The British Sundial Society

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Cover Illustration - The finest example of an early Saxon sundial, Kirkdale Church, North Yorkshire, circa AD 1065. It is well protected by the much later porch built over it. An article on this important dial will be published in a future issue of the Bulletin.

DIALOGUE

DE ZONNEWIJZERKRING

Bulletin 92.3 contains an account of the AGM in which the suggestion is made that members of the BSS should visit the Netherlands.

A married couple moved to a new house and laid out the garden to receive a sundial. The centre was a stainless steel plate 800mm in diameter which was raised slightly off the ground and was engraved, with the lines filled in black. The plate was surrounded by a paved circle about 5mm in diameter which was itself surrounded by flower beds. Local times and winter clock time are given by a small gnomon on the plate and summer time by a large gnomon which casts its shadow on the outer ring of stones which are marked accordingly.

A short discussion on magnetic v. sun compasses is followed by a puzzle where readers have to determine certain facts from a drawing of a sundial at a given latitude and longitude showing a certain time and also the date on which the readings were taken.

One of the members has composed a song about the Society and an enthusiast in Spain is compiling a list of sundial terms in a number of different languages. A magnetic sundial constructed as an ellipse is described together with the mathematics, but the author comments that the method is rather complicated.

The next article deals with a crossed wire sundial invented by Professor Hugo Michnik in 1922. The instrument consists of a horizontal plate with the hour indications on it and above there are two wires parallel to the surface but at different heights and at right angles to each other. The time is shown by the shadow of the point where the wires cross. The system can also be adapted for vertical dials.

A description and illustration is given for the sundial on the church at Rijswijk. This contains some interesting historical facts and reproductions from contemporary account books. A member describes the making of an instrument to find the North without using a watch, which involves a lot of mathematical discussion.

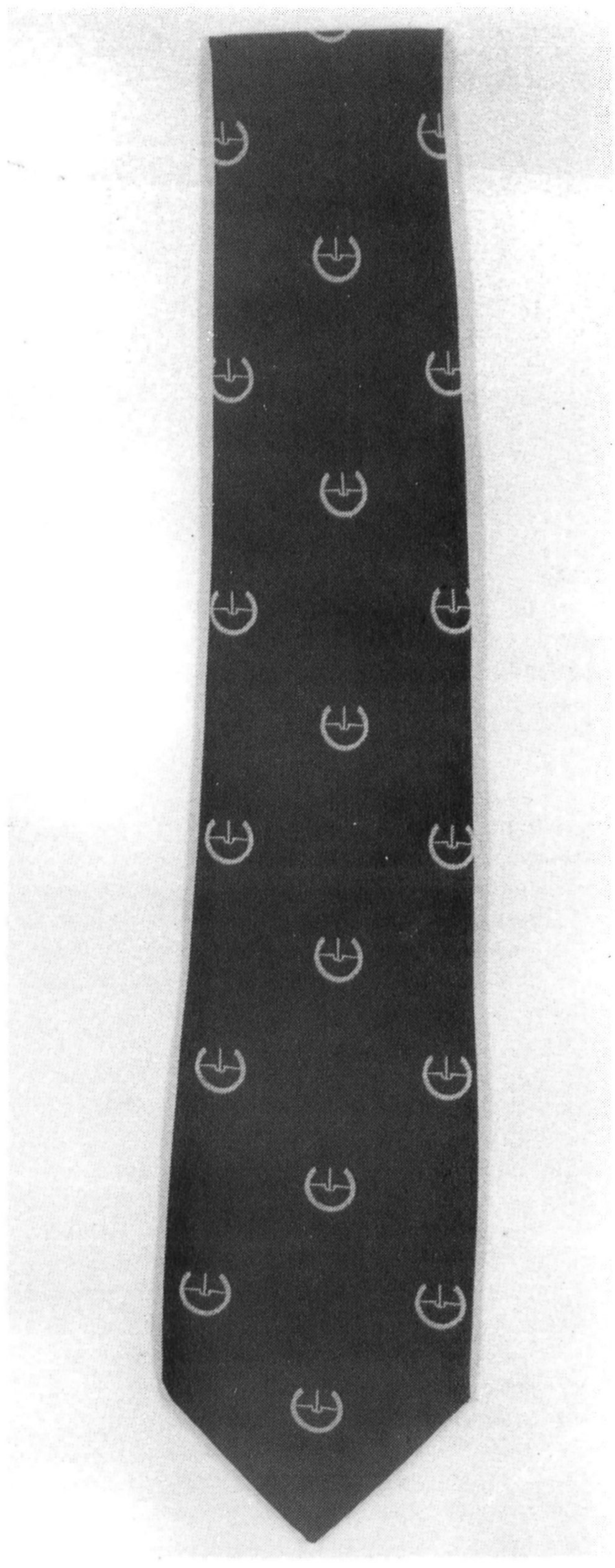
After some letters from members comes a description of fixed dials to be added to the Society's archives, and a review of books and periodicals including a report from the "Scientific American" on a digital sundial.

Bulletin 92.4

Eise Eisinga, the maker of the planetarium at Franeker, designed a pocket sundial which is described here. The principle is that of the "Capuciner", which is described in a further article. A reprint of an article of 1908 gives a detailed description of the Eisinga dial with a commentary. Examples of the dial have been presented to the planetarium curator.

Further comments on the Eisinga instrument together with the mathematics are given and there are some remarks on conical dials in which Eisinga appears to have taken some interest. A number of designs show how the dials are to be set out and references to previous articles in the Bulletin and other publications are given which relate to the subjects concerned. There is also a discussion on the terms used in dialling.

EJT



The tie designed exclusively for BSS members is now available, with the BSS symbol repeated at intervals.

Obtainable from: Mrs. Anne Somerville, Mendota, Middlewood Road, Higher Poynton, Cheshire SK12 1TX. Price £8.00, which includes postage and packing. Cheques payable to BSS.

'DOMUS COELESTIS': DOMIFYING CIRCLES OR CIRCLES OF POSITION

BY CHRISTOPHER ST. J.H. DANIEL

Above the porch of Tawstock Church, in North Devon, there is an 18th century slate sundial with an iron gnomon. It is a direct south vertical sundial and is an excellent example of the art of dialling in that it is adorned with an impressive array of dialling 'furniture'. It is dated 1757 and is signed 'John Berry', a local mason born at Muddiford in the parish of Marwood in 1724. Berry was noted for his sundials, quite a number of which, still extant, bear his name and the date of their construction. John Berry died in 1796, at the age of 73 years, and was buried in Marwood churchyard.

It might seem curious that a local stone mason in the remote countryside of North Devon should have the knowledge and expertise to execute such fine, mathematical works of art. However, most, if not all of these sundials are on local churches, and most, if not all are direct south dials, which, when placed on a wall declining from the cardinal point, have been wedged out to face due south.

It seems very probable that Berry was fortunate enough to have been directed or influenced in his endeavours by a mathematically minded member of the clergy. Indeed, the living of Marwood is in the gift of St. John's College, Cambridge, and it is more than likely that the incumbent would have been a Fellow of the College, who, no doubt, would have been both a classical scholar and an accomplished mathematician. Thus, Berry's achievements may have been derived from the good offices of such a tutor, who might well have provided the calculations for his sundials, or at least given him access to the works of such 16th and 17th century masters as John Blagrave, Thomas Fale, Samuel Foster, Edmund Gunter, William Leybourn, Joseph Moxon, William Oughtred, Thomas Stirrup and many others of considerable esteem. Indeed, several of John Berry's dials appear to bear the 'hall-mark' of that prolific author of dialling works, William Leybourn.

The Tawstock sundial is perhaps rather more elaborate than most others in North Devon. In addition to the hour-lines, it indicates the time of noon in various places around the world, displays vertical lines of azimuth giving the bearing or direction of the sun in degrees throughout the day, and is delineated with diurnal arcs or declination curves. These indicate not only the 'first points' of entry of the sun into the respective 'signs' of the zodiac, but also the length of the day, giving the number of hours from sunrise to sunset. Additionally, there are certain straight lines delineated, emanating from the point of intersection of the meridian (or noon-line) and the horizon line. Including the meridian and the east/west aspects of the horizon line, there are seven such 'hour' lines, mysteriously denominated in reverse order to the standard hour-lines: Dom VIII, Dom IX, 'Dom X' (coinciding with the noon-line), Dom XI and Dom XII. 'Dom VII' and 'Dom I' are not indicated, but lie on the horizon line, east and west respectively of the XII noon-line, ie. the meridian. Dom VIII and Dom XII are complementary to each other, the former cutting the equinoctial line at its intersection with the IV hour-line and the latter cutting the equinoctial at its intersection with the VIII hour-line. Likewise, Dom IX and Dom XI are also complementary to each other, cutting the equinoctial at the intersection of the II hour-line and the X hour-line respectively.

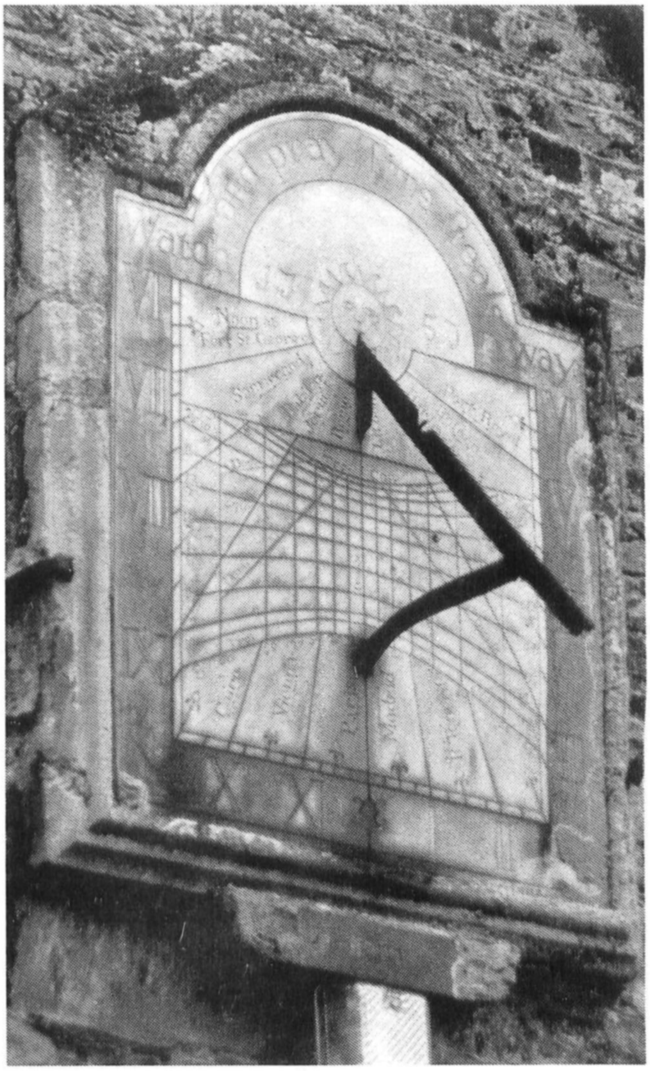


FIGURE 1: The vertical slate sundial, signed by John Berry, dated 1757, above the porch of Tawstock church. Note the 'W'-shaped nodus, cut into the upper edge of the gnomon, enabling the position of the sun to be indicated on the 'furniture' of the sundial.

These apparent 'hour' lines are not unequal, antique, seasonal, or planetary hours, as one might at first think. Indeed, they are not 'hours' at all, but the demarcation lines between the six celestial 'houses' above the horizon, enabling the observer to determine in which of the twelve diurnal 'houses', pertaining to astrology, the sun may be found at any time, during the course of the day. In fact, these lines represent the projection of the great circles of the celestial sphere, called domifying circles or more commonly called circles of position, the planes of which lie at 30 degree intervals one from another, having their common intersection with the planes of the meridian and the horizon. On a sundial, of course, as with the meridian and the horizon, these projected great circles appear as straight lines, being delinated in a clockwise direction from the western horizon.

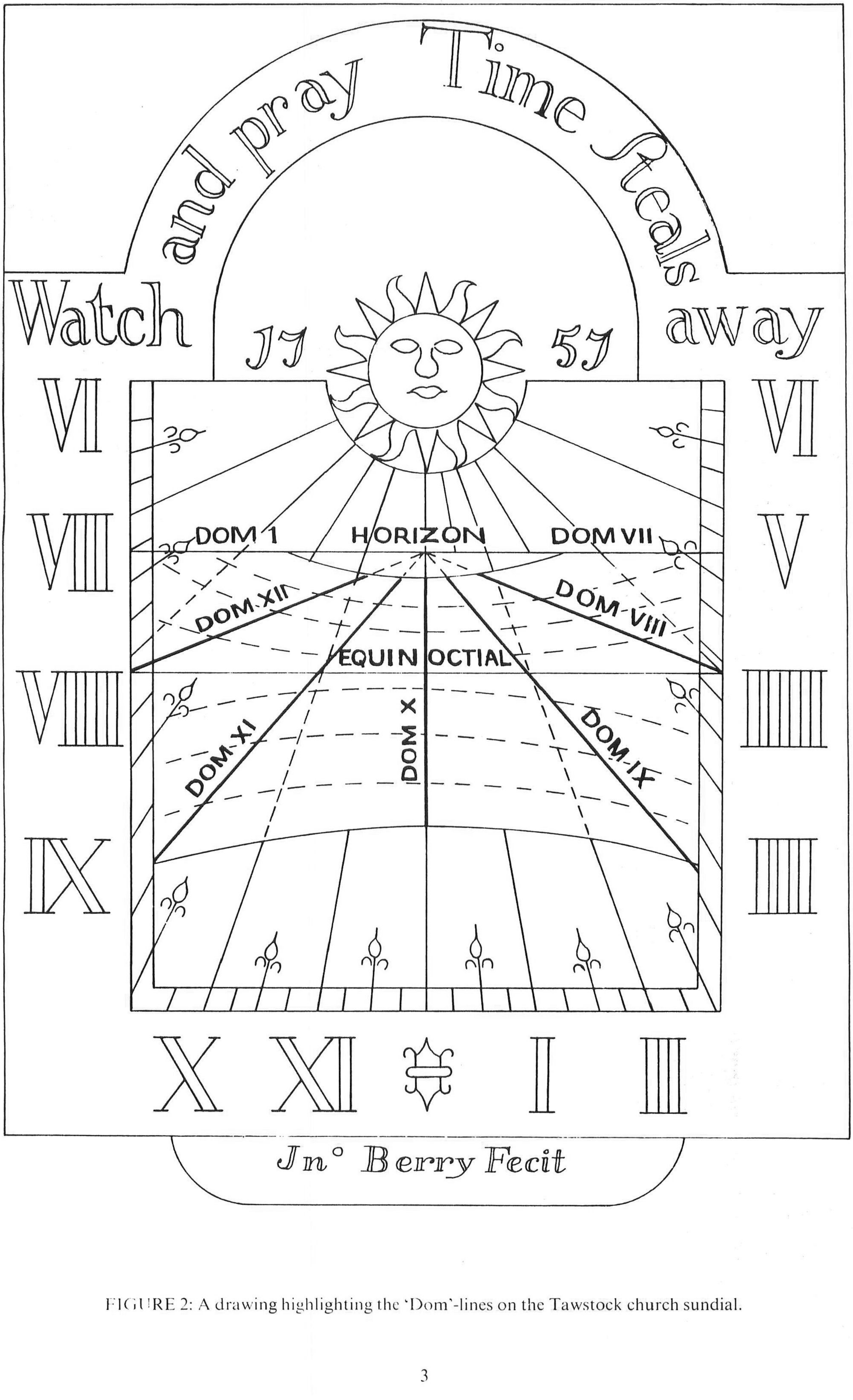


FIGURE 2: A drawing highlighting the 'Dom'-lines on the Tawstock church sundial.

The abbreviation 'Dom' stands for Domus (house), or, to be more precise Domus Coelestis (celestial house), such that the line 'Dom XII', for example, represents the threshold or the point of entry into the twelfth 'house'. In essence, these astrological 'houses' supposedly form a trinity with the 'signs' of the zodiac and the planets. The position of the sun in the zodiac, of course, is directly related to the date. Consequently, the signs of the zodiac, delineated on a sundial by means of the respective declination lines for the sun's point of entry into each 'sign', provided and still provide a useful piece of dialling 'furniture'. The shadow or spot of light projected by a nodus, incorporated into the gnomon of the sundial, enables the observer to ascertain the date in question by simple inspection. Thus the astronomical value of the zodiacal 'signs' is retained to-day, whereas the purely astrological purpose of the 'Dom' lines is of little consequence. Nevertheless, since they are to be found on a number of historic sundials, their purpose should be understood and appreciated.

The sundial on the porch of Tawstock church, of course, displays the 'Dom' lines for a direct south vertical dial; but, as Leybourn shows in his classic work on 'Dialling' of 1682, the 'Dom' lines may be easily delineated onto sundials in other planes. For example, on a horizontal sundial, the 'Dom' lines are drawn parallel to the plane of the meridian, ie. the 12 o'clock line. Likewise in direct east and west dials, the 'Dom' lines are drawn parallel to the plane of the horizon. In each case, respectively, they are drawn to intersect the equinoctial line with the same hour-lines specified in the case of the direct south sundial. Thus they are not necessarily difficult to identify amidst a complex arrangement of dialling 'furniture'.

Despite the fact that domifying circles or circles of position may be found occasionally on early sundials, they are by no means a common piece of dialling 'furniture', no doubt due to their purely astrological purpose. Thus, the Tawstock sundial is a rare example of this aspect of the art of dialling, more in keeping with the 17th century than the 18th century. We are certainly indebted to John Berry, and surely to his mentor, for including this obscure feature on this particular sundial.

