been. Calculation placed it in the right inferior quadrant at 27°, yet here the orbit appeared completely empty. Once more I felt discouraged...

For a time I abandoned my search then I thought of scanning this place with the help of a powerful lens (x12), hoping to find some trace of the missing image. To my surprise it was the drawing itself that appeared just visible in isolated portions that without my calculation I would have overlooked a thousand times. Looking hastily for the position of Mars which I had reckoned to be 74° in the same quadrant, I found the orbit was empty but at the same degree between the neighbouring orbits of Jupiter and Saturn, there appeared the faint remnants of the black outline of a star placed there by a careless painter, a few centimetres from its orbit.

By now I had in my hands all the data required for drawing in full size[6] the dial and its fresco, which I could complete in a few days following the final decipherment (Fig. 2). After a whole year in preparation, the dial was restored in 1979 (Fig. 3).

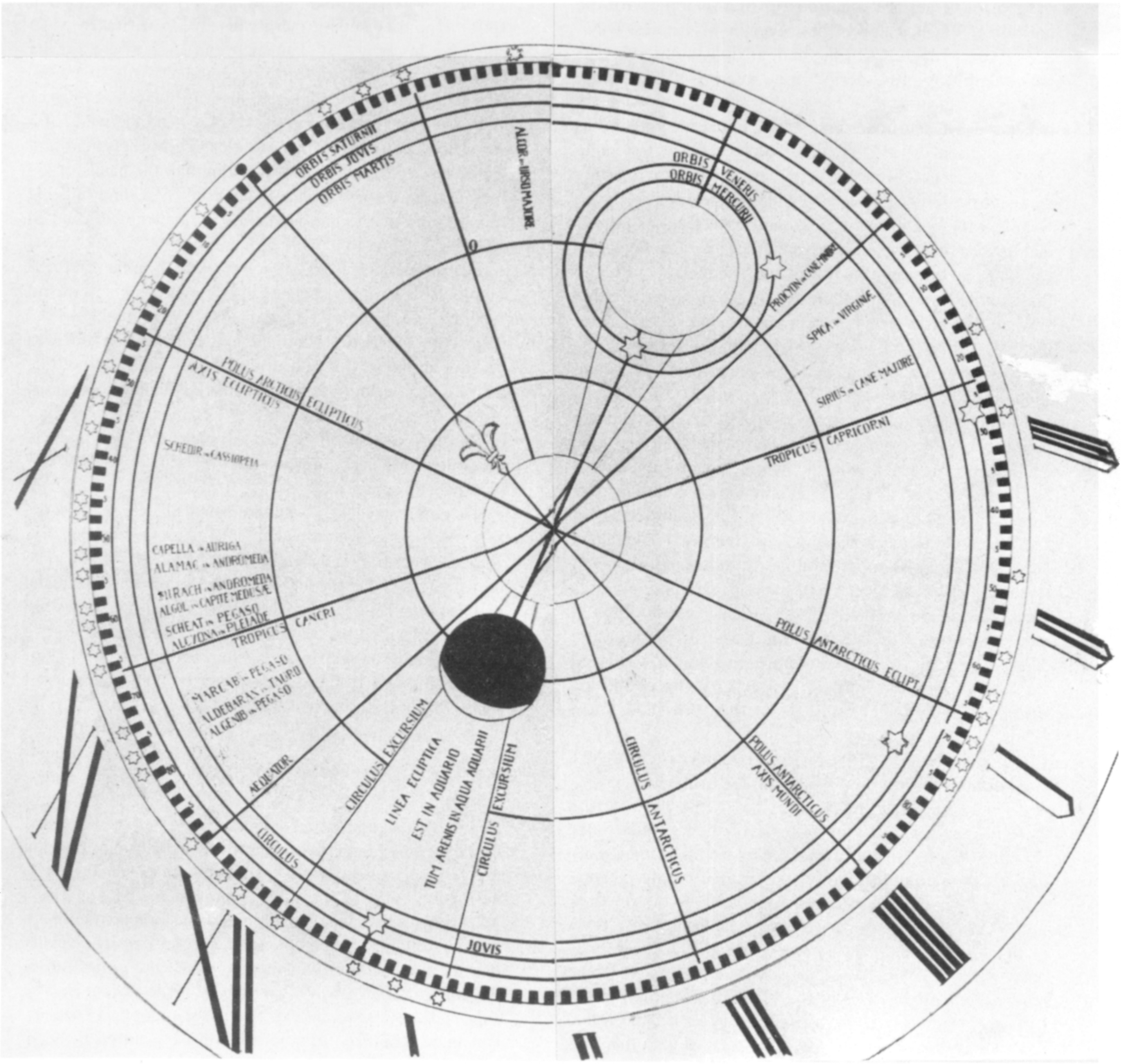


FIGURE 2: The Reconstituted Drawing, 1977.

FIGURE 3: The Dial after its Restoration, 1979.

One question remains, possibly it may never be answered: it is to know what really happened in Rouffach on the evening of 16th August 1617[7]. One might approach the truth by the employment of some imagination in placing oneself in the position of those now long-forgotten wine-growers observing the heavens at the time.

The sun had been setting at 19.04 local time, but for some minutes the shadow of the Honeck, a mountain in the nearby Vosges chain, had already immersed the town in its habitual twilight. The moon began to rise in the east where the summits of the Black Forest Mountains had delayed its appearance for some minutes, so when presently it became visible above the Belchen crest, it was a beautiful full moon made to seem enormous by the proximity of the mountain peaks. But instead of its customary brilliance it shone in the colour of old copper. No one could ever remember having thus seen the moon in the middle of an eclipse![8]

The eclipse had been partial until 17.05, arriving at totality 18.54, to end 88 minutes later. For about 80 minutes the reddish moon rose up and up in the sky, and only towards 20.21 did a small white sickle herald the end of a marvellous celestial spectacle.

Now all this occurred in a time of superstition, people believed in sorcery, phantoms and astrology; with foremost the customary fear of the end of the world[9].This moon therefore could not but be announcing the approach of some terrible calamity, perhaps the end of all known things. An indescribable panic seized the populace, some rushing to the church, others hastened to the abbey for sanctuary.

It follows from the fresco that at least the monks were able to appreciate and explain the true nature of the event. They had obviously taken part in the celestial spectacle but were more impressed in the unexpected stage rehearsal of an end-of-the-world scenario by the local populace, a more salutary effect than ever produced by their best sermons given from the open-air pulpit of their church! Their impression of this night was strong enough to commission a representation of it on their church wall, framed for safety by the circle of hour numbers of a sundial. Great credit must be given to the unknown astronomer who observed the positions of the planets on that remarkable night and recorded these in the orbits given on the dial[10]. It was the accuracy of his work which made it possible to rediscover the origin and age of this outstanding dial when all records referring to it had been destroyed.

NOTES

1. I used Opplolzer, Canon der Finsternisse, Vienna, 1887.
2. A revolution of Mercury takes 88 days only, I have tried to reduce possible errors by calculating this position on the date of the first passage of the planet over the disc of the sun observed by Cassendi on November 6th 1631.
3. The Saros cycle is a period of 18 years (of 365·2422 days) and 11 days, after which all the possible eclipses of sun and moon repeat themselves in the same order and at the same intervals.
4. M. Eloi Badina from near Pfaffenheim, now deceased, merits remembrance and our thanks.
5. I made use of the map in Peter Apianus: Astronomicum Caesareum, Ingoldstadt, 1540.
6. My drawing (Fig. 2) was 1.80 x 1.80 metres.
7. A remarkable oddity may be noted, this eclipse repeated itself after exactly 20 Saros cycles on March 24th 1978. (See 1)
8. Partial eclipses of the moon show a grey colour to the darkened area which turns to the colour of old copper during totality.
9. This fear remained chronic throughout the Christian world for many centuries after 1000 AD.
10. He almost certainly had the use of an astrolabe to aid his observations.

HELP WANTED

Ou member, Jill Wilson who was recently elected to Council has agreed to help us research, and eventually produce a definitive catalogue of British sundial makers in conjunction with the Scientific Instrument Society. A valuable source of data will be our own register of sundials but if any member has collected records of dial makers or has made a study of any one dial maker we would be pleased if they would send the information to Miss R. J. Wilson, Hart Croft, Pear Tree Close, Chipping Campden, Glos., GL55 6DB.

MEMBERS REQUESTS

Mr. A. R. Eden of Torberry House, West Harting, Petersfield, Hampshire GU31 5NZ would like communication from anyone interested in Pilkington and Gibbs Sundials.

Th. van den Heiligenburg of Kapelweg 33, 3566MK Utrecht, Holland is an actuary and would like to hear from other sundial enthusiasts who are also actuaries.

ASTRONOMY AND STONEHENGE

BY ROBERT MILLS

The people who constructed Stonehenge were worshippers of the Sun and Moon, as were many early civilisations. The Sun figured as a God, and the Moon as a Goddess, so that the eclipses of these were events of great importance and caused great communal excitement. Efforts to understand and be able to predict these eclipses were matters of great concern to the thinkers and leaders of those far-off days. Any person who could predict a coming eclipse could rise to a position of great eminence.

Recent studies of Stonehenge have made it clear that the monument was much more than a device for forming a calendar to mark the seasons and the passing of the days of the year by means of a circle of stones. This was the practice on many Neolithic sites.

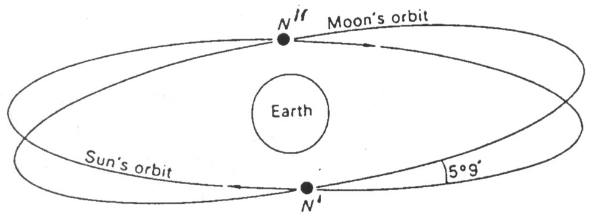


FIGURE 1: The apparent paths of the Sun and Moon in the sky lie in planes which intersect at an angle of 5° 09. The points of intersection N.N. are the nodes of the Moon's orbit.

ECLIPSES

An eclipse occurs when the Earth, Sun and Moon are perfectly in line. If the Moon lies between the Sun and the Earth, we have a solar eclipse, similarly if the Earth lies between the Sun and the Moon, we have a lunar eclipse. From an inspection of Fig 1. it can be seen the apparent paths of the Sun and Moon as seen from the Earth, appear to intersect at the two points marked N and N', which are known as the Nodes of the Moon's orbit, but whereas the Sun's apparent path is regular throughout the year; the Moon's path seems to change from day to day, and from year to year in a most complex manner, such that even the great scientist Isaac Newton admitted that the study of its motion gave him a headache. The main reason for this apparent complexity of the Moon's motion is that its orbit around the Earth is inclined to the Ecliptic by an angle of about 5°, which causes the angle between the extreme positions of the Moon's rising to vary from 60° to 100°, as in Fig 2.

STONEHENGE

The early, and it must be said, brilliant observers at Stonehenge, made it possible to keep track of the Sun and Moon, and the nodes by providing a large circle of 87.7 metres in diameter and dividing this into 56 equal parts by means of 56 equally spaced holes, (known today as the Aubrey holes after John Aubrey the English antiquary [1626-1679] who worked on the Stonehenge site). See Fig 3, where hole number 1 represents the Sun at the Summer Solstice. The selection of 56 must have been arrived at by a stroke of genius on the part of some Newton or Galileo of 2000 BC, as it most elegantly allows the Sun to follow an annual path of 364 days, the Moon to travel round the circle in 28 days, and most importantly the Nodes to complete the circuit in 18·6 years by the following simple procedure suggested by Professor Sir Fred Hoyle, in his book on Stonehenge, using markers to represent the Sun, Moon and Nodes.

1. The marker for the Sun is moved anticlockwise 2 holes every 13 days, and so completes its circuit in one year of 364 days.
2. The marker for the Moon also is moved anticlockwise, but two holes every day, and so completes its circuit in a lunar month of 28 days. There were 13 lunar months in the year.
3. The Nodes move clockwise, 3 holes each year, and so complete the circuit in 56/3 years (18·6 years), which is known as the Metonic cycle or Saros.

If the markers are initially placed with the Sun, Moon and Nodes together to represent a total eclipse, the, by following the previous procedures 1, 2 and 3, the markers will again all be together for an eclipse after 18·6 years.

A total eclipse of the Sun observed from any particular

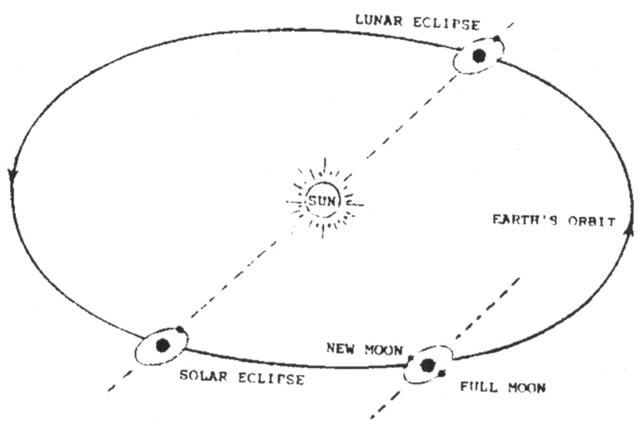


FIGURE 2: Solar and Lunar Eclipses
An eclipse of the Sun or Moon occurs when the Sun, Moon and Earth all lie in a straight line as in this figure. If the plane of the Moon's orbit was exactly in the Ecliptic, a solar eclipse would occur at each new Moon. The two planes are however inclined at an angle of about 5 degrees and intersect at the Moon's nodes only. As a result, eclipses are observed only when the Sun is at or near node, and the Moon is near the same node (solar eclipse) or the opposite node (Lunar eclipse). Because of the relatively small size of the moon, total solar eclipses are visible only over a small area of the world's surface at any one time, see text.

place on earth is a relatively rare event. For example in the British Isles we have only two total solar eclipses in the 20th century, one occurred in 1927, and another is due in 1999. Eclipses of the Moon, are of course, much more frequent, merely because the Earth is a much larger body than that of the Moon, and its shadow is more widely spread; so total or partial eclipses of the Moon occur once or twice each year. The Stonehenge observers could have predicted these events approximately by means of the alignment of their marks.

Figure 4 depicts the apparent paths followed by the Sun and the Moon as they move across our celestial hemisphere. The Sun is shown at its two extreme positions of Summer and Winter Solstices. The Moon's paths are indicated by dotted lines and illustrate the rapid changes in the Moon's declinations over half a Metonic cycle of 9·3 years, between the extreme positions given by the range $\pm(24° + 5°)$ and $\pm(24° - 5°)$. It is these swings of declination that account for the ranges of Azimuths of the risings mentioned previously. Maximum range in the risings of the Moon is from Azimuth 40° to 140°, and the minimum is from 60° to 120°, ie a maximum range of 100° and a minimum range of 60°. These figures can readily be checked using a calculator on the simple relation $\cos Az = \sin \partial / \cos \phi$, where ∂ is the declination and ϕ is the latitude (51° for Stonehenge).

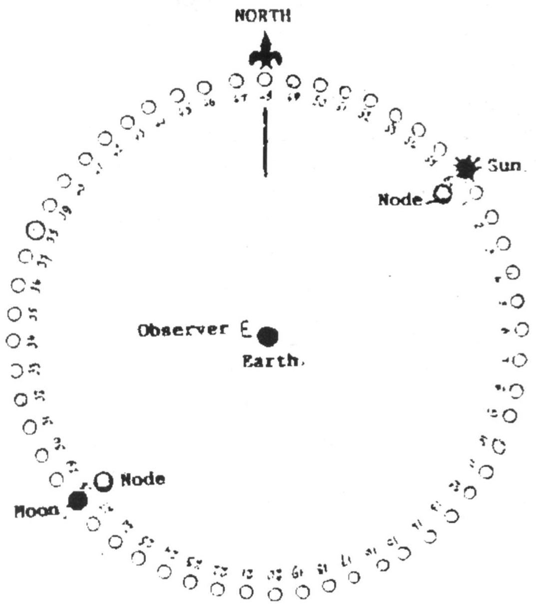


FIGURE 3: An eclipse of the Sun or Moon occurs when the Sun, Moon, Earth and the Moon's nodes are aligned with the Observer on the Earth at E.

CELESTIAL HEMISPHERE

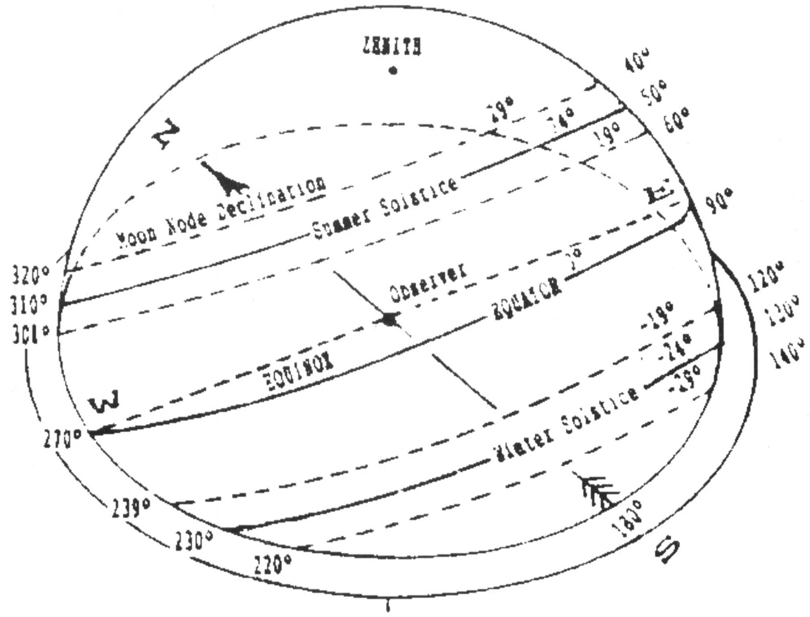


Figure 4: The Horizon or Azimuth Circle

Continued from page 21.

Comberton near Cambridge frequently uses slate for his dials, an excellent long lasting material less prone to weathering and lichen growth than limestone. So we may reasonably hope that the late twentieth century sundials of Cambridgeshire will be readable three hundred years hence.

ACKNOWLEDGEMENTS: I am grateful to Mr. M. Cowham for the photographs, and to the following for help and information: Mr. Philip Sanderson of Huntingdon Record Office, Miss E. Thurmott of Ely, Miss D. Hersey of Hemingford Grey, Mr. B. Wegg of Wisbech, Mr. J. Hurst of March.

CAMBRIDGE SUNDIALS: ALEXIS BROOKES, MARGARET STAINER

Twenty-six Sundials in and around the City of Cambridge, described and illustrated with colour photographs: with an Introduction and location map.
Price £5.50 plus 50p p. & p. from Dr. M. Stanier,
70 High Street, Swaffham Prior, Cambridge, CB5 0LD.

AN INTRODUCTION TO THE EQUATION OF TIME

BY DAVID W. HUGHES*

Throughout history the Sun has been the main marker of time. The day is the interval between noon and noon. Noon is the time when the Sun is not only at the highest point of its daily journey across the sky, but also the time when the Sun is due south, its centre being on the celestial meridian - a circle that passes through the observer's south point and the point in the sky that is directly overhead. Some civilisations have changed the start-point of the day to midnight, sun-rise or sunset.

The year is the time it takes the Sun to pass through all the zodiacal constellation and return to the same initial position with respect to the fixed stars. Less prosaically, it is the time it takes our planet Earth to go round its sun-centred orbit.

Astronomers start the day at noon. The Sun's complete circular path around the sky is divided into twenty-four intervals (the hours), the Sun moving about 15° per hour. It is this solar movement that is recorded by the gnomon shadow on a sundial. The time recorded by a sundial is called local apparent solar time. The word local is used because the recorded time would change if you moved the dial to the east or the west. The word apparent must be thought of in terms of its root "appear". It is the time as it appears to an observer at a specific place on the Earth's surface. Unfortunately local apparent solar time is not the time that is measured by normal mechanical timepieces, these tick to a monotonous, uniform, regular beat. The Sun does not. It has an irregular eastward motion through the zodiacal band of constellations. The reason for this is simple. The distance between the Sun and the Earth changes throughout the year. The Earth has an elliptical orbit and not a circular one. Around January 4 each year, the Earth passes through perihelion, the point on its orbit when it is closest to the Sun - 147,096,300 km. Six months later, in early June, the Earth passes through aphelion, when it is 152,099,500 km away from the Sun. The rate of motion of the Sun across the sky thus varies from day to day, and it is faster in January than it is in June. This means that the length of the apparent solar day (the time interval between successive noons) varies from season to season. On December 23, for example, it is 51 seconds longer than it is in September. As soon as clocks become accurate enough to detect this discrepancy, the Equation of Time became a topic of interest.

There are two reasons for the variation in the length of the apparent solar day. Before we discuss them we need to define the terms celestial equator and ecliptic and this is best done by referring to Fig. 1. Here the Earth is at the centre of the system and the large circle represents the celestial sphere. The Earth is spinning, and the extension of its spin axis (the vertical dashed line in Fig. 1) intersects the celestial sphere at the North Celestial Pole. The extension of the plane that contains the Earth's equator intersects the celestial sphere producing a circle known as the celestial equator. The intersection of the Earth's orbit with the celestial sphere produces another circle known as the ecliptic. These two are inclined with respect to each other at an angle of 23.45° this being the angle between the Earth's spin axis and its orbital plane. The Sun moves along the ecliptic, going all the way round in a year and passing through the Vernal equinox around March 21, the

Footnote: * Department of Physics, The University, Sheffield, S3 7RH.

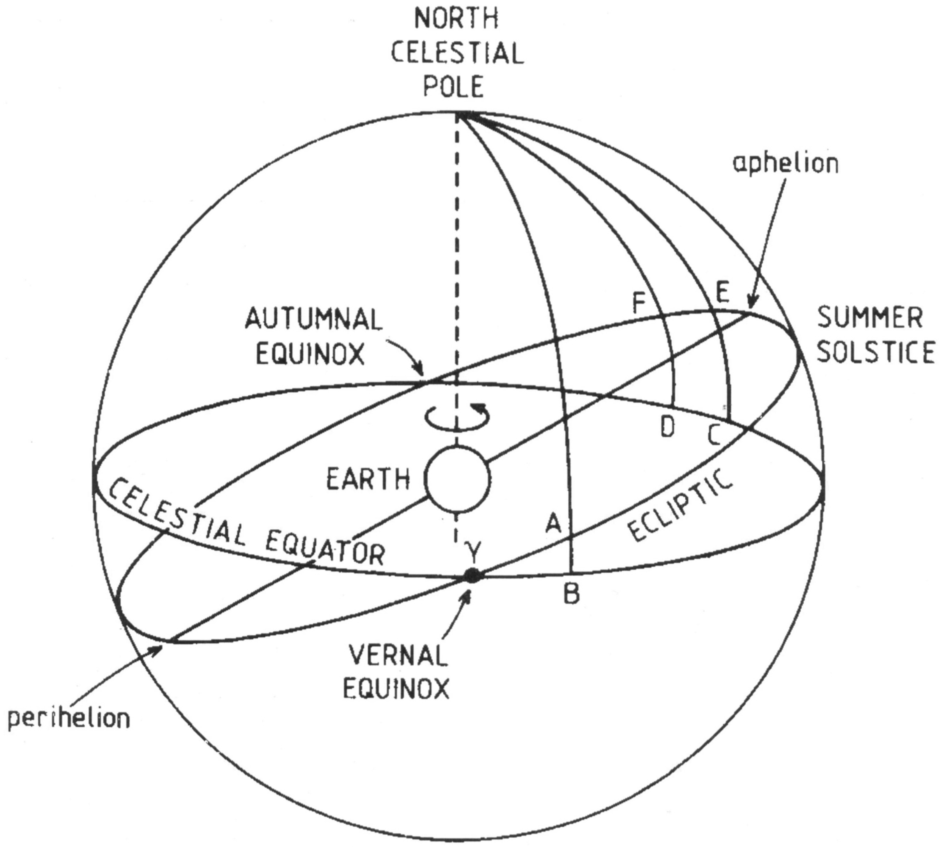


FIGURE 1: The Earth is at the centre of the celestial sphere. The Sun travels around the ecliptic circle once in a year. Clock time is, however, measured with respect to a hypothetical mean sun that travels at a uniform rate around the celestial equator.

Summer solstice around June 21 and the Autumnal equinox around September 23.

The first problem arises from the fact that time is measured with respect to the celestial equator, and the motion of the Sun along the ecliptic, when projected in the direction parallel to the celestial equator, changes throughout the year. At the equinox the angle between these two motions is 23.45°. This can be seen by comparing the directions of the lines τB and τA in Fig. 1. The angle between the two motions decreases to zero at the time of the solstices as can be seen by comparing the directions of lines DC and EF.

The second problem occurs because the elliptical nature of the Earth's orbit makes the Sun appear to move faster when it is near perihelion than it does when it is near to aphelion.

These variations in the motion of the Sun can be removed from out time measurement system by introducing a fictitious Sun, which is usually referred to as the *mean Sun*. This *mean Sun* moves along the celestial equator at a uniform speed, this speed being the average rate of motion of the real Sun along the ecliptic throughout the year. So during one whole year the mean Sun is, on average, as much ahead of the real Sun as it is behind. It is the motion of the mean Sun that is used to set the "going" of clocks and by which we time our activities. The time interval between two successive passages of the mean Sun across southern meridian is called the mean solar day. These days have a constant length and this is equal to the average length of the all the apparent solar days in one year.

The Equation of Time is simply the difference between the apparent solar time and the mean solar time. It tells you by how much your sundial differs, and during a year this varies between -14.2 minutes and +16.3 minutes. Thus the Equation of Time has to be added to the apparent solar time (sundial time), plus the difference in longitude from Greenwich, to give the mean solar time (clock time).

A graphical representation of the Equation of Time is shown in Fig. 2. The component of the equation due to the ellipticity of the Earth's orbit is marked E. The amplitude of this component is about 7.7 minutes and the E curve crosses the horizontal abscissa at perihelion and aphelion passage times. In 1993 these occur at Jan 4^d 03^h and July 4^d 22^h respectively. At perihelion the apparent Sun has its greatest velocity and shoots ahead of the mean Sun. The distance between them continues to increase until about three months after perihelion, when the velocities become equal, and after that the distances diminish until it becomes zero at aphelion. The second component, marked 0 in Fig. 2, is due to the mean Sun moving along the celestial equator whereas the Sun moves along the ecliptic. This curve has an amplitude of about 9.9 minutes and crosses the horizontal abscissa at the equinoxes and the solstices. The curve looks rather like a sinusoidal curve. It is not quite such because the lengths of the seasons are not the same. For example, the interval between summer solstice and autumnal equinox in 93.6 days whereas the interval between autumnal equinox and winter solstice is 89.8 days.