There are eight known vertical sundials signed by John Berry still extant in North Devon today, namely:

Tawstock:	1757
Marwood:	1762
Kentisbury:	1762
Bittadon:	1764
Landkey:	1768
Stoke Rivers:	1770
Pilton:	1780
Yarnscombe:	1788

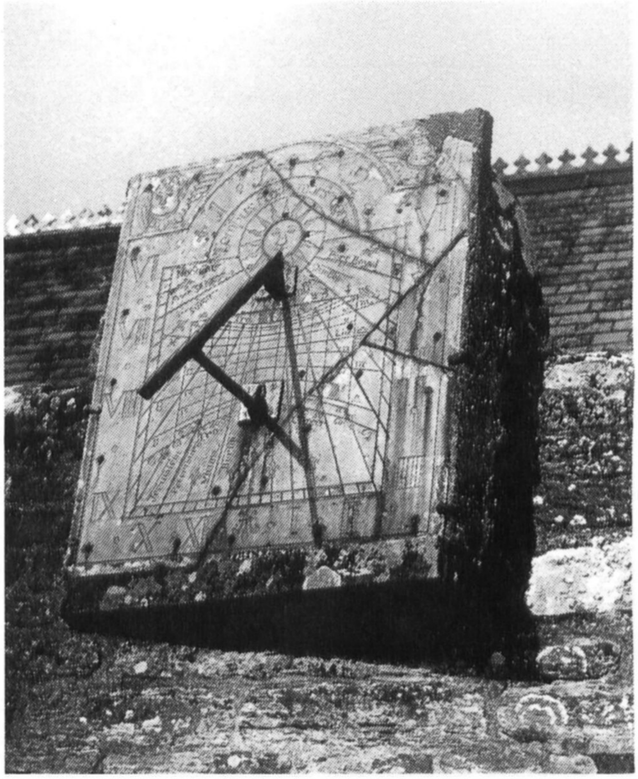


FIGURE 3: The elaborate sundial by Berry, dated 1762, on Marwood church. There are no 'Dom'-lines on this dial.

In addition, there are two dials which bear his signature and that of his third son Thomas, who went into partnership with his father:

Heanton Punchardon:	1795
Braunton:	1795

Thomas evidently carried on the business after his father's death in 1796, since there is a dial signed by him, dated 1819, on the church at East Buckland. At the other end of the scale, on the church at Brendon, Exmoor there is a plain slate sundial dated 1707, which has similar characteristics to those produced later by John Berry. Perhaps this was the work of his father, who knows? In any event, I know of no sundial by John Berry, other than the dial on Tawstock church, that has been delineated with astrological circles of position or 'domifying circles'. The similarly elaborate sundial on Marwood church, damaged alas, made five years after that at Tawstock, does not bear any 'Dom'-lines. Berry, it seems, had decided by this time that it was no longer worth his while to include them in a display of dialling furniture.

For the present, *Sundials in North Devon* by Jeanie Crawley, published in *Transactions of the Devonshire Association for the Advancement of Science, Literature and Art,* Vol. 89, pp. 175-191, 1957, is the best source of information on Devonshire sundials. In this will be found some information on the Berry family. The article (somewhat outdated by the progress in dialling research) was also published as a separate pamphlet. The Editor has a copy of the pre-publication papers prepared by Jeanie Crowley, of which the most interesting feature is the set of original pen and ink sketches of the sundials. These are very neatly done by a competent artist.

NOTE: Richard and Janet Thorne have been making a survey of Devon sundials, with particular reference to the Berry family in North Devon. In due course it is hoped that this survey will be published.

THE SCRATCH DIAL AND ITS FUNCTION

BY ALLAN A. MILLS

It is proposed that scratch dials should be thought of as highly effective 'event markers' rather than as inaccurate timekeepers.

THE 'SCRATCH DIAL'

Careful examination of the south porch and adjacent walls of the older parish churches in the Midlands and South of England will frequently disclose one or more variations of the patterns shown in Figures 1 and 2 scored into the stone. Known as SCRATCH DIALS,[1] the considerable age of these artefacts is made obvious by the degree of erosion that has commonly occurred, some having been reduced to little more than a few ghostly lines radiating from a central depression. Indeed, looking for holes in the stonework is often the best way of discovering scratch dials, their details sometimes being accentuated by the slanting illumination from a morning or evening sun.

It is suspected that - as with medieval stained glass and sculpture - the rate of erosion has accelerated over the past fifty years as a result of the 'acid rain' associated with power stations, automobile exhaust gases, and industrialization in general. It is therefore vital that search and recording (including photographs) of scratch dials be made on a country-wide scale,[2] and added to the register maintained by our Society.

Scratch dials are also known on church walls in Normandy, Alsace, Poland, and elsewhere on the Continent,[3,4,5] but appear to be even less studied and valued than in this country.

Another group of dials, generally much better made but apparently similar in pattern, are the so-called SAXON DIALS.[1] These will not be considered here - except to draw attention to the fact that recent examination has proved most to be in a far more seriously eroded condition than is suggested by the illustrations in the older books on dialling.[6]

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The first author to produce a work devoted entirely to scratch dials was Dom Ethelbert Horne, later to become Abbot of Downside. His booklet *Primitive Sun Dials or Scratch Dials*[7] was published in 1917, and was followed in 1929 by an expanded version entitled *Scratch Dials: their Description and History.*[8] In the interval, Dr. A.R. Green's *Sundials: Incised Dials or Mass-Clocks*[9] appeared, and was reprinted in 1978. The third author always associated with the study of English scratch dials in T.W. Cole but, as he appears to have published and distributed the material himself, his booklets[10–12] are rare items nowadays. Apparently more accessible is his only journal article,[13] but this proves to be an edited summary. Charles Aked has recently produced a biographical study of Cole and his work.[14] The latest monographs concentrating on the collection and illustration of scratch dials in specific areas are those by Richard and Catherine Botzum[15] (Herefordshire) and Laurence Price[16] (N.W. Somerset).

PROBLEMS WITH THE SCRATCH DIAL

Although occasionally referred to as 'mason's marks' or mystical 'sunburst' figures, the radial geometry and generally south-facing position of the patterns immediately suggests a connection with solar timekeeping. This hypothesis is strengthened by placing a temporary peg in the central hole, resulting in a shadow which, rotating about the base of the peg, is vertical at local noon (Figs. 3 and 4).

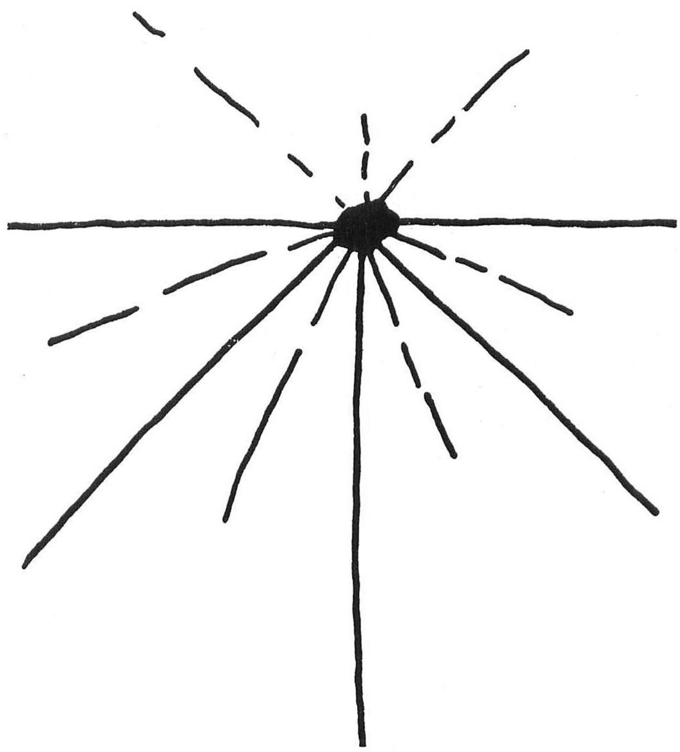

FIGURE 1 A generalised form of the scratch dial: the 'sunburst' design.

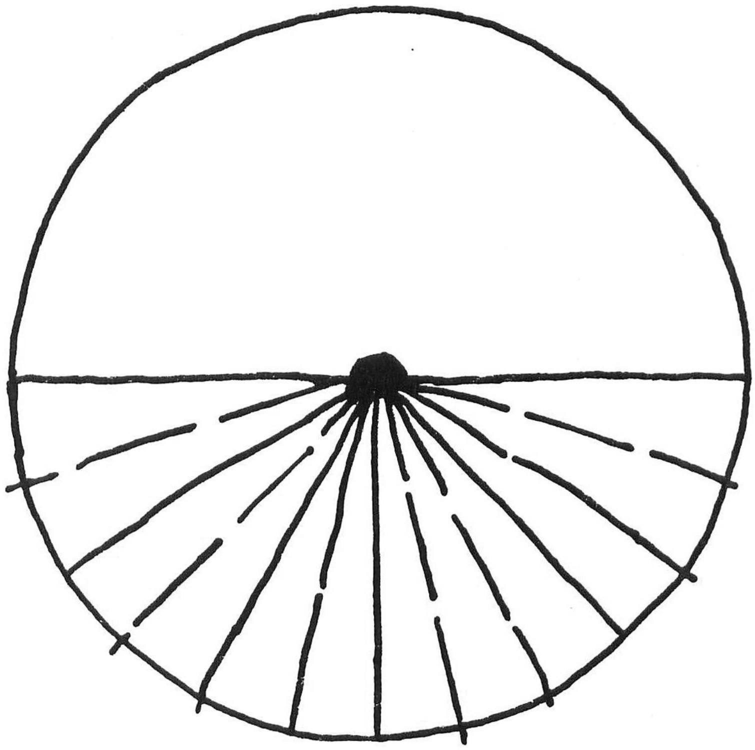

FIGURE 2 A generalised form of the scratch dial: the protractor-like impression given by a circumscribed circle.

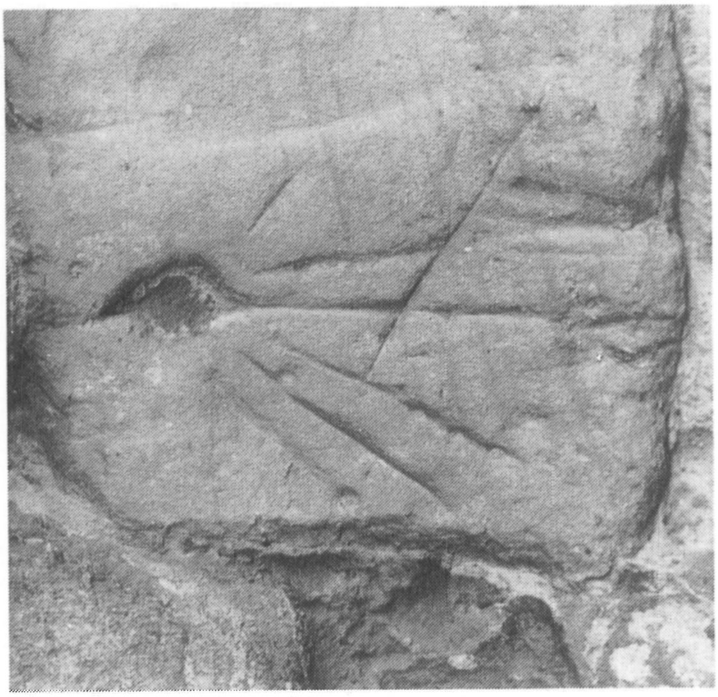

FIGURE 3 Remains of crude 'sunburst' dial at Beeby, Leicestershire.

FIGURE 4 A scratch dial at Pillerton Hersey, Warwickshire. Though firmly fixed, the gnomon is not thought to be original. 'Protractor' design, with erroneous radii above the horizontal. Apparently made by joining the central hole to smaller holes dividing the outermost arc.

Obstacles to the universal acceptance of scratch dial as a sundial have been:

a) The absence of any surviving gnomon.
b) The hole (when in good condition) is always perpendicular to the face of the southerly wall - whereas a vertical sundial commonly incorporates a sloping gnomon pointing upwards at the celestial pole.
c) The radial lines are - or were apparently intended to be - equiangular, whereas the hour lines on a well-made vertical sundial tend to bunch downwards towards the noon line in a pattern characteristic of the latitude of the site.
d) The straight hour lines on such a dial converge upwards upon the point where the stile of the sloping gnomon intersects the dial plane, not upon a point perpendicularly below the apex of the gnomon.
e) The shadow of a perpendicular gnomon can never fall above the horizontal line through its base - but many scratch dials do incorporate lines in an upper semicircle.

Horne preferred to avoid controversy by confining his long period of study of scratch dials[17] to collection and description rather than speculation on function. However, he instinctively felt that there must be some connection with an indication of the time at which services (particularly the mid-morning Mass) should take place in the church.

THE SCRATCH DIAL AS AN EQUAL-HOUR SUNDIAL

Green,[9] aware of the sloping gnomon characteristic of modern sundials, proposed that the socket of a scratch dial originally contained a rod bent downwards at some empirical angle to suit the radiating scratches. He was able to show by experiment that reasonable concordance could thereby be achieved with clock time, *but only at certain periods of the year.* It will be obvious that, even if a malleable metal gnomon is bent until it is at the correct polar angle, the equiangular dial pattern will remain incorrect. An equiangular dial (and its matching horizontal peg gnomon perpendicular to a south-facing wall) will only keep in step with a clock throughout the year at a site on the equator - and even then only if the correction given by the equation of time is applied. Green's theory is untenable, but he clung obstinately to it throughout his life.[18] The 1978 reprint of his book has unfortunately given it renewed influence.

THE SCRATCH DIAL AS A SEASONAL-HOUR SUNDIAL

Much older than equal-hour timekeeping is the seasonal-hour system,[19] where the period of daylight is always divided into twelve equal parts throughout the year, and numbered 1st hour, 2nd hour, 3rd hour, etc. The result, for any site not on the equator, is that the 'hour' is longer in summer than in winter, so this unit is referred to as the 'seasonal' or 'unequal' hour. The disparity varies non-linearly with latitude, being quite small at 20° but gradually accelerating.[20]

Ancient sundials were therefore expected to indicate this varying seasonal hour. I have elsewhere[19] shown how this could in principle be done very accurately by correctly shaped and calibrated Roman dials utilising a spherical cavity, provided only the *tip* of the gnomon (positioned at the centre of the bowl) was taken as the shadow-casting index.

These three-dimensional sculptural dials would have been expensive: their two-dimensional projections upon the vertical plane would have been easier and cheaper to make, but were not at all easy to lay-out accurately. All extant ancient dials (vertical or horizontal) are approximations - although perfectly satisfactory below

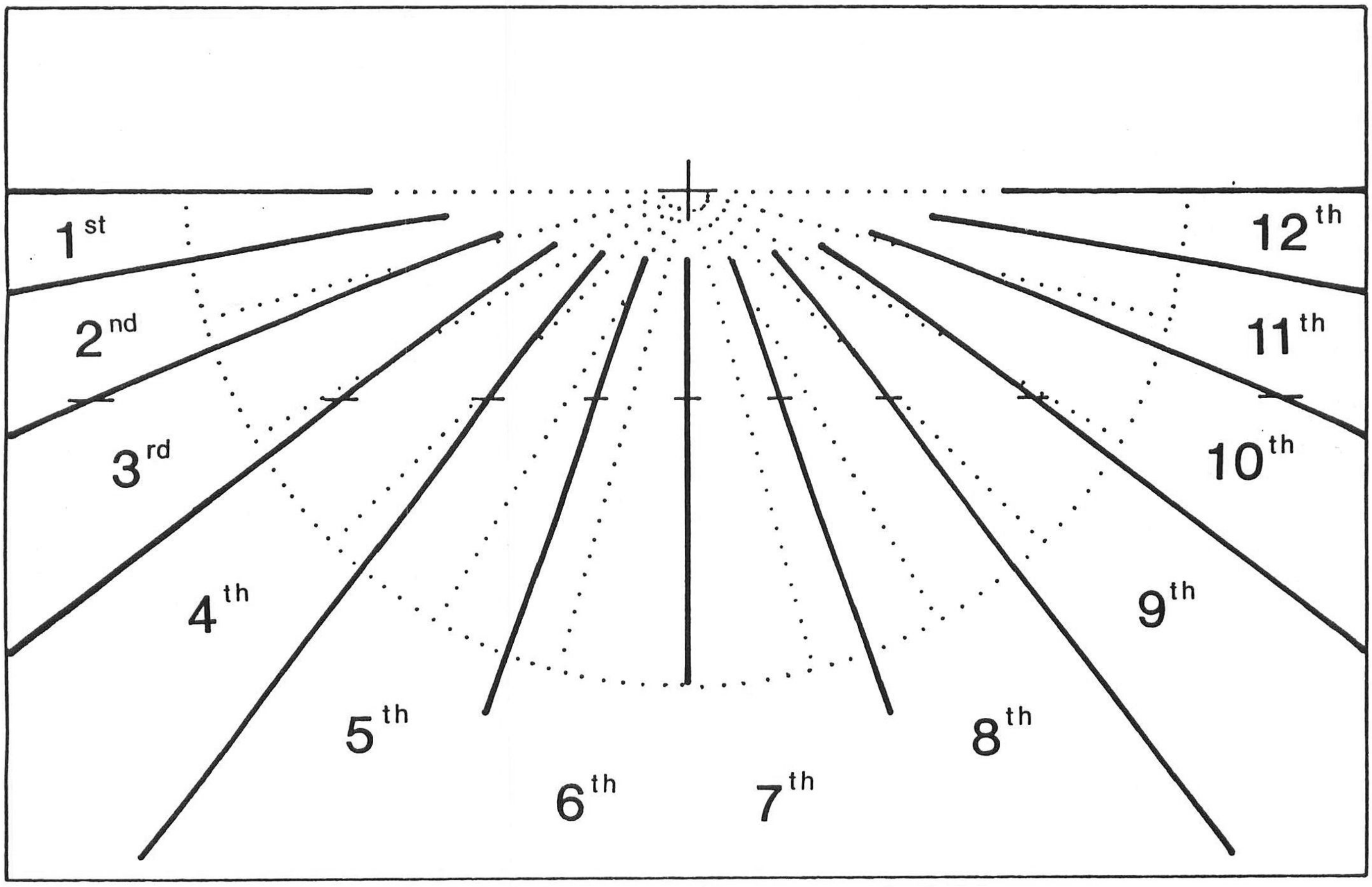

FIGURE 5 An accurate seasonal-hour vertical dial for Leicester (52.6° N). The tip of the south-facing gnomon is 1/5 the length of the long axis of the box above the plane of the dial. The dotted lines show an idealized scratch dial with its equiangular hour lines converging on the base of the gnomon.

45° N - for trigonometric computation has shown that the exact hour lines are *curves* rather than straight lines.[19]

The true seasonal-hour sundial for a mid-England site is compared with the equiangular (15°) scratch dial in Fig. 5, the latter being shown in dotted lines. It will be seen that the end of the 3rd hour as imputed by the scratch dial is always ¾ to 1 seasonal hour late for the true-mid-point of the morning. Similarly, the mid-afternoon conclusion of the 9th hour is always indicated ¾ to 1 seasonal hour too early. Only noon is correct on both dials.

In summary, the scratch dial shares the 'pointed gnomon perpendicular to a south wall' characteristic of ancient vertical seasonal-hour sundials, but as a result of its empirical 15° grid is liable to be very inaccurate as a timeteller at any point other than noon.

THE SCRATCH DIAL AS AN 'EVENT MARKER'

But is this 'inaccuracy' relevant? I think the authors cited above were, without consciously realising it, too conditioned by the universal timekeeping that now dominates our lives. The point is that *there is no discernible error if everyone is using the same pattern of dial* and there is no independent timekeeper with which to compare the shadow's indication. To make this more obvious, the scratch dial should perhaps be reclassified as an EVENT MARKER not as an incompetent sundial.

And it seems very clear that the 'events' signified were, as Horne suspected, the points during the day at which communal and institutionalised prayer was to be offered. The monastic Rule stipulated that monks should gather together and pray at dawn, halfway through the morning (close of the 3rd hour), midday, halfway through the afternoon (close to the 9th hour), and at dusk. Sunrise and sunset are obvious by direct observation, but are represented on the dial by the horizontal line, whilst midday is defined by the shadow covering the vertical noon line. What more natural then than to place the intermediate 'mid-morning' and 'mid-afternoon' points at the halfway positions (45° angles) in each quadrant? *We* know they are not the true midpoints on a uniform timescale, but this was not important. What was important was that the priest said Mass at a defined point during the day, and that anyone in the district who wished to join him and fellow Christians in prayer then, or at the other defined times, had only to scratch a similar pattern around a nail in any convenient south-facing fence or wall and watch the shadow.

The scratch dial admirably fulfilled the criteria of simplicity and practicality and was, in its unpretentious way, a highly successful instrument. Otherwise there would not be so many of them!

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REPORT ON THE BSS COUNCIL MEETING

Editor's Note: It is intended to issue a precis of BSS Council Meetings so that members are aware of the issues being discussed.

A meeting of the BSS Council was held on 12th September 1992 at Bath during the Conference. Matters under discussion included an approach to the National Trust about the inventory of details in their paintings so that sundials could be included, the Secretary spoke about the number of articles on dialling by members appearing in newspapers and magazines recently, these always resulted in enquiries. Hereford Cathedral had requested assistance in the restoration of their dial damaged in a storm, Michael Maltin had visited the Cathedral to assess the damage, it is such that a restoration expert was recommended. David Young reported also that the Horniman Museum, London, was installing an analemmatic dial in the grounds, to be followed by others to form a sundial trail, correspondence was being exchanged with the Scientific Instrument Society to cooperate in the production of a list of sundial makers; and Christchurch, Oxford, had written suggesting that the BSS might arrange a competition for a sundial in their new garden.

The financial position of the Society was reported to be healthy by the Treasurer, Mr N Nicholls; there was £11,400 in the bank but this included the Bath Conference money. The BSS had paid out some £500 in VAT and the treasurer suggested that consideration should be given to registering as a charity. He was worried about the high cost of sending mail to the USA and other Postal Zone 2 countries. Since no auditor was appointed at the AGM, the Council instructed the treasurer to employ a local professional auditor.

The computer record data base was discussed and it was agreed to ask for volunteers at the Conference to help search for duplicated records and check that accuracy of present records. A membership total of about 500 was reported, a number of members failed to re-subscribe but these were made up by new members. The Membership Secretary, Robert Sylvester had impressed the Council with his work and he was officially congratulated. There was little to report on Jodrell Bank (see report by Jane Walker elsewhere in this issue). The plan to attract a possible sponsor was debated at length, some Council members were prepared to contribute the sum of £50 each to finance a study of this, a small sub-committee has been formed as a result. The Education Secretary gave a brief report and spoke of the successful sales of the group booklet. The group is now turning its attention to producing an educational dialling video and would welcome help. The Editor reported delays with the printers, he was authorized to reprint issues of the Bulletin now out of print.

The next Conference was discussed and it was agreed that the venue would be Jodrell Bank in Spring for the AGM. The Dutch invitation to visit Holland in Autumn was to be put to the Conference (where it was enthusiastically endorsed later).

The Organisers of the Bath BSS Conference, David and Jenny Brown, were warmly thanked for their work in making the Conference a huge success.

The next meeting of the BSS Council will be at Higher Poynton, Cheshire, in January 1993.

THE TOWER OF THE WINDS, ATHENS

BY CHARLES K. AKED

Lecture read at the BSS Conference, September 1992

INTRODUCTION

For many years the only knowledge I had of the Tower of the Winds in Athens was gained from old engravings, most of them showing a small building in a desolate scene. Few horological works contain any reference to the Tower of the Winds and none convey any idea of its true size, nor of its importance to the citizens of Athens just before and after the birth of Christ. At the time of its construction, it represented the highest peak of scientific achievement in a society already renowned for its sculptures, buildings and contributions to philosophy, mathematics and astronomy. As an example of the type of illustration given, here is one taken from Tardy's book *La Mesure de la Temp.* It is quite inaccurate in detail because it is a copy of a copy. The illustration in Mrs Gatty's book (1900 edition) is much better but shows only the top part of the tower, and her description of the eight dials on the tower is minimal, the south dial alone being shown and that as it appeared in the 19th century.

My first encounter with the Tower of the Winds was one wet day when I peered over the parapet surrounding the Acropolis and caught a glimpse of it on the foot of the northern slope, up to then I had no idea of where it was situated. In the evening of the same day I walked around the Acropolis to see what the Tower would look like in the evening, for it is supposed to be one of the most romantic places by moonlight. Alas, the Plaka district surrounding the site throbs with life in the evening, strident Bouzouki music everywhere, offering many attractions totally unconnected with dialling. So although I had chosen an evening with moonlight, which made the Parthenon appear romantic, the Tower itself was lit up with floodlights for the benefit of tourists like myself.

I had two hours to spare on the last day before catching the flight home, and so I set off along Aiolou Street at 8am from the hotel, carrying much photographic gear. I was disappointed on arrival at the Tower of the Winds in that it was quite misty around the Acropolis although the sun was breaking through with thin rays, and even more disappointed to find that the site was closed to visitors on that particular day. Here is a view of the Tower of the Winds taken in the square in which it now stands. It is much nobler in appearance than the usual clock book would have us believe, for it is about 47ft in height and about 26ft across, an octagonal tower constructed from white Pentellic marble, mellowed to a soft yellow by the passing of centuries.

Having travelled so far, I was not going to be put off by the site being closed, so after taking as many photographs as I could from all the external vantage points round the site in colour and black and white, plus cine film, I climbed over the iron railings, and spent about an hour inside the site itself, fully expecting to be arrested at any moment. However I was taken to be a photographer on official business and no one took any action, the only barriers that I could not penetrate were two iron grilled doors which prevented access into the interior of the Tower and none of my keys would turn the locks completely; all I could do was peer into the dim internal area of the tower and take photographs with the aid of flash.

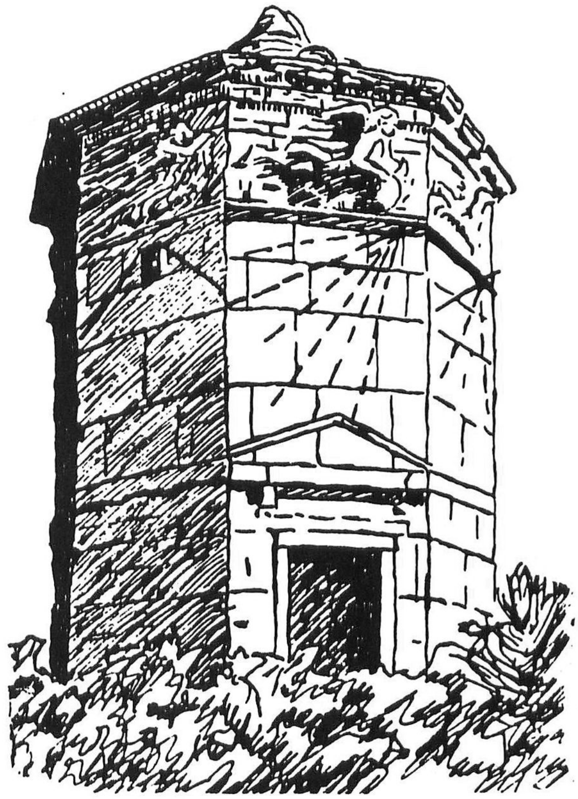

FIGURE 1 The Tower of the Winds after Tardy.

EARLY ACCOUNTS

Sir George Wheler was the first to bring the Tower of the Winds to the notice of English antiquarians in the seventeenth century, for nothing was known about it in Europe until then. He published details of the Tower, correctly stating that it had been built to house a water clock, although at the time the natives thought it had been built as a monument to the philosophers Plato and Socrates. James Stuart and Nicholas Revett published a very full account of the Tower in 1762, this contains 19 engraved plates which give views and plans with much detail. When they visited the site, the Tower was buried up to a depth of 16ft or more in places, the rubble of centuries having raised the ground level; it had at least one house built on to it, and the building was used by the whirling dervishes for their religious dances. Greece was then ruled by the Turks, they had been told that this was a monument to Plato and Socrates, and even they paid respect to the memory of these great philosophers.

It says much for the two Englishmen that they persuaded the Turkish authorities to allow them to excavate the building, and they also persuaded the owner of the adjoining house to remove and rebuild it some distance away. For the first time for many centuries it was possible to see the entire building again although it had suffered some damage in the various changes wrought upon it. Stones had been removed to allow light into the building, and the allegorical figures around the top of the tower had been damaged by children throwing stones at them except for the two covered by the house. There had been a large stone on the roof, this was knocked off and replaced by a Turkish turban made of wood. A photograph in Alice Morse Earle's book *Sundials and Roses of Yesterday*, 1902, shows the Tower with this Turkish turban, it was removed by Orlando in 1919, and the original marble finial, which still lay on the ground was replaced. However some of the damage had occured in a much earlier age when Christians converted it to a church, cutting openings in the walls to allow light in.

The thoroughness of Stuart and Revett's work was such that no one since 1760 has taken fresh measurements, not even Sharon L. Gibbs for her thesis on Greek and Roman dials. Looking at the site today, in spite of the efforts of the American School of Classical Studies in Athens over many years, it looks as though it has been used for bombing practice, with broken fragments of carving and sculpture lying everywhere, and it requires a great deal of thought to be able to unravel the details of this jumbled and chaotic mass.

It would be true to say that most of our present knowledge of the Tower of the Winds comes from the accounts written by Marcus Terentius Varro who lived from 116 to 27 BC, and wrote of the Tower of the Winds about 37 BC, when it was a comparatively new building. Another later but contemporary account was given by Vitruvius in his work *De Architectura Libri Decem*, this was written before AD 27, when he was an old man. The dates of Vitruvius's birth and death are not known but he was in the service of the Emperor Augustus. His great work was lost for centuries until a copy was found in a European monastery in AD 1486, and it is the only Roman treatise on architecture still extant. Therefore it is most disappointing that both of these early writers mention the Tower mainly on account of the wind vane fitted to the Tower in the form of a Triton, then a new invention. Varro does indeed mention the hydraulic clock in passing, whereas Vitruvius is silent upon this point; and neither mention the eight dials upon the tower. Vitruvius deals at length with sundials in Book IX of his work, and yet says not one word about those on the Tower of the Winds, which were a departure from the normal hemicyclium found in dozens around Athens. It would seem these were the only plane sundials placed in a public place at this period of time. Vitruvius names many types of dials, some of which have never been identified or discovered in the form of actual sundials.

From these accounts we learn that the Tower of the Winds was designed, built, and paid for by Andronicus Cyrrhestes, a native of Macedonia living at Kyrrhos who had a great admiration for the city of Athens. He was a very able astronomer who designed many sundials and he was the inventor of the wind vane, now more commonly known to us as a weather cock. The subject of winds received much debate in this era, the majority opinion was that there were but four distinct winds, whereas Andronicus maintained that there were eight distinct winds, hence the eight-sided tower based upon this theory. In practice it did not matter very much because the Tower lies in the shadow of the great rock outcrop forming the Acropolis, thus being shielded from the influence of the free winds having a southerly component in them. Thus the direction indicated by the wind vane was merely that of the localised currents of air.

THE ROMAN AGORA

Over the centuries the whole area has been subject to extensive building and rebuilding following invasions and destruction from time to time. But when the Romans decided to build the new Agora or Market Place in 10 BC, the Tower of the Winds seems to have escaped destruction merely because it was relatively new and was the chief public time indicator of Athens. Even so, when a Roman building was erected for the overseers of the market, a corner of this building, which still exists in a ruined state today, rested upon the foundation of the Tower, its shadow rendering one of the sundials inoperative as result. This is one of the few pieces of direct evidence that the sundials were cut into the Tower at the time of its first being built. I myself first formed the opinion that the dials were a later addition when I actually inspected the Tower, it was only later that I changed my mind and came to the conclusion they were contemporary with the building, although having suffered some minor changes over the centuries. However, at the time, 1979, I was more interested in the water clock which the tower once contained than the sundials, and if truth be known, the dials were very faint indeed even then. The polluted air of Athens has done more damage in the last few decades than the same number of centuries before, for marble is quite unable to withstand the attack of any acid content.

On the occasion of my visit, I knew absolutely nothing about the Tower, simply because none of the horological works I possessed included a word about it, the information was locked up in archeological books. So I took as many photographs as I could so that I could study them later at leisure on my return home. Had I then known what I was to learn later, I would not have bothered with all this work, at the time "ignorance was bliss". It was only when an article of mine on the Tower of the Winds was published in the *Bulletin* of the NAWCC in America in 1980, that I became aware that someone else had also investigated the Tower and much more thoroughly and with far greater resources than myself. Professor de Solla Price wrote a letter to me saying that he had written the definitive article on the subject in 1967, and thought that I had merely plagiarised his text. My article matched his point for point with the exception that I had then decided the dials were more modern than the building; but I had not the remotest idea that his article had ever been published. I would not have had the nerve to have published an article to follow such a magnificent one as that produced by Professor de Solla Price. When he realized that my article was the result of my own research, he was very kind and sent me much material on the subject. The positive advantage which resulted was that two independent thinkers had reached pretty much the same conclusions.

Before going on to discuss the dials themselves, the illustrations from de Solla Price's article will be of interest. A very clever artist named Robert C Magis, in 1966 painted the scene of the building being built and its final appearance when completed, a magnificent edifice. It must have been quite gloomy inside because no windows for lighting the interior were installed, only the light through the open doorways entered the building. On the occasion of my visit, even with the sun shining strongly, it was gloomy inside the Tower. Professor de Solla Price sadly died a few years ago and we never completed our exchanges of ideas on this particular subject.

THE TOWER OF THE WINDS

The square in which the Tower stands is known as *Oi Aeridhes* (The Windy Ones), and a road runs round the south, east and north sides, the south being bounded by a stone wall built to contain the soil and rock of the slope, the other two sides being bounded by iron railings, all preventing a close approach to the tower. The nearest point is about fifteen metres away and here the view is screened by trees, fortunately for me it was early in the year and they were leafless. To the right of the Tower, ie the West lies the extensive ruins of what was the Roman Agora, built between 10 BC and AD 2 when Athens was under their control. In this area there had been several water clocks before the Tower of the Winds was built, and others existed in the same period but of less complexity.

The reason why the Tower of the Winds is so-called is because of the frieze which surrounds the top of the tower, it is formed from eight panels, each measuring about three feet in depth by ten feet in width. Carved upon each surface is an allegorical representation of the wind which comes from that direction, together with its name.

THE EIGHT WINDS

Commencing with the north side of the Tower, we have Boreas - the north wind - represented by an old man blowing on a conch, or sea shell. The north wind is bitterly cold, fierce and biting; when it blows, certain caves in Athens give forth a loud hollow sound, hence the sea shell which gives a similar sound.

Going clockwise round the Tower, the next panel shows Kaikias, the north-east wind which brings clouds, wet and cold with snow, hail and tempest in some seasons. He is shown as an old man with a severe countenance, he holds a shield containing hail stones, which he throws out.

The east panel shows a young man, Apeliotes, who brings gentle rain, the skirt of his mantle is filled with fruit, ears of corn, and a honeycomb.

Euros, the south-east wind, brings much rain, sultry weather and gloom with overcast clouds. He is represented by an old man with a morose expression, and is the only figure of the eight who does not hold something in his hands.

Notus is the south wind, very sultry and wet, represented by a handsome young man emptying an urn of water. The urn was broken after being uncovered in 1762 by Revett and Stuart.

Lips is the south-west wind which blows across the Saronic Gulf towards Athens. He is represented as a robust man holding the aplustre of a ship which he pushes before him, the precise function of this part placed on the stern of a ship is not known.