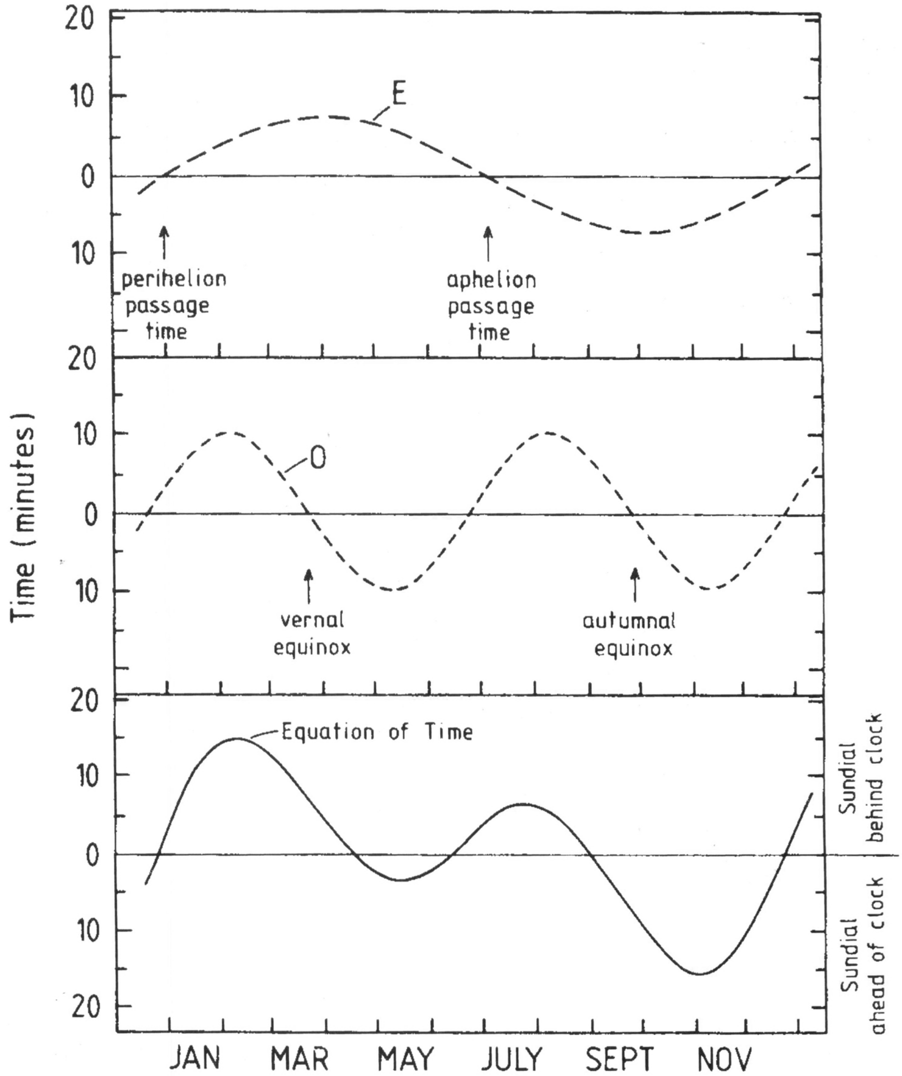


FIGURE 2:
The lowest graph shows the Equation of Time plotted as a function of time throughout the year. This Equation is the sum of two components. Component E is due to the ellipticity of the Earth's orbit. Component 0 is due to the mean Sun's path being the celestial equator whereas the apparent Sun moves along the ecliptic.

The Equation of Time is obtained by adding curve E to Curve O and this is shown at the bottom of Fig. 2.

Let us consider the Equation of Time during January 1993. During this month a line of longitude on the spinning Earth will overtake the mean Sun before the apparent Sun. The mean Sun, by definition, crosses the meridian at 12.00 noon.

The apparent Sun crosses later, ie. at $12^h\ 03^m\ 11.2^{om}$, 12h $07^m\ 36.2^{om}$, $12^h\ 11^m\ 05.27^m$ and $12^h\ 13^m\ 20.70^m$ on January 1, 10, 20 and 30 respectively. On January 30th the sundial reads noon at a clock time of $12^h.\ 13^m$. The sundial is slow and the Equation of Time has to be added to all its readings. Returning to Fig. 2, the reading on the lower graph has to be added to the sundial time whenever that graph is above the horizontal (zero time) line and subtracted whenever it is below that line.

On certain sundials the equation of time is represented by a skewed figure-of-eight, which is often called an analemma. A typical example is shown in Fig. 3, this one being suitable for a vertical dial on a south-facing wall. The gnomon is just above the top of the figure. The position of the shadow of the tip of the gnomon changes as a function of the height of the Sun above the horizon. In midwinter, when the Sun is low in the sky the distance between the shadow tip and gnomon tip is shorter than it is in summer. Let us again take January as an example. The Equation of Time is positive in January and has a value of about plus 13.3 minutes on January 30. At mean solar noon (ie. "clock" noon) on that day the tip of the gnomon shadow will be pointing to the January 30 dot in Fig. 3 and the shadow will read $11^h\ 46.7^m$. The figure-of-eight is the locus joining the positions of the tip of the gnomon

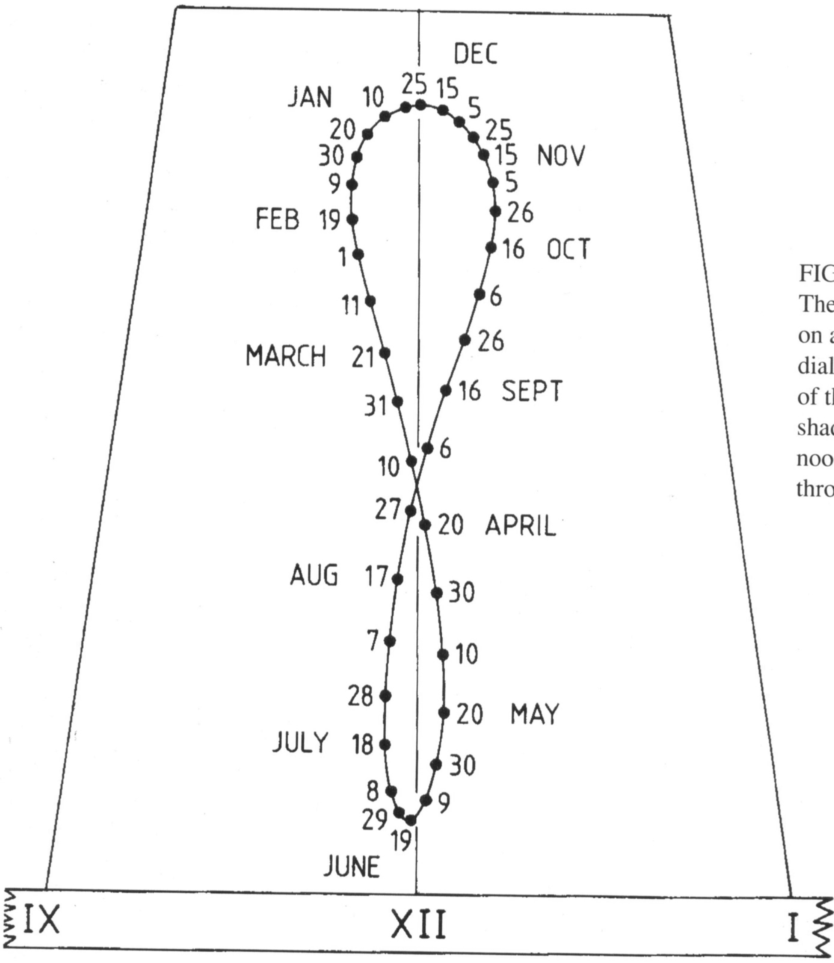


FIGURE 3: The typical figure-of-eight on a vertical analemmatic dial represents the position of the tip of the gnomon shadow at mean solar noon (ie. clock noon) throughout the year.

shadows of at mean solar noon throughout the year.

Historically the Equation of Time was placed on a firm footing by John Flamsteed (1646-1719). Flamsteed was appointed as England's first Astronomer Royal in 1675 at the Royal Greenwich Observatory near London.

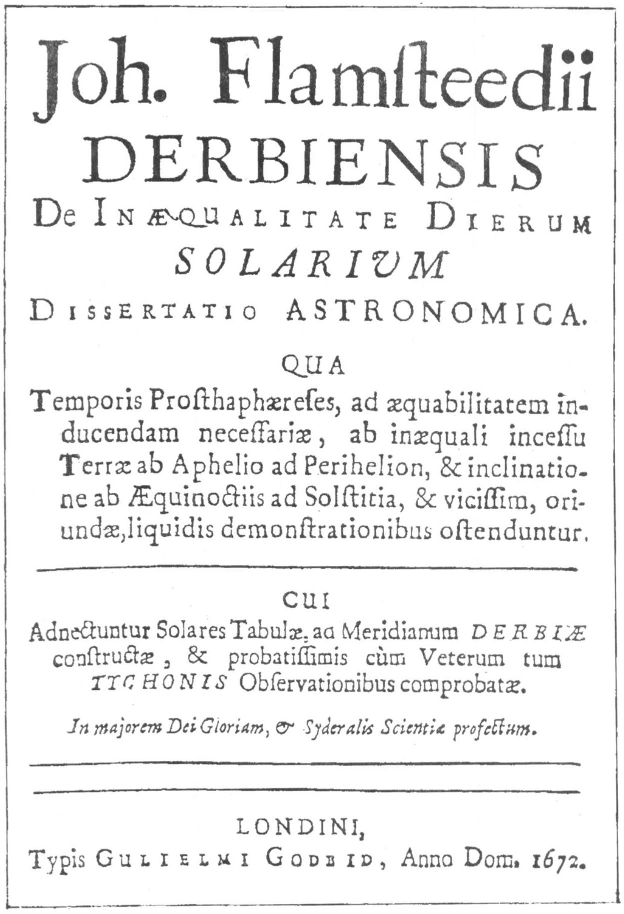
The first page of his 1672 key-note paper is reproduced as Fig. 4. This was a dissertation "in which the error of time arising from the unequal progress of the Earth from its aphelion to its perihelion, and from the inclination of its orbit between the equinoxes and solstices, and back again, are shown in a clear fashion". Flamsteed solved the problem completely and removed all the previous sources of confusion. To quote the first few lines of his paper,

"the inequality of the solar day has occasioned much discussion amongst practical astronomers so that, even disregarding the opinions of the ancients, we hardly find two of today's astronomers holding the same opinion about it. Some have denied the inequality of Civil days, among whom Jacob Cristman and Witich are especially numbered. Their reasonings are considered to be so invalid that scarcely anyone considers them worth discussing, the only exceptions being those who, through ignorance, patronise these views. To them we may add Windelin, who is said to have given his opinion in the following phrase:

In Coelis par est hodiernae crastina sumae.

(In the heavens, tomorrow's total is equal to today's.)

As confirmation of his opinion Windelin quotes the time of occurrence of 45 lunar eclipses which have been calculated using his own tables. He rejects, however, the eclipses observed by Tycho Brahe (1546-1601) and regards their timings as suspect. "These timings,



Joh. Flamsteedii
DERBIENSIS
De Inæqualitate Dierum
SOLARIUM
Dissertatio ASTRONOMICA.
QUA
Temporis Prosthaphæreses, ad æquabilitatem inducendam necessariæ, ab inæquali incessu Terræ ab Aphelio ad Perihelion, & inclinatione ab Æquinoctiis ad Solstitia, & vicissim, oriundæ, liquidis demonstrationibus ostenduntur.
CUI
Adnectuntur Solares Tabulæ, ad Meridianum *DERBIÆ* constructæ, & probatissimis cùm Veterum tum *TYCHONIS* Observationibus comprobatæ.
In majorem Dei Gloriam, & Syderalis Scientiæ profectum.
LONDINI,
Typis Gulielmi Godbid, Anno Dom. 1672.

FIGURE 4: The Title Page of John Flamsteed's paper on Equation of Time, published in 1672.

together with a great many others that have been observed more recently, are different from those predicted in his tables, this difference strongly pointing towards the existence of an equation of time (Temporis aequationem). I will pass over the diverse opinions expressed by Kepler, Longomontanus, Lansberg, Morin and others as these serve no purpose. . . "

Flamsteed produced a table of 360 values of the equation of time for the year 1672, there being one value for each degree of the Sun's path around the zodiac. A more useful version gives a value for each day of the year and a typical example is shown in Fig. 5.

Let us finish this brief introduction to the **Equation of Time** by turning to slightly more complicated matters. Because the year does not contain a whole number of days the exact form of the Equation varies slightly throughout the four-year leap year cycle. Secondly, the Equation varies over longer time periods due to temporal changes in the three parameters that it depends upon, these being the position of the perihelion of the Earth's orbit with respect to the vernal equinox, the obliquity of the ecliptic (ie. the angle between the ecliptic and the celestial equator) and the eccentricity of the Earth's orbit. The main reason for the slow changes in the equation is the precession of the lime of apsides of the Earth's orbit (ie. the line joining the perihelion to the aphelion). The longitude of the perihelion increases by about 1.72° per century. So around 4000 BC, at the time of the building of the Great Pyramid in Egypt, perihelion passage occurred near the autumnal equinox, whereas it now occurs around January 4. Equations enabling you to calculate the equation of time for any epoch within 30 centuries of the present day, to a precision of about 3 seconds of time are given in a research paper by David W. Hughes, B.D. Yallop & C.Y. Hohenkerk in Monthy Notices of the Royal Astronomical Society, 238, 1529-1535. Typical examples are shown in Fig. 6.

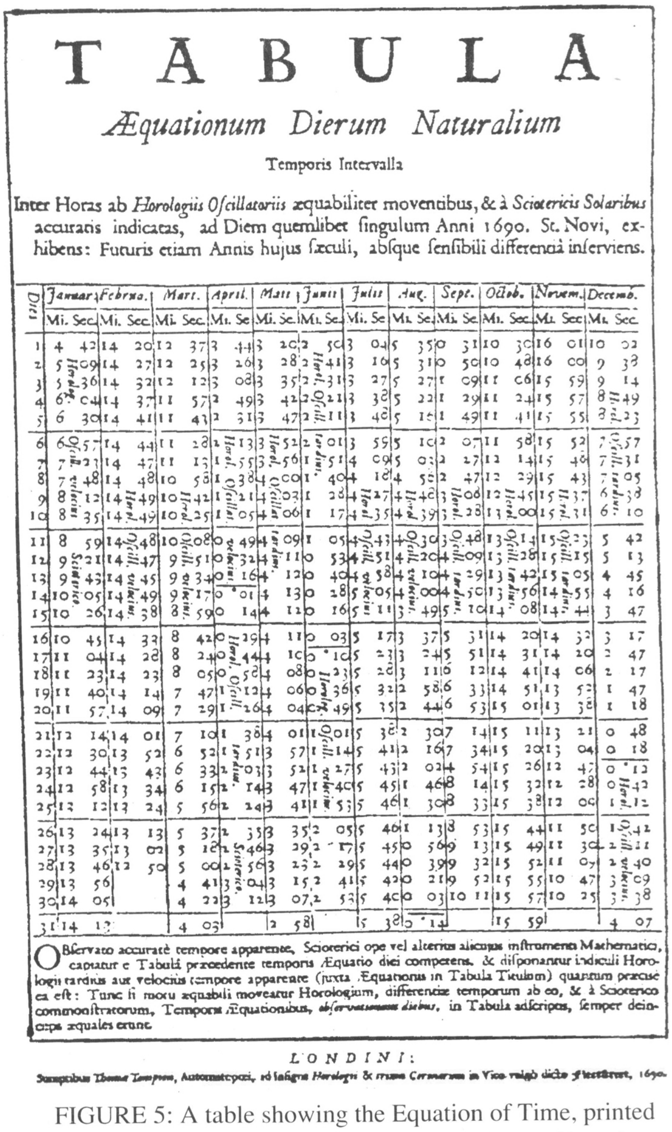
Readers with scientific calculators and a propensity for mathematics can calculate an approximate value for the Equation of Time, ET, (in seconds of time) from the simplified expressions given below.

$$ET = 13751 \left\{ 2 \times 0.01675 \sin (L - 281.22) - [\tan (23.45/20)]^2 \times \sin 2L \right\}$$

(see Sir Robert S. Ball, *A Treatise on Spherical Astronomy*, Cambridge University Press, 1908, p. 232-242. Expanding this equation gives

$$ET = 89.6 \sin L + 451.9 \cos L - 592.3 \sin 2L \quad \text{seconds}$$

In the first of these equations the quantity 0.01675 is the eccentricity of the Earth's orbit, 281.22° is the argument of the perihelion of the Earth's orbit (ie. the angle between the line joining the Sun to the vernal equinox and the Sun to the Earth's perihelion point) and 23.45° is the angle between the ecliptic plane and the equatorial plane. The major variable in the two equations is the angle L, this being the solar longitude. This is the angle between the Earth - vernal equinox line and the Earth - Sun line. The solar longitude is zero when the Sun is at the vernal equinox (March 21) and increases by 0.98563 degrees per day as the Sun journeys along the celestial ecliptic.



TABULA
Æquationum Dierum Naturalium
Temporis Intervalla
Inter Horas ab *Horologiis Oscillatoriis* æquabiliter moventibus, & à *Sciotericis Solaribus* accuratis indicatas, ad Diem quemlibet singulum Anni 1690. St. Novi, exhibens: Futuris etiam Annis hujus sæculi, absque sensibili differentiâ inserviens.

Dies	Januar.		Februa.		Mart.		April.		Maii		Junii		Julii		Aug.		Sept.		Octob.		Novem.		Decemb.	
	Mi.	Sec.	Mi.	Sec.	Mi.	Sec.	Mi.	Se.	Mi.	Se.	Mi.	Se.	Mi.	Se.	Mi.	Se.	Mi.	Se.	Mi.	Sec.	Mi.	Sec.	Mi.	Sec.
1	4	42	14	20	12	37	3	44	3	20	2	50	3	04	5	35	0	31	10	30	16	01	10	02
2	5	09	14	27	12	25	3	26	3	28	2	41	3	16	5	31	0	50	10	48	16	00	9	38
3	5	36	14	32	12	12	3	08	3	35	2	31	3	27	5	27	1	09	11	06	15	59	9	14
4	6	04	14	37	11	57	2	49	3	42	2	21	3	38	5	22	1	29	11	24	15	57	8	49
5	6	30	14	41	11	43	2	31	3	47	2	11	3	48	5	15	1	49	11	41	15	55	8	23
6	6	57	14	44	11	28	2	13	3	52	2	01	3	59	5	10	2	07	11	58	15	52	7	57
7	7	23	14	47	11	13	1	55	3	56	1	51	4	09	5	03	2	27	12	14	15	46	7	31
8	7	48	14	48	10	58	1	38	4	00	1	40	4	18	4	55	2	47	12	29	15	43	7	05
9	8	12	14	49	10	42	1	21	4	03	1	28	4	27	4	46	3	08	12	45	15	37	6	38
10	8	35	14	49	10	25	1	05	4	06	1	17	4	35	4	39	3	28	13	00	15	31	6	10
11	8	59	14	48	10	08	0	49	4	09	1	05	4	43	4	30	3	48	13	14	15	23	5	42
12	9	21	14	47	9	51	0	32	4	11	0	53	4	51	4	20	4	09	13	28	15	15	5	13
13	9	43	14	45	9	34	0	16	4	12	0	40	4	58	4	10	4	29	13	42	15	05	4	45
14	10	05	14	49	9	17	0	01	4	13	0	28	5	05	4	00	4	50	13	56	14	55	4	16
15	10	26	14	38	8	59	0	14	4	12	0	16	5	11	3	49	5	10	14	08	14	41	3	47
16	10	45	14	33	8	42	0	29	4	11	0	03	5	17	3	37	5	31	14	20	14	32	3	17
17	11	04	14	28	8	24	0	44	4	10	0	10	5	23	3	24	5	51	14	31	14	20	2	47
18	11	23	14	23	8	05	0	58	4	08	0	23	5	28	3	11	6	12	14	41	14	06	2	17
19	11	40	14	14	7	47	1	12	4	06	0	36	5	32	2	58	6	33	14	51	13	52	1	47
20	11	57	14	09	7	29	1	26	4	04	0	49	5	35	2	44	6	53	15	01	13	38	1	18
21	12	14	14	01	7	10	1	38	4	01	1	01	5	38	2	30	7	14	15	11	13	21	0	48
22	12	30	13	52	6	52	1	51	3	57	1	14	5	41	2	16	7	34	15	20	13	04	0	18
23	12	44	13	43	6	33	2	03	3	52	1	27	5	43	2	02	7	54	15	26	12	47	0	12
24	12	58	13	34	6	15	2	14	3	47	1	40	5	45	1	46	8	14	15	32	12	28	0	42
25	13	12	13	24	5	56	2	24	3	41	1	53	5	46	1	30	8	33	15	38	12	09	1	12
26	13	24	13	13	5	37	2	35	3	35	2	05	5	46	1	13	8	53	15	44	11	50	1	42
27	13	35	13	02	5	18	2	46	3	29	2	17	5	45	0	56	9	13	15	49	11	30	2	11
28	13	46	12	50	5	00	2	56	3	23	2	29	5	44	0	39	9	32	15	52	11	07	2	40
29	13	56			4	41	3	04	3	15	2	41	5	42	0	21	9	52	15	55	10	47	3	09
30	14	05			4	22	3	12	3	07	2	53	5	40	0	03	10	11	15	57	10	25	3	38
31	14	13			4	03			2	58			5	38	0	14			15	59			4	07

Observato accuratè tempore apparente, Sciotericі ope vel alterius alicujus instrumenti Mathematici, capiatur e Tabulâ præcedente temporis Æquatio diei competens, & disponantur indiculi Horologii tardius aut velocius tempore apparente (juxta Æquationis in Tabula Titulum) quantum præcise ea est: Tunc si motu æquabili moveatur Horologium, differentiæ temporum ab eo, & à Sciioterico commonstratorum, Temporis Æquationibus, *observationum diebus*, in Tabula adscriptis, semper deinceps æquales erunt.

LONDINI:
Sumptibus *Thomæ Tompion*, Automatopœi, ad Insigne *Horologii* & *trium Coronarum* in Vico vulgò dicto *Fleetstreet*, 1690.

FIGURE 5: A table showing the Equation of Time, printed for the English Clockmaker Thomas Tompion in 1690.

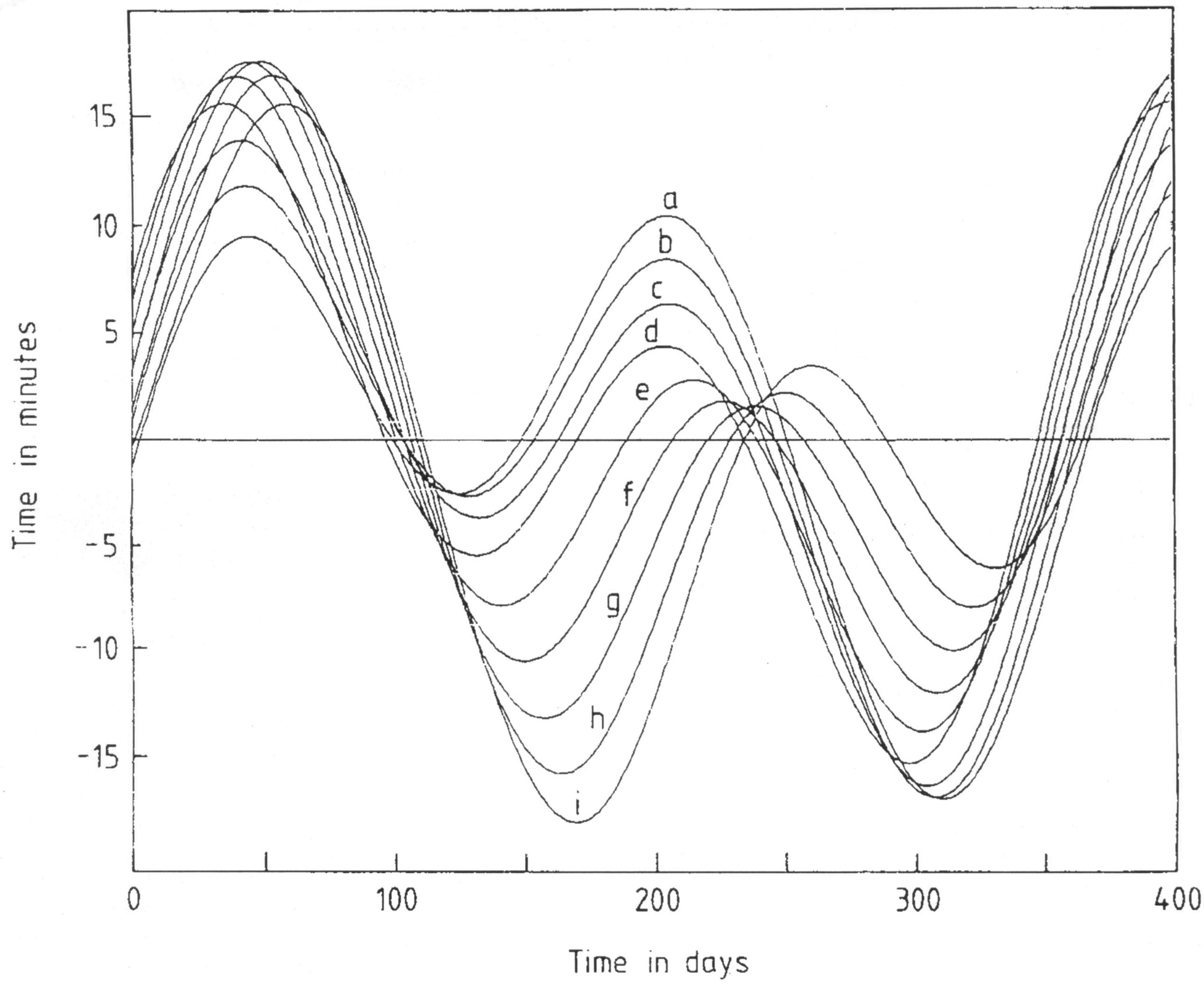


FIGURE 6: The Equation of Time is plotted as a function of time throughout the year, starting at noon on January 0 in the year in question. The nine epochs correspond to (a) AD 4000, (b) AD 3000, (c) AD 2000, (d) AD 1000, (e) 1 BC, (f) 1001 BC, (g) 2001 BC, (h) 3001 BC and (i) 4001 BC.