Zephyrus is the pleasant warm wind of early spring which favours the growth of plants, but is sultry in Summer. He is shown as a beautiful youth wearing only a loose mantle, the skirt of which is filled with flowers,

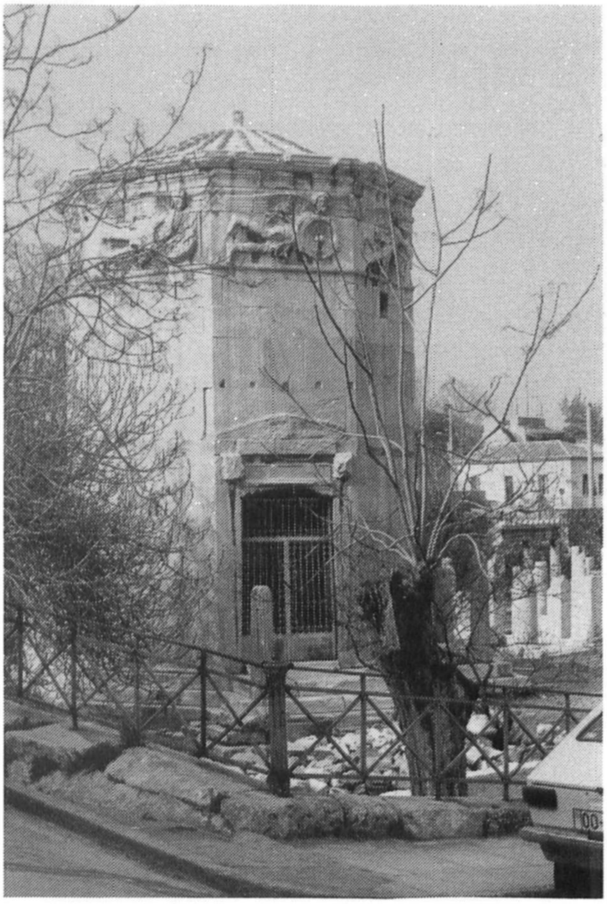

FIGURE 2 The Tower of the Winds seen from the North-west, the figure upper left is Apeliotes the East wind, the other is Kaikias, the North-east wind.

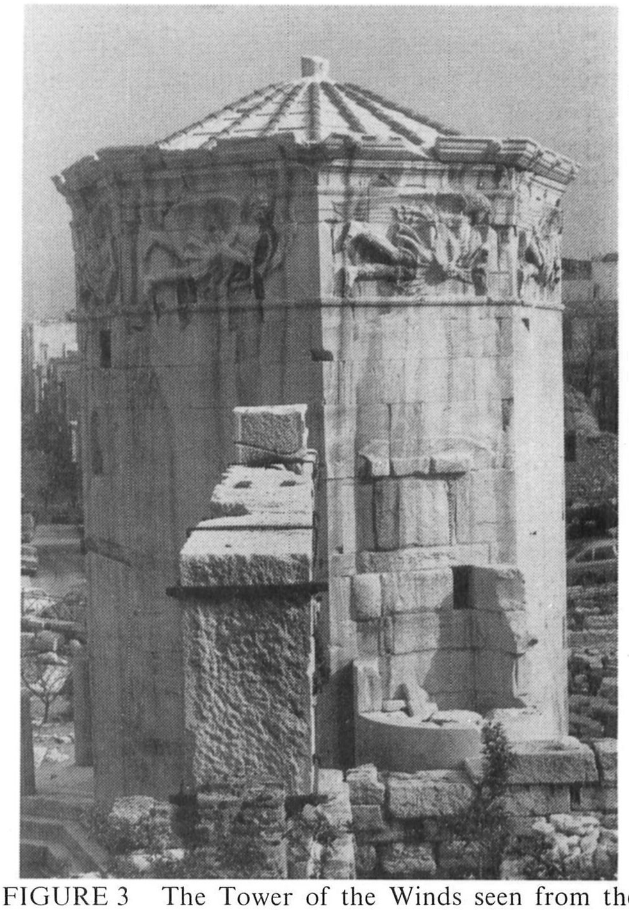

FIGURE 3 The Tower of the Winds seen from the South, Notus the South on the right, Lips the South-west wind on the left. The wall to the left is part of the Roman Agora Overseers' building.

FIGURE 4 The figure of Apeliotes, the gentle East wind.

since this wind favours the appearance of these.

Skiron, the last of the winds to be depicted, is from the northwest direction. It is the driest wind which blows in Athens, extremely cold in winter, but is scorching and often accompanied by violent and frequent lightning in summer. It causes great damage to plants through dehydration. The face of Skiron has an air of langour, he grasps what appears to be a water jar but is in reality a brazen firepot, from which he scatters ashes and burning coals.

The figures of Lips and Notus were covered for many years by a Turkish house, and so not visible until Revett and Stuart persuaded the owner to pull it down and rebuild it some distance away. These figures were unblemished when exposed.

Above the panels are lions' heads which direct rainwater drained from the roof away from the building, they are rather shapeless today. The roof had the appearance of tiles but was actually made of marble. In 1919 some restoration work was carried out on the Tower and terra-cotta tiles were placed over the leaking joints of the original roof. Immediately below the panels are placed sundials, one on each face. These are all planar dials and quite a radical departure from the usual hemicyclium type of dial then in common usage.

THE SUNDIALS

Each dial carries two solstice lines and the equinoctial line, so the dials are rough calendars as well as time indicators. At one time it was supposed that other lines were included but through not being so deeply incised, they have now disappeared. The south dial is a normal vertical dial, the faces of the tower being aligned accurately so that the orientation of each plane is correct. This is perhaps another reason for deducing that the faces of the tower were intended for the placement of sundials from the beginning.

The dials included each had a popular name, that of the north face is the "quiver" which complements the readings of the south sundial which only covers 6am to 6pm briefly at the equinoxes, and is called the "axe-head". If the outline of the south dial is turned through 90°, the resemblance to an ancient axe is made clearer. Because the tower is accurately aligned in the north-south direction, the dials on complementary faces are repeated in reverse. It must be mentioned that it is very difficult to see the outlines of these dials today, indeed many who view the Tower and are not aware of its design and function, must turn away without ever seeing these fugitive lines. They have been restored on a number of occasions, including picking out the lines with paint, as in the restoration of 1845, when they were also furnished with Roman figure hour indications as shown in Margaret Gatty's book, last edition published in 1900.

The original system was, of course, the old temporary hours dividing the days into twelve, quite unlike the mean hours of today except at the equinoxes. Yet a number of observers have checked the dials with their watches and declared them to be excellent and accurate indicators. I must admit that my own check on the south dial, taking into account the difference of the Equation of Time and in longitude to Greenwich (I never alter my watch when in foreign parts), gave a quite sensible answer. The gnomons are, of course, modern replacements which were installed by Palaskas in 1845-6, they are made of bronze or iron rods with balls at the ends, quite unlike the originals which would have been triangular or square in section, resembling slender obelisks; and fitted with a "T" end for fixing in a socket in the wall by lead. Some gnomons seem to have been lowered from the original positions, the original holes may be seen above.

The original gnomons were of the normal Greek type of the period, projecting out horizontally, only the tip of the gnomon being employed to give the useful shadow indication. As the gnomon tip may be regarded as a fixed point upon a polar gnomon, the indicating lines can be accurately delineated for the whole year. No doubt at this time, the passage of the shadow was marked out during the passage of the year and the lines produced from the joining of all the observed points on the various dials. This might be a reason for the dials appearing some time after the building was completed.

A possible method of delineating sundials by geometrical construction at the time is given by Vitruvius in his book *De Architectura* . . ., by means of a figure which he calls "analemmatos". This figure is an effort to avoid the use of a three-dimensional representation of the celestial sphere by considering the various circles of the sphere projected on to the meridian plane. Vitruvius only hints at the possible application of this figure to sundials, and it was only many centuries later that diallists demonstrated how it could be achieved. So although possibly known at the time of the construction of the Tower, it would be more difficult to apply this method than direct observation; on the other hand Andronicus Cyrrhestes was an able mathematician. Those who wish to follow up these possibilities may make a start by studying Sharon L Gibbs' book where these matters are given as an appendix, pages 105 to 117.

To the south of the Tower of the Winds is a circular annexe, this housed the reservoir for the water to operate the water clock. The blocks of marble here are held together by bronze clamps set in lead, and the joints made water-tight by hydraulic cement. The use of bronze clamps resulted in great damage to many ancient buildings when looters removed these clamps for the value of the metal. In the case of the Tower of the Winds the main part of the annexe was buried, however the top was removed to allow the Turkish house to be built. When I examined this part of the Tower I found parts of a sundial were cut into it, it had been noticed for the first time when de Solla Price investigated the site in September/October 1964, but I did not then know about this. There remain a few faint lines only because of the marble blocks being removed before the building of the Turkish house. No one to date has even ventured a guess on the form of this sundial, but because of the circular wall, there would have to be at least two gnomons, and perhaps another for a noonmark.

Since this dial was completely in the shadow of the Roman overseers' building immediately to the south and built perhaps seventy years later, it would have been a complete waste of time to have cut a sundial upon which the sun would never shine, so one must assume that the dial was indeed cut prior to the erection of the adjacent building in about AD 2. The accuracy of the orientation of the Tower is the other main argument for the early placing of the sundials, such accuracy was hardly required for the wind vane alone, whereas any departure from the correct orientation would have caused great difficulties in the delineation of the sundials if calculations were employed, and of course complementary dials would no longer be true mirror images. Another argument that the dials are very old is that two of these had been covered by a Turkish house for a long time even by 1760, and it is unlikely that anyone would have taken the trouble to cut these dials showing seasonal hours after the age of scientific dialling had arrived, by which time the concept of clock time had spread throughout Europe and division of the day into twelve parts varying with the seasons was no longer practised. Looking at many of the Greek inscriptions of that age, it is difficult to believe that they were not cut in modern times, the letters being cut so precisely into the stone; similar inscriptions found at Pompei display the same crispness of execution and look as though they were cut only yesterday.

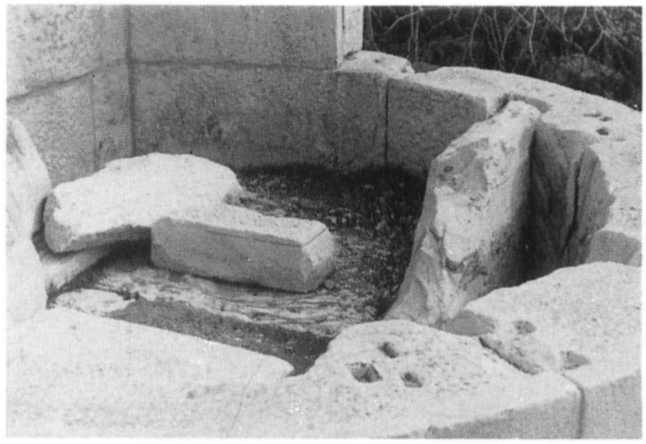

FIGURE 5 The water reservoir for the hydraulic clock. Note the holes for bronze clamps set in lead.

THE DIAL MEASUREMENTS

The dimensions given here are approximate to the nearest half inch. Sharon L Gibbs has converted Revett and Stuart's measurements to decimal equivalents and thus gives some measurements to the nearest one thousandth of an inch for a length of 126 inches, an obvious impossibility.

South Face

The dial is 88 inches in height, 64 inches in width, the gnomon is slightly above the horizon line. From the gnomon the distances to the various lines is: Winter Solstice 6 inches, Equinox 24 inches, Summer Solstice 54.5 inches. The present horizontal gnomon is modern, a rod with a ball at the extremity. The distance from the third hour line to the noon line is about 17 inches at the equinoctial line. Gibbs quotes two values differing by an inch. the dial is delineated for use at latitudes 38° 00′, and the angle of deviation is zero.

East Face

The dial is 144 inches in height, and 126 inches in width. Five hour lines are indicated, marking the first to the fifth hour of the day between the summer and winter solstices, plus the engraved equinox. This dial ceases its indications some time before solar noon. The distance of each solstice curve from the equinoctial line is almost identical at 11 inches.

North Face

The gnomon is just above the horizon line. The dial is $33\frac{1}{2}$ inches in height and $129\frac{1}{2}$ inches in width. Two hour lines and the summer solstices are engraved.

South-east Face
The height of this dial is 265 inches and its width is 128 inches, the gnomon hole is about ten inches from the meridian which coincides with the edge of the Tower. Five hour lines are engraved, plus the equinoctial and solstice lines.

North-east Face
This dial is 126 inches in height and 127 inches in width, containing four hour lines plus the solstice and equinoctial lines, only one of which crosses the winter solstice, three intersect the equinox, and four lines intersect the summer solstice.

The dials on the North-west and Southwest faces are similar to their mirror counterparts, just as the West dial is similar to that on the East face. It seems that none of these four dials has ever been measured, evidently even Revett and Stuart took no measurements, or at least did not publish their results.

Traces of dark material were visible in some of the lines at the time of the visit, this helping to pick out the lines. In general the lines are very faint and stand out better when lit by glancing sunlight. Perhaps the better state of the South dial is through being covered by the Turkish house for a long time.

My sketch of the South dial was produced by projecting a transparency on to a sheet of drawing paper and tracing the lines, obviously my photograph of the dial, being taken from a level almost forty feet below has distorted the dial, for the equinoctial line is quite displaced from its true position. The dotted lines indicate the joints in the marble blocks, whilst the outline shown below represents the roof of the former water reservoir which only just misses intruding on to the dial surface. M. Rohr told me in a letter that my diagram was the best he had seen of the South dial, I think he was being diplomatic and very kind. Professor de Solla Price's illustration shows much the same position of the equinoctial line although it is slightly lower. Perhaps the measurements given by Gibbs are in error.

FURTHER RESEARCH
I understand from Mr. James Richard, who kindly loaned me a model of the top of the Tower of the Winds showing the dials, that Michael Wright of the Science Museum, London, has prepared a lengthy treatise on the subject of the dials, using mathematical means to delineate the hour lines, etc, on the eight faces. I have not seen this myself and did not know that anyone was working on the subject until told by Mr. Richard. After having published my own articles in various magazines, I have not pursued the matter further except to take an interest in the subject. There are a number of copies of the Tower of the Wind, the most notable one is in the Vatican Garden, another is at Oxford in the grounds of the Radcliffe Infirmary, another is in the gardens of Alton Towers, another in America, and Mr. James has discovered two more acting as lodges to a large house. I have also seen a most beautiful model, exquisitely detailed, in a jeweller's shop in New Bond Street. For what purpose this was produced I have no idea, I would dearly liked to have owned it.

Mine is necessarily a brief outline only, it is evident that the Tower of the Winds requires examination by a more competent researcher than myself, however it would require a team effort to make it worthwhile, plus equipment to gain close access to the dials themselves so that proper measurements might be made; plus observations on the indications of the dials themselves. I have never studied the dials closely since at the time of my visit my main interest was in mechanical clocks. Experience has proved to me that photographs taken on the site can be quite deceptive for purposes of making scale measurements, since rarely can one be on the same level and at right angles to the dial plane. Incidentally Professor de Solla's investigations covered a period of many years and several people were employed in the work, I had but an hour and a half on the site.

Essential reading on these matters are the articles by Dr. Allan Mills, one on "Seasonal Hour Sundials" in the Winter 1990 issue of *Antiquarian Horology*, pages 147 to 170; and his article on seasonal hour sundials in the BSS *Bulletin* No. 90.3, October 1990. As the first covers all latitudes from 0° to 65°, the Athenian dials come well within this compass, the second is more restricted and covers the British Isles only. Most of the ideas expressed on these dials by the earlier writers are found to be wanting in credibility when scrutinized closely. Of course seasonal hours dials are much more practical in those areas of the world nearer the equator than in our northern climes; notwithstanding this improvement, the seasonal hour in Athens still varies to a surprising degree compared with mean solar time. The time system we now use seems almost instinctive to us, the ancients were much more flexible and used expressions such as "in the first hour", with no hint of the subdivision of the hour itself beyond quarters. So the actual indication on the dials of the Tower of the Winds would be quite adequate for anyone's purpose at the time.

The water clock inside the Tower of the Winds was intended to supplement the dials during the hours of darkness and may have been of an anaphoric type which follows the indications of the celestial sphere. The clock itself had to be emptied at the start of each day, and means were provided to adjust the flow rate every few days to follow the variations of the seasonal hours, plus the different rates for the night and the day, usually by the employment of two orifices, or alternatively separate scales used with one orifice. The daily emptying of the clock was employed to turn the anaphoric clock disc through one 365th of a revolution corresponding to one day of the year, a small peg which represented the sun being inserted in one of the 365 holes drilled in the periphery. No doubt the clock was reset at noon each day if the sun shone, since this is the most accurate observation possible, not from the external dials but by the sun's rays through an opening in the wall falling upon an internal noon line. The longer distance of the noon line from the hole would make it a much more accurate standard than the shadow indication of the short gnomon of the south dial.

Like myself, the main interest of Professor de Solla Price was the hydraulic clock within the Tower, so again the sundials were, in the main, neglected. He did compare the execution of the Athens dials with a dial executed by Andronicus Cyrrhestes on Tenos; coming to the

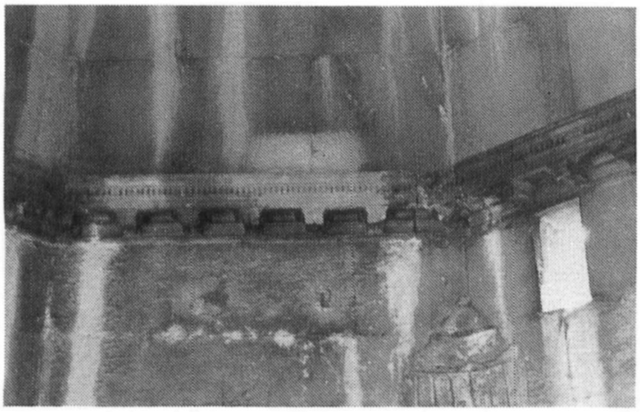

FIGURE 6 Part of the interior roof of the Tower of the Winds, showing one of the holes cut in the wall to admit light.

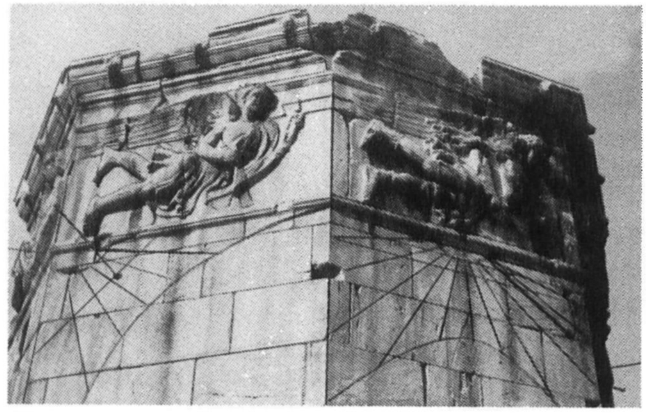

FIGURE 7 The figure of Lips, the South west wind, on the left; and Notus, the South wind, on the right.

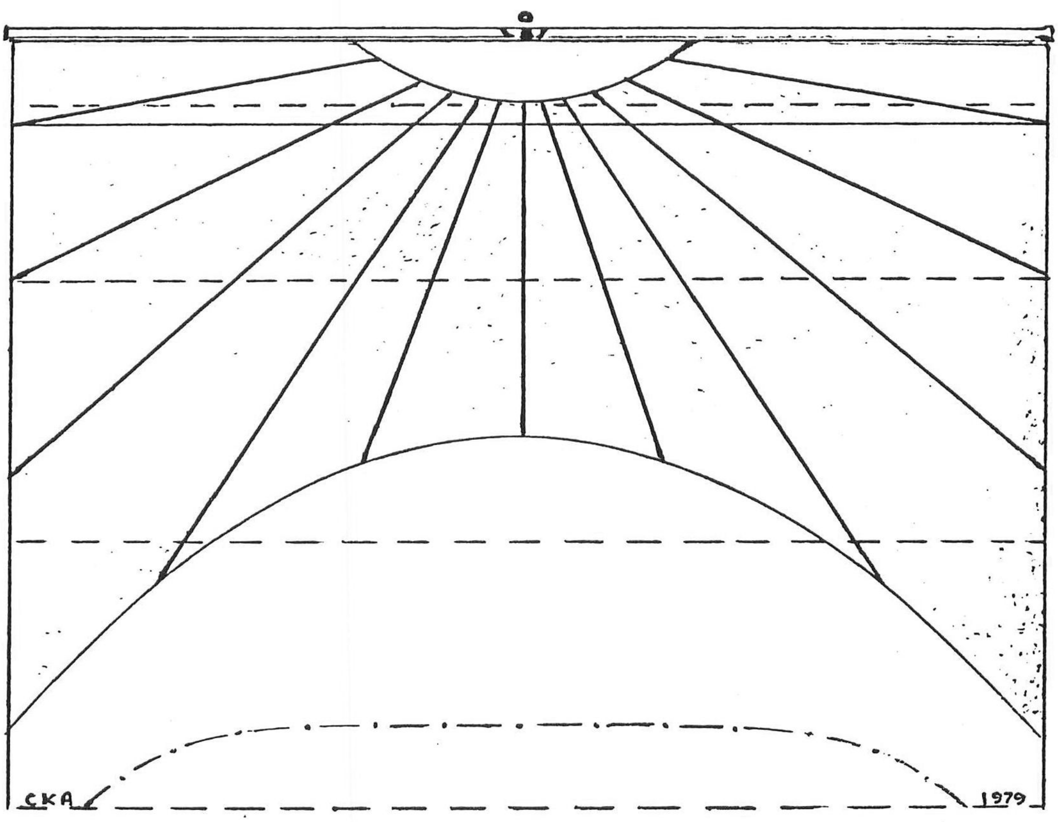

FIGURE 8 Sketch of the sundial delineated on the south-facing wall of the Tower of the Winds, Athens. It is not to scale. In particular the equinoctial line is incorrect.

Key to diagram:
The solid lines at the top boundary represent the stone ledge below the panel of the south wind, the original gnomon was fitted in this at the point marked with a dot. The present gnomon is fitted at 0. The solid vertical lines on the outside represent the edges of the south-facing wall, all the dotted lines represent horizontal courses in the masonry, whilst the chain-link line represents the roof of the original water reservoir below the dial. The solid line is the equinoctial line. The resemblance to an ancient axe-head may be seen if the diagram is turned sideways.

conclusion that they were from the same hand. In spite of this he did not include much commentary upon the eight dials although he managed to illustrate some of the dial lines with his views of the allegorical panels showing the eight classical winds.

The water clock and the sundial were complementary as neither could provide timekeeping over the twenty-four hours of the day without the help of the other, the water clock requiring constant correction, and the dials being without indication in darkness and on sunless days. It is therefore surprising that most researchers tend to treat each class of time indicator in isolation. One of the reasons is the very scattered nature of the information which is locked away in obscure archeological books and journals. In general the expert in time measurement knows little of the classical scene, whilst archeologists have little knowledge of the history of timekeeping. Nevertheless it is strange that the sundials of the Tower of the Winds have not received more attention from diallists before now. Any diallist looking for a research project would find the Tower of the Winds dials a worthwhile subject and one which has not been investigated by an expert on dialling matters to date. Had I not been asked to give a lecture and had to look around for something to speak about, my own file on the Tower of the Winds would have remained closed; I had taken my work to the limits of my own knowledge at the time and more data would have been required to make further progress. At the time interest in sundials was minimal and I was not even aware of Sharon L. Gibbs excellent book published in 1976.

It would be marvellous if the hour lines could be renewed on the Tower of the Winds, possibly by applied strips so that what remains of the original lines is preserved without alteration. In a few years time the whole pattern of lines will be extinguished by the relentless decay of the exposed surfaces by atomospheric pollution, alas the Tower of the Winds is but one of the jewels in a whole casket of finery from that era, and

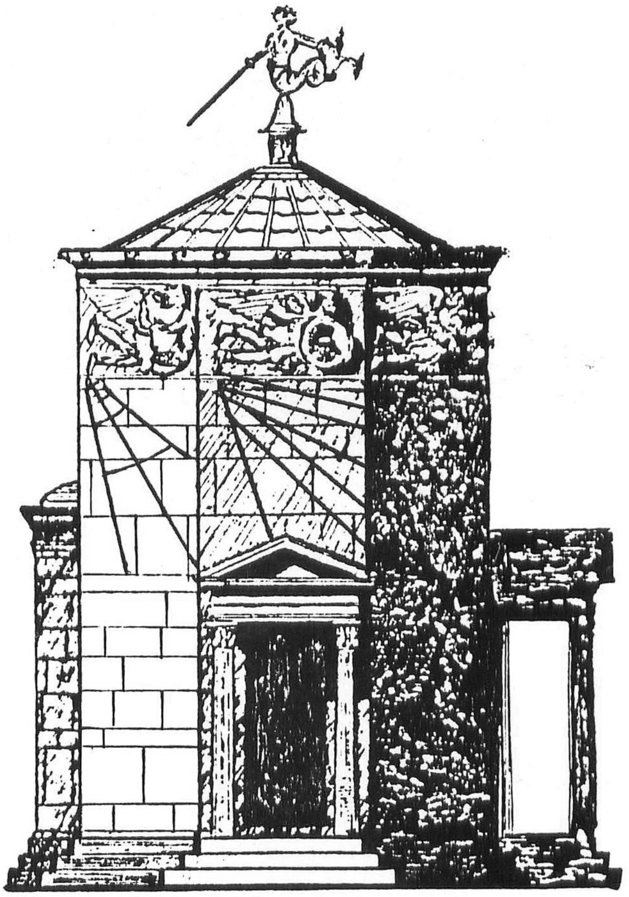

FIGURE 9 Stuart and Revett's reconstruction of the Tower of the Winds in 1726. Above is the Triton wind vane.

structures such as the Parthenon must take the lion's share of attention. Only the American School of Classical Studies in Athens has the muscle to undertake restoration of small items. It would also be nice if the original porches could be replicated, the work would not be very costly to restore the Tower of the Winds to something like its original glory. Much of the missing stone is still on the site and only wants identifying for replacement purposes.

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TWO NOTABLE SUNDIAL MAKERS OF LEICESTERSHIRE

BY W.D. WELLS

If you had found yourself in South Kilworth in the early years of Queen Victoria's reign and had wanted to know the time you would have been well-advised to ask the parson!

William Pearson who had been presented to the living at the age of 50 in 1817 and was rector there for the next 30 years already well-regarded as an astronomer. He came originally from the Lake District and it is interesting to discover that he was educated at Hawkshead Grammar School, where he would have been just three years older than the young William Wordsworth who also was a pupil there between 1778 and 1783. It is tempting to infer that a common interest in natural science was somehow encouraged in both of them, although it was to lead them along rather different paths.

For his part, in addition to training for holy orders, William Pearson made a serious study of the motions of the planets and constructed a planetarium and an orrery. He also wrote popular books and articles about the use of observatory instruments and was one of the original proprietors of the Royal Institution.

When he eventually came to South Kilworth he did not abandon his work in astronomy. In 1821 he erected an observatory, first in a wing added to the rectory and later as a separate building. He reported on the appearance of Halley's Comet in 1835 and published a precise catalogue of 520 stars in 1841 "with the assistance of a village mathematician named Ambrose Clarke". For his work he was awarded the gold medal of the Royal Astronomical Society and it is clear that this Leicestershire parson made an important contribution to nineteenth century science.

The accuracy of his observations would have depended on his having a well-regulated observatory clock and it may have been for that purpose that he constructed the very precise direct vertical dial which has fortunately been preserved and will shortly be displayed at the Snibston Discovery Park. Carved upon a massive block of slate, measuring 1 metre by $1\frac{3}{4}$ metres, it carries a Latin motto: 'Sine pede curro - sine lingua dico' and the simple statement: 'William Pearson del (ineavit) 1834'.

By referring to the shadow on this dial, with its accurate 5-minute intervals, one could have set one's watch to South Kilworth local time, as indicated by the motion of the sun - always 4 minutes and 26 seconds behind the local apparent time at Greenwich, because of the difference in longitude. In those days the difference was of importance only to travellers, who would understand and make due allowance for it.

However, some sixty years later, when Leicester acquired one of its best-known public sundials, the intention was not to so much to provide a timekeeper as to set up an elegant sermon in stone, illustrating a biblical text. It was in 1897, the year of the Queen's Diamond Jubilee, that a new slate dial was made for St. Martin's Church (now Leicester Cathedral).

The Vicar, Dr. Sanders, explained in the parish magazine: 'It was at first intended to make the Dial after the fashion of one of Sir Isaac Newton's, but though the complex geometry and astronomy of Newton's Dial is exceedingly interesting and appropriate for a secular building, it was considered better to make this one more Ecclesiastical in design'. A previous dial had recently been lost when the Vaughan Porch was constructed over the south door and the new one was the work and gift to the church of a well-known Leicester engineer, water-colourist and maker of decorative metalwork.

Thomas Scott Elgood was born in 1845. He was the fourth of ten children in the family of Samuel Elgood, a cotton commission agent who lived in Oxford Street. His grandfather, George Shirley, farmed 200 acres in the Liberty of New Parks and Thomas was evidently inclined towards a practical career. After leaving school he received training in a locomotive engineering works in Darlington and later with an art metal firm in Birmingham. Like several of his brothers and sisters he had an artistic talent and a number of his sketches and water-colours of buildings and scenery have been preserved in the archive at the Leicestershire Museum and Art Gallery.

In 1880 he set up the Leicester business of Elgood Brothers, in partnership with two of his younger brothers. They were in the trade of art metal-work, locksmiths and builders' ironmongery and various examples of their work can be found in the city. Elgood taught machine drawing at the Technical School and was particulary interested in wrought-iron work, making his own sketches of good examples in the county and giving lectures on the subject. He lived until 1912 with his wife and daughter in a house almost opposite the New Walk Museum. The house has since been demolished.

Elgood's 1897 design of the St. Martin's dial comprises a carved and partly gilded slate panel, with a simple bronze gnomon or style, on which is inscribed: "Thos. Scott Elgood Inv: Sc: et Don". The centre of the dial-face forms a Greek Cross, with the symbols of the four Evangelists carved in the sunken panels between the arms of the cross: - the Angel (Matthew), the Bull (Luke), the Eagle (John) and the Lion (Mark). The dial is without precise hour-lines although the margins display the hours in Roman figures. The upper margin carries the motto: - "Coeli enarrant gloriam Dei" (The heavens declare the glory of God). This is a quotation of part of Psalm 19, verse 1 in the Vulgate bible, made familiar to singers in its setting in Haydn's 'Creation' Oratorio. The date MDCCCXCVII is engraved, but not gilded, on the dial.

It is a pleasant thought, as one pauses at the Discovery Park or in the Cathedral precinct on a sunny day, to consider the makers of these harmless and beguiling objects; two men, a lifetime apart, one a scientific parson and the other an artistic engineer, who both understood the moving shadow and the ceaseless rolling of the Spheres.

The above report is a preview of an article to be published in the Transactions of the Vaughan Archaeological and Historical Society, Volume XXX, 1991-1992.

PORTABLE DIALS - THE BUTTERFIELD STYLE

BY JOHN MOORE

The so called 'Butterfield Dial' is perhaps the best known of all portable dials. It has been named, rightly or wrongly, after Michael Butterfield of Paris, whose workshop turned out large quantities in the years around 1700. The design was so popular that it was copied by many contemporary workers who tried to cash in on his success. In fact many of these other workers were known to have signed their dials 'Butterfield à Paris' because his dial was at the time the 'brand leader'. It is however debatable whether Butterfield himself originated the style and it is more than possible that the basic design came from London some years before. Butterfield himself was English but moved at an early age to Paris. He may have taken the idea with him, but it is more likely that he would have returned home at least once and may have seen such a dial by an English maker.

Before discussing the various details and variations of the design it is important to establish exactly what a Butterfield dial should look like. From a study of over 100 of these dials, 78% had an octagonal dial plate, 86% had a gnomon supported by a bird with its beak pointing at a limited latitude scale, 100% had a built-in compass, 61% had four individual chapter rings and 62% were silver, with most of the remainder, 32% brass. From these figures it is easy to get a picture of a typical dial. In practice there are many variations and two identical dials have yet to be found by the author. Some of the variations produced have given some exceptionally interesting dials.

HISTORY OF THE BUTTERFIELD DESIGN

As has been mentioned it is possible that the basic idea originated in England, but, to trace its origins, we find some dials made in France some years earlier. These had fixed gnomons but often had the octagonal or elliptical dial plates and always had the built-in compass. They were usually of silver, smaller than the average Butterfield and were usually made by watch and clockmakers, frequently outside Paris. The finely fretted gnomons (Fig. 1) on some dials are reminiscent of the balance cocks fitted to early verge watches. These dials are being included because they are so similar to Butterfield dials, although strictly they do not belong to this family.

Butterfield was active in Paris between 1674 and 1722 and was well known as a maker of quality scientific instruments. Some Butterfield dials by the English maker Richard Whitehead (Fig. 2) are known. He flourished in London between 1663 and 1693 and it is quite possible that he originated the design. However he did not make large quantities as did Butterfield and Bion. Nicholas Bion was a well known French instrument maker. He worked in Paris between 1652 and 1723 and he could well have been the originator of the style.

As the eighteenth century progressed, more and more workers turned their hand to this design which continued to be popular well into the nineteenth century. A few were made in England, always in small quantities but accurately executed and well made. They were probably made to fulfil the orders from individual clients who may have seen the French versions. Apart from Richard Whitehead the other English makers were Thomas Heath, John Rowley, John Coggs and later James Simons.

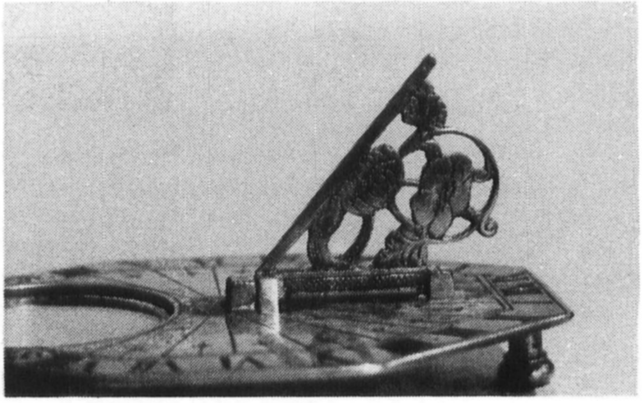

FIGURE 1 Finely fretted gnomon on dial by Nicholas Lemaindre c1670

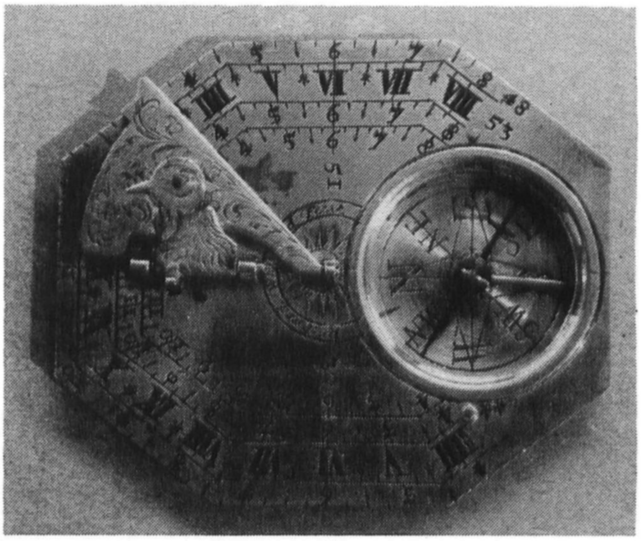

FIGURE 2 An English Butterfield by Richard Whitehead

The author has to date noted 48 different signatures on these dials and further ones are still to be discovered. Of these 48 the majority came from Paris and were known as instrument makers, often of renown, but some are just names with no details being traced. It is quite probable that some of these are merely retailers who insisted on having their names on their goods. Of the French makers several were outstanding, producing superior quality dials and often other scientific instruments. The better known ones are Jacques Baradelle, Nicolas Bion, Roch Blondeau, Michael Butterfield, Canivet, Jean Chapotot, Haye, Claude Langlois and Jacques Le Maire. These all produced the highest quality dials and several held royal appointments as instrument makers.