A TRIPLE-SUNDIAL

F J de VRIES (NETHERLANDS)

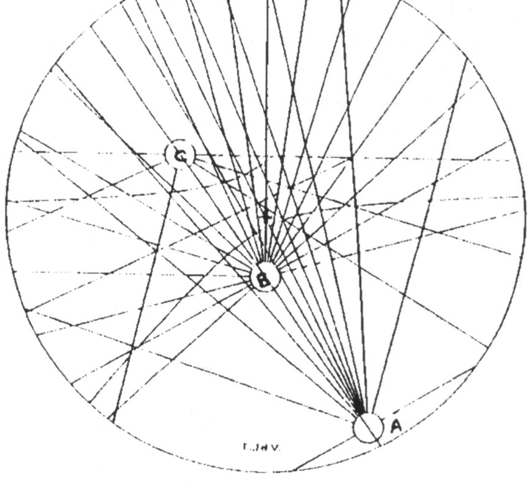
It is well known that solar time can be read by means of the shadow-line of a style parallel to the earth's axis, but it is rather less well known that the same principle can be used with a vertical style to indicate azimuth or that a horizontal style can indicate the astrological houses.

Normally an index is used for these lines and the shadow point of the index employed to read the azimuth and houses.

A rather interesting sundial arises when all three styles are located on the dial in such a way that these styles intersect at a single point. This point of intersection can be used as an index to enable the reading of various lines on the dial plane.

In the accompanying drawing, an example of such a dial is shown. The dial is delineated for a latitude of 52°, it has an inclination of 45° and a declination of 45°.

The polar style starts at A, the vertical style at B and the horizontal style at C. They intersect at a point above +.



Latitude 50° • Inconation 45 ° • Declination 45°

SHEPHERDS AND SPREADSHEETS

MICHAEL HICKMAN

INTRODUCTION

Members may have tried to design and make shepherds' dials by calculating and plotting the sun's altitude against time throughout the year, as suggested by Waugh[1] and Mayall and Mayall[2]. If they had sufficient time, patience and drawing skill they may have succeeded, but they probably found it not as easy as the references imply.

Access to a computer and printer and also to a spreadsheet program enables design and production of such dials to be greatly simplified.

This feature outlines the principles involved, which should enable any spreadsheet program to be used. It also shows a shepherd's dial designed and made using LOTUS 1-2-3[3].

An advantage of a spreadsheet approach is that little knowledge of programming is required and the mathematics are more visible and evident than if the more common language BASIC is used. I suspect also that use of BASIC requires considerable computer knowledge if the output is to be plotted on a line printer, though BASIC is fairly easy to use if the print-out is to be on an X-Y plotter. Members' comments on this will be appreciated.

I would be happy to discuss the detailed use of spreadsheets and BASIC with any interested reader and to make my programs available to them.

For those members interested only in the end product I am also willing to print a dial for them, on A4, in return for details of the required latitude and a stamped addressed envelope, preferably large enough to take an A4 sheet unfolded.

DIAL DESIGN

Design of shepherds' dials comprises determination and then plotting of the tangent of the sun's altitude for various times of day at intervals throughout the year.

Altitude may be determined either from sight reduction tables prepared for astro-navigation purposes (such as those in the Nautical Almanac) or by calculation. The formula for altitude requires as inputs latitude, hour angle and declination and is given in different forms in different publications.

The best formula to use is, I suggest, that quoted in the Nautical Almanac. That quoted in my edition of Waugh's book[4] is in fact wrong - a printer's error appears to have crept in, but when it is corrected it is identical to that in the almanac. (Formula 2 on the same page for azimuth is also wrong. Another printer's error?)

Mayall and Mayall also give a formula[5] which may be transformed into that in the almanac. However it uses an intermediate function which makes it unnecessarily long.

The formula for altitude that I have used is:

$$\text{Sin Alt} = (\text{Sin Lat} \times \text{Sin Dec} + \text{Cos Lat} \times \text{Cos Dec} \times \text{Cos H})$$

where Alt = the altitude to be calculated
Dec = the sun's declination
Lat = latitude
H = hour angle

but what we have to actually plot is the tangent of the altitude.

Thus we need to prepare a spreadsheet to calculate the following function for each hour throughout the year.

$$\tan(\text{Sin}^{-1}(\text{Sin Lat} \times \text{Sin Dec} + \text{Cos Lat} \times \text{Cos Dec} \times \text{Cos H}))$$

SETTING UP THE SPREADSHEET

We need to set up a table with times in the top row, at hourly intervals, and periods through the year, at 1/3 month intervals, in the left-hand column.

We also need to input latitude and to turn this from degrees, minutes and seconds into radians, as computers work in these rather than in degrees.

The times need to be processed to give hour angles in radians and the periods through the year are used to give, from standard tables, the sun's declination, again ultimately in radians.

We thus now have a table looking something like the small extract shown in figure 1. In spreadsheet work the intersection of each row and column of such a table is known as a cell. For each cell we need to process the relevant hour angle and declination, which depend on the cell location, and the latitude which is of course constant in our table.

The way in which we process the data for each cell will depend in detail on the spreadsheet we are using, but it will be basically the same in each cell. This is where spreadsheets prove their worth.

The formula already given in the foregoing will need to be put into the correct format for the spreadsheet program to be used. In LOTUS 1-2-3 this means that what are called @functions must be used, so that, for example, the sine of an angle is found from the function @sin, the cosine from @cos and so on. Reference should be made to your program documentation for detailed instructions.

While it is somewhat tedious to type the formula in the first time it is no trouble to replicate it in all of the cells. We then end up with a matrix of cells, each containing the appropriate value to be plotted for each hour of each period of 1/3 month. Figure 2 shows, for LOTUS 1-2-3, the formula for each cell of the extract shown in figure 1. Thus the value in cell E8, the intersection of column E and row 8, is -0.15. This is derived from the appropriate formula shown in figure 2 for cell E8.

PLOTTING

The exact procedure for plotting the values in the matrix will depend on the spreadsheet program in use and I can only refer you to your handbook for this. However some general comments may be helpful.

The dimensions of the plot need to be arranged to fit on a sheet of paper to be mounted on the required cylinder. I found it convenient to plot on A4 landscape to a size suitable for my intended cylinder as described later; the eventual size of the plot will in turn determine the required length for the gnomon. LOTUS 1-2-3 permits the height and width of the graph to be any required values and other programs doubtless provide the option.

You may of course dimension the plot to suit the gnomon length, but I'm sure you will find the other way round simpler, as I describe later on.

My spreadsheet program will allow only six curves to be plotted - which means that the hour lines for only 7am. - 5pm. local apparent time may be shown and the effects of longitude and the equation of time must be allowed for separately.

A1	B	C	D	E	F	G	H
2							
3	LAT DEG	50.72	LA TIME	7	8	9	10
4	LAT RAD	0.89	HA DEG	285	300	315	330
5			HA RAD	4.97	5.24	5.50	5.76
6							
7	MONTH	DEC DEG	DEC RAD--------		TAN SUN'S ALT.		--------
8	JAN	-23.07	-0.40	-0.15	-0.01	0.11	0.21

FIGURE 1: Extract from the spreadsheet

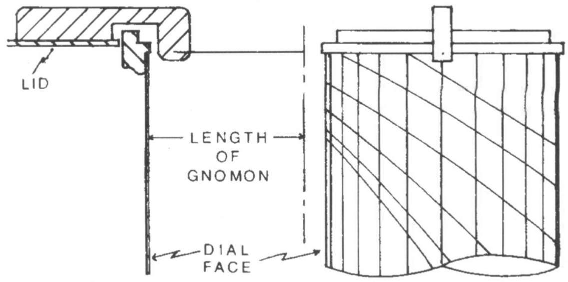


FIGURE 4: Detail of mounting of gnomon on cylinder lid

```
B3: ^LAT DEG
C3: 50+43/60
D3: [W7] ^LA TIME
E3: [W8] 7
F3: [W8] 8
G3: [W8] 9
H3: [W8] 10
B4: ^LAT RAD
C4: +LAT*@PI/180
D4: [W7] ^HA DEG
E4: [W8] 180+E$3*15
F4: [W8] 180+F$3*15
G4: [W8] 180+G$3*15
H4: [W8] 180+H$3*15
D5: [W7] ^HA RAD
E5: [W8] +E$4*@PI/180
F5: [W8] +F$4*@PI/180
G5: [W8] +G$4*@PI/180
H5: [W8] +H$4*@PI/180
B7: ^MONTH
C7: ^DEC DEG
D7: [W7] ^DEC RAD
E7: [W8] '---------
F7: [W8] ' TAN SUN'S ALT.
H7: [W8] '--------
B8: ^JAN
C8: -23.066666667
D8: [W7] +$C8*@PI/180
E8: [W8] @TAN(@ASIN(@SIN($C$4)*@SIN($D8)+@COS($C$4)*@COS($D8)*@COS(E$5)))
F8: [W8] @TAN(@ASIN(@SIN($C$4)*@SIN($D8)+@COS($C$4)*@COS($D8)*@COS(F$5)))
G8: [W8] @TAN(@ASIN(@SIN($C$4)*@SIN($D8)+@COS($C$4)*@COS($D8)*@COS(G$5)))
H8: [W8] @TAN(@ASIN(@SIN($C$4)*@SIN($D8)+@COS($C$4)*@COS($D8)*@COS(H$5)))
B10: '-----------------------------------------------------------------
-------
C12: '
```

FIGURE 2: Formulae used in the spreadsheet

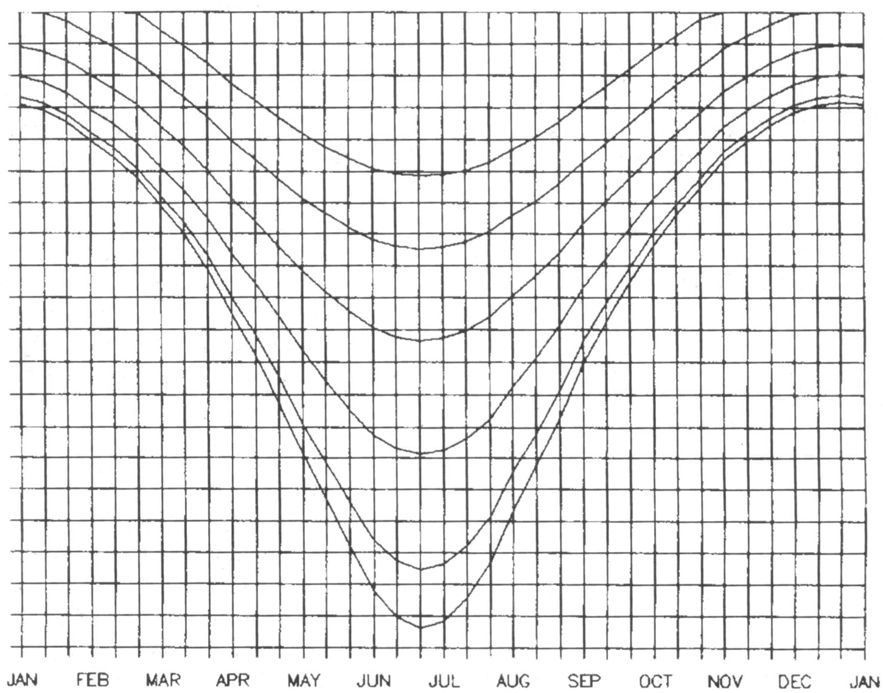


FIGURE 3: Plots of tangent of sun's altitude

If all plotting is done manually then longitude and equation of time can be allowed for in the plot. This does however mean that a curve for each hour must be plotted whereas if these functions are not incorporated in the calculations then each curve will do for two times symmetrically located about noon, as in Waugh's book.

Using each curve for two times also has the benefit of reducing the number of curves and hence their crowding together on the plot. This will help legibility.

The end results are shown in figure 3.

CONSTRUCTION

For an A4 plot the cylinder needs to be of the order of 70mm diameter and 160mm long. I found a Sharwood's iodised sea salt container, 500 gramme size, to be particularly suitable as it has a smoothly rotating lid fixed to it. This lid is ideal, with a little wood or plastic work, as a mount for the gnomon and the container might well have been designed for a shepherd's dial. The photograph shows the dial I made based on such a container.

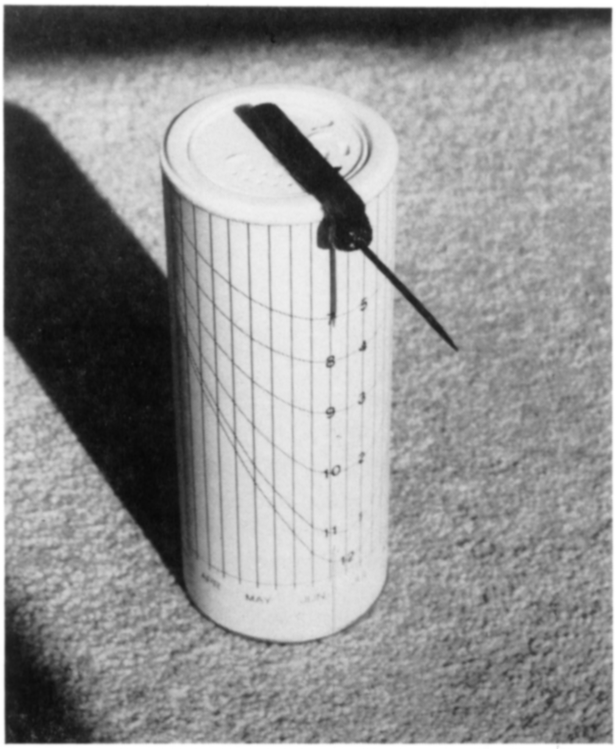


FIGURE 5: The Finished Product

There are doubtless other containers that will serve and my wife suggests those for Parmesan cheese as an alternative. The 85 gramme size made by Galbani looks suitable and would require a slightly reduced A5 plot.

Ideally the container should have a rotating lid that is secured to it and the container itself should be a smooth cylinder, preferably of cardboard to lessen weight and avoid breakage if it is dropped.

Cocktail sticks make suitable gnomons. They need to be cut to the required length and then mounted so that they are horizontal, radial and at the level of graph zero.

The length of the gnomon is easily calculated from the plot. The steps are:

Determine the maximum altitude of the sun for your latitude. This will be given by subtracting your latitude from 90° and adding the sun's maximum declination (23° 27' N on 21 June). Thus for Dorchester where I live (Latitude $50^\circ 43'$ N) the sun's maximum altitude will be $90^\circ - 50^\circ 43' + 23^\circ 27' = 62^\circ 44'$. Let this be Altitude

The length of the gnomon is then given by the expression

$$\text{Plot/Gnomon} = \tan \text{Altitude}$$ [6]

$$\text{so that the gnomon length} = \frac{\text{Plot}}{\text{Tan altitude}}$$

which for my plot and my latitude gave a gnomon length of $12.7/\tan 62^\circ 44' = 12.7/1.94 = 6.55$ mm.

This is a convenient length for a wooden cocktail stick to be used, and this has a useful sharp point at the end.

Note that the length of the gnomon is the amount by which it projects from the face of the dial, as shown in figure 4. The gnomon may be mounted on the container lid by means of a block of balsa wood shaped so that the gnomon is horizontal, with its line passing through the centre of rotation of the lid, and at the level of the horizontal zero line of the graph.

If desired the dial, when finished, may be sprayed with an aerosol clear varnish to make it less vulnerable to damp. However care is needed to avoid spraying the lid as it may well no longer rotate once the varnish has dried.

USE

The use of such dials is well described in the standard works. In essence it comprises rotating the lid until the gnomon is over the appropriate column for the date. The whole cylinder is then rotated, with its axis vertical, until the shadow of the gnomon is vertical.

The point of the shadow of the gnomon will then indicate local apparent time, though it will usually be necessary to interpolate between the hour lines, which are not linearly spaced. Remember that dial time must be modified to allow for longitude and the equation of time, and the cylinder must be vertical.

COSTS

The materials for the dial I have made were all to hand so that the hardware cost was nil. A circular level costs £2-3 but I did not bother to fit one. The software cost was of course another matter and I don't suggest that you buy a computer or a spreadsheet program just for shepherds' dials.

CONCLUSION

As I mentioned at the start of this feature I am willing to provide A4 plots, for members only, for any latitude. Please send me a suitable large stamped envelope, and of course details of the required location. My address is - 1 Lancaster Road, Dorchester, Dorset, DT1 1QH.

REFERENCES

1. Waugh "Sundials: Their theory and construction" pp 150-4.
2. Mayall and Mayall "Sundials" pp 162-6.
3. This was designed and printed using LOTUS 1-2-3 version 2.01 which has been superseded by later versions. However any difference will be only in points of detail rather than in principle.
4. Waugh "Sundials: Their theory and construction" p 139 formula 1.
5. Mayall and Mayall "Sundials" p 243.
6. Mayall and Mayall "Sundials" p 166 and Waugh "Sundials: Their theory and construction" p 152.

THE IVORY DIPTYCH DIAL - PART 1

JOHN MOORE

The diptych dial was probably introduced in the 15th or 16th centuries possibly in the Low Countries or Germany. Craftsmen made it initially in small quantities, usually in brass, which was often silvered or gilded. This design was also made in other countries throughout Europe and in particular, Italy, from whence some of the more ornate designs have originated.

Soon afterwards the diptych dial was also made in ivory, the largest numbers coming from two main centres, Dieppe and Nuremburg.

Dieppe was, and still is, a relatively small fishing port on the northern French coast. Its dial makers were small in number and it is amazing how many of their products have survived from the relatively short period of their manufacture which is believed to have been between the years 1600 and 1700.

Nuremberg, on the other hand, a large and prosperous town in southern Germany, had many workers making ivory dials. These workers, however, came from just a few families and between them they turned out large numbers of diptych of dials between 1550 and 1650.

The subject of Nuremberg dials and their makers has been superbly covered by Penelope Gouk in her book *The Ivory Sundials of Nuremberg* (Ref.1) and it is not proposed to repeat this information except as required for completeness.

Other areas in Europe also made the ivory diptych dial but not in any quantity. Examples are known from other parts of France and from Spain and Italy.

The word diptych comes from both Latin and Greek. The Greek word *diptukha* is from *di*, meaning two and *ptakhos*, to fold. In English a diptych is generally an ancient two leaved writing tablet or a religious painting with two leaves that close like a book.

Diptych dials also consist of two leaves and when folded and latched may be carried safely in the pocket without risk of damage. Original protective cases for these early dials are unknown but a later English model (Fig.8) and some of the wooden examples made in Germany do have them. It is probable that the metal diptych dials did have cases, which were important to protect their engraving and gilding. The case would also protect the pocket from their sharp metal edges.

All diptych dials have a built-in compass for correct orientation. The compass is often a good aid to fairly precise dating of these dials from the magnetic declination (Ref.2) which is usually marked in the bowl.

Ivory is a very durable material which can easily be sawn, cut to shape and polished. However, in time it dries out and over the 300 to 400 years since these dials were made cracks have appeared along the grain. In some case they have completely split, usually across the compass bowl and require expert restoration. One such dial by Jacques Senecal of Dieppe (Fig.1) had badly split and in restoration it was completely disassembled. When the lunar volvelle was removed a hidden engraving (Fig.2) was found which showed a fine sailing ship. Most materials, and brass in particular, were very expensive and engravers were often known to use scrap pieces, or hidden areas to practice their skills. One sometimes finds clock dials made from old garden sundials and even a sundial made on the reverse of an old engraved copper printing plate. Very little was sent for scrap.

The calibration lines were incised into the ivory with a sharp tool or graver, but, in virtually all cases, the numerals and letters were applied with metal punches. Each instrument maker would make his own set, or sets, of punches, probably during his apprenticeship. This was a slow and painstaking process and would have occupied him for a considerable time. These punches would then stay with each maker throughout his working life and would only be replaced when a punch was damaged or worn. It is interesting to make comparisons of one particular makers set of punch marks over a period of years. One finds that occasional changes are made as the punches are replaced. It is believed that (Ref.1) secret formulas were developed for softening the ivory to take the punch marks without splitting. Marking by punches was probably the only successful way of annotating these dials as ivory is relatively brittle and could be expected to chip when deeply cut with a graver in the same way that metal can be engraved. One dial (Fig.3), unsigned, but probably of Dieppe manufacture is known which has been engraved throughout. However, close inspection shows that there are no small markings that would be likely to chip such as figures with small circles or triangles 6, 8, 9, A etc. and the engraver has played safe with large Roman numerals. The delicate engraving shown on the vertical section is very shallow and hence is unlikely to promote chipping.

NUREMBERG DIPTYCH DIALS

Most dials have markings on all four faces and for convenience these will be referred to as Face A, Face B, Face C and Face D starting on the outside top face.

The Nuremberg diptych dials in their simplest form (Fig.4) are only calibrated on Faces B & C. These are standard vertical and horizontal dials operating from the shadow formed by the string gnomon. This is set for a fixed angle, ie. one particular latitude. Some dials have alternative anchoring holes for the top of the string gnomon so that they may be used at several latitudes. However the hour lines are set for a fixed latitude and errors will be found, particularly at 9am and 3pm on the horizontal dial unless alternative scales have been provided for each latitude. When this type of dial is correctly aligned North - South with the aid of the built-in compass and placed on a horizontal surface, a quick and reasonably accurate reading may be obtained. The main errors are as outlined above and also due to the small size of the compass and its out-of-date magnetic declination mark. The contrast obtained on the white ivory surface from the gnomon's shadow gives a crisp and clear line, unlike many metal dials where the shiny surface can obscure its image. Face A on this dial also carries a simple volvelle with a lunar calendar. This dial is obviously one of the cheaper models that were available. It is small in size and economical in its use of ivory and its body is thickened with a boxwood insert. In fact the 'ivory' is most probably bone. Several dials of almost identical appearance are known and each is signed simply on Face D with a punch marked hand outline, thought to be the trademark of a member of the Karner family, probably Albrecht.

The more typical Nuremberg diptych dials were somewhat more complex, often with a Wind Rose on Face

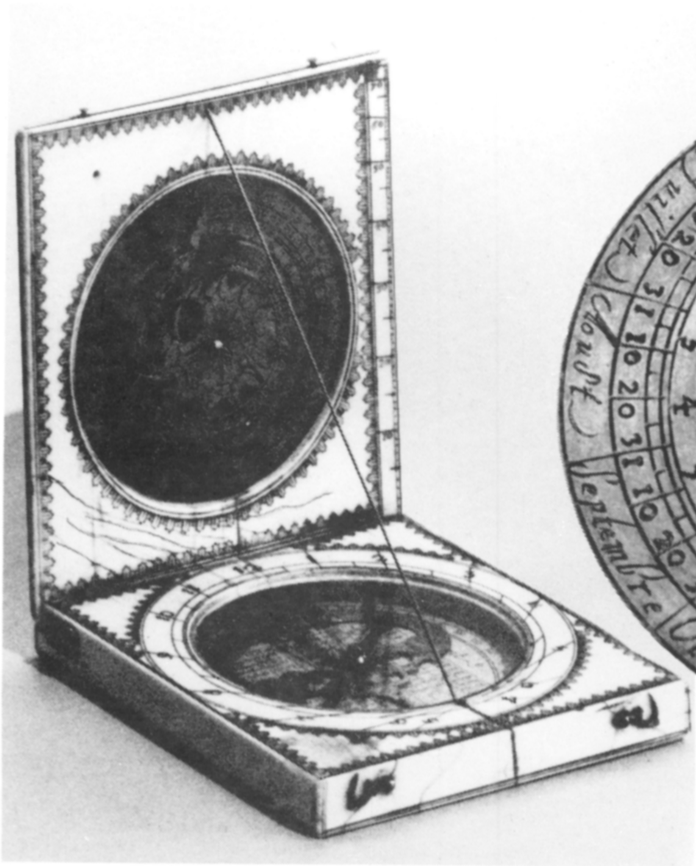


Fig. 1. Dieppe Ivory Dial by Senecal

Fig. 2. Hidden Engraving on Senecal Dial

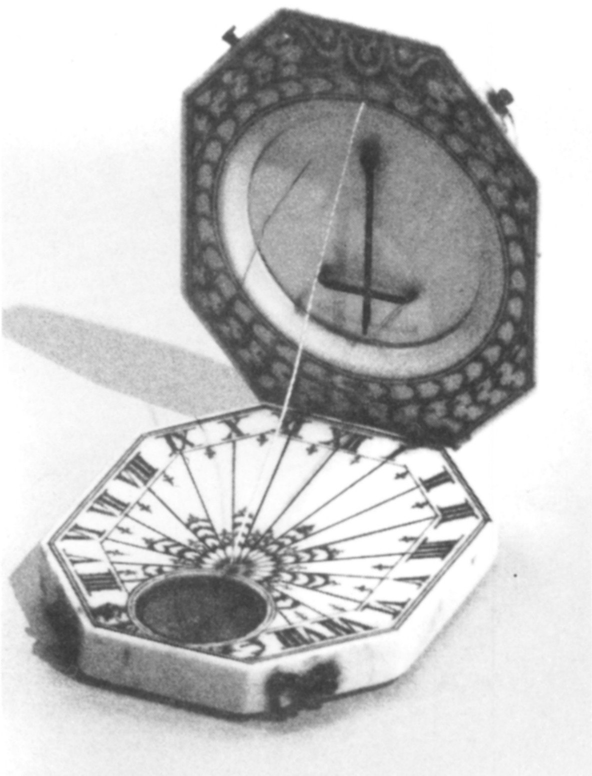


Fig. 3. Simple Dieppe Dial

Fig. 4. Simple Nuremberg Dial by Karner

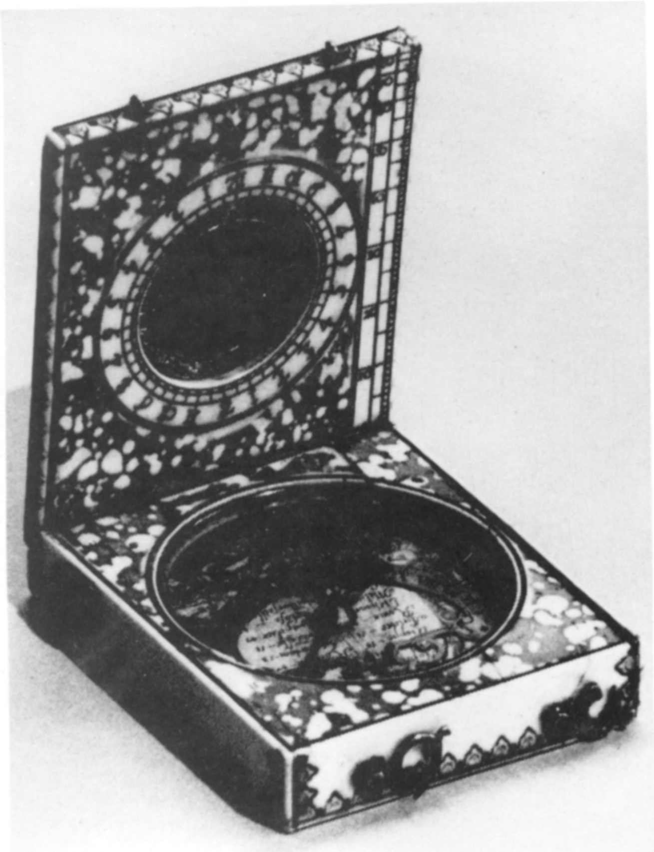


Fig. 5. Magnetic Azimuth Dial by Nicolas Crucifix, Dieppe

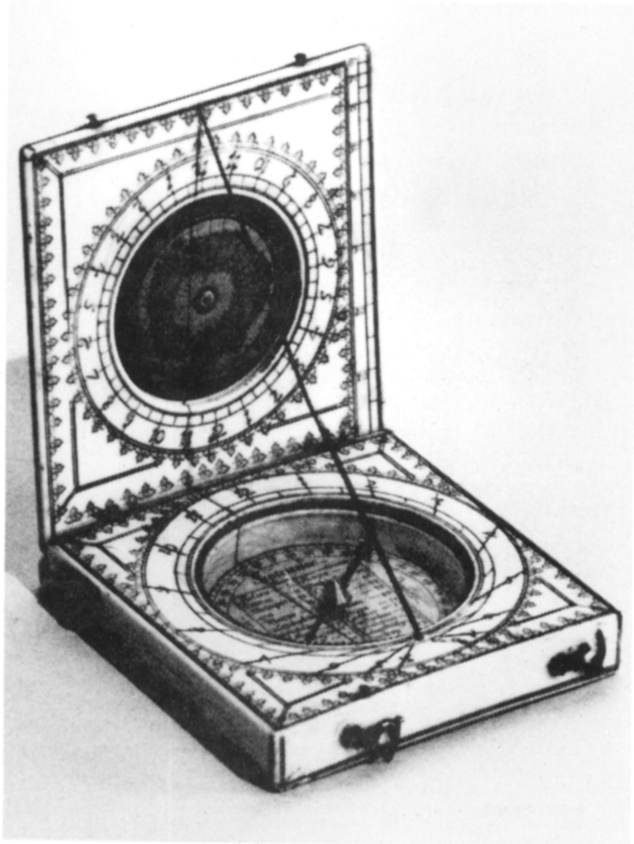


Fig. 6. Dieppe String Gnomon Dial

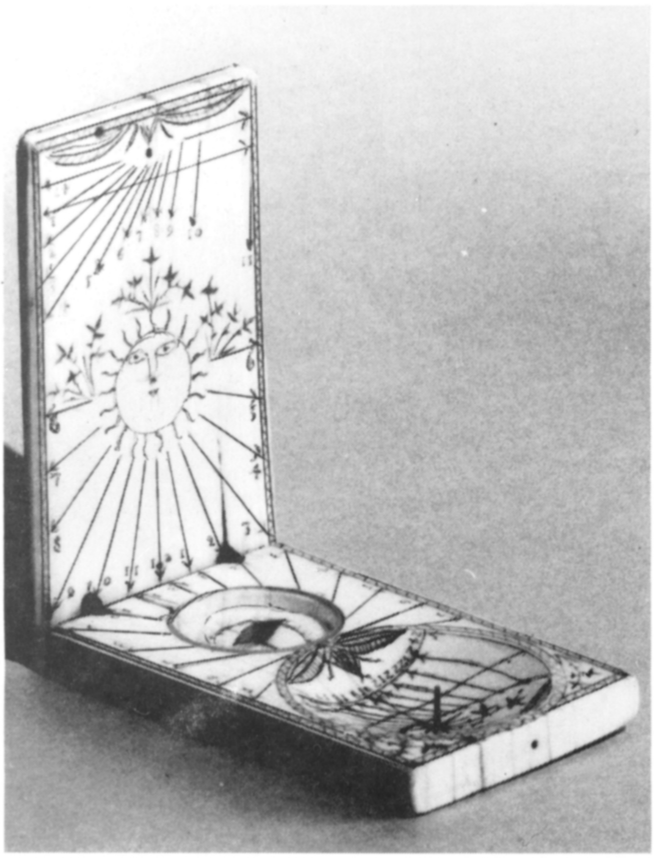


Fig. 7. Spanish Diptych Dial

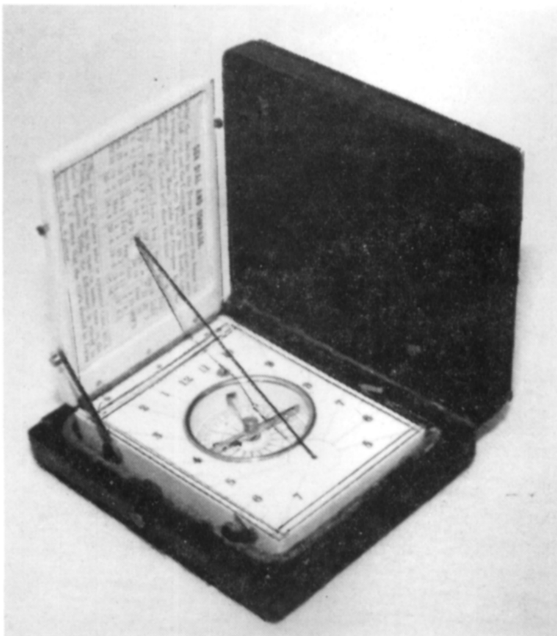


Fig. 8. Ivory Dial by R. & J. Beck, London

A and with some form of Perpetual Calendar on Face D. Other scales on faces B and C would possibly show day length, astrological signs as well as Babylonian and Italian hours. These scales and how they were used will be explained in Part 2.

DIEPPE DIPTYCH DIALS

These are generally quite different in design and function to those from Nuremberg. In its simplest form (Fig.3) the Dieppe diptych dial will be found with just two faces engraved. Face B also incorporates a simple form of plumb bob as an aid to levelling it. Again it has a common string gnomon operating both vertical and horizontal dials. Several almost identical dials are known some of which are signed BLOUD A DIEPPE on Face B. The compass sunk into Face C is one of the smallest ever found on portable dials and severely limits the accuracy of setting. The compass card is of printed paper and is aligned exactly with the body of the dial ie. zero magnetic declination. This suggests a manufacturing date of close to 1660. (Ref.2)

The more usual form of Dieppe diptych dial, the Magnetic Azimuth dial, (Fig.5) rarely has a string gnomon. It relies on the shadow being formed by the open lid along its edge. The time is then read from the scale beneath the compass needle. This particular dial is of very fine quality and is by a little known maker, Nicolas Crucifix. It is the only dial by this maker known to the author. Its unusual mottled appearance is probably formed on the ivory surface by the use of acid with a wax resist. The darker areas are red-brown and are lower than the whiter areas. Three other similarly mottled dials, all from Dieppe, are in the Museum of the History of Science in Oxford.

Another French diptych dial, again probably from Dieppe, is of a more usual design (Fig.6). It does have traditional string gnomon and its shadow can be read from the horizontal dial around its compass on Face C. It also incorporates an Equatorial dial on Face A to enable it to be used at other latitudes. However this type of Equatorial dial can only be used in the summer months when the sun is above the Earth's equator. This particular dial, which is unsigned, still has its original pin gnomon which is kept in the small side pocket on the left. Very few of these pin gnomons have survived.

An explanation of the various scales on these dials and how to read them will follow in Part 2.

OTHER IVORY DIPTYCH DIALS

Ivory diptych dials are occasionally found from other countries, usually Spain or Italy. Unfortunately they were seldom signed and their origins can only be attributed to a particular country by general styling. A dial which is probably of Spanish origin (Fig.7) is typical of many to be found. Its decoration differs substantially from both French and German types and its engraved lines are beautifully coloured with red and green in addition to the basic black calibrations.

A rare and most interesting ivory diptych (Fig.8) was made by R. & J. Beck of London as late as c1870. It is superbly made and is fitted into a neat morocco leather case. Its fittings are of gold and the instructions for its use are pasted inside the dial's lid. Close inspection will reveal that the compass appears reversed, its hour lines also. Both features are indicative of a dial made for use in the southern hemisphere and these are particularly uncommon. Its gnomon angle of 30° suggests that it is made for one of the British Colonies, possibly South Africa or Australia.

FAKES AND FORGERIES

Many goods made from ivory and bone have been replicated in recent years. This is particularly evident from the masses of scrimshaw work that may now be found. These goods are often made from resins with mineral fillers, such as chalk, to make them white and dense. It is even possible to replicate cracks and discoloured areas, and it is often quite difficult, even for an expert, to tell the difference. However there is one simple test which may be performed, preferably out of sight of the vendor. A pin or needle may be heated in a match flame and then pushed into the ivory. If it is resin or plastic it will melt. If it is real ivory or bone it should withstand this test. However in doing this there is a risk of discolouring or scorching the ivory so a hidden area should be chosen. A more scientific approach is to use an electrician's soldering iron fitted with a fairly fine tip. These are designed to operate at around 400°C, hot enough to melt most resins and plastics but usually safe against ivory, at least in the short term.

The Japanese have recently developed a method of making ivory from the shells of hens' eggs. This is an attempt to slow the trade in illegal ivory. The results that they have achieved are virtually indistinguishable from real ivory except that the moulded blocks of material do not contain any grain markings that would be found in natural ivory.

Ivory diptych dials are not exempt from being replicated. Always be careful. Fortunately forgeries and replica dials are quite rare, the forgers preferring to concentrate their efforts on more popular ivory goods.

The second part of this article will concentrate on the various markings shown on diptych dials and will attempt to explain simply how they were used and to show what other important information they carried.

In addition to the list of books about portable dials (Ref.3) a recently published volume by Stephen Lloyd, 'Ivory Diptych Sundials 1570 - 1750', is an excellent record of the dials in the collection at Harvard University, U.S.A.

REFERENCES

Ref. 1. GOUK. P. The Ivory Dials of Nuremberg, 1500-1700
Ref. 2. AKED. C. BSS Bulletin, 92.2 p.20.
Ref. 3. MOORE. J. BSS Bulletin, 92.2 p.18.

ACKNOWLEDGEMENT

The author would like to thank Stuart Talbot for providing the photograph of the R. & J. Beck dial, Fig. 8.

DIPTYCH DIAL MAKERS

The following ivory diptych dial makers have been recorded as working in Dieppe between the years of 1650 and 1750.

ASSELINNE, David
BERNILLE, Mathieu
BLOUD, Carolus (Charles)
BLOUD, Gabriel
CRUCIFIX, Nicolas
GUERARD, Jacques
SENECAL, Ephraim
SENECAL, Jacques

SOME SUNDIALS OF CAMBRIDGESHIRE

The county of Cambridgeshire holds a good number and variety of sundials. The B.S.S. Fixed Dial Locations summary for June 1992 lists 60 (far more than the paltry 25 reported in BSS Bulletin 93.1, p.17) and this list is certainly not yet complete. Within the City of Cambridge there are at least 30 dials, and many Cambridge colleges use sundials as architectural ornaments or for commemorative purposes. This article however is mainly about the dials in the Cambridgeshire countryside, where they are to be found on parish churches and house walls, in gardens and grounds of houses from manors and halls to simple village dwellings. Out of this abundance I will choose and describe some of the more interesting ones.

A favourite place for a sundial is above the door of a church. Examples of such dials are found at Great Shelford just south of Cambridge, where there is a good dial dated 1789; and at Isleham between Ely and Newmarket. The Isleham dial is unusual in being inscribed in a truncated oval within a square; it bears the motto LUX UMBRA DEI. The dial over the door at Horseheath Church in the south-west of the county is set at an angle into its stone frame, to give the precise southerly orientation; the dial face is unusual in having arabic numerals. The churchyard bushes have grown so much that the dial would, alas, be in shadow for most of the summer months.

Some of the dials on the south walls of churches have been placed rather too high for convenient reading. But we have two magnificent church wall dials, large and clearly visible, in excellent condition. One of these is at the east end of the south clerestory wall at Hemingford Grey church, 4 miles S.W. of Huntingdon. The dial, painted on a square of wood, is orientated south declining slightly west; the white central square is surrounded by a blue border bearing gold numerals; and at the root of the gnomon is a red square with the date 1986. This is the date of a recent restoration carried out by the church architect, Peter Foster. The dial probably dates from the eighteenth century, and it may have undergone an earlier restoration in 1859. Mr. Foster records that in 1986 he found that '...the old Roman numerals and hour lines had been carved proud of the ground so it was easy to re-instate these in gold leaf'.

A second church wall dial well worth seeing is on a buttress close to the south door of Ely Cathedral. On this splendid square dial the hour lines emerge from a sunburst at the root of the gnomon and the half-hours are marked by crosses. In handsome Greek capitals along the top is the motto ΚΑΙΡΟΝ ΓΝΩΘΙ 'Know the (right) time' (or 'Recognise the right moment') The sundial dates from 1690 when the Dean and Chapter paid a Mr. Rider £10 for making the sundial, the payment being made out of a source of the Cathedral's revenue called the Onslow Leases. In 1962 the Friends of Ely Cathedral had the sundial restored at a cost of £36.

Each of these fine old dials has been restored at least once. The task now being undertaken at Wisbech (in the north of the county) is not mere restoration but an entire replacement in replica. Over the south porch door of the Church of SS Peter & Paul at Wisbech stood a handsome dial of late seventeenth century construction, with ledge, pediment and side pillars. When the bolts fixing it to the wall became corroded, an attempt to replace them resulted in the shattering and crumbling of the entire dial face of marble, as the marble had weathered beyond repair. A copy

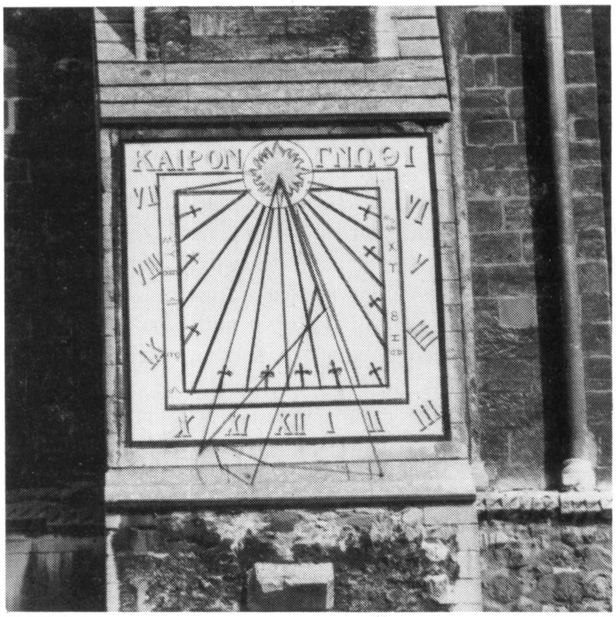


FIGURE 1: The Dial at Ely Cathedral

made in Ketton Stone is now under construction, and the hour lines and gnomon angle are being recalculated for the latitude of Wisbech. So before the end of this summer (1993) the church should have a sundial as beautiful as its predecessor, and more accurate.

Many of the churches of Cambridgeshire show scratch dials (mass dials) particularly good examples being found at Keyston in N.W. Cambs., Balsham in the south-east, and at Hauxton 4 miles south of Cambridge. A couple of quaint examples of misplacement are to be found: at Madingley the stone bearing the scratch dial is inserted into the east wall of the church; and at Girton the dial is not only on an east wall but is also inverted.

Horizontal dials of the rose-garden type are to be found in abundance. In Trinity College Great Court, in Wandlebury Country Park 4 miles south of Cambridge, and at Fulbourn Manor 3 miles S.E. of the city there are dials of almost identical design and size, probably all eighteenth century. They are by three different makers: Troughton, Jo. Jackson and Thomas Eayre. (Was this a current fashion demanded by all patrons, or did the makers copy from each other?) The gnomon stands in a compass rose, and the dial face, marked in concentric circles, carries a circle giving the months and the year, and arcs marked 'Watch Faster' 'Watch Slower'. A charming small horizontal dial is to be seen in the churchyard at Weston Colville. It is mounted on a cylindrical stone plinth on a square stone base. In addition to the maker's name and date (Thomas Soame 1665) it bears the mysterious motto 'WEE MVST'. (We must what? 'We must hasten'? 'We must all die'? Or do the two words alone suffice to show the compulsive urgency of Time?)

As to other types of dial, there are two armillary spheres in Cambridgeshire, both being fine examples of this form. One is in the Fellows' Garden at Wolfson College, a modern dial made to commemorate the presidency of the first President of the College. The other is in a garden (but visible from the road) of a house in Chippenham five miles north of Newmarket. This was not made for this site, but was purchased as an antique by the house owner and installed here in the 1980's.

There are several analemmatic dials in the county,

FIGURE 2: Chippenham Armillary Sphere at Old School House

designed for a human gnomon. A simple one is set up in a playground at Chesterton on the eastern edge of Cambridge City. A more elaborate design has been made for the playground of the Junior School of King's School Ely.

Perhaps the most interesting dial in Cambridgeshire is one not placed on a church or in a garden but by a roadside. In the village street of Great Staugton on the A45 road in west Cambridgeshire, there stands a polyhedral dial, a square stone block surmounted by a stone sphere, set on a plinth which was formerly part of the village cross.

FIGURE 3A: Great Staughton, Sundial

On three sides of the block--south, east and west-- there are inscribed dials with iron gnomons. The fourth side bears the initials E.I. and the date 1637. The initials are those of Edmund Ibbott, who lived at Beechampstead, one of the manorial areas of Staughton, and died in 1641. He is described as a carpenter, but he may have been a master-

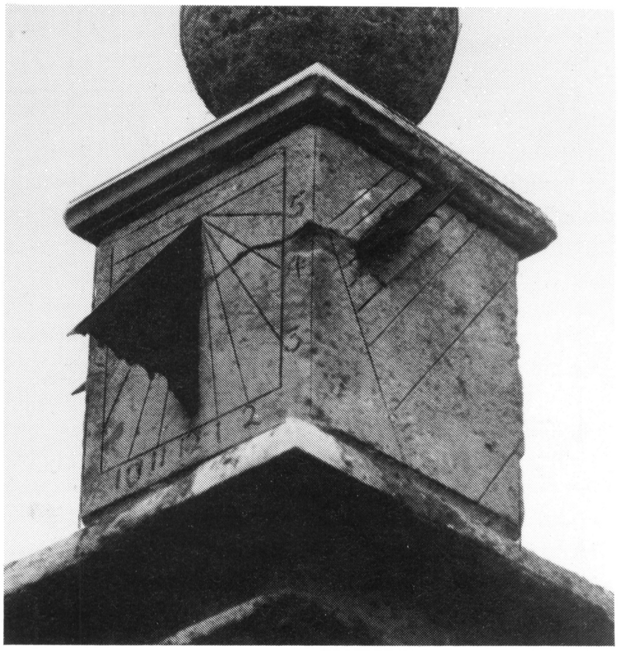


FIGURE 3B: South and east faces of dial

builder. He was certainly a man of means, as shown by his will: he left £137, a tidy sum for a village craftsman of those days, and he possessed a 15-room house. There is no record of whether he himself gave the sundial to the village or whether it was placed there after his death. Only one of the three dial faces is in good condition but all are readable.

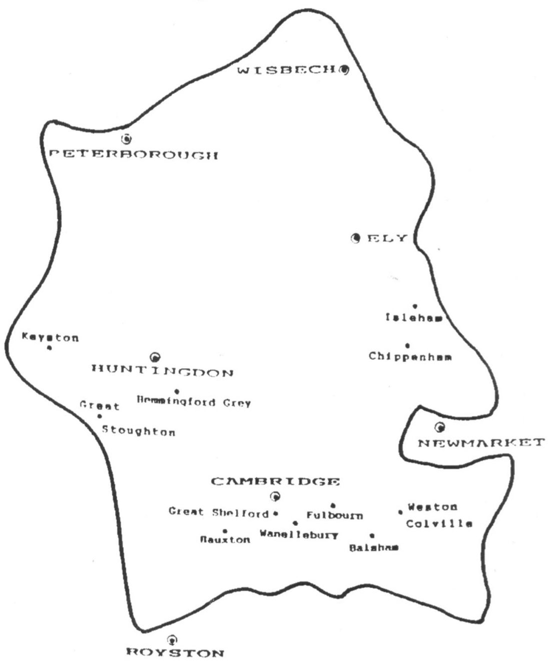


FIGURE 4: Sketch map of Cambridgeshire showing places mentioned in the text

We are losing dials all the time, as stone surfaces become weathered or moss-grown, and painted letters and numbers fade. Of the church sundials at Wicken, Soham, Somersham, Elsworth and Godmanchester, nothing remains but a rusty iron gnomon; they are not dials but mere dial-remnants. Fortunately we are gaining dials too. A sundial is now seen as a happy way of remembering an event or a person, and several Cambridge Colleges have set up sundials for commemorative purposes. One such dial, that at New Hall dated 1981, is handsomely carved on a slate surface. A local sundial designer and maker living at

Continued on page 7

"THERE'S A THINGEY ON THAT WHATSIT!"
OR THE JOTTINGS OF A BIG DIAL HUNTER
BY COLIN THORNE

Sundial hunting is fun, of that there is no doubt, it gets you out and about visiting interesting places that you would never have seen otherwise. Fresh air, sunshine (hopefully!), driving down country lanes in hot pursuit of a "quarry", the thrill of the chase and the final satisfaction of "bagging" a previously unknown dial. There is the preparation of the safari route planning, posing over well used maps, making sure the notebook and a sharp pencil are packed, together with a supply of BSS dialling record forms; plenty of ammunition for the Canon (actually it is an Olympus but I couldn't resist the pun). Ready for the fray and surely big game hunting in Africa could hardly have been as exciting as this!

To the casual observer, the diallist exhibits one of two distinctive behavioural patterns upon discovering there is, or is not, a dial on a previously uncharted and unvisited church. If there is, he or she emits a whoop of joy, which can be heard in the next parish, quickly followed by much frantic writing in a small notebook and considerable expenditure of colour film. He is often observed pacing agitatedly, muttering to himself, whilst the only cloud in the otherwise unblemished blue sky obscures the sun.

If there is no dial to be found, it would be difficult to imagine a more dejected creature. He mopes all around the building, even inside if he can gain entrance, in the vain hope of finding one of the lesser but elusive sub-species - the scratch dial. He may even wander aimlessly through the graveyard just on the offchance that some enlightened amateur has placed a dial on their loved one's headstone; finally departing in a very subdued manner. It may be several cups of coffee later before he regains even a semblance of his former composure.

On the other hand the diallist himself often finds the local populace abysmally ignorant of the art and science of dialling, or even for what purpose the sundial is actually intended! On one occasion when I was photographing a church dial (which was not easy because some idiot had planted a tree in front of it which now largely obscured it), when an ancient person with an even more ancient scythe on his shoulder came up to me. For one terrible moment I thought it must be Old Father Time himself, although I had earlier observed him cutting the grass in the churchyard. He politely enquired as to why I was taking snaps of "that thing up there". I thought it best to keep things as uncomplicated as possible, so simply replied that it was a sundial. In the course of the ensuing conversation it transpired that he had hardly noticed it in all the years he had tended the churchyard, he certainly did not know why it had been placed there, and had never had cause to use its indications. I patiently explained its function in words of as few syllables as possible how to read the shadow and to allow for British Summer Time and longitude - "One hour plus sixteen minutes, say an hour and a quarter", the Equation of Time being only a couple of minutes on that particular date, so best to ignore this and not complicate matters any further. He went back to his scything, obviously pleased with his newly-acquired knowledge and muttering about knowing when it was time to "go 'ome for me tay". Come the end of February, if the sun is shining, he is going to be a bit later for his "tay" than he expects, maybe I should have told him about the equation of time.

To the dedicated dial-hunter driving through unfamiliar towns and villages, it is a great advantage to have an understanding wife in the car, for whilst he is concentrating on his driving, she is looking around at likely buildings and gardens. I have bagged several dials which would have got away otherwise, missed entirely by the driver. However this simple scheme is not quite without its hazards and false alarms.

One sunny afternoon, in response to the casual remark "was that a sundial?", I screeched to an emergency stop in the narrow village street. Several cars behind me simultaneously did the same thing and I remember thinking "funny! they can't all be diallists, can they?". We ran back to the recently passed church, only to find that what appeared to be a dial without its gnomon was actually nothing more than a nicely engraved slate tablet warning all prospective vandals (they seem to have had them even in 1735), of the dire retribution and eternal damnation about to fall on them if as much as a single blade of grass in the churchyard was defiled. Much disappointed, we strolled casually back to the car, to find a complete traffic jam had developed in our absence. We drove off, ignoring the general abuse, and left them to sort themselves out now the highway had been cleared of the main obstacle to their progress. Really that village does need a by-pass to prevent parked cars from blocking their narrow "High Street".

Another occasion was much more rewarding. The village of Combe Martin in North Devon is only about twelve miles from our home and we frequently drive through it. There are two dials on the church, the usual direct south and also a noon mark, two for the price of one! However, the village is probably better known for its famous hostelry, The Pack of Cards.