HOW TO USE THE BUTTERFIELD DIAL

Its design is relatively simple and could be relied upon to give a reasonable indication of the time of day over a fairly wide geographical area. Firstly the latitude of the place must be found. A list of towns was usually engraved on the back of the dial with their latitudes. After finding the latitude the gnomon is erected, it normally lies flat in transit, and it is adjusted so that the bird's beak points at the correct figure on the scale engraved on the gnomon. The dial is then placed on a horizontal surface, or may even be held carefully with a steady hand. It is then rotated until the compass needle point to the magnetic north marked in the compass bowl. This was usually just a few degrees west of north at this period. The dial plate is then inspected as it usually has three, four or even five separate chapter rings, each for different latitudes. The nearest one is selected for the reading, or by extrapolation between two, a reasonable time can be arrived at from the shadow of the gnomon on the dial plate. In theory this technique appears simple, but, in practice, it was often quite difficult and frequently inaccurate. In particular most dials were made from silver and because of its highly reflective surface it was most difficult to see the shadow falling upon it. Also a reflection of the gnomon could be seen and no doubt this was often confused with the shadow. If the silver dials were allowed to tarnish then they could be read much more easily, but would any self respecting gentleman carry a 'dirty' dial? The compass is also very small and as such is subject to quite large errors. The writer Dom Francois Bedos de Celles in his work 'Gnomonique Practique' of 1760 is most critical of Butterfield's dials 'with their considerable faults that do not put them in the class of good portable sundials. His compass is too small to be able to read with any precision. Even when one measures the divisions of the circle on the floor of the compass they are not sensible enough because of its too small diameter. The three or four dials which are marked on the horizontal plane for different latitudes renders the surface confused. It is difficult to distinguish the hour. We are therefore to be concerned that this is a bad dial and it should not be counted to see the hour but imperfectly'. We therefore have this damning criticism from this Benedictine doctor from his great treatise on gnomonics. However, in fairness, Butterfield's dials had been around for some 50 to 100 years by the time this book was published and by then great improvements had been made to portable dials generally. However the Butterfield Dial was still being made by later workers and it continued to be made for at least another 50 years. The Butterfield Dial however remained popular as it was a most decorative item. We should not look too seriously on it as a precision instrument. It was really a decorative object to be carried in the pocket, often as a status symbol. The vast majority of Parisian instrument makers produced a wide range of highly decorative instruments to grace the drawing room, fashionable salon or cabinet of instruments. They were intended for rich collectors rather than for being for precision measurement. The contemporary London instrument makers however were producing by this time precision instruments, functional and not too elaborate. Dom Bedos' main complaint is of the compass which is too small. The nineteenth century Butterfield dials (Fig. 3) were usually made with a large compass with its consequent improvement in accuracy. However, an example is known of Butterfield's work (Fig. 4) where he had obviously tried to overcome the small compass problem by making a dial with an exceptionally large compass bowl. Compromises had to be made with this design. The compass is now partly obscured by the dial plate and the gnomon. This means that North cannot be seen and therefore Butterfield has used the other end of the compass needle to point to the South instead. He has achieved his aim and has not sacrificed his style, which is as good as ever. This dial is even gilt and so was obviously made for an important customer.

FIGURE 3 A late Butterfield c1820

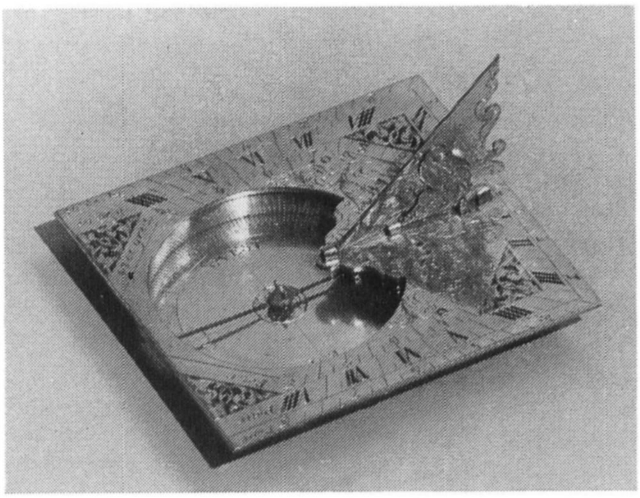

FIGURE 4 Gilt brass dial by Michael Butterfield with extra large compass

DIAL DETAILS

One of the most charming features of these dials is the bird which supports the gnomon and whose beak is used to indicate the latitude. The bird tends to be fairly standard, but several variations do occur, some being particularly chubby or rounded (Fig. 5, 6 & 7). The eye of the bird is used as the pin which rivets both halves together and travels in the cut out arc in the gnomon. On a silver dial the eye pin is often gold or gilt brass making a pleasing contrast. Occasionally some other gnomon support and accompanying pointer is used such as a leaf edge (Fig. 8).

The dial plates themselves vary considerably by shape and size. The octagonal shape is commonest, followed by elliptical. Other dials with rectangular and round outlines may sometimes be found. One most unusual type by

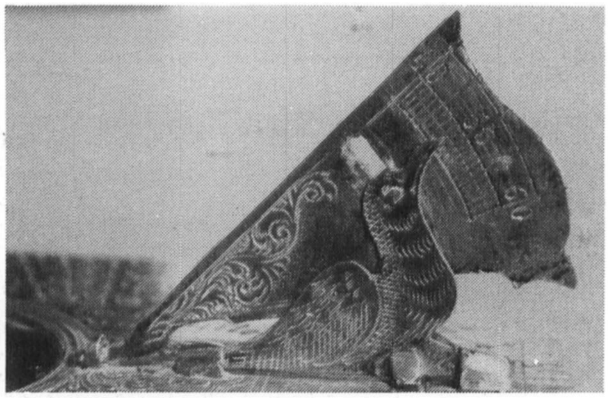

FIGURE 5 Bird Pointer, Michael Butterfield?

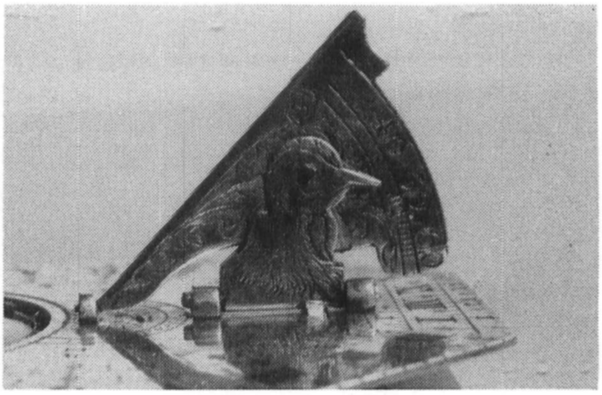

FIGURE 6 Chubby bird pointer, Richard Whitehead

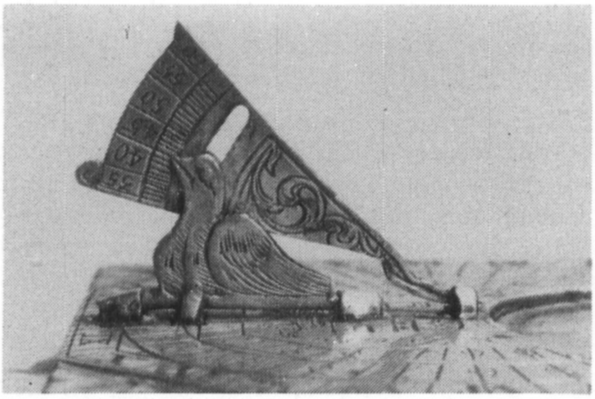

FIGURE 7 Bird Pointer, Nicholas Bion

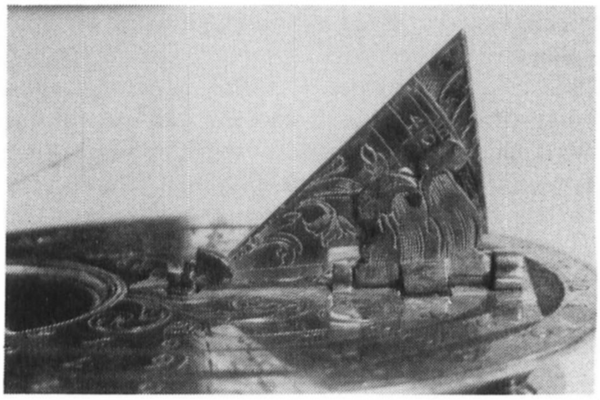

FIGURE 8 Unusual Pointer, Chevalier

Thomas Heath with a figure eight design will be mentioned later (Fig. 9). The scales on the plates generally consist of three or four chapter rings. These are usually numbered alternatively in Roman and Arabic numerals. The outer scale is usually the prime scale and hence has the greatest accuracy. On most French dials this is marked for 49°, ie. the latitude of Paris. The other scales often include 40°, 45° and 52° (London). Some of the English dials are much more precise. An elliptical dial by Thomas Heath has its prime scale for 50° 20′ which can only sensibly be attributed to Plymouth. It is interesting to note that a second dial by Heath also has this unusual latitude marked. It seems likely that both dials were made for sailors or ships' captains. Portable sundials of all sorts were most popular with seafarers. A further dial by Heath has the main dial engraved for 51° 32′, obviously London. Another interesting feature of these Heath dials is that the magnetic declination of the compass could be adjusted by means of a sliding button on the side of the compass bowl against a finely divided declination scale of ± 20°. Alas when these dials were made around 1730 the magnetic declination was only about 12° west and Heath was in no position to predict that the maximum declination would exceed his 20° figure. As has been seen the declination for London reached as high as 24°W in about 1820 and somewhat less for Paris. However the adjustable declination mark made the dials of Heath much more universal and more suitable for travelling around the world.

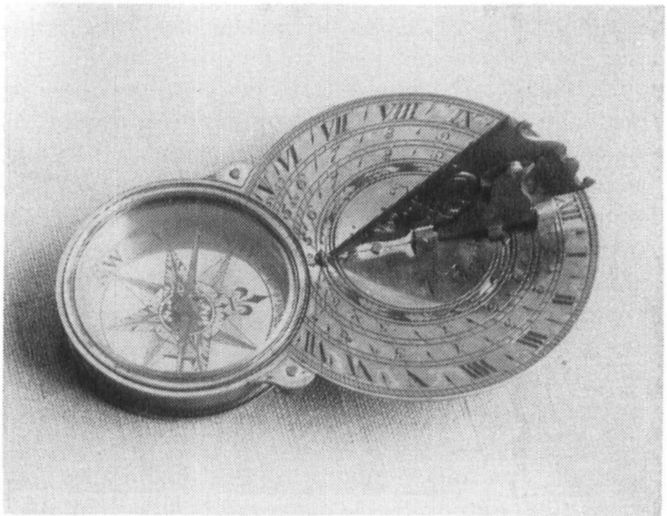

FIGURE 9 Figure eight style, Thomas Heath

One major problem with the Butterfield dial is that it is not fully universal. Its latitudes can only be adjusted through about 20° to 30° and then only for the Northern Hemisphere. However at least one Southern Hemisphere dial is known. Apart from the various shapes of dial plates, two distinct patterns evolved of the shape of the chapter rings. On most dials the scale follows the outer profile of the plate. An interesting variation has been employed which uses two shapes, octagonal and elliptical which are used alternatively. This produces a quite pleasing effect and no doubt helped to remove some of the clutter complained of by Dom Bedos (Fig. 10).

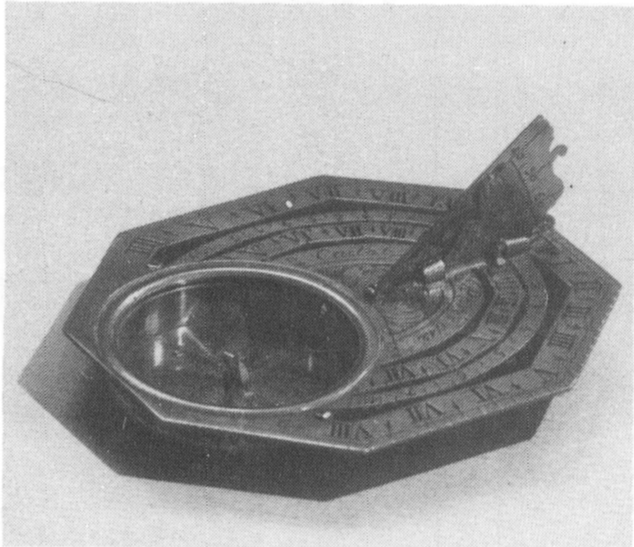

FIGURE 10 Octagon - Ellipse style by Chapotot 1742

FIGURE 11 List of English towns on a dial by Chevalier

THE UNDERSIDE

In virtually every case the underside of the dial is engraved with a list of towns and their latitudes. It is interesting to look at the list and see where the dial may be expected to be used. Usually they were made for the international traveller, but predominantly towns in one's own country would feature. Thomas Heath advertised his dials and was prepared to make out individual itineraries for his customers. 'If any Gentleman about to travel, is pleased to communicate the Tour he designs to take, he may have a Catalogue of the Towns in his way and their Latitudes, From Mr Heath, with the instrument (the universal dial) in order to ease him of the Trouble of Searching Maps, Globes or Geographical Books.'

One particular dial by Cheualier (sic) who was almost certainly French, possibly a Hugenot in exile, has a list of only English towns on it (Fig. 11). The style and quality of engraving is equal to the best produced in England and is, in fact, reminiscent of the work of Edmund Culpeper.

The back of the compass bowl was often used as extra space for the gazeteer. At other times it was engraved with a floral or foliate pattern.

CARRYING CASES

Many of the dials extant retain their original cases. These were usually made of fish skin in black or green and were lined with red or green velvet. The quality of the cases is usually comparable to the quality of the dial contained within. The case fitted to a dial by Richard Whitehead (Fig. 12) is most unusual, being lined with boxwood which has been hollowed out to take the lower profile of the dial including its feet and compass bowl. It is also fitted with silver hooks and decoration.

THE MAKERS AND THEIR WORKPLACES

A list was made of 48 makers so far found and brief details are included of their places of work, date of activity and brief biographical details. Most of this information was obtained from reference books (see list).

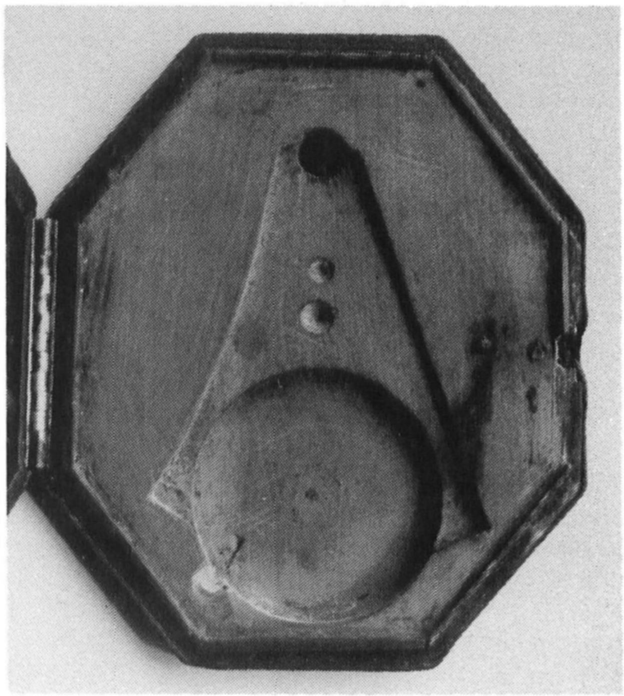

FIGURE 12 Case for dial by Richard Whitehead

There are however, several makers who deserve a more detailed mention. The most famous and prolific of these is, of course Michael Butterfield. It is not certain when he went to Paris from England but it was probably before 1663. Little is known of his early life, but he went to school in Paris. He was appointed Engineer, or Instrument Maker, to Louis XIV and looked after his mathematical instruments. He made many sorts of instrument including graphometers, compasses or proportion etc. In 1677 he invented a new type of level, and in 1681 he perfected his odometer. He is sometimes confused with a Buterfield (with one t) who is thought to be of German origin. His death is recorded as 28th May, 1724.

The second most prolific maker was Nicolas Bion. He again was an accomplished instrument maker. In 1709 he published his famous book 'La Construction et l'Usage des Instruments de Mathematique' which ran to five editions by 1752. The book was first translated into English by Edmund Stone in 1723, with a revised edition in 1758. It is a rich reference book covering all types of instrument, describing each in detail and explaining how it was to be used. His illustrations (Fig. 13) show various types of sundial in use at the time, including one of the Butterfield type. Bion was also appointed Engineer to the King for mathematical instruments.

It is interesting that most of the instrument makers of Paris were clustered together in one small area. In this case it was around the Quai de l'Horloge on the Île de la Cité (Fig. 14). This was also the area of the clock and watch makers and it is thought that several of the instrument makers were also involved in the clock trade as there was not such a strict division of crafts as in Britain, where the various guilds of the City of London carefully regulated and censored their members.

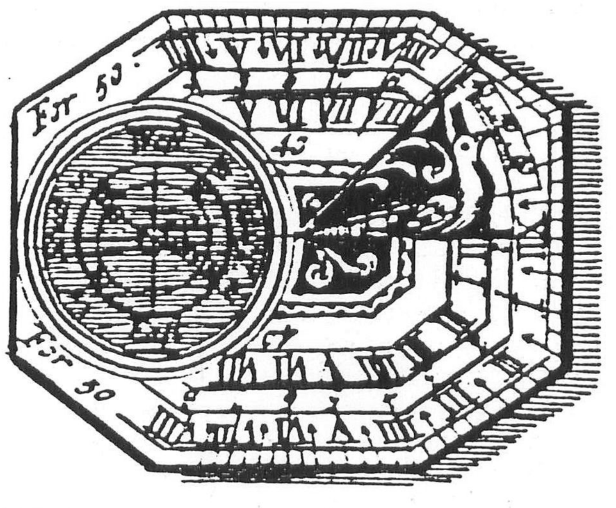

FIGURE 13 Butterfield dial illustrated in Bion's book (Stone 1758)

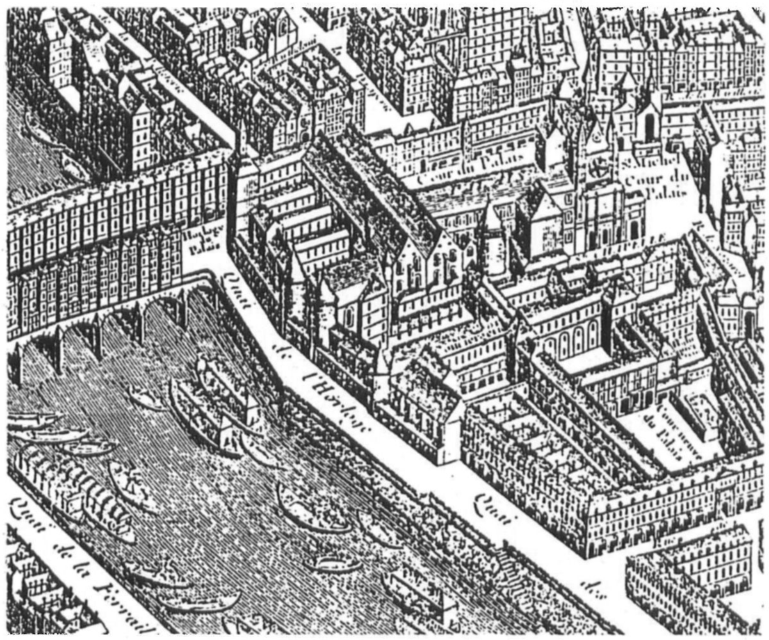

FIGURE 14 View of Quai de l'Horloge from Plan de Paris by Louis Bretez, engraved by Claude Lucas at the command of Tirgot 1734-1739

UNUSUAL DIALS

Three dials should be mentioned which clearly fall outside the usual patterns so far described. The first is a late round dial of about 1820 which is owned by one of our members. It has the hour scale running anti-clockwise and a shallow, but variable, angle of gnomon. This was obviously made for the Southern Hemisphere. It is completely unsigned, but is, almost certainly, of French manufacture - possibly from Lyon. Studying the range of latitudes on the gnomon has not given any clue to its intended region of use, but most probably it would be one of the French colonies. A similar dial (Fig. 3) for the Northern Hemisphere was probably made for somewhere in North Africa.

Another dial with a low angle gnomon (Fig. 15) was made 'pour 14 dégrés 45 minutes' and is signed 'Canivet à La Sphére à Paris 1764'. This is a rare example of a dated dial and its unusual latitude can only be for the island of Martinique in the West Indies. It did not need an adjustment gnomon. The products of the English makers differed in several details from their French contempories. Thomas Heath was no exception and one dial by him (Fig. 9) uses a most unusual figure of eight design. This style also overcomes the problem of the small inaccurate compass, giving both compass and dial their own parts of the plate, thus avoiding possible conflict.

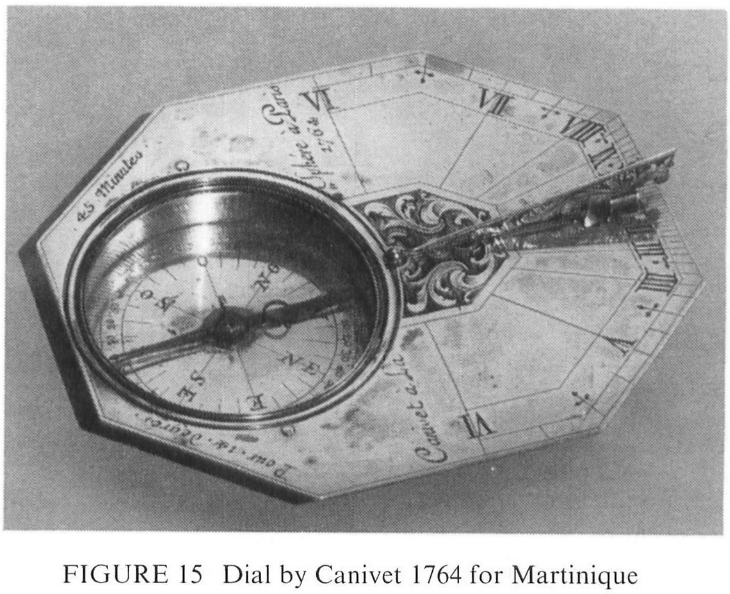

FIGURE 15 Dial by Canivet 1764 for Martinique

THE DECLINE OF THE BUTTERFIELD DIAL

The design remained popular throughout the 18th century and it is not difficult to understand why. It is still a most attractive object which many collectors would like to own. It was made for the nobility who could afford to pay for such a fine and decorative device. However the French Revolution of 1789 soon removed the potential market and for a time production must have stopped. No doubt there were many dials flooding the diminishing market. Many, especially those of silver, must have been melted down for their metal. When production was revived in the early 19th century the style had changed. It was no longer over-decorative but much more utilitarian. Most dials of this period were round with a large compass bowl (Fig. 3) and were usually of brass which was then silvered. Many kept to the bird design for supporting the gnomon, but this was a most thin and uninteresting fowl compared with a century earlier.

FAKES AND FORGERIES

The Butterfield dial has always been popular and much in demand. For this reason it is the most copied dial to be found. Today several models are being made as reproductions, often sold in museum shops or nautical 'antique' shops. These are easy to tell from the originals, mostly from the techniques used in their manufacture. However, they are still decorative and relatively cheap and as such are quite popular with collectors. However, the Butterfield dial has been copied almost since it was first offered for sale. The copies were often made by the less competent craftsmen and to make them more saleable they were signed with a well known name, usually Butterfield's. These copies are more difficult to separate from the orginals except to the trained eye. They are, in fact, interesting in their own right and are worthy of study.

One silver dial by 'Butterfield' in a beautiful shagreen case (Fig. 16) is almost certainly not from his workshop, but from that of another maker. Close examination shows that the engraving is not of the quality to be expected and, if such were produced in his workshop, it would not have been allowed to be sold. There are also some interesting mistakes in the dial's calibration. The 8 and 9 am marks are displaced by two quarters on all four chapter rings. There is also some confusion around 3 and 4 pm with the wrong number of quarter divisions in certain hours. This dial is, however, contemporary with Butterfield and unusually carries a Paris poinçon, or hallmark, of the period. This is the only dial known to the author which does have a hallmark. Mistakes in engraving are not particularly unusual, but often they are discovered and attempts made to correct them. On this dial the quantity of mistakes is also most unusual and it is clearly the work of an inferior craftsman trying to cash in on Butterfield's popularity and reputation. Deliberate fakes are not unknown but the author has not yet knowingly come across any. It really comes down to the basic economics. Is it really worthwhile to try to make a copy to fool someone into parting with his cash? When one considers the amount of time required to make one and the skill to engrave it, complete with correct calibration and division, such that it will pass reasonable scrutiny, it is most unlikely that it would prove lucrative. It seems unlikely that this type of deliberate forgery would be worthwhile. However, genuine Butterfield dials are often found with gnomons or compass bowls missing. A skilled craftsman can restore these items and some are most difficult to spot. Once the dial is restored it is obviously more collectable and the gain in this case is worth the effort.

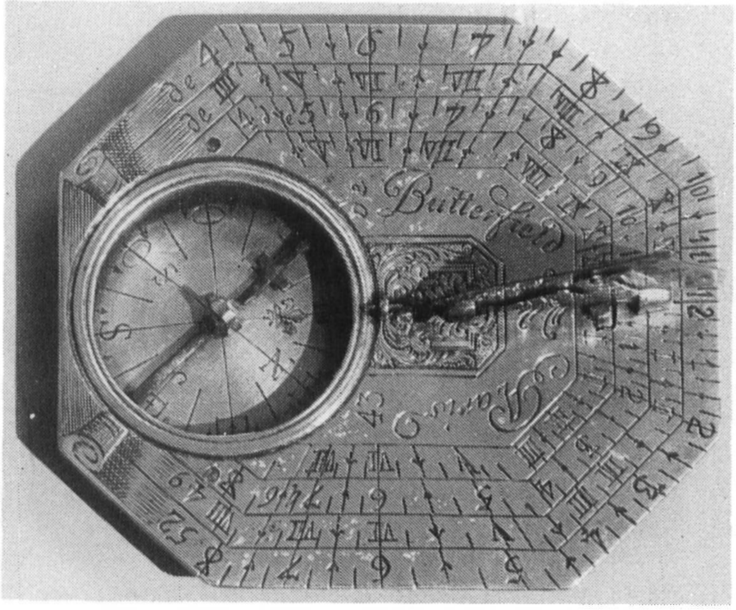

FIGURE 16 Dial signed by 'Butterfield à Paris' but with several errors

ACKNOWLEDGEMENTS

The author would like to thank the following people for their assistance in providing material for this article. Mr. A.J. Turner for Fig. 14. Trevor Philip & Sons for the photograph of the dial in Fig. 3.

SOURCES OF BIOGRAPHICAL INFORMATION

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Scientific Instruments of the 17th and 18th Centuries and their Makers.
HENRI MICHEL
Les Cadrans Solaires de Max Elskamp.
HENRI MICHEL
Catalogue de Cadrans Solaires du Musee de la Vie Wallone.
E.G.R. TAYLOR
The Mathematical Practitioners of Tudor & Stuart England.
The Mathematical Practitioners of Hanoverian England.
JOYCE BROWN
Mathematical Instrument Makers in the Grocer's Company 1688-1800.

MAKERS OF BUTTERFIELD DIALS

Note: fl = flourished

The following list shows brief information so far found of makers of all signed included in this study. In some cases dials may be by father or son, frequently with the same first names. The name of examples known are also recorded.

BAILLOU Pierre c 1720 Milan — 1 example
Probably made in Paris for the Italian market.

BARADELLE Jaques L. c1740 d1794 Paris — 12 examples
1752 Quai de l'Horloge du Palais under the sign À l'Observatoire. His son Nicholas Eloi worked with him from 1774-1814.

BERNIER c1800 Paris — 2 examples
Au Niveau de Paris

BIANCHI c1820 Toulouse — 1 example
Italian worker in France

BION Nicolas 1652-1733 Paris 30 examples
Quai de l'Horloge at Au Soleil d'Or
1710 Au quart de cercle
Appointed Ingenieur de Roi for mathematical instruments.

BLONDEAU Roch. Active 1665-1673 Paris 2 examples
1665 Quai de Grand-Cours de Eau at the sign of the compass (la Boussole).
Also B. Blondeau and Nicholas Blondeau were known as sundial makers in the 18th century.

BLOUD Charles/Carolus c1670 Dieppe 1 example
Famous for his ivory diptych dials.

BUTTERFIELD Michael 1674-1722 Paris 78 examples
1678 Rue Neuve des Fosses in the Faubourg St Germain
1697 Aux Armes d'Angleterre at Quay des Morfondes

CADOT 1726-1742 Paris 3 examples
Sometimes dated his dials. Two known 1742.
He used the octagon-ellipse style.

CANIVET c1744 d1774? Paris 3 examples
1751-1756 Quai de l'Horloge, À la Sphére.
Nephew of Langlois. High reputation for quality work.

CHAPOTOT Jean c1665-c1680 Paris 16 examples
c1680 Quai de l'Horloge. À la Sphére.
Father & Son. Father active late 1600's and son around 1721. Father constructed instruments for the Observatoire de Paris.

CHEVALIER Louis Vincent 1734-1804 Paris 2 examples
31 Quai de l'Horloge.
Son Vincent 1771-1841 and grandson Charles 1804-1859. A Chevalier also recorded as working in Guernsey 1770-1791.

CHEVALLIER Jean Gabriel Augustin 1796 Paris 1 example
1796 on the corner Pont Neuf and Quai de l'Horloge.
Optician.

CHOIZY Early 18th century Paris 1 example

COGGS John fl 1690-1740 London 1 example
Nr. St Dunstans Church, Fleet St. at the Globe & Sun.
Also son John fl 1730-1759 at the same address.

COTY Late 18th century Paris 1 example

COLLET Timothée c1660 Paris 1 example

CREMSDORF(F) 18th century Paris 1 example

DELURE c1700-1720 Paris 5 examples

DUHAMEL Paris 1 example

GARY c1710 Paris 1 example

GEORGE c1740-c1760 Paris 3 examples
Rue Dauphine. c 1750 Quai de Conti - optician to the Academy of Science, very few objects known with his signature.

HAYE c1710 Paris 3 examples
1716 Published a book on dialling.

HEATH Thomas fl 1714-1765 London 3 examples
In the Strand at the sign of Hercules & Globe, next to the Fountain Tavern.

LANGE DE BOURBON c1753 Paris 2 examples

LANGLOIS Claude fl 1730-1780 Paris 4 examples
Aux galleries du Louvre. Quality instrument maker. Engineer to the Academy of Science, his workshop carried on later by Canivet.

LASNIER c1700-1750? Paris 2 examples

LE FEVRE/LE FEBVRE Jean 1650-1706 Paris 3 examples
At the sign Aux deux Globes.
Probably father of Etienne-Jean who died 1753.

LEMAINDRE Nicholas, c1660 Blois 1 example
Clockmaker to Catherine & Marie de Medici.

LE MAIRE Jacques fl 1720-1740 Paris 25 examples
Nouveau Quartier Anglais, Quai de l'Horloge a coin de la Rue de l'Horloge. His son Pierre fl 1739-1760 but Jacques normally associated with sundials.

LE SUER c1700 Gisors 3 examples

LIGEON 1 example

LORDELLE 1738, 1742 Paris 2 examples
Possibly successor to Bion.

MACQUART fl 1726-42 Paris 8 examples
Maker of fine instruments and sundials.

MARTIN c1780 Paris 1 example
Au Temple/Versailles

MAULEVAUT c1720 Paris 2 examples
Very few instruments carry his signature.

MENANT I c1750 Paris 5 examples
Adopted sign 'Au Butterfield'.

MEURAND fl 1780-1794 Paris 1 example
Quai de l'Horloge du Palais.

NORRY P 1649 Gisors 4 examples

NOURRY J Lyon 3 examples

PASSEMANT Claude Simeon
b1702 d1796 Paris 1 example
Louvre, Rue de Monnaie at the sign of Pomme d'Or.
An outstanding optician.

POUILLY J 1686, 1692 Paris 1 example
1683 Au Compas Marin in Rue Dauphine.

ROWLEY John fl 1698-1728 London 1 example
1704 at the sign of the Globe under St Dunstans Church.
1710 Johnsons Court, Fleet Street.
Master of Mechanics to the King.

SAUTOUT Paris 1 example
L'aine de Paris.

SEVIN (CEVIN) Pierre fl 1665-1683 Paris 3 examples
Excellent maker of mathematical instruments.

SIMONS James fl 1791 London 3 examples
Isaac Newton's Head, 17 Marylebone Street.

THOURY I c1700 Paris 3 examples

WHITEHEAD Richard fl 1663-1693 London 4 examples
Gunpowder Alley, halfway up Shoe Lane leading out of Fleet Street.

FIGURE 13:
The work *La Construction et l'Usage des Instruments de Mathematique* by Nicolas Bion, translated by Edmund Stone into English in 1723, was revised in 1758. Figure 13 in the main text above is shown as Fig 1 in the Plate XXIV in the 1758 edition.
Stone's edition was reprinted in recent years and may still be obtainable from horological booksellers. It is a very large book and it is difficult to find a place for it in the modern home.

A PORTABLE POLAR SUNDIAL

BY H.R. MILLS

The Polar sundial usually consists of a rectangular plane dial surface that lies parallel to the Earth's polar axis, and has a central style fixed at rightangles to the plane. The Hour Angle lines are drawn parallel to the Earth's axis and spaced at the distance x calculated by the relation $x = h \tan HA$, where h is the height of the style above the dial face, 6 cms. This relation results in x being inconveniently large for Hour Angles >75°. For example at Sun times 7am (HA = 75°) and 5pm the dial would be 45cms long, and to show times half an hour earlier and later than these times the dial has to be about one metre long. For the hours 6am and 6pm the dial would be infinitely long ($x \tan 90° = \infty$).

The photographs and figures show a simple model with hour lines marked using the style, edges BC and AD that are 6cm high, and a length of dial of 24cms that can accurately accommodate the full range of times from 6^h to 18^h. The dial is easy to make from a small sheet of aluminium ABCD 24 x 6cms and 1mm thick. The markings shown in Figures 1 and 2 can be made using a sharp scriber or "permanent" pen. The disadvantage of a metre long dial face is overcome by turning the two end squares AEFD and BCHG through 90° to form endpieces shown in Figure 1 and also to serve as two styles, the edges AD and BC of which, make the shadows when the dial is in position as shown in the photographs. The style BC will cast a shadow during the forenoon and show the hours marked from 6am to 12 noon. The style edge AD then takes over the task and shows the afternoon hours from noon to 18^h. The shadow of BC just covers the edge AD at 6am, and the shadow of AD just covers the edge of BC at 18^h, as marked. In this way the problem of having an infinitely long dial face is overcome.

Instead of calculating the positions of the hour lines, the positions can be found graphically using a protractor and then marking the angles as shown in Figure 2 which also shows how the two end styles reduce the unwieldy length of the dial from "infinity" to 24cms, as each style end undertakes the task of showing the hour angles for 17^h, 18^h and 7^h, 6^h. The half hour markings should not be made by dividing the intervals into two equal parts, but by calculation or by using half Hour Angles.

This Polar Dial can readily be adjusted in position to correct its readings for the Equation of time, or for its Longitude East or West. This is done by using a small wedge to raise the Western edge FE by a few millimetres which effectively adds a few minutes to the Local Sun time recorded, or correspondingly by raising the Eastern edge of the model the Local Sun times are reduced, and in each case the increase or decrease is at the rate of four minutes for each degree raised. The wedge shown in the photograph can be calibrated to facilitate these adjustments.

As an example during early November, the Equation of Time is 16 minutes, which means that the Sun's Hour Angle is 16 minutes ahead of Mean Sun Time or 4° ahead in Hour Angle. The correction for this can be made by simply turning the face FEHG through 4° about the edge FE, by raising HG by $FH \sin 4° = 12 \sin 4° = 8.3$mm using the calibrated wedge P in the photograph. Similarly during mid February the equation of Time is -14 minutes so the wedge is inserted under the Western edge FE to raise it by 14/4 minutes that is by $12 \sin 3.5 = 7.3$mm.