One evening, driving slowly through the village, the peace was shattered by 'M' suddenly grabbing my arm and exclaiming "There's a thingey on that whatsit!". Fighting to control a rapidly decelerating car and narrowly missing a parked heavy goods vehicle and a rather surprised cyclist in the process, I casually enquired "A thingey on a whatsit?". "Yes, a card on the pack of sun ... a pack on the dial of car ... A SUNDIAL!!!". "Oh, a thingey! ... which whatsit?" This time, a little impatiently I thought, the correct version appeared - "A Sundial on the Pack of Cards!". But we had driven past it countless times, so why hadn't we seen it before? A sundial on The Pack of Cards! Fancy that! By Jove!!

An hour or so later we drove back through the village and stopped opposite the pub. Sure enough, even in the dark, the shadowy outlines showed it was undoubtedly a sundial. Resolve was taken to ensure that the next time we came through the village it would be daylight and the sun would be shining. A week later found us once more in Combe Martin in the middle of a summer's afternoon and the sun should have been shining. Well, it was when we left home; someone up there doesn't like diallists! Nevertheless, notes were scribbled, photographs taken, pity that such a nice dial has no date on it, but it has been there for a good many years, there are weeds growing between it and the supporting wall. One more in the bag and about to have my number against it in the BSS List. How could we have possibly missed seeing it before?

DETERMINATION OF LOCAL SOLAR TIME BY OBSERVING A SHADOW ON THREE OCCASIONS

BY J. G. FREEMAN
UNIVERSITY OF BRADFORD

ABSTRACT
To determine the local solar time by means of a sundial it is necessary to know two of the following[1]:
(i) the north (ii) the observer's latitude (iii) the sun's declination. This suggests the following problem: is it possible to determine the time by observing a shadow if the north, the observer's latitude and the sun's declination are all unknown? It will be shown that this can be done if one observes a shadow on three separate occasions on the same day.

1. OBSERVATIONS

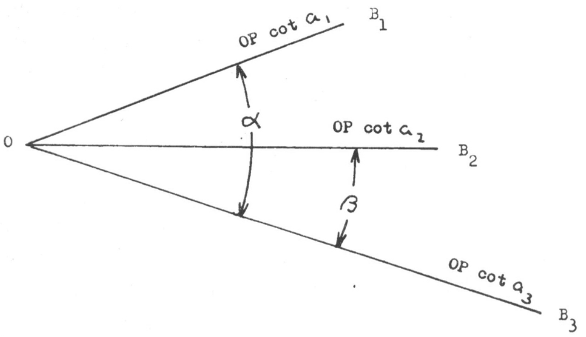
In the diagram below OB_1, OB_2 and OB_3 are the shadows on a horizontal plane of a vertical pole OP on three occasions on the same day.

Lengths of OP, OB_1, OB_2 and OB_3 as are the angle between OB_1 and OB_3 and the angle between OB_2 and OB_3 which will be denoted by $\propto$ and β respectively.

If a_1, a_2 and a_3 are the values of the sun's altitude corresponding to the above shadows, these may be obtained from

$\cot a_1 = OB_1/OP$, $\cot a_2 = OB_2/OP$ and $\cot a_3 = OB_3/OP$, and if A_1, A_2 and A_3 are the corresponding values of the sun's azimuth west

$$A_1 = A_3 + \propto \quad \text{and} \quad A_2 = A_3 + \beta$$



2. CALCULATION OF THE SUN'S HOUR ANGLE

This is done by using the formulae

$$\sin\partial = \sin\varnothing \sin a + \cos\varnothing \cos a \cos A \qquad (1)$$

$$\sin a = \sin\varnothing \sin\partial + \cos\varnothing \cos\partial \cos H \qquad (2)$$

where $\varnothing$ is the observer's latitude, ∂ is the sun's declination, and H is the corresponding hour angle.

Substituting in (1) the values of a and A corresponding to shadows OB_1, OB_2 and OB_3 gives

$$\sin\partial = \sin\varnothing \sin a_1 + \cos\varnothing \cos a_1 \cos A_1 \qquad (3)$$

$$\sin\partial = \sin\varnothing \sin a_2 + \cos\varnothing \cos a_2 \cos A_2 \qquad (4)$$

$$\sin\partial = \sin\varnothing \sin a_3 + \cos\varnothing \cos a_3 \cos A_3 \qquad (5)$$

The value of ∂ changes during a day, but the change is so small, being never greater than 0°.1 in six hours, that it will be regarded as constant during the period of the three observations. Since $A_1 = A_3 + \partial$ and $A_2 = A_3 + \beta$ these equations may be written

$$\sin\partial = s_1 \sin\varnothing + c_1 \cos\varnothing \cos (A_3 + \propto) \qquad (6)$$

$$\sin\partial = s_2 \sin\varnothing + c_2 \cos\varnothing \cos (A_3 + \beta) \qquad (7)$$

$$\sin\partial = s_3 \sin\varnothing + c_3 \cos\varnothing \cos A_3 \qquad (8)$$

writing c_i for $\cos a_i$ and s_i for $\sin a_i$ (i = 1,2,3) for brevity. In these three equations there are three unknowns A_3, $\varnothing$ and ∂. They may be solved as follows.

Eliminating ∂ and $\varnothing$ from (6), (7) and (8) by a determinant:

$$\begin{vmatrix} 1 & s_1 & c_1 (\cos A_3 \cos\propto - \sin A_3 \sin\propto) \\ 1 & s_2 & c_2 (\cos A_3 \cos\beta - \sin A_3 \sin\beta) \\ 1 & s_3 & c_3 \cos A_3 \end{vmatrix} = 0$$

Dividing the third column by $\cos A_3$ and rearranging gives

$$\tan A = \frac{c_1 s_{23} \cos\propto + c_2 s_{31} \cos\beta + c_3 s_{12}}{c_1 s_{23} \sin\propto + c_2 s_{31} \sin\beta} \qquad (9)$$

where $s_{ij} = s_i - s_j$, from which A_3 may be determined.

From (6) and (7)

$s_1 \sin\varnothing + c_1 \cos\varnothing \cos (A_3 + \propto) = s_2 \sin\varnothing + c_2 \cos\varnothing \cos (A_3 + \beta)$

Dividing throughout by $\cos\varnothing$ and rearranging gives

$$s_{12} \tan\varnothing = - c_1 \cos (A_3 + \propto) + c_2 \cos (A_3 + \beta) \qquad (10)$$

from which $\varnothing$ may be determined.

Now that A_3 and $\varnothing$ are known, ∂ may be determined from (8).

Finally the hour angle H_3 corresponding to the shadow OB_3 can be calculated from (2) which becomes

$$\sin a_3 = \sin\varnothing \sin\partial + \cos\varnothing \cos\partial \cos H_3 \qquad (11)$$

when values of a and H corresponding to the shadow OB_3 are substituted. Alternatively, instead of calculating H_3 we may set up an equatorial dial when A_3 and $\varnothing$ have been determined, for the north and latitude are then both known.

3. NUMERICAL EXAMPLE

Suppose the measurement of the shadow diagram gives:

$OB_1/OP = 0.724$ giving $a_1 = 54°.1$
$OB_2/OP = 0.920$ $\quad a_1 = 47°.4$
$OB_3/OP = 1.209$ $\quad a_3 = 39°.6$
$\propto$ = angle $B_1OB_3 = 45°.8$
β = angle $B_2OB_3 = 16°.9$

Then, from (9), $\tan A_3 = -1.927$ and $A_3 = -62°.6$ or $117°.4$.

When the sun's azimuth west is negative, the sun is in the east and its altitude increases with time; in this example the altitude decreases with time and the positive value of the azimuth west is therefore the correct one and $A_3 = 117°.4$.

From (10), $\tan\varnothing = 1.198$ whence $\varnothing = 50°.1$.

From (8), $\sin\partial = 0.2616$ whence $\partial = 15°.2$.

Finally, from (11), $\cos H_3 = 0.7048$ whence $H_3 = 45°.2$ and the time is 3 hr 12 min pm.

The closer together are the observations taken the smaller and less accurate do the values of s_{12}, s_{23} and s_{31} become. In practice it was found that observations separated by an hour or more gave reasonable accuracy.

The values of A_3, $\varnothing$ and ∂ could also have been obtained by a graphical method based on stereographic projection; this method has been described elsewhere (2).

REFERENCES
1. J. G. Freeman - A Latitude-Independent Sundial, Introduction. Bulletin of the British Sundial Society 91.1.
2. J. G. Freeman - A method of determining the North and Latitude. Mathematical Gazette 1975.

A TYNESIDE SHIPYARD SUNDIAL

FRANK EVANS

There is a nineteenth century book about sundials, famous among sundialists, called indeed, "The Book of Sun-Dials". It went to three editions between 1872 and 1900 and was the work of a lady called Mrs. Alfred Gatty. That was how she described herself on the title page, although she was sufficiently eminent in her own right to gain an entry in the Dictionary of National Biography. Her name was in fact Margaret. She was a writer of children's tales under the name of "Aunt Judy", and she was also a calligrapher, and an authority on seaweeds; the less well-known Alfred was for sixty-three years the vicar of Ecclesfield, just north of Sheffield.

The first edition of Mrs. Gatty's book, which I have not seen, appears to have consisted mostly of notes of numerous dials around the country, together with their localities and citations of their mottoes. The remaining editions, both published after her death and considerably added to by her daughter and others, carry an appendix on the geometrical construction of dials. This appendix was supplied by a contributor distinguished in the 1889 edition only by the letters 'W.R.' but who in the 1900 edition revealed his full name as J. Wigham Richardson. Wigham Richardson was the well-known Tyneside shipbuilder who in 1860 established the Neptune Shipyard at Walker. He began to build ships there at the age of twenty-three, with an able assistant called Denham Christie, who subsequently became his partner.

Richardson was born, in 1837 into a wealthy Quaker family. As a young man he served a shipbuilding apprenticeship on the Tyne, no doubt of the premium variety, and during this time he took lessons in mathematics from a Mr. Daniel White, before proceeding to London University. (He was debarred, as a dissenter from entering Oxford or Cambridge.) He was clearly an able pupil, for the appendix on the construction of sundials reveals him as a skilled geometrist, capable of giving a lucid exposition of a complex subject. But he was essentially a practical man and it is not surprising to discover in Mrs. Gatty's "Book of Sun-dials" the following:

> Entry 372 (in the 1900 edition; the 1889 entry, no. 177, has trivial differences):
>
> Harum dum spectas cursum
>
> Respice ad novissimam horam
>
> C.C. Walker 1881 Lat 54° 58' W.R.
>
> Watching these fleeting hours soon past
>
> Remember that which comes at last
>
> On a storehouse of the Neptune Works, Newcastle-on-Tyne, erected by J. Wigham Richardson, Esq., to whom the motto and its translation are due.

In the preface to the 1889 edition Horatia Gatty, Mrs. Gatty's daughter, wrote: "He put a motto on the dial which adorns his Neptune Works at Newcastle-on-Tyne, and was interested to find how many of his own and of other workmen wished to learn the art of mechanical dialling."

A hundred years later, coming across that remark, it occurred to me to wonder whether Wigham Richardson's dial still existed, since the building at Walker on which it was placed (Fig. 1) had long been dismantled. I was moved to write to the current owners of the Neptune Yard, Swan Hunter Shipbuilders Ltd. and in time received a reply from Mr. H.D. Archbold, Project Manager. He told me that the dial had been set aside and was not in very good condition. He enclosed with his letter two excellent photographs of the dial as it had been in 1981, just before its removal to storage.

Some time afterwards I happened to visit the Trinity Maritime Centre, a small museum on the Quayside in Newcastle, devoted to the history of nautical Tyneside. There I met one of the founders of the Centre, Captain Bill Clark. When at last we had stopped reminiscing about Tyne-built ships of a bygone age I told him of Wigham Richardshon's dial. He responded by expressing an interest in preserving it at the Centre. It was, after all, a historic artifact, known to generations of shipyard workers and seamen who had passed through the Neptune yard; amusingly Mr. Archbold had been able to quote from memory the gloomy motto under the dial which he had encountered daily at the yard gate during a long working life.

I wrote again to Mr. Archbold asking if we might see the dial and subsequently, Capt. Clark and I had the pleasure and excitement of seeing Wigham Richardson's handiwork of 1881 in the shipyard joinery where it was lodged (Fig. 2). Far from being in poor condition it had been beautifully restored by an expert signwriter and truly glowed in its new white paint and black markings (Fig. 3). The lengthy motto, which once extended over the width of the building had not, of course, been retained. The Trinity Maritime Centre has now made a formal offer to house the dial and put it on public display. However, the future of the dial is at present problematical.

There remains a puzzle. On the dial plate, according to Mrs. Gatty there formerly appeared two pairs of initials, W.R. and C.C., although these have since been lost. (It is obvious that the dial must have been repainted several times and, for instance, the equation of time curve no longer has a indication of either minutes or months.) The initials W.R. were obviously those of the dial's maker, but who was C.C.? I wondered at first if it may have been Richardson's wife? But no, his obituary in the "Wallsend Herald" for April 1908 gave his wife's maiden name as Thoel. Was it Christie, then? But his name was Denham Christie. Eventually it becomes clear that as the years had advanced both men had shuffled through their various Christian names; Richardson had begun as John W. Richardson, succeeded by J. Wigham Richardson and eventually plain Wigham Richardson; Christie was at first Charles J.D. Christie, subsequently John D. Christie, J. Denham Christie and finally Denham Christie. So C.C. was Denham Christie. He was, of course, the grandfather of the well-known director of Swan Hunter's of that name.

Also in the joiners' shop was an unhung and unregarded portrait of Wigham Richardson. It is a copy, done by Dorothea Dudgeon in 1932, of a painting by a famous Tyneside artist of the last century, Ralph Hedley. The painting was damaged, but shows a handsome figure, dignified, benign and intellectual in appearance, seated and holding a book. Here is the maker of the Neptune Shipyard dial.

By the way, my recent visit to Swan Hunter's was my first return after forty-five years. But that is another story and cannot be told here.

FIGURE 1: The Dial in place at the entrance to the Neptune Shipyard. On the centre beam is carved "Walker is 6 minutes behind Greenwich".

FIGURE 2: Captain G.W. Clarke (centre) with two Swan Hunter's joiners and the Wigham Richardson Dial.

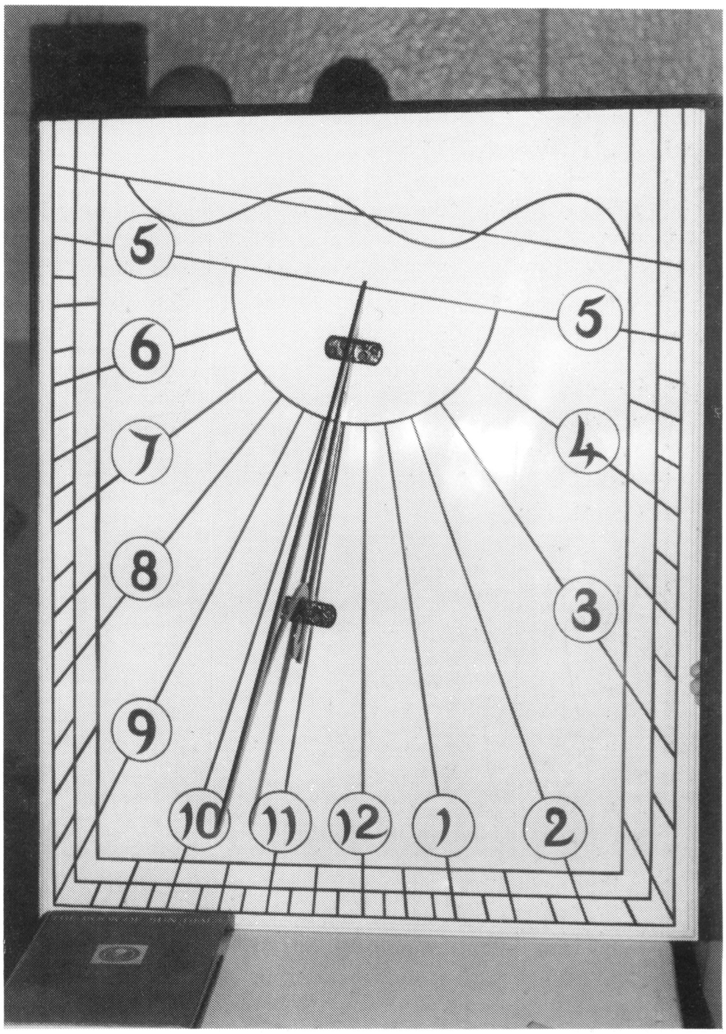


FIGURE 3: The restored Dial freshly painted.

SUNDIALS DOWN UNDER

JOHN WARD AND MARGARET FOLKARD

INTRODUCTION

We decided to celebrate the completion of a large 500 kg equatorial bronze sundial for the Mount Tomah Botanic Garden by having an Open Day to show our friends what we do in our Sundial Workshop. Mount Tomah in the Blue Mountains is the Alpine plant garden of the Royal Botanic Gardens in Sydney, New South Wales.

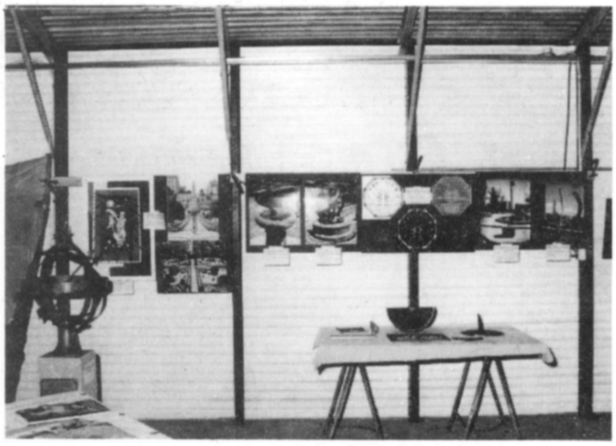
Our day was lovely and sunny and, much to our amazement, more than 220 people came to see us! We provided the usual tea, coffee, soft-drinks etc, as well as champagne and lamington cakes. We had previously decided to divide our mini exposition into 8 different sections and duly apportioned various benches and walls of our workshop to display the sections which are listed below:-

HISTORY OF SUNDIALS
SUNDIAL DESIGNING AND MAKING
SUNDIAL TYPES
ANALEMMAS
WATER JET MACHINING
EQUATORIAL SUNDIAL FOR MOUNT TOMAH
NAVIGATION INSTRUMENTS
SUNDIAL LITERATURE

A brief description of each of these sections will now be given.

HISTORY OF SUNDIALS

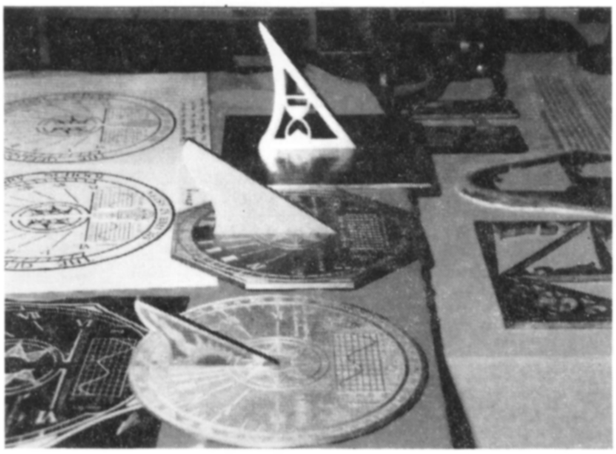
To introduce our visitors to the huge history of sundials in a short space of time was not a real possibility, so instead, we decided to show them a couple of models that we had made of a wooden Egyptian shadow stick and a polyurethane plastic replica of the hemicyclium devised by Berosus in about 375 BC. The horizontal gnomon of this hemicyclium was a thin paintbrush handle and a well defined shadow was cast onto the curved internal surface of the sphere quadrant used for the demonstration. Most people were surprised to find out that sundials were in everyday use so long ago. The literature with these models briefly mentioned that the Greeks had been involved with sundials of similar design since about 600 BC. We didn't introduce them to the various stories and arguments which surround the origin of the Egyptian shadow stick and any other sundials prior to these two particular types.



History of Sundials

SUNDIAL DESIGNING AND MAKING

This section of our display was designed to show how to produce a very high quality casting using relatively simple techniques. In summary, a high quality black and white line drawing is made which incorporates all the hour lines, numbers, drawings, quotations, time correction graph etc as needed. A conventional, black and white photographic negative of the desired size is then made from this original drawing. The negative is then placed in contact with a photopolymer which is sensitive to ultra-violet light. It is then exposed and developed. The result is an in-relief replica of the original line drawing. A major advantage of this method is the ability to control the side angle of the lines and numbers on the photopolymer by changing the degree of collimation of the incident ultra violet light.



Sundials with different gnomon angles

The hard, photopolymer plate is used as the pattern for sand casting at the foundry. Using this photopolymeric technique it is also possible to alter the background texture upon which the lines and numbers are located. If the tops of the lines and numbers are semi-polished in the finishing process they will behave in a specular fashion when sunlight is incident upon them, meanwhile the rougher surfaced background will behave as a hemispherical scattering surface. This will result in a high difference in contrast between the numbers and the background and make the sundial much easier to read than one made using traditional engraving or etching techniques. This high contrast will remain constant as the patina forms throughout the years.

On display we had high quality black and white line drawings of various sundial designs, a high contrast black and white photographic negative, the resultant photopolymer pattern and finally the as cast sundial. The machinery we use for converting rough castings into finished sundials was also on display. We had made most of the specialist machinery ourselves because it just was not available from the local engineering tool suppliers or was too expensive. The photograph shows the display together with a background display board detailing the methods we use for making high quality drawings, negatives, photopolymers, sundial plates and gnomons.

Making Sundials with Photopolymers

Sundial Types

SUNDIAL TYPES

For simplicity we divided sundials into 19 different types. These basic types are listed below:-

1. Analemma Sundial - Fixed Hour, Variable Date
2. Analemmatic Type Sundial - Fixed Date, Variable Hour
3. Armillary Sphere Sundial
4. Corner Dial
5. Cube Dial
6. Decimal Dial
7. Equatorial Dial
8. Exedra
9. Globe Dial
10. Hemicyclium
11. Horizontal Dial
12. Pillar or Shepherd's Dial
13. Polar (Portable/Monumental)
14. Polyhedral Dial
15. Projection Type Dial
16. Reclining Dial
17. Ring Dial
18. Sun Compass
19. Vertical Dial

We had all of the above sundial types on display with the exception of the exedra and a globe sundial. We had photographs of the Hutchins Exedra in Central Park New York and a copper float from a water cistern marked with a felt pen to clearly demonstrate the principles of operation of a globe sundial.

Each sundial had an attached card with a description of the principle involved, method of use, and a few words about the origin of the particular sundial. We have travelled around the World several times during the last sixteen years studying gnomonics, and during these journeys we have amassed quite an interesting and large collection of sundials. There was usually a story attached to the acquisition of each dial on display. By the end of the day we had told each story many times, in particular, how we got hold of our oldest sundial. This is a portable equatorial dial made in about 1720 AD by Andreas Vogl in Austria. The dial is made from brass, is still in the original case and in excellent condition. We bought this dial from the Vienna Time Museum in 1984.

The display included a gunmetal bronze, analemmatic sundial with an adjustable nodus according to the date. It was designed for Adelaide, South Australia (35 degrees South 138 degrees East) and had a conventional horizontal sundial cast next to it, thus effectively becoming a sun compass. We had also made several analemmatic sundials of human involvement located around Australia. Typically, these sundials consist of an elliptical ring of hour markers having a major axis of about 5 meters and a minor axis of 3 meters. The markers have been made from a range of materials including granite, cement and in one particular case, columns of basalt. These basalt crystals are similar to those found on the Giants Causeway in Antrim, Northern Ireland. Each hour marker has a number on it, which is either carved in or made from cast bronze.

Analemmatic Sundial of Human Involvement, Mount Annan N.S.W.

Inside the ellipse, and located along the North-South line, is an analemma with dates marked on it at fortnightly intervals around its circumference. The user places his feet on the correct date and then looks along his shadow, if the person is short then he can raise his hands above his head and become a bit taller. Correct clock time is then given by the shadow position. We realise that this simple method does not give precise clock time throughout the whole year, however the small errors (which occur in the early morning and late afternoon at times of the year corresponding to the maximum and minimum of the equation of time) lie within the width of the shadow produced by your body. The novelty value of being able to read clock time directly from a sundial, and particularly the added interest of being able to read it from your own shadow, well compensates for the slight mathematical imperfections introduced! Generally we install a horizontal sundial nearby so that the time shown by the shadow reading can be checked against a sundial of higher time telling accuracy. On a standard dial of this type accuracies of around plus or minus 1 or 2 minutes can be achieved with a sundial which is 300mm in diameter. A model of an analemmatic sundial of human involvement located at Mount Annan near to Campbelltown in New South Wales is shown in the display.

ANALEMMAS

Some years ago we noticed that many people had quite a lot of difficulty with the concept of the word analemma (this of course excludes all gnomonists!). To enable our visitors to quickly grasp the principles underlying the formation of an analemma, we laid out a large analemma on the floor of our workshop. Firstly, we made a circular stained glass window about 700mm in diameter with an opaque metal plate, about 150mm in diameter, located centrally in the window. In the centre of this 3mm thick brass plate we drilled a hole 12mm in diameter which was bevelled on one side only at such a low angle so that a very thin edge of metal was produced. This window was fixed into the side of our workshop at a height of about 3500mm above the ground, and the plane of the window was arranged to lie approximately in the East-West plane facing North. We then let the sun plot out the analemma for us, by marking out on the concrete floor with an indelible felt pen the outline boundary of the image of the sun when it was precisely solar noon and clock noon (Central Standard Time CST). We did this every Saturday for a year and the result was a nice straight line, located along a true North-South line. The plots of 12 noon Central Standard Time resulted in a beautiful analemma which clearly showed the variations of the sun's apparent position throughout the year. We also plotted declination curves throughout the day for specific dates such as midsummer, midwinter and equinox. The equinox line was plotted out in March and September for a few hours on either side of solar noon and resulted in a straight line at right angles to the true North-South line. We clearly labelled the sun's image position with the date thus the analemma could be used as a calendar of modest accuracy throughout the whole of the year. Every week we made our readings we made sure that our watches indicated correct Central Standard Time. Naturally, on a few of the Saturdays we did this on the weather was not ideal for doing these plots, so we filled in the gaps the following year.

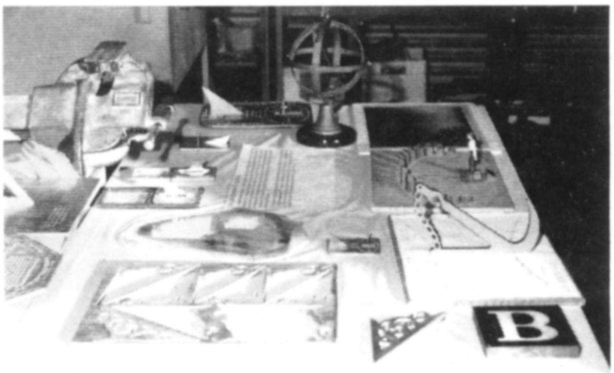
Adelaide, South Australia, where we did these plots receives about 2500 hours of sunshine every year. In England it might take a bit longer than a year to produce enough points so that a nice smooth analemma curve is formed. The analemma was about 5 metres long and 0.6 of a meter wide at the widest point. Everybody walked all over it on our open day and it certainly made it easier to explain the difference between solar time and clock time in terms of the analemma.

WATER JET MACHINING

Over the years we have had many difficulties when piercing or removing metal to produce a decorative effect such as needed when making a filigree gnomon, this is particularly so when the metal is reasonably thick. We often use bronze with a thickness range between about 10 and 30mm. The usual methods for making these attractive swirling curves can involve pattern making in a soft material such as wood, then casting at the foundry. The worst part of the job now begins, drilling, milling, filing, grinding and polishing - all of this is most tedious and very time consuming.

An alternative to the above agony of cutting patterns out of heavy gauge metal is to use an abra file or, as a last resort, fabrication techniques with all the associated limitations.

The method we now use involves making a good quality, free form, actual size, black and white line drawing of the shape you want to make. This shape is then scanned by a digitiser, then digitised coordinates are transferred to a computer controlled high pressure jet of water which is held above a large tank of water with supporting struts of steel across it. The material you wish to cut is simply placed upon the supporting struts and the pattern you require is cut out by the jet of water at pressures between 60,000 and 80,000lbs per square inch. The water cut surface is quite smooth and for most purposes requires no further finishing. The photograph shows some of the shapes which we have had cut out using this method. A wide range of materials can be machined this way including bronze, glass, jade, granite, marble etc. Thickness up to about 75mm can be comfortably and accurately cut on the machine which we have access to. The major disadvantage of this technique is its considerable expense.



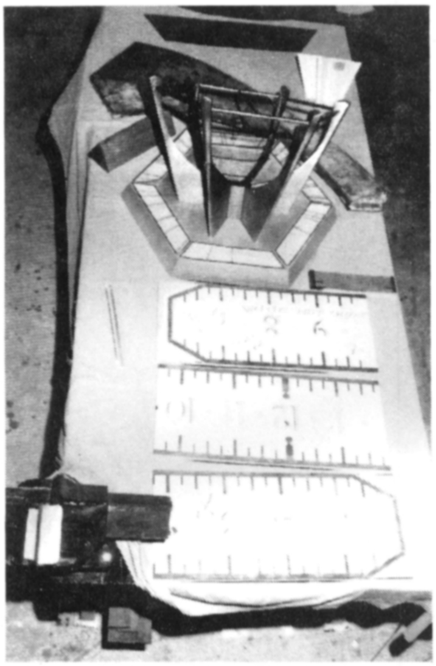
Water Jet Cutting of Bronze, Granite, Jade and Marble

EQUATORIAL SUNDIAL FOR MOUNT TOMAH

Mount Tomah is in the Blue Mountains of Australia not far away from Katoomba. It is also the Alpine Plant Garden of the Royal Botanic Gardens whose headquarters are in Sydney, New South Wales. We were asked to design and make an equatorial sundial for the alpine garden there at a height of 1100 meters above sea level.

We began by making a model which was one third the proposed size out of wood, and because we wanted to check that the model would still be attractive when it was full size, we decided to make it full size out of thick cardboard and plastic plumbing pipes. This cardboard model enabled us to finalise the proportions and begin making the wooden pattern.

As can be seen from the photograph (overleaf), the design was composed of 6 curved arms connected at the base and separated from each other by an angle of sixty degrees. The angular separation of the arms was maintained by large triangular blocks of silicon bronze which were welded to the bottom of the arms. The summetry of the arm design made it easier for us to make a single pattern composed of 3 separate parts which plugged into each

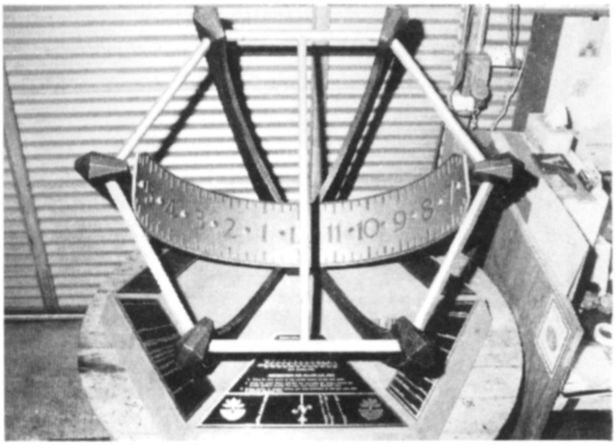


Mount Tomah Patterns

other. The three connected parts were cast first, one portion was removed and the two connected parts were cast, finally, the remaining portion was cast. Each time a casting was done 2 arms were made because of the symmetry of the construction. Prior to making the casting we had to calculate the base angle of each arm so that when completed it would sit accurately on a horizontal surface. This involved some quite difficult 3 dimensional trigonometry and we were both delighted when it was finally installed, the sundial sat nice and evenly upon its horizontal pedestal surface. To give the arms a pleasing texture, we coated the wooden patterns with beeswax and then combed the beeswax with a coarse toothed dog comb! The result, when cast in silicon bronze, was most satisfying and quite tactile, almost from the installation day people began to rub their hands over this attractive surface and a well handled, well used look has already appeared on the parts of the sundial most readily accessible to probing human hands.

Prior to welding the cast silicon bronze arms together we inserted a ring of hexagonal section brass rod to define the upper surface of the dial. We used hidden joint techniques so that prying fingers would not be able to find any crevices to explore or screws to undo. The brass gnomon with stainless steel insert was attached in a similar fashion to the brass hexagon ring. The sundial was about 1500mm in diameter and with its base weighed more than 1000kg. It was difficult to move such a large sundial around our workshop and after fitting the bronze time scale we were somewhat pleased to arrange for it to go to its mountain home at Mount Tomah. The fitting of the time scale also posed a few problems, it was cast in three parts, using traditional pattern making techniques.

The three separate parts were then welded together and rolled into a semicylindrical shape. This cylinder of course did not fit well into the hemispherical surface of the arms. To overcome this, we generated a cylindrical surface by attaching an angle grinder to the gnomon itself with a wooden bearing so that we would not damage the surface and then rotated the grinder about this axis. The grinding wheel converted the spherical into a cylindrical surface and we were able to attach the time scale with high tensile bronze bolts which we made ourselves from manganese bronze. The diameter of the gnomon had been arranged so that including the effect of the sun's divergence angle, its own shadow occupied a time interval of fifteen minutes.



The Complete Mount Tomah Sundial

A bronze dedication plate, including a graph of the equation of time which had the longitude time difference incorporated into it, was attached to the hexagonal, basalt table upon which the sundial was mounted. A set of six director plates which showed the direction and distance from Mount Tomah of various famous botanic gardens around the world was also attached around the circumference of the basalt table. The attached photographs show some of the models and patterns which were used to make this sundial.

NAVIGATION INSTRUMENTS

We have been asked many times to make replicas of ancient navigation instruments for use during the re-enactment of various expeditions taking place around the World.

Navigation Instruments

The display seen in the photograph shows a range of these instruments. We made the heliodon so that we could attach any of the models to it and study the shadows produced at any location, any date and any hour of the day. When in use, we illuminated the object with the lightbeam produced by a 35mm slide projector which had been slightly modified to produce a beam more parallel than that normally emitted by the projector. The rotation of the heliodon then enabled us to study the shadows produced throughout the year by the object. Annual and diurnal variations of the shadows and their positions could easily be measured and photographed. Any modifications could be made at the model stage thus avoiding costly changes of structure later on. In addition, the future sundial owner could see where the shadows would fall and whether any of the adjacent buildings would interfere with its function.

There is a mariners astrolabe made from 20mm thick brass plate, a Chinese spoon compass with its magnetic South seeking spoon, and a Chinese star finder made from a slab of jade 6mm thick with holes in it. The outline shape of the star finder and the small holes in the jade were cut with the high pressure water jet system. These devices will be used aboard a junk called 'Princess Cocachin' during the re-enactment of Marco Polo's second journey from China to Europe in AD 1292.

The sun compass was made for use on Project Blizzard land expedition led by Jonathan Chester to the Antarctic. The sun compass was designed for use at latitudes 63 and 68 degrees South. This expedition retraced the footsteps of Sir Douglas Mawson the Australian explorer and geologist who had his early Antarctic training with Sir Ernest Shackleton, the famous British explorer.

We designed and made an analemmatic vertical sundial for use aboard a catamaran raft which drifted with the current from Bali in Indonesia to Madagascar. This epic journey called 'Flight of Sarimanok' was described in The Australian Geographic Magazine (January/March 1987, No.5) and illustrated with graphic photographs. The brass quadrant was also used on this fascinating journey. The above descriptions do not by any means fully list our adventures into the designing and making of replicas of instruments used for navigation, rather does it outline some of our involvements.

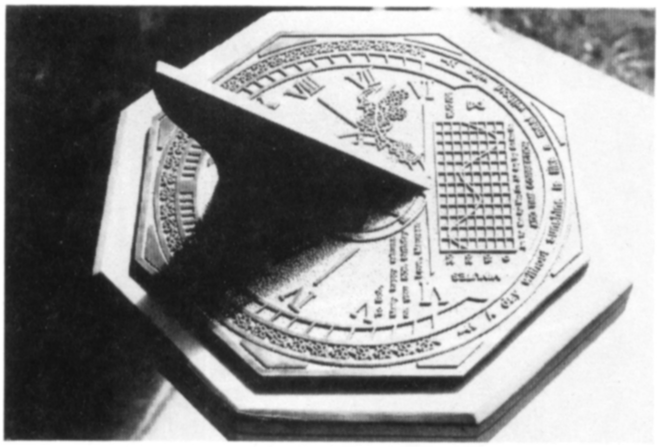
SUNDIAL LITERATURE

A range of literature about gnomonics was provided for our visitors to browse through. This included some of the articles which we have written ourselves for publication in journals and magazines within Australia as well as a small representative selection of books written about sundials by overseas authors. We decorated the walls with a collection of sundial photographs taken on our trips around China, India, Russia, Europe and America.

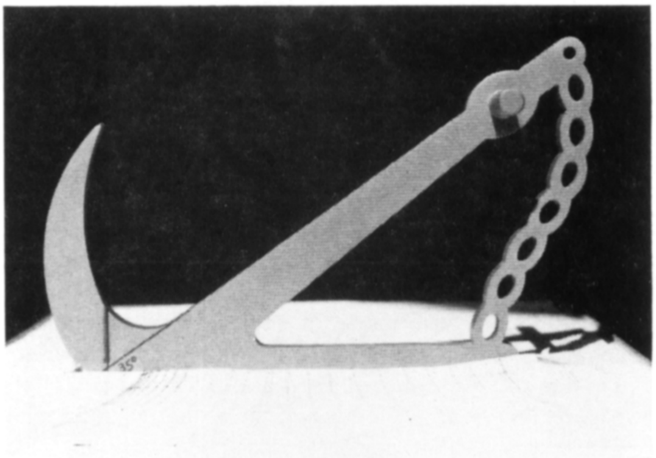
FINAL COMMENTS

Overall our 'SUNDIAL OPEN DAY' was a most pleasing success. We have now spread the gnomonic word around Adelaide and a good time was had by all. It might be appropriate to finish with the well known verse;

The clock of life is wound but once
And no man has the power
To say just when the hands will stop
At late or early hour
Now is the only time you own
Live, love, toil with a will
Place no faith in tomorrow
For the clock may then be still



High Contrast, Bronze, Horizontal Sundial



Close up of 'Anchor' Gnomon with Elliptical Holes

Stained Glass Window Sundial for Adelaide, South Australia

BUYING A SUNDIAL
THE TEN COMMANDMENTS

M. J. COWHAM

These notes refer generally to buying an antique horizontal garden sundial but many of the points also apply to most dials, old and new.

1. The 6am to 6 pm line MUST always be straight and at right angles to the gnomon. The gnomon itself should be in line with noon, ie. North-South, and its toe MUST intersect the mid point of the 6 am-6pm line.
2. There MUST be a gap at noon exactly the same width as the gnomon. (See dimension W in the diagram.)
3. The hour lines are NEVER equally spaced (unless it is an Equatorial Dial). The divisions will be slightly closer together around the noon and a little more spread towards dawn and dusk.
4. The gnomon MUST be at the correct angle to suit the dial plate. If it is missing the latitude can simply be determined as in Note 1. Even if the gnomon is present it is still wise to cross-check these angles.
5. In the Northern Hemisphere the hour divisions on a horizontal dial will ALWAYS increase in a clockwise direction.
6. If there are additional scales which are usually known as Dial Furniture (lines for the equinox, solstices or zodiac), the gnomon MUST have a Nodus to be able to use them. This is normally in the form of a nick in its sloping edge about 1/3 of the distance from its toe.
7. If it is an early dial from the 17th or 18th century, the main plate will have been hammered flat from a rough casting which is usually made of brass or bronze. It WILL vary in thickness and this may be checked with a micrometer. Except to find around 10% variation over the area of the plate. Also expect to see hammer marks on the back. Modern rolled brass was not available until the mid 19th century.
8. The dial WILL normally be engraved. Replica dials were often cast complete with all of their markings. Do not be fooled by a motto like "TEMPUS FUGIT" or a date such as '1695'. Look particularly for signs that the markings have been acid etched. The lines from an engraving tool tend to be V shaped. Etched lines are U shaped often with undercutting at the edges, however these points may be difficult to check if the lines are filled with wax.
9. If the dial has lived outside for many years it SHOULD have a rich patination. The colour may vary considerably due to the composition of its metal and the dials outside location. It may have been near to the sea or close to an industrial area. Expect the colour to vary from a pale green through to a deep brown. Also expect some of the finer surface details to have weathered, possibly to the state where they are now illegible. Avoid dials which have been highly polished. This removes centuries of patination and can hide evidence of age (or lack of it). Besides, a polished dial is difficult to read in sunlight.
10. WHERE did it come from? Was it stolen? Many old dials have been obtained illegally at sometime in their history. This is a dilemma to which there is no satisfactory answer. Generally we agree that if the dial has been in free circulation for some years then its original ownership may be deemed invalid. If we try to find its original owner we may end up losing our precious purchase with little or no compensation.

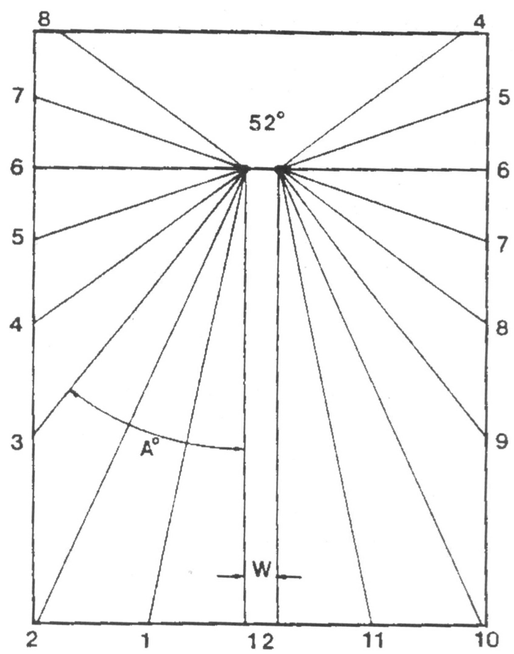
NOTE 1. A simple way to check the latitude of a horizontal sundial is from its hour lines. Refer to the Figure. At any latitude the 6am-6pm line will be straight and at right angles to the noon line. This means that the most sensitive indications must be mid-way between them, ie. at 9am and 3pm. The general formula is $A=Tan^{-1}(Sin\ L)$, where A is the angle of these lines measured from noon and L is the Latitude.

For those of us who do not feel comfortable with mathematics the following tables will be a useful quick reference guide.

NOTE 2. If the dial is required to be set up at latitude other than that for which it was designed, do NOT change the gnomon angle. This will partially compensate but will not correct the readings. All that is necessary is to tilt the dial plate by the latitude difference so that the sloping edge of its gnomon remains parallel to the earth's polar axis.

LATITUDE	ANGLE A
40°	32.73°
42°	33.79°
44°	34.79°
46°	35.73°
60°	40.89°
48°	36.62°
50°	37.45°
52°	38.24°
54°	38.97°
56°	39.66°
58°	40.30°

TOWN	LATITUDE	ANGLE A
New York	40°45'	33.13°
Chicago	41°50'	33.70°
Rome	41°53'	33.76°
Paris	48°52'	36.99°
Plymouth	50°22'	37.60°
London	51°30'	38.05°
Cambridge	52°11'	38.31°
Dublin	53°21'	38.74°
Manchester	53°28'	38.78°
York	53°58'	38.96°
Edinburgh	55°57'	39.64°



DESTRUCTION BY DECAY

BY CHARLES K AKED

What is your substance, whereof are you made,

That millions of strange shadows on you tend.

William Shakespeare, Sonnet LIII.

There is a very rich heritage of dialling in the British Isles, including Ireland, covering many centuries, indeed one may regard many of the areas represented under this appellation as having unique examples. How much longer will these treasures be left to those who are destined to follow in our footsteps as they take up the stewardship of the remaining examples?

It has greatly puzzled the writer when contemplating the most ancient examples, generally represented by the remaining scratch dials in England (mass or canonical, according to taste), and the relatively few Anglo-Saxon dials, as to why and how any of these could survive for nearly one thousand years; when at the same time he has witnessed the steady deterioration in their condition over the last two or three decades. On a personal visit to Lincolnshire a couple of years ago to examine scratch dials around Louth, the writer had great difficulty in finding more than two out of twelve listed in Origin and Use of Church Scratch Dials by T W Cole, published 1938. In fact at one site, not even the church could be found, merely an enclosed space overgrown with vegetation.

On visiting a well known example which was quite well delineated when the writer first saw it, it was sad to see that someone had scratched new lines because the old had practically disappeared, thus its value as an example has been lost for ever. Near Sheffield, at Tankerton, the stone of the church walls had been dressed to remove the surface damage, including that where a dial had been located, now only visible to the most careful observer with the keenest of sight. That this pattern could be repeated all over the country, there is no doubt. The writer cannot remember one example of a scratch dial still mounted in its original place and provided with protection from the vagaries of the English weather.

Yet surely this present rate of decay cannot be blamed upon the weather alone? For if it were so, then the ancient origins of these dials must be discounted. However the date of the making and erection of early Anglo-Saxon dials is known in some cases, and whilst those in exposed places have suffered great deterioration, the better part of a thousand years has not been enough to efface them completely; those more fortunate examples under cover have. of course, fared rather better although even these are not pristine.

BEWCASTLE CROSS

The example which has caused most concern is that of Bewcastle Cross in Cumberland, which the writer first visited in 1972. He wrote an article on this in the December issue of Antiquarian Horology, December 1973, pages 497-505, surprisingly the first time an horologist had done so. The writer was singularly ill-equipped to take photographs at the time since he did not have a zoom lens, nor that most essential accessory - a stepladder, for the dial is over ten feet above the ground and is only 10 inches across and 7 inches in height.

Several casts were taken of the Bewcastle Cross in the last century and also early in this, the details of these have become mislaid, however there is a complete Bewcastle Cross in the Plaster Court in the Victoria and Albert Museum, London; and an even better one in the old dormitory at Durham Cathedral. Several museums have casts of the dial, eg Edinburgh, one in Australia and in the Science Museum, London, in the Time Gallery. It is believed that the London example is a cast of the cast dial in Edinburgh, and so perhaps less accurate in detail than the first cast. These plaster dials record the condition of the dial and "freeze" it at the time it was taken, whereas the actual dial naturally continues to deteriorate steadily or, as it would seem, at an accelerated rate. According to which cast is examined, the condition is seen to vary slightly. The London example is poor inasmuch it shows a huge recess for the gnomon which does not exist in the actual dial, see Fig 1.

When we examine old engravings of Bewcastle Cross such as that in The Book of Sun-Dials, 1900 edition, page 50; the condition of the dial is better than when the writer first saw it, on the other hand the essential features were all present in 1972 though not as clear as it appears in the various plaster casts.

Mr Robert Sylvester visited the site on 29th August 1990 and took some excellent photographs (he had the use of a stepladder and had taken the proper photographic equipment). He kindly sent a print of the dial, the receipt of which almost reduced the writer to tears, such is the obvious deterioration in the stone of the dial, see Fig 2. Most of the lines on the eastern side have gone for ever, the vertical line has been caused by the dripping of rainwater and perhaps an inherent fault in the composition and structure of the stone (a sandstone and not the granite which was the assumption of many years). The best way to compare these two photographs is to invert them (deliberately and not accidentally by the printer as done in the writer's first article), when the loss of lines is seen to be horrendous.

It is considered that the dial was first cut with an horizontal line, noon line, and two lines bisecting the right angles, these last three having small cross lines cut near the ends; the duodecimal division being a later addition. If one examines the Science museum cast (upside down), the extra lines seem rather thinner and more uncertain in execution than the previously described lines.

The Bewcastle example has been detailed at length because it is unique as an early Anglo-Saxon sundial, generally accepted as being made about AD 670 (but by no means certain); and because it entered the twentieth century relatively unscathed by erosion of dial itself. It is true the inscriptions (in runes) have been all but indecipherable for many decades, if not centuries. The interpretation of these by the Reverend Haigh and later Professor Baldwin Brown is highly suspect, these led to the date of AD 670.

Nevertheless, in less than twenty years, the dial of Bewcastle Cross has been reduced from a recognisable sundial with twelve divisions to an almost featureless semi-circular slab. This deterioration, and the parallel deterioration in other ancient dials, cannot fairly be blamed on the usual weathering factors, something more must be at work. It has been suggested that acid rain may be the

FIGURE 1: Plaster cast of the Bewcastle sundial in the Time Gallery, Science Museum, London.

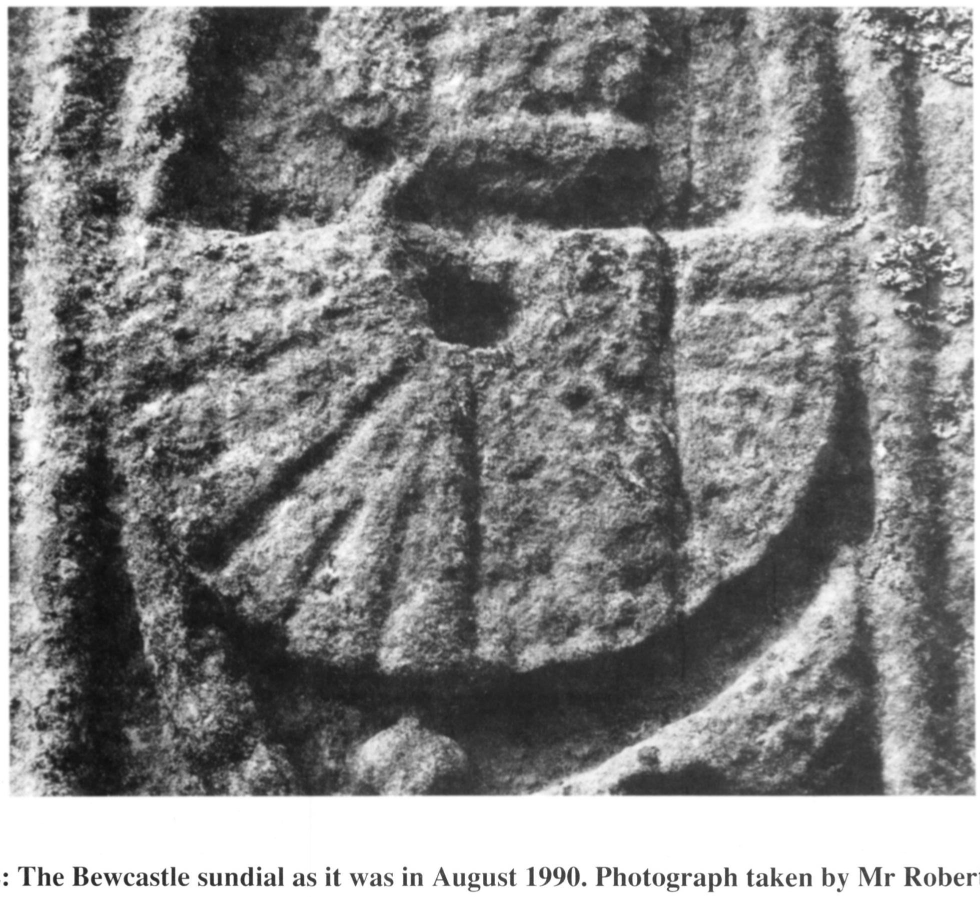


FIGURE 2: The Bewcastle sundial as it was in August 1990. Photograph taken by Mr Robert Sylvester.

culprit, yet Bewcastle is in the rolling country-side and one would think the atmosphere would be relatively untainted, being so far from any industrial complex.

At the time of his first visit, and until that time the Cross was visited by few except antiquarians, certainly not by diallists; indeed the writer was exceedingly surprised when talking to the foremost diallist of the time, to find that he had never visited Bewcastle Cross, or that other jewel of dialling at Kirkdale. Now this latter dial has been fortunate in being covered, either by plaster for some centuries, or as in the last two centuries by an added porch which affords complete isolation from the weather. This is shown in Fig 3, or rather a plaster cast replica. The condition of this is excellent, as is the slightly later example at St Andrew's Church, Weaverthorpe, Yorkshire; again this is under the protective canopy of an entrance porch.

WATER INDUCED DECAY

If we look at those scratch dials which fortuitously have finished up by being incorporated into internal walls, for example as at Northleach Church, Gloucestershire; the condition of these contrast starkly with those of dials which have always stood outside and braved the elements. Therefore it is not a case of the pollutants in the atmosphere alone which is causing the accelerated rate of deterioration, for those external dials protected from wetting by rainfall appear to be unaffected compared with those which are not thus protected. Wetting of the dial is the catalyst to the accelerated decay, but whereas in the past it only resulted in damage when the absorbed moisture was frozen by wintery conditions and expanded within the pores of the stone, later to spall off the surface. Evidently this was a very slow process if the accepted age of these dials is correct, so it seems the rain contains dissolved constituents which is responsible for the present alarming rate of decay in stonework.

This thought struck the writer at the BSS Cambridge Conference, for he was surprised to see the Gate of Honour, Caius College, enclosed in scaffolding, yet he remembered the previous restoration when the hopeless task of delineating the many dials on the stonework was finally recognised and dials prepared in vitreous enamel were substituted. The stone used for this monument is not very good at resisting the weather, and this applies equally to many of the sandstones employed in building work. The sandstone in Lincolnshire seems to be very poor in this respect, so huge cavities are created in walls, and the friable surface may be removed by merely rubbing with the hand. Similarly many churches in Shropshire are built with sandstone which is rather poor for resisting the weather. Hence this type of stone is not very good for delineating any kind of dial.

It must be said that protection from direct rain does not always guarantee preservation, for at Durham Cathedral, on the southern side of the cloisters is the meridian line drawn by Wharton and Carr in 1829, this continues up the cloister wall from the pavement. In 1991 this was found to be in a most derelict state, the stone sadly decayed, with great flakes peeling off the surfaces. No one in the cathedral knew of its existence and it really took some searching to locate. It is evident that here, less than two centuries have sufficed to reach effacement, and whilst the line on the pavement is subject to being walked upon, that on the wall has no antagonist to resist but the atmosphere. Perhaps it is the moisture seeping upwards through the stonework that is responsible for the damage, since the surface of the stone is unimpaired from about the height of a man upwards.

PAINTING OF DIALS

Most diallists of today have seen bare stone dials only, and thus are apt to assume that these must have always been so, yet when we read medieval accounts, we cannot help but be struck by the constant reference to painting, and it is obvious that entire surfaces were covered to provide the background for the different colours of the lines denoting the various elements of the dialling scheme. In those cases where stone is protected by paintwork, its life is greatly prolonged, as may be seen by an inspection of Fig 4, where the dial surface is in good order but the surrounding stone is beginning to decay. The effect of the paint spreads beyond its immediate boundaries, so the untreated stone within the dial still benefits from the protection of the paint.

Paint is a poor means of protection unless renewed periodically, as witness the state of the Pelican sundial at Corpus Christi College Oxford. It is only about twenty-five years since this had a complete restoration, by now large patches of paint are beginning to peel from it (all the stonework is painted), so even modern paint compositions have a restricted period of protection, no matter how careful the initial preparation and execution. The old system of an annual coating of limewash was an excellent means of protection, even though it was apt to fill up lines and hide features over a long time. The coats of limewash could always be removed when required to reveal the stonework untouched by the effects of decay. The lime, being alkaline, neutralised the effects of any acid; and absorbing carbon dioxide from the air, gradually turned into calcium carbonate. This again would reduce the effects of any acid constituent of rain falling on it.

Inspection of graffiti on church walls is illuminating inasmuch it gives an indication of the rate of decay, bearing in mind that these amateur inscriptions are generally mere scratches compared with those from a professional carver. Even in a poor stone, the inscriptions generally last for a couple of centuries before serious decay softens their outlines. This is not the case when the stone is subject to salt by being near the sea, for if one looks at the gravestones in the churchyard at Whitby, the slabs themselves decay into shapeless horrors in a couple of centuries, whereas stones of a similar age protected in some way remain in good condition.

The foregoing is only a tentative venture into this relatively unexplored field, and the writer must confess his complete ignorance of knowledge of the qualities of stone used in building. Judging by the examples of our most ancient buildings, a thousand years is more than enough to reduce them to rubble without constant care and refurbishment. Even Stonehenge could not resist the despoliation of time. Granite, which seems a most durable material, succumbs eventually, the surface begins to pit and gradually the stone deteriorates.

ANCIENT DIALS

What then of the most ancient examples in Greece? These were cut mainly from the much more pollution sensitive limestone or its crystalized version, marble. Fortunately most of these have been recovered and placed in museums, and though often battered and broken when discovered, are now saved from further deterioration. A few remain in situ, gradually being eroded into anonymity by the foul

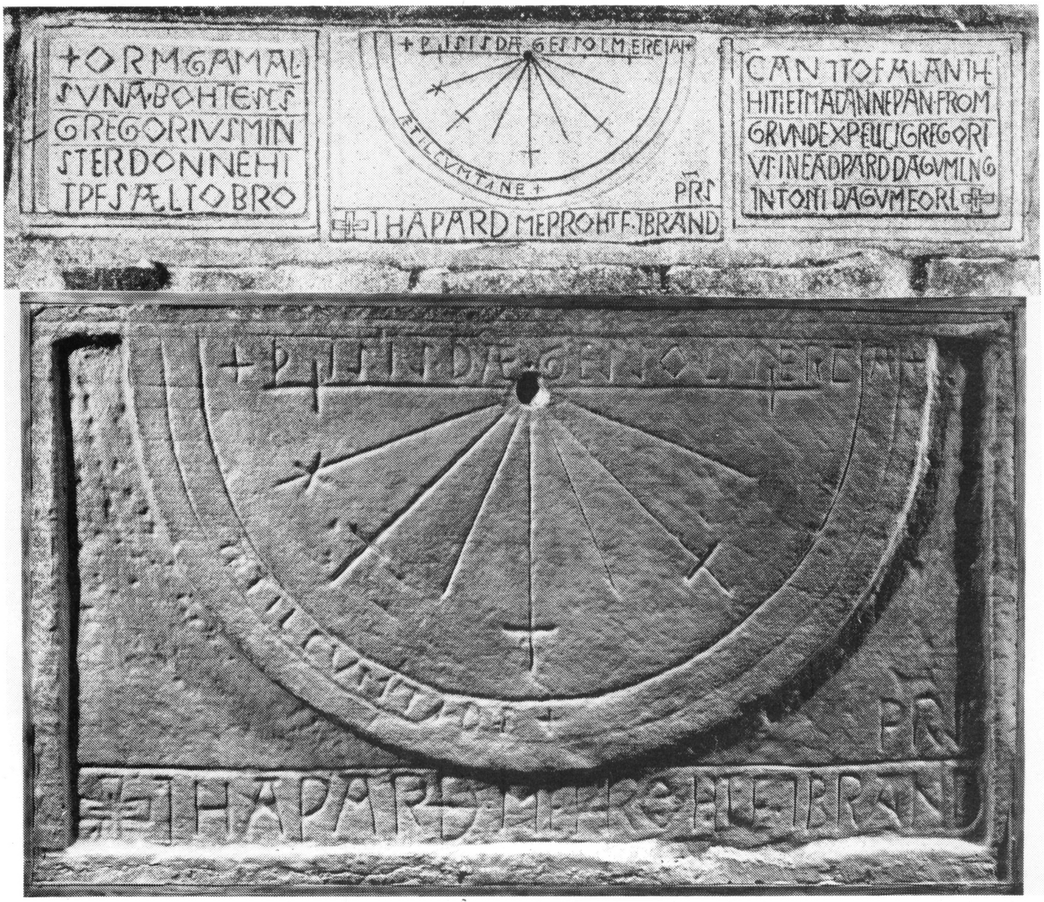


FIGURE 3: The Kirkdale sundial, circa AD 1056. A plaster replica in the Science Museum, London; with the full panel above.

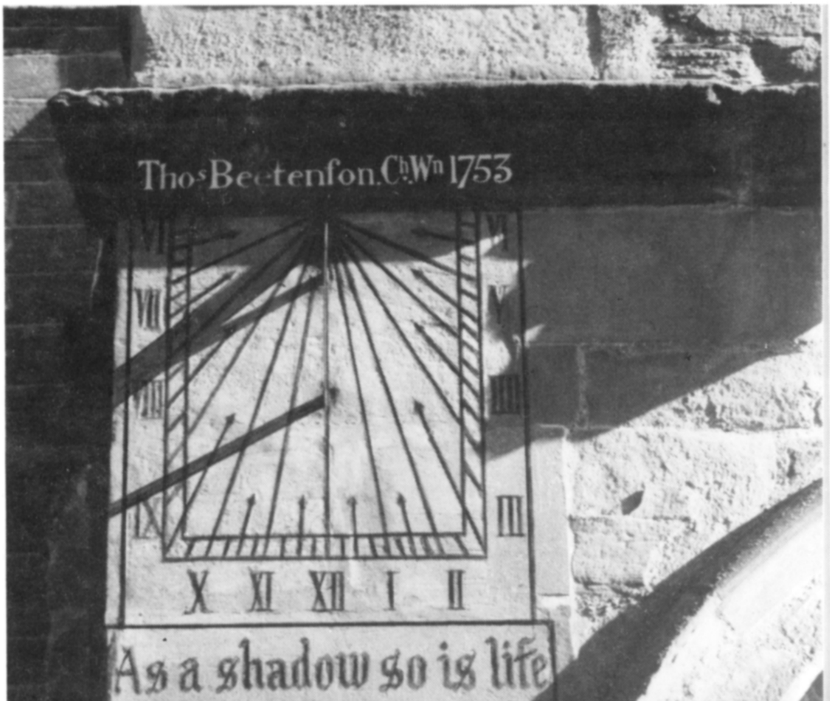


FIGURE 4:
A sundial painted directly on the stone surface, St Edmund's Church, Shropshire; about 7.40 am solar time. First painted AD 1753, the surface remains in excellent condition.

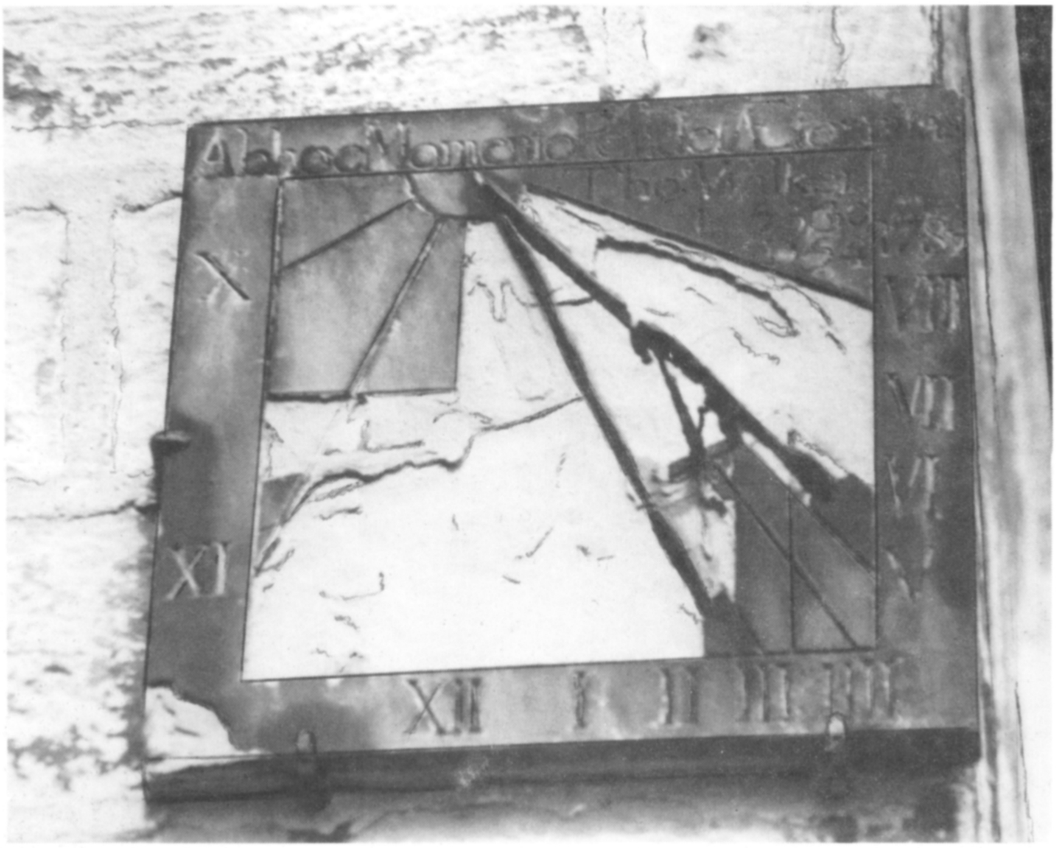


FIGURE 5: The cankerous remains of a well made sundial on St Peter's Church, Tankersley, signed Thos Walker. The dial declines by 54°. The Latin motto translates - "On this moment hangs eternity". The iron gnomon is practically destroyed. Even the fastenings to the wall are insecure.

FIGURE 6: One of the dials delineated by the St George's Chapel, Windsor, in 1714. 270 years have almost effaced it. Note that the lower left part is on a better piece of stone, also how most of the gargoyles have deteriorated.

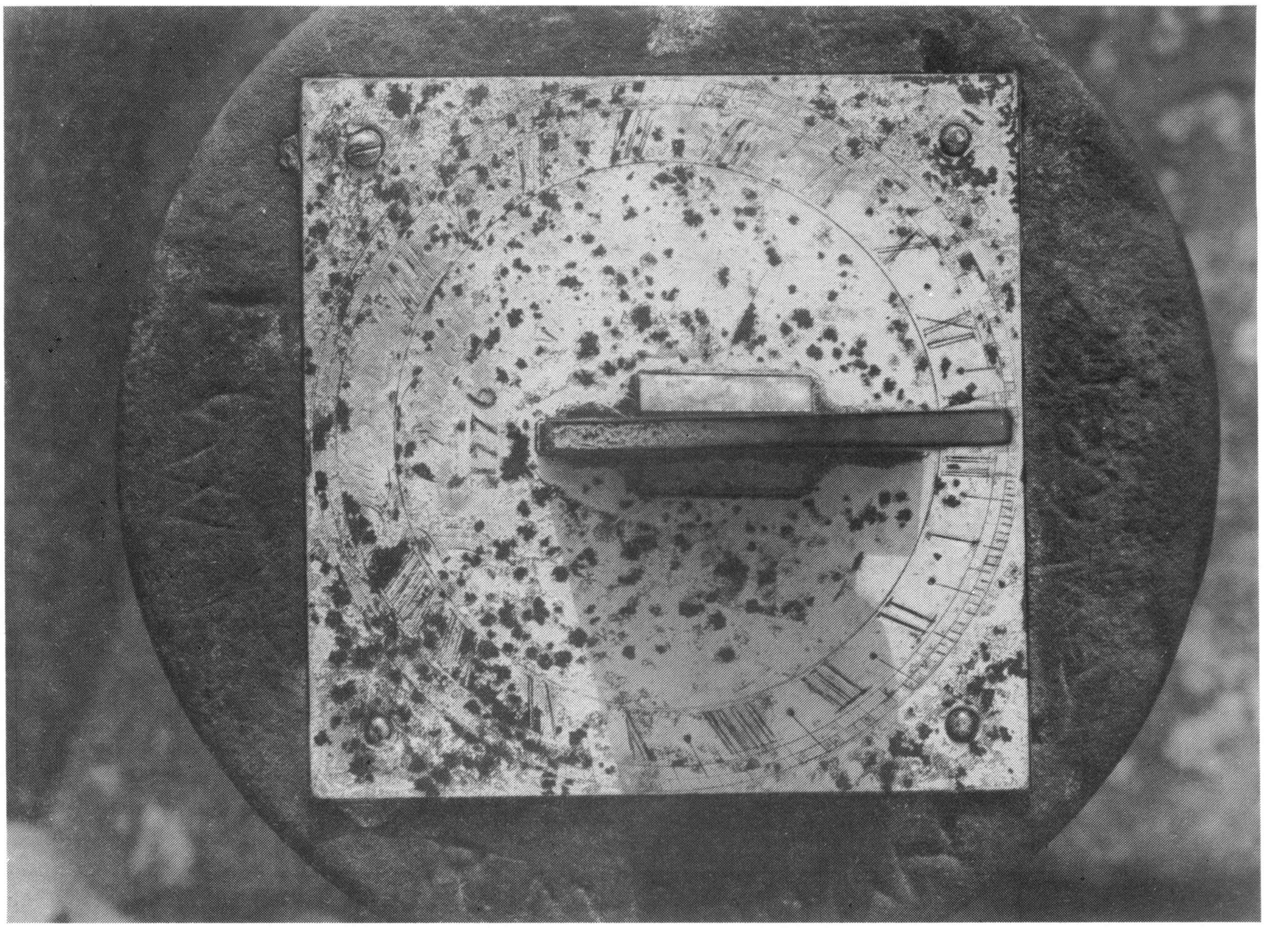


FIGURE 7:
A typical brass horizontal sundial after two centuries of weathering in Gnosal churchyard, Shropshire. The gnomon is a replacement (often wrenched off by vandals).

FIGURE 8:
An excellent dial on the Manor House, Chipping Norton, currently being restored (courtesy of Colin McVean).

atmospheric conditions of modern Greece. The planar dials of the Tower of the Winds are all but extinguished and will soon be but a memory conserved in various writings about them. It has taken about two thousand years to efface the carvings of the craftsmen who thought their work would last for ever, and most of this damage has occurred in this present century, visible to an observer in his own lifetime. Had these magnificent dials been located in England, they would hardly have been a memory by now.

What can be done to halt or reverse this decay? In the case of Bewcastle, it is clear that such an important part of our history should be given the protection of indoor conditions, far better the actual cross should be in the Victoria and Albert Museum than a plaster replica. Alternatively it could be placed within the church as in nearby Ruthwell, where the fine cross similar to that at Bewcastle (it has no dial) was smashed to pieces at the Reformation and used as building rubble. It was recovered and rebuilt inside the church and is now safe from further deterioration. If needs be a fibre glass replica could be erected in the churchyard at Bewcastle. It is sacrilege to allow such an important symbol of our history to deteriorate into shapelessness.

Possibly treatment by coating with silicone based waterproofing liquids may be of use to slow down the rate of decay. Whatever is used, the stone has to be able to "breathe", if covered by an impervious layer, the surface of sandstone fritters and flakes in the presence of moisture. Stone saturated with moisture, as when first excavated, is known as "green" and can be more easily cut and worked than when it is dried out and "seasoned". Since sand-stone is formed from minute particles of abraded rock which have settled into layers which have subsequently been coalesced into a solid mass by pressure alone, it does not have the resistance to corrosion that material bonded by pressure and heat possesses.

We are all aware, indeed many sundials carry admonitory phrases such as "Tempus Edax Rerum" - Time consumeth all things, of the transitory nature of our beloved idols. This is one of the many aspects which led to the formation of the British Sundial Society in 1989, the realization that there were so few engaged in the active preservation of sundials. To remind members, the aims of the Society are as follows:

a) to promote the science and art of gnomonics and the knowledge of all types of sundials.
b) to catalogue the dials which still exist in the British Isles and research their history
c) to advise on the preservation and restoration of old sundials and the construction of new ones
d) to publish and circulate to members periodically, a Bulletin or Journal containing original articles, reports from other societies, news and other items of interest to other members.

Under the laconic words of c) is hidden the necessity for an immense amount of effort required even to institute the area of the problem involved, we have not even managed to catalogue the dials under threat, let alone formulate how to proceed to eliminate the danger of extinction for the most endangered specimens. How are we to advise on preservation when we are not sure of the cause of premature decay. Others who work on stonework of far greater value, eg statues and figures on the exterior of churches and cathedrals, appear not to have evolved techniques of preservation either, and here the amount of effort, time and money is far in excess of that required for even a complicated sundial. Fortunately, Dr Andrew Somerville, in compiling the rules which now govern the BSS, only stipulated "to advise ..."; for the problem which presently faces us is immense and can only be resolved by each individual cathedral, church or other building, being responsible for the care of the dial, or dials, delineated upon it. Perhaps in special cases the BSS could contribute towards the cost of restoration/preservation.

How best to proceed in this endeavour? First we must have details of all the old dials, with adequate notes upon their state of preservation and local environment, so that those most at risk can be identified. A means of protection which does not detract from their appearance and function must be devised, perhaps a tough glass panel to cover scratch dials might offer a solution. The old Anglo-Saxon dials would benefit from such protection, and it would not cost much to protect a scratch dial. Even a short jutting out section above the dial would deflect most of the rain from a dial, certainly the drips which seem to cause much damage.

Examining the whole problem dispassionately, it appears desirable to set up a panel which can examine the problems outlined here and begin a period of investigation into the mechanics of the decay mechanism, formulate methods to counteract the effects of time and weather, and actively promote the preservation of those sundials which are of the utmost importance, such as that at Bewcastle. If we who are interested in sundials do nothing, why should we blame others for not doing anything when they do not have any interest in them at all? It is up to us to get sundials recognised as national treasures and a comment upon history, not the archaic and useless symbols of past ages as the majority of our fellow citizens appear to believe. For whilst man-made clocks may measure our time, the sun still rules our daily lives.

Continental diallists have rather stolen a march upon British diallists, for there has long been programmes of restoration of sundials in Europe. These restorations are mainly of vertical sundials painted on walls but if the dial is painted on stucco coated walls, then much knowledge and patience is required to fix loose coatings on walls, repair blemished surfaces, and fill cracks, before the work of restoration of the actual sundial may commence. A book dealing with this type of work is Restauration de Cadrans Solaires, published by Club du Vieux Manoir, 1987. The text is French, with copious illustrations of actual work. The writer knows of no English book on restoration techniques.

Perhaps a group could be set up to deal with this aspect of dialling techniques. There is certainly a massive effort required to save the older dials from extinction.

* * * * *

NOTICE

The BSS Scratch Dial Group has called a meeting to be held at Billesdon Old School near Leicester on 16th October 1993, commencing at 11.00 am to end at 4.00 pm. The discussions will include classification, recording, computer programming and relevant matters raised by the attending members. All BSS members are welcome to the meeting. Further details may be obtained by telephoning the Secretary - Mr David Young, Tel: 081 529 4880.

SWINDON MEMORIAL SUNDIAL

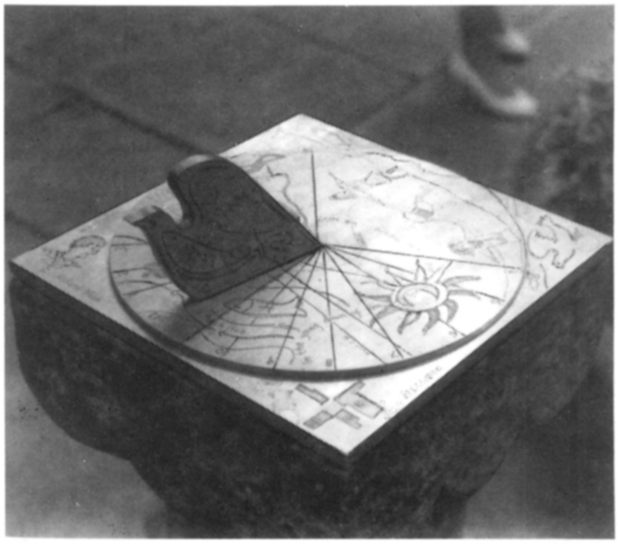
BY COLIN McVEAN

Many months ago now I was approached by two young ladies, one from Thamesdown Borough Council's Public Arts Unit in Swindon, the other an artist, Marie Brett. A sundial was being commissioned in memory of a well-respected Police Constable, Richard Webb, who died of cancer in 1988. The dial was to be placed in Swindon Town Gardens amongst the roses. They wanted help in laying out the hour lines and asked if I could assist them. I took the latitude off the Ordnance map which was 51°30'N and drew out the hour lines with a node on the style to show the equinoxes and the summer solstice. I sent the drawing to the artist and thought no more about it.

Then just recently I was asked to go and help place the dial in the right way and at the same time, received an invitation to the ceremony of dedication to take place the day after. Accompanied by one of my grandsons, I presented myself at Town Gardens armed with a table of the sun's bearing from 0900 hours to 1000 hours every four minutes, a home-made theodolite, a reliable compass and a map. As usual in these matters the sky was overcast, there was no definite point visible to take a bearing from and the matter was urgent; so I had to fall back on the compass.

The ordnance survey section in Swindon gave the magnetic variation as 6°30' West and checking that the compass in various parts of the garden did not show any local interference, the dial was set by compass. About 1100 hours the sun's position could be judged approximately through the clouds and indicated that the setting of the dial was in the right direction.

The next day my wife and I went to the dedication which was well attended by local residents. The dedication was short and touching with appreciation from the local community who had raised the money, a fellow officer of the deceased and the vicar. The sun was shining on this day and I was able to check the sundial time which was correct.



The dial itself is a very sturdy bronze construction showing pictorially the constable's beat through the gardens and his well known interests.

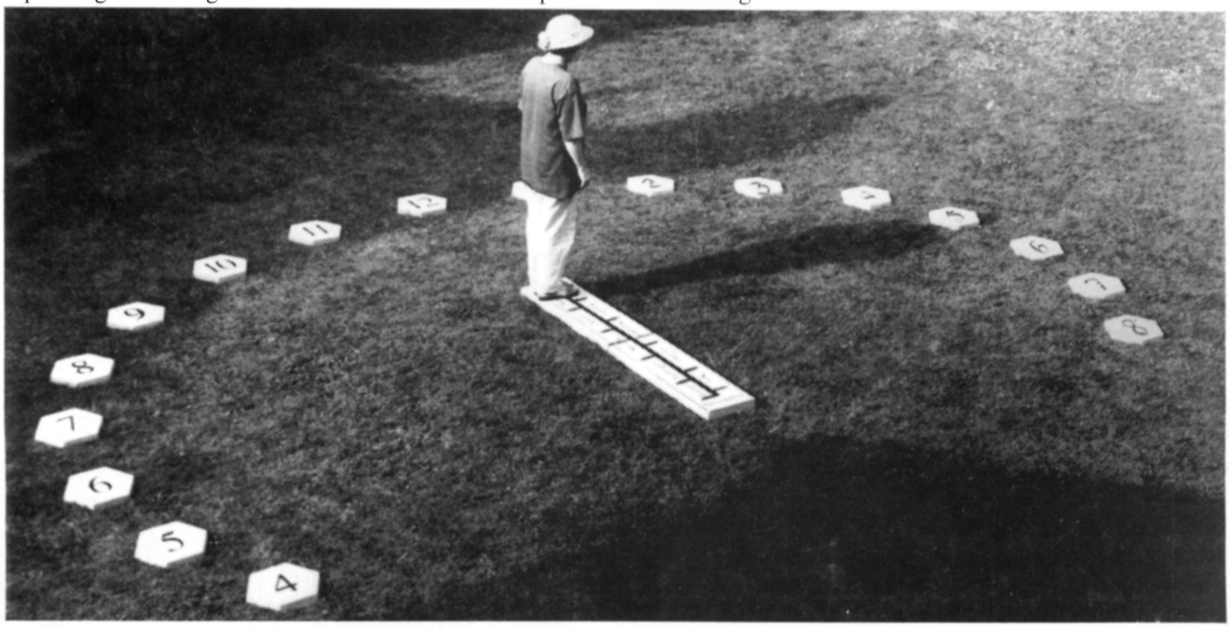
I was very happy to be of use in this affair and was warmly thanked by Thamesdown Borough Council as well as being given a nice box of chocolates by the artist.

A NEW ANALEMMATIC DIAL AT LEICESTER

A photograph taken during the preliminary laying-out of the dial now installed at the Museum of Technology, Leicester.

The observer acts as the gnomon when standing at the corresponding date along the minor axis of a 6 metre ellipse of hour markers.

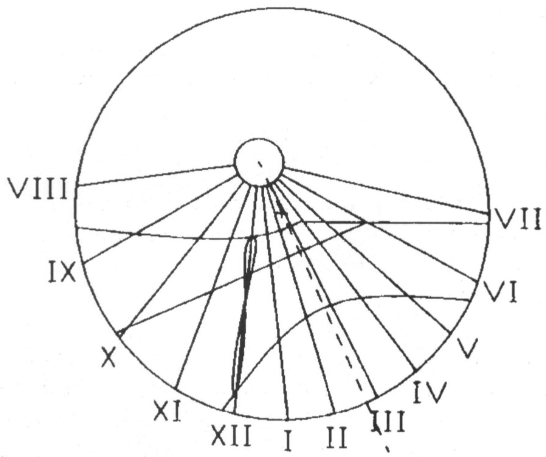
Designed and constructed by members of the Department of Physics and Astronomy, University of Leicester, with financial support from the Enterprise Learning Initiative.



BIFILAR GNOMONICS

F. J. de VRIES

FIGURE 1



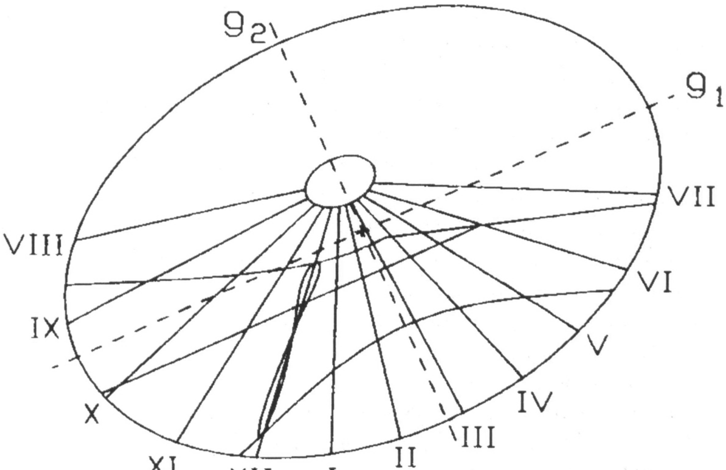


FIGURE 2

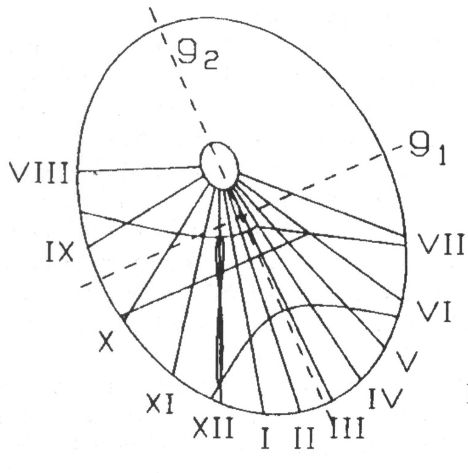


FIGURE 3

In Bulletin 93.1 there was an article by Mr. Sawyer about the (equiangular) bifilar sundial.

There are several formulas to calculate such a dial, but I would like to mention an easy method to transform a drawing of a 'normal' sundial into a bifilar sundial. Because the calculation of a 'normal' sundial is a better known procedure, this method will help members to make a bifilar sundial. This method is suitable for all flat sundials with any type of lines.

In Fig 1. is a 'normal' sundial for a latitude of 52 degrees with an inclination i = 100 degrees and a declination d = 30 degrees.

The height of the pole style for this dial v = -41.45 degrees and the angle between the substyle and the line of slope b = 24.25 degrees.

On the style there is an indicator for the lines of declinations, the equation of time curve, the horizon or to any other lines present. The distance of this indicator perpendicular to the dialplate we call g_1. Through the indicator we place a thread, parallel to the plane and in a direction perpendicular to the substyle.

We place a second thread above the substyle and also parallel with the plane with a height of $g_2 = f.g_1$ where $f > 0$.

If we choose for the factor f the absolute value of 1/sin(v) then the final result of the bifilar sundial will be an equiangular dial for the suntime-lines but this is not strictly necessary.

The remaining operation is to transform the drawing of the dial in the direction perpendicular to the substyle with factor f.

A modern copier with separate multiplying factors for the x and y axis can do the job for you.

In Fig 2. the final dial is drawn where $f = |1/\sin(v)| = 1.511$, so this transformation leads to an equiangular bifilar sundial.

The bifilar sundial in Fig 3. is the result of transformation with a factor f = 0.75. This means that the thread g_2 is beneath the thread g_1.

BOOK REVIEWS

Cardrans Solaires des Alpes by Pierre Putelat and Paul Gagnaire. 96 pages, 120 colour plates, and 2 line diagrams; the coloured plate of page 33 is repeated on the front cover, whilst that of page 85 is repeated on the back cover. Published June 1993, 22·5 cm height, 27·5 cm width, ISBN 2-9505792-5-6. Price 245 French Francs, or from the author/editor 285 F, which is 245 F for the book and 37 F for postage and insurance; M. Pierre Putelat, 05 350 Molines en Queyras.

This is almost entirely a picture book illustrating 116 sundials of the Alps and is split into three main parts: The northern Alps of the Haute Savoie, Savoie and Isère, the Italian Alps of Piémont and Val d'Aoste, and the southern Alps, Alpes de Haute Provence and Maritime Alps. The text covers a mere seven pages, and opens with the classical reply of Saint Augustine to the enquirer of "What is Time?". A very short history of the events in dialling history is given, ending at 1802, but mentioning the decline of the sundial in the first half of this century and its present renaissance. The rest of the text deals very briefly with conservation, principles of functioning, dial time - clock time, and on the last textual page the correction of sundial time to clock time.

Unlike English books which give a list of the contents and the illustrations, this book has no such aid for the reader. Furthermore the illustrations themselves carry no captions, in some ways this improves the appearance of the dials shown, but it means the viewer must turn to the section titled "Légendes des Photos" for these. Sadly most of these references carry very little useful information other than location, date and the motto (where applicable). Since there is no index to the book, nor list of contents, it will generally mean a search through the whole book to find a particular example if at some future date it is necessary to find it again. Because of the format of the book, it will have to be placed on the bookshelf on its end, few modern bookcases will accommodate such a wide book (almost 11 inches).

The photography and the reproduction of the dials are really excellent. They are nearly all vertical dials but included are Meridian Lines, a Star of David, a Reflection Dial and others. Some have suffered through repainting by less than competent artists, and some have suffered through neglect. This book is an almost perfect record of these dials as they were at the time of being photographed. The reviewer would have like to have seen more indicating shadows, but having been frustrated many times himself at the end of a long journey, realises that the conditions are never quite as the photographer would like to have them and often one has to settle for a picture taken under a clouded sky.

The last illustration is really an advertisement for the author's book on Sundials in the High Alps, specifically devoted to these examples alone.

Pierre Putelat is the photographer-editor of the book, he has a passion for sundials and visits the dials regularly to photograph these under the best conditions. He has published many books on this theme, mural posters and post cards.

Paul Gagnaire is a member and Laureate of the Astronomical Society of France who encountered his first sundial in 1934 and is now regarded as one of the dozyens of the dialling world in France. He provided the text to M. Putelat's illustrations.

For those interested in Continental sundials, this book is a necessary acquisition, and although the text is in French, the sundials will be found to speak for themselves (in English).

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Oronce Finé's Second Book of Solar Horology by Peter I. Drinkwater. 32 pages, 28 illustrations, paper covers, 14 x 24 cm. Published by the author, Shipston-on-Stour. Price £4.50.

Finé's First Book on Solar Horology deals with devices that stand still and have a moving shadow. The Second Book deals with portable instruments that mainly operate by the measurement of solar altitude. Included are quadrants with plumb lines, cylindrical dials, ring dials, and dials based upon the astrolabe. The Regiomontanus dial is complicated but fascinating, whilst the ship dial derived from it is somewhat simpler.

The illustrations are based on the originals with the Latin explanatory words, but the text gives the explanations of how such dials were constructed. This should be an interesting exercise for someone skilled in metal work, the biggest problem is the engraving.

As with the first volume, the typeface is small which makes it difficult to read, and there are some typesetting errors. It is necessary to concentrate in order to understand the points being made, and for those who wish to undertake to make any of the instruments, it would be a good idea to make one's own working drawings to a large scale.

The greatest interest in the book is in learning what the state of the art was in the early sixteenth century. There must have been a large demand for portable timekeepers, the watches of that time were not only very expensive, but inaccurate.

The book is an interesting addition to early dialling literature. It may be ordered directly from the author at 56 Church Street, Shipston-on-Stour, Warwickshire, CV36 3AS, or from booksellers Rogers and Turner, or Mrs R.K. Shenton.

E.J. TYLER

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EDITOR'S NOTE:

Quite a number of members have told the Editor that they have difficulty in understanding the erudite articles in the BSS Bulletin, so he makes no apology for including the light-hearted essay on the trials and tribulations of the sundial enthusiast on his safaris (see page 22). In fact he as decided also to include a few deliberate errors so that those whose greatest pleasure is in finding these phantoms normally inserted by the printer's devil, can also have their portion of unadulterated pleasure.

The only sundial he can remember on a public house is one in Newark, I am sure that BSS members know of many more, let me know about them and we can have that special sub-section allocated in the computer records. Truly there is no end to the diversification of dialling, but Mr Thorne is the first to make "public" his thoughts on the subject.

LETTERS TO THE EDITOR

Dear Sir,

I read with great interest (in February's Bulletin) M. Rohr's erudite article - "Some Reflections on Neolithic Astronomy". Stonehenge has always held a special fascination for me since my early childhood days were spent in a neighbouring valley.

I have still maintained my interest over the years in all Neolithic standing stones - including the famous "Loupin' Stanes", which happen to be on my property in the Borders. The mystery of their construction remains as to why these configurations sprung up simultaneously over all Neolithic Europe so soon after the retreat of the Ice Age glaciers.

However there could, in my view, be a very simple answer to this intriguing question. It is well known that the continued preservation of a species which has survived near extinction in the past, must depend upon its ability to adapt to meet changing circumstances in the future. This ability can only exist through possessing a reliable early-warning system to guard against any future situation, which may threaten its survival.

Homo sapiens is no exception to this rule. Survivors of the most recent glaciation may have owed their existence to some kind of forewarning - plus their ability to adapt successfully to a new life-style and diet. Neanderthal man, on the other hand, may have become extinct - according to recent archaeological evidence - by leaving it too late to relocate Southwards or change his diet.

Neanderthal man may have also overlooked certain aberrations in the sun's behaviour prior to the onset of the Ice Age. These were correctly identified by his cousins - homo sapiens - as precursors of environmental catastrophe. Could the 20,000 year old pebble markings mentioned by M. Rohr perhaps be crude records of solar movements, from which pre-glacial man made his original decision to move South?

The dinosaur was apparently an earlier victim of an alteration in the global climate, which broke its food chain. Most scientists now appear to say this was caused by a sudden change in the earth's axis. This could have been due to the impact of a very large meteor or small asteroid. Could the onset (or the termination) of an Ice Age have also been caused by a rapid change in the earth's attitude towards the sun - by further impacting of planetary debris from outer space?

No one can pretend to know today the exact answer to these perplexing questions; but suppose for a moment that pre-glacial humanity had witnessed major changes in the diurnal and annual behaviour of the sun - prior to the onset of the Ice Age? Would not those communities which survived, have connected deviations of the sun's movements with life-threatening environmental turmoil?

Would it not therefore be logical for the survivors of such a catastrophe to build, as a matter of priority, permanent solar observatories for the protection of future generations? Their first efforts may have only been crude stone markers or standing stones as they are today; but they would have done the essential job of checking out the solar positions at the solstices. Later on, it would be quite natural for some of these relatively simple configurations to have been refined and extended into the larger and more sophisticated solar/lunar observatories like Stonehenge.

Would it also not have been reasonable to expect Neolithic architects to identify the main purpose of their observatories - by incorporating menhirs which were ice-flow related? Could not the blue (Aubrey) stones from the Prescelly Mountains in Stonehenge have been put into the design - simply to remind us of the nature of the ultimate threat to all life in Northern Europe? A threat which is especially relevant to those who live there at the close of an extended inter-glacial period - as we do today?

My rather amateur conclusions are that the Neolithic standing stones and megaliths of post-glacial Europe were erected as solar observatories. They were intended to be primarily an early-warning system of global climate change. The fact that they became used for religious purposes and for observing other celestial movements later on may be entirely secondary.

I wonder if M. Rohr and other experts would agree with this rather simplistic if not controversial interpretation? I do not believe it is original in that I must have read it somewhere ... unfortunately I cannot find any direct reference to this interpretation among the copious works I possess connected with Neolithic stone circles! Perhaps some more qualified members of the BSS than myself may be able to help? Can they suggest where I could obtain further information in my attempts to solve this age-old mystery created by our forebears?

TANLAW

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ERRORS

Following the commendable lead of the Chairman, I take the liberty of pointing out three "errors and misconceptions" in the June Bulletin: not in any spirit of 'picky' criticism, but merely, I trust, to strengthen the value of the three article in question.

A JAPANESE SUNDIAL - R.A. MILLS

Mr. Mills's guess about the tall stepped pillar being associated with the Solstices is correct. The shadow of the pillar will strike the Sun Symbol on the true Noon Mark at the Summer Solstice: the shadow of the middle step will strike it at the Equinoxes: the shadow of the lowest step at the Winter Solstice. This is clear and requires no demonstration, it is an arrangement which might be copied elsewhere. Mr. Mills's diagram errs (on the clear evidence of this photograph) in shewing AB lined up with the 12 o'clock line; it is actually lined up with the true noon mark, exactly as one would expect.

KIRCHER'S SUNFLOWER CLOCK - J. BRIGGS

One should not underestimate the "sense of humour" of writers from the past, but the sunflower dial as illustrated does actually work (even allowing for artistic license; the equally divided circle is shewn (? even according to the rudimentary perspective used) as inclined to the plane of the Æquator) as one would expect an Æquinoctial dial (as this is) to be. More consequentially, the Greek inscription quoted should be read as [c]ΩΡΟΣΚΟ ΙΟΝ [c]Ε ΙΟΡ ΙΚΟΝ, which transliterates as "Horoskopin Heliotropikon = "A picture of the Heliotropic Horoscope", or "The Image of a Sunflower Sundial".

A COLD LOOK AT KRATZER'S "POLYHEDRAL" SUNDIAL - P.I. DRINKWATER

The Editor has (perhaps wisely) dropped the Author's original main title and has surreptitiously removed a few slangy expressions from the text, but the error in the last paragraph is all the author's own: any fool (and perhaps many of the wise) can readily see that the dial in the hands of the master has already been marked up with hour lines; that they are (in this instance) equally spaced, and therefore quite inappropriate to the planes upon which they are drawn. The fool will also notice that Kratzer has already made a move in the right direction by modifying the spread of Hour lines on the side facets: probably his third (unrecorded) attempt was entirely correct - let us leave it so! The Author had intended to pull a slight 'con' of his own in saying what he did in this last paragraph, purely to save the face of this old diallist, from whom he has learned so much and for whom he still retains the greatest regard. The Editor in reproducing the portrait (which wasn't included by the Author) has cruelly exposed both the Author and his Subject! Good for him. Old Kircher (see above), as a good Jesuit, would have known the value of confession: "mea culpa, mea maxima culpa". After going through this ritual (whether sincerely of otherwise), one can justifiably brazen out any criticism which, comes, whether justified or not!

PETER I. DRINKWATER

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EDITOR

1. The diagram was actually redrawn by the Editor, who may have been the cause of this possible error.
2. After reading the article to his group of sundials in his garden, the Editor must report that his sunflowers are singularly unresponsive to the daily journey of the sun, they correspond to a non-functioning clock.
3. The portrait of Kratzer has not reproduced well from the original but it was never intended to castigate Mr. Drinkwater, the text should have been changed slightly by the Editor, on noticing the conflict of words and picture, to avoid this contretemps.

* * * * * *

SHINING HOURS

In The Friendship Book annual for 1992, under the date of Saturday October 2 is the following:

I have been reading about an old sundial bearing the inscription Horas non numero nisi serenas, meaning "I only count the hours that are bright" (better rendered as 'I count only the shining hours'). It's a true statement for a sundial can only record the time when the sun casts a shadow on the pointer.

It's unlike life where everything we do (or don't do) leaves its mark on us and those we come in contact with. We may today be experiencing the benefits of something we began years ago, and in the same way today is, quietly and surely, shaping our tomorrows.

What we do with our time, our talents and our lives is largely in our own hands, and its worth pausing from time to time to make sure that our 'sundial' is set to record the brightest and most worthwhile things possible.

This is well expressed by the Glasgow writer Hazel Aitken:

You did your best and yet you failed,
You feel that Life's unfair,
But nothing's ever wasted,
Especially the care,
And thought and planning
You lavished on your schemes;
So if they're worth it, try again
And you'll fulfil your dreams.

But the final word is from the Editor's small grandson who when asked on a cloudy day why he thought the sun disappeared every now and again, pondered for a while and then said: "To give all the sundials a rest, grandad".

* * * * * *

YOUR RAINBOW

SUNSHINE, cloud, and wind, and rain,
As so much else on Earth, are unpredictable;
The grey and dark of storm unfurl haphazardly.

But behold, above this restless world,
The logic of a rainbow
In beauty calm, and ever thus shall be so.

Half-hid by earth's horizon
The rainbow is the halo of the sun,
An immaterial wheel of coloured light,
Gathered from chaotic, flashing,
Falling sunlit drops of rain.

ANALOGY: the troops are mustering
A horde of tiny droplet spheres,
Condensing from the vapour of a cloud,
Then falling down in uncontrolled succession.

Falling from the cloud to brightness,
Each drop admits the rays of sunshine;
Splits apart the spectrum colours,
Red through green to violet
Splays, reflects then inwardly,
Then shoots them out wide-spread,
A barrage of colour flashes.

The drops of water must all obey
This optic rule, but you perceive
Colours only in the rainbow's arch;
Other flashes do not hit your eye,
And going by, disperse unseen.

All halo centres must align themselves
With source of light and a perceiving eye
And, with such line, rays of distant sun
Are parallel; a simple symmetry prevails:
Rays that fall full four square upon the halo-wheel
Are gathered back as colours to your eye;
Others converge too near, or far away.

Such symmetry translates angles into circles
A colour flash from droplet to your eye,
Joining there the halo axis,
Becomes the angled compass
Tracing your coloured arcs in sky.

Optic and geometric features thus compose,
Believe it you can,
A gift to you of coloured curves in space.

PARADOX: your eye is in the central place,
The centre cannot be avoided,
If you move the coloured curves move too;
Surely the rainbow is attached to you.

(For my unbelieving daughter-in-law)

GEORGE WOODFORD (France)

SECRETARY'S NOTEBOOK

Many members would have seen a well illustrated article on Sundials in the August edition of 'Practical Gardening'. It created a lot of interest amongst members of the public and it has resulted in a constant stream of enquiries, rather hard on your overworked Secretary but good for the Society! Let us hope that this will result in more members - and while a large society can be less friendly and more remote for individual members it is a fact that another hundred subscriptions would enable us to produce four Bulletins a year without us having to go into the red.

URCHFONT MANOR

You would have read elsewhere details of our Annual General Meeting and Conference next April where we have this time abandoned the usual University campus for the delights of Urchfont Manor in rural Wiltshire. One piece of extra information I can tell you is that the Andrew Somerville Memorial Lecture will be given by a very popular lecturer, Allan Chapman of Wadham College, Oxford. Dr Chapman has been engaged in the re-building of fully working replicas of 16th and 17th century astronomical instruments and his talk will be entitled: "Measuring the sun and stars: reconstructing angle measuring instruments of the Renaissance". An event not to be missed.

1000 WELCOMES AWAIT YOU . . .

. . . In Ireland! Our plans for a whole weeks holiday in the Emerald Isle are progressing well thanks to our Dublin based member Owen Deignan who many of you have met at our past conferences. The provisional starting date is Thursday 15th September 1994. I emphasise that this is a holiday and not just a sundial tour - it will have a strong sundial interest but members partners who may not be quite so enthusiastic about sundials should know that Owen has produced an itinerary with plenty of visits to gardens, castles, and other places of historic and scenic interest. If you don't believe me just look at the provisional tour summary below:

DAY 1: Reception at Trinity College in the heart of Dublin, afternoon tea and dinner followed by lecture on early Irish dials.

DAY 2: Bus tour of the city plus a look at two or three dials. Afternoon free to wander, evening lecture on N. Ireland dials.

DAY 3: Bus tour to Newgrange to see 5,000 year old passage tomb (first solar observatory?) then to Monasterboice and Malahide Castle.

DAY 4: Coach to Cork via Powerscourt, landscaped gardens, beautiful Glendalough and hopefully the Rock of Cashel.

DAY 5: Overnight at the University, in the morning to Blarney Castle, then free time in the old city of Cork. Evening lecture.

DAY 6: General tour of Kerry and lakes of Killarney (sundial/s on the way!). Return for final dinner, drinks and social chat.

DAY 7: Return to Dublin with visits to Cahir Castle and Peakaun monastic sundial on the way, arriving Dublin by 5.00 pm.

The above is a poor shadow of the detailed itinerary that Owen has sent me but hopefully it will give you a flavour of what you could expect. The project cost (£312) from Dublin back to Dublin includes six nights accommodation, three meals daily, all transport and tours, lectures, entrance fees etc. It does not include teas/coffees (or other liquid refreshments) taken 'enroute', and it does not take into account your journey to Dublin. With our membership so scattered it is not practical to make group bookings from any one destination. As a price guide todays economy return air fare to Dublin varies from £75 - £97 depending on which, airports and which airline you choose. Full details, itinerary and booking form will be sent with the January Bulletin. To be sure of a place (without any obligation) write a line to Owen Deignan, 72 St Lawrence Road, Clontarf, Dublin 3. You will be sent a booking form direct by the end of the year as will be all those of you who had booked on last year's abortive trip to Holland.

A STOLEN SUNDIAL

We have been asked by the police to help trace a sundial recently stolen from Helmingham Hall, Suffolk. Fortunately the details of the dial had been recorded by our member Mr A. R. Astbury. It is a fine horizontal brass dial made by George Adam, Instrument Maker to King George III. The noon time of various places throughout the world are engraved but what makes it unique is that this includes the name Helmingham itself. Auction Houses in this country have been notified but of course it could be sold privately or sent abroad. The owners, Lord and Lady Tollemache would be delighted to hear from anyone who knows its whereabouts. [The dial has now been recovered - Editor.]

SUNDIALS IN THE NEW WORLD

The other day I was reading a book on the early days of American history and came across a picture of one of the earliest coins minted in New England. This was the so called Fugio Cent minted first in 1787. On one side are the thirteen circles of the union, on the other side is a picture of a horizontal sundial with the word "Mind Your Business". There

is the same motto by a church clock in Furneax Pelham. The only dial I know of, with a similar motto, is the one on the Parish Church in Clare, Suffolk, "Go about your Business". The interesting thing about this is that this dial is dated 1790 only three years different from the coin. It is also a fact that many of the pilgrims and adventurers that left for the new lands at that time took ship from Harwich and came from the 'puritan' counties of Essex and Suffolk. Indeed looking at a map of the New England states there can be found a great number of places named after towns in these counties; there is Braintree, Maldon, Dedham and Harwich, to name but a few.

It would be worth while to do some research on this matter. Alice Morse Earl in her book "Sundials and Roses of Yesterday" seems to think that sundials were 'very rare' in New England at the beginning of the last century; it would be interesting to hear from our American members on the subject.

USEFUL ADDRESSES

Mr. Charles K. Aked 54 Swan Road WEST DRAYTON Middlesex UB7 7JZ	[Editor]	Tel: 0895 445332
Mr. C. St. J.H. Daniel 57 Gossage Road PLUMSTEAD COMMON London SE18 1NQ	[Chairman]	Tel: 081 3178779
Mr. R.A. Nicholls 45 Hound Street SHERBORNE Dorset DT9 3AB	[Treasurer]	Tel: 0935 812544
Mr. P. Nicholson 9 Lynwood Avenue EPSOM Surrey KT17 4LQ	[Sponsorship]	Tel: 037 27 25742
Mrs. Anne Somerville Mendota Middlewood Road HIGHER POYNTON Cheshire SK12 1TX	[Library, Archival Records & Sales]	Tel: 0625 872943
Mr. Robert B. Sylvester Barncroft Grizebeck KIRBY-IN-FURNESS Cumbria LA17 7XJ	[Membership]	Tel: 0229 89716
Mrs. Jane Walker 31 Langdown Road Little Sandhurst CAMBERLEY Surrey GU17 8QG	[Education]	Tel: 0344 772569
Miss R. J. Wilson Hart Croft 14 Pear Tree Close CHIPPING CAMPDEN Gloucestershire GL55 6DB	[Council Member]	Tel: 0386 841007
Dr. I.D.P. Wootton Cariad Cottage Cleeve Road GORING-ON-THAMES Oxon RG8 9BD	[Registrar]	Tel: 0491 873050
Mr. D.A. Young Brook Cottage 112 Whitehall Road CHINGFORD London E4 6DW	[Secretary]	Tel: 081 529 4880

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