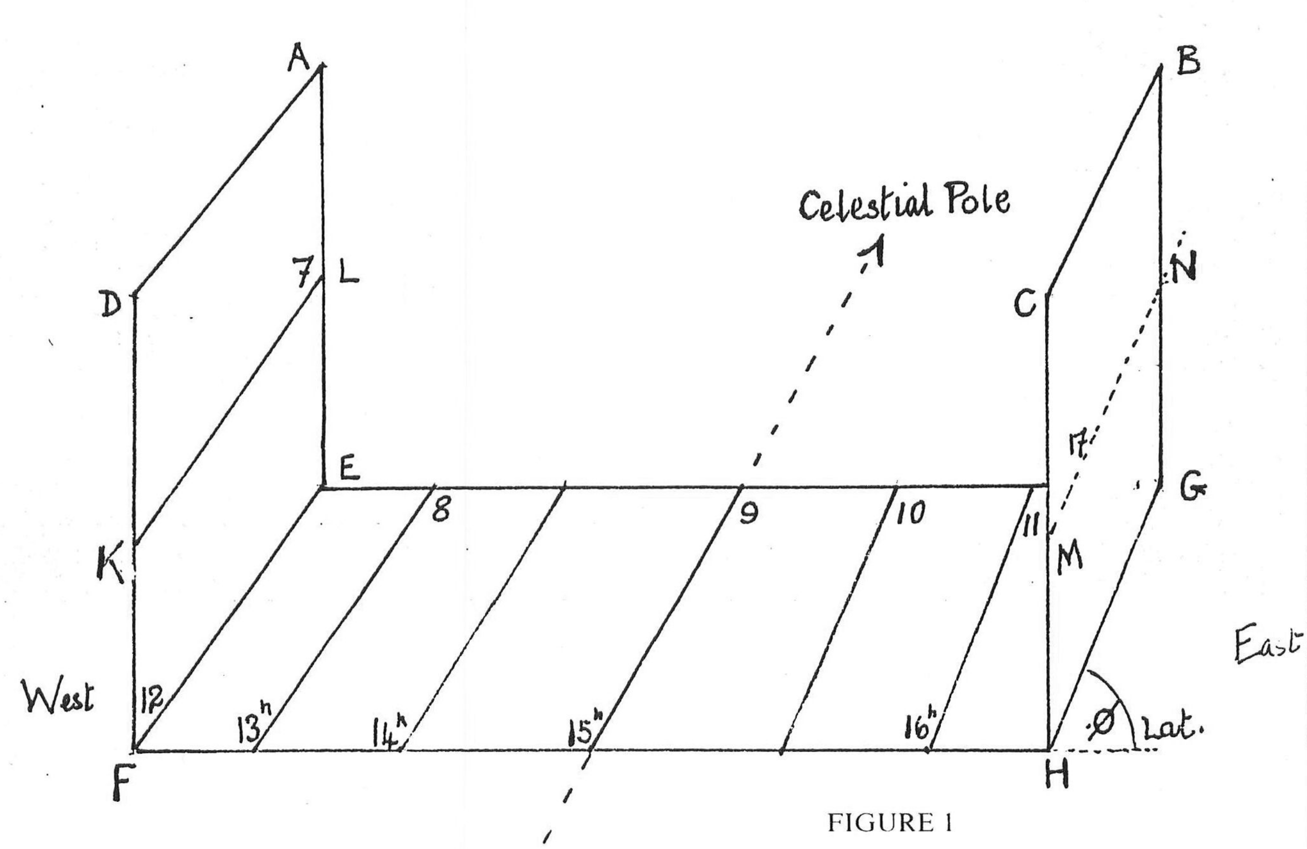


FIGURE 1

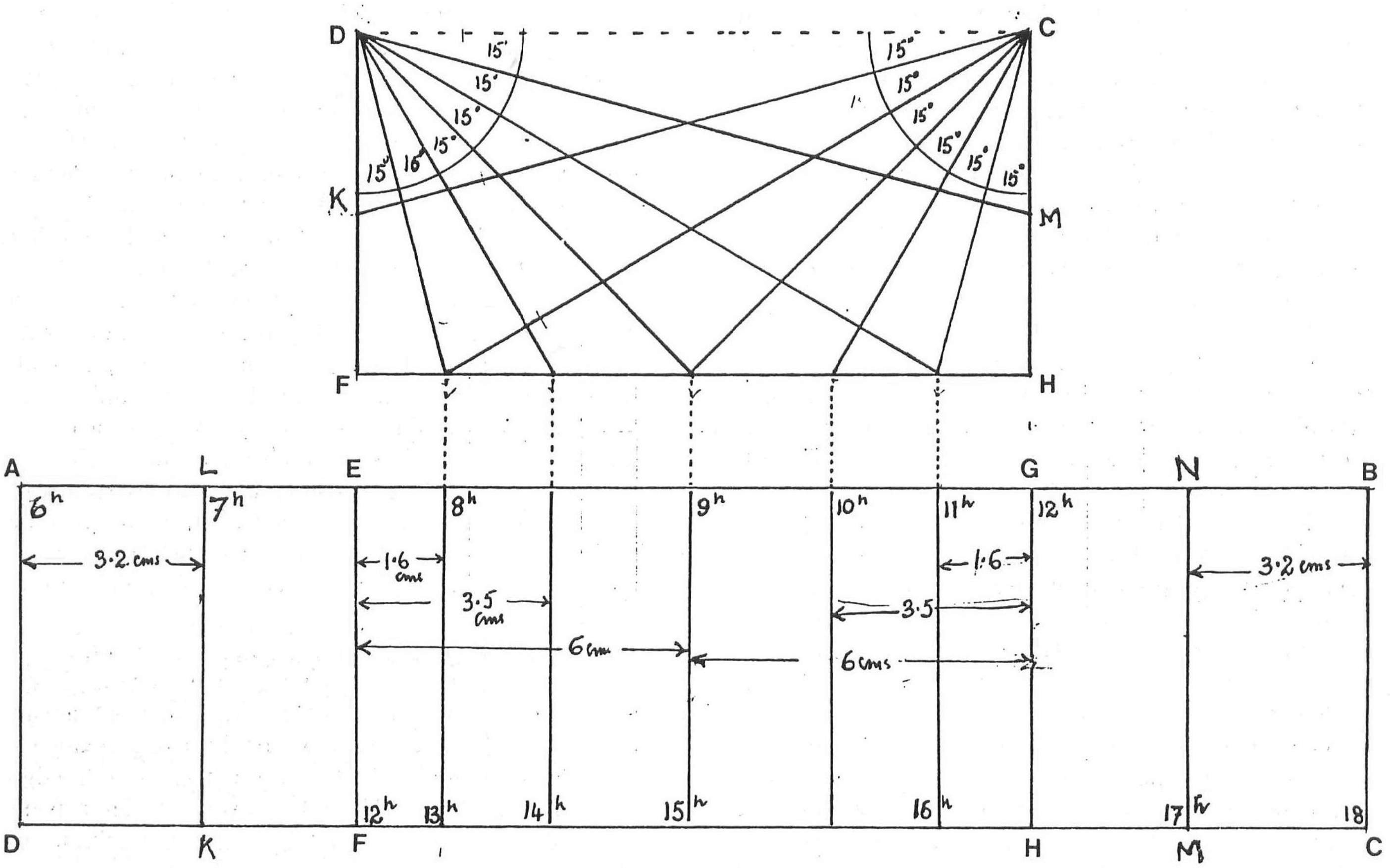
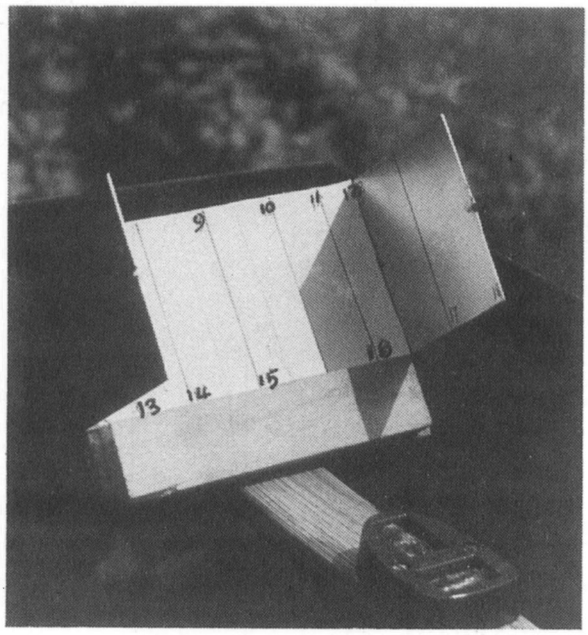
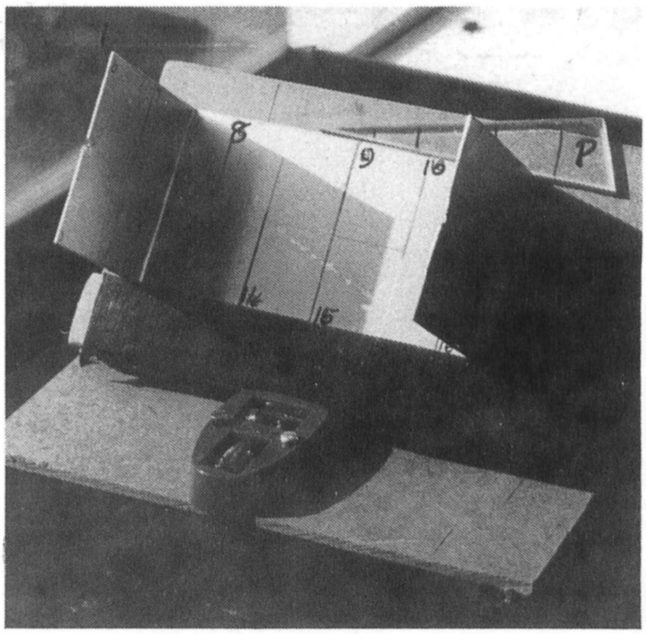


FIGURE 2



Dial showing time 10^h am.
The dial is small and portable so I have included a spirit level.



Showing time 15^h 20^h
P is the Correcting Wedge (but not in use).

DIALLING ON URANUS

BY BERNARD OAKLEY

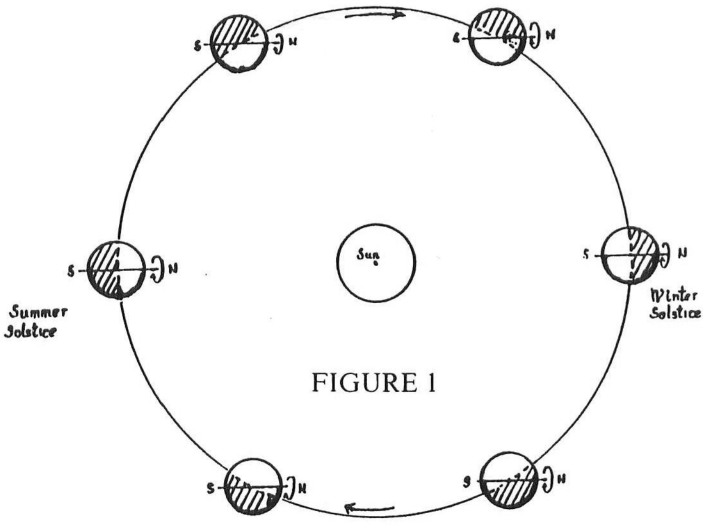


FIGURE 1

Noon line or Meridian drawn with a heavy line

Whilst I was travelling home after the BSS Conference at Bath in September I gave further thought to Professor P. Adam's talk "The Celestial Sphere" and in particular as to why the inclination of the earth's axis should affect the length of the day. For those of you who were not at the conference, this was demonstrated with the aid of an excellent model by which he could exagerate the tilt of the earth's axis to about 60 degrees; a look at the model and it was so obvious! On the journey home I contemplated what would happen if the axis was tilted still further to 90 degrees, which is more or less the situation with the planet Uranus.

So let us suppose that the orbit of Uranus is circular, the tilt of the axis is exactly 90 degrees and that the atmosphere is such that the sun is visible from the surface of the planet.

First consider the situation at the summer solstice: at the north pole the sun will be directly overhead, on the equator it will be due north on the horizon and elsewhere in the northern hemisphere somewhere in between. There it will stay, the sun remaining at the same point in the sky for days. But what is a day in Uranus? There is no sunrise or sunset, nor any other change. If sunspots are visible it could be noted that the disc of the sun is rotating, otherwise - nothing.

Now is the time to commence your dialling experiments, put the end of a rod in the surface so that its axis faces the sun and therefore casts no shadow. At or near the equator the rod will of course be horizontal, facing north-south, and will have to be supported above the surface.

As the sun moves away from the summer solstice it will be observed that the sun appears to be travelling in small but slowly increasing circles, a spiral in fact. The rod will now cast a shadow, which at the north pole will be a small circle which can be divided into 24 equal divisions corresponding to the Uranus solar hour, elsewhere it will be necessary to project this as on the earth. The highest point of the circle will be noon and a line drawn along the shadow (the noon line) will be the origin from which the 24 divisions will be made. At the equator, day and night will now appear as the sun will dip below the horizon for each rotation of the planet.

These circles continue to get larger and larger until at the next equinox, the sun will travel in a great circle, round the horizon for an observer at the north pole, and overhead at the equator. After the equinox, the sun will not be seen again for six months from the north pole, while at the equator the path of the sun will continue its journey southwards until the circles decrease to a point, due south at the winter solstice. This pattern of events is reversed for the second half of the year.

Now as the axis of rotation of the planet is at right angles to the axis of rotation around the sun, the length of day measured by the dial will be a siderial day, not a solar day. As the number of solar days in the year of Uranus is one less than the number of siderial days, where has the missing day gone to?

To understand this, return to the dial which was constructed so that the noon line points to the sun. At the time of the solstice the dial is useless for indication and some other method of measuring the time will have to be used. When the dial next allows a reading, the time is found to be 12 hours out! This is because the noon line which formerly pointed towards the sun, is now found to be pointing directly away from it. The diagram (fig 1) will make this clear. At the next solstice, the dial will be 12 hours out once again and so the solar year of Uranus is obtained.

Another way of looking at it is to note that the ecliptic passes through the celestial poles, so fig 2 shows what an observer looking from a celestial pole will see as the planet passes through a solstice. However the tilt of the axis of Uranus is actually 98 degrees, so the ecliptic will just miss the celestial pole, and fig 3 shows how, at the solstice, there is a rapid change in the length of day which accumulates to 12 hours.

FIGURE 2

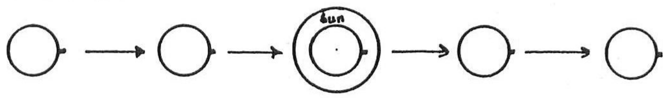
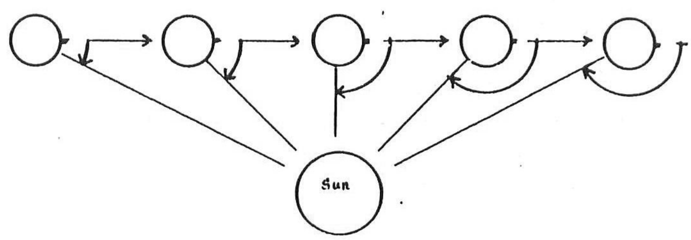


FIGURE 3



To return to Professor Adam's lecture, if the tilt of the planet's axis is zero, the extra day will be lost in equal amounts, if the axis is tilted the amounts are regularly repeated but unequal in duration, and if the axis is at right angles, the changes are in two increments of 12 hours at the solstices.

SUNDIAL LINE DRAWING DEVICE

FORWARD:
The following article, with its illustrations, was sent to Mr Alan Partridge in 1987 by the late Noel Ta'Bois. Mr Partridge kindly made this available for publication in The Clockmaker, the payment for the article being donated to the British Sundial Society Funds; and it is now repeated here. Noel Ta'Bois was a Meccano enthusiast and would often translate his ideas into reality through the use of this medium before making a permanent model in the conventional way.

SUNDIAL LINE DRAWING JIG

BY NOEL C TA'BOIS

This Meccano jig can be used to draw hour lines and declination lines on a sundial plate of any shape, not just plane surfaces. It was designed and built as a result of a request from Brookbrae for advice on how to draw the hour and declination lines on a Roman type of sundial which was commissioned for St Paul's, City of London School, the indicating surface being the inside surface of a section of a cone.

The principle of the instrument is that a telescopic arm is set by calibrated dials so as to be in line with the sun at given latitude, declination and hour angle. The point about which this extendable arm swings is set to correspond with the nodus of the sundial being marked out. When set to a given point, the telescopic arm is extended to touch the dial surface, and the point marked with a pencil or in any other suitable way. This mark will be the position of the shadow of the nodus.

After setting the latitude and hour angle dials, the declination may be adjusted to give a series of points, if points are joined, then the resultant line will be the hour for that latitude. On the other hand, if the latitude and declination are set, and the hour angle varied to give a series of points, the resultant line will be a declination line.

Figure 1 shows the jig attached to a piece of board representing a sundial plane, on which the hour lines and declination lines for a horizontal dial for use at the latitude of London were drawn in about 15 minutes.

The structure on the left consists of a vertical column which is clamped to the baseboard and which has a few inches of side to side adjustment. This allows the jig to be precisely aligned with the meridian line of the dial being marked out. Once the column is accurately aligned, it is locked in position to prevent unwanted movement.

Through the action of a rack and pinion gear, a horizontal frame slides up and down the column in a similar fashion to that of a vertical photographic enlarger, the higher the frame is set, the larger will be the sundial produced. This frame must be set precisely parallel to the sundial plane, adjustable outriggers being provided to achieve this condition, which is checked by measuring the height of all four corners of the frame and adjusting these for equality.

The heart of the jig is at the right hand end of the frame in Fig 1, and is seen in greater detaill in Figures 2, 3 and 4. Figures 2 and 3 also show parts of the hour and declination lines drawn by joining marked points determined by the jig.

A split horizontal axis (best seen in Fig 2), with a worm and pinion at one end and a latitude scale at the other, carries a built-up U-frame at its centre, in the middle of which is a rod carrying a pointer moving over an hour scale marked in 15 degrees an hour and calibrated from 6am to 6pm. The horizontal axis must lie in the same plane as the horizontal frame, that is, it must be parallel to the dial plane. The rod carrying the hour pointer must be in line with the split horizontal axis, and where these two would cross, corresponds to the nodus of the sundial being drawn.

Also passing through this point is a long and perfectly straight rod with a short rod turned to a sharp point fixed at its bottom end. This long rod slides through a coupling and two collars held in line by 2 inch narrow strips, and is the telescopic arm referred to previously.

The movements of all the adjustable parts are lockable by means of small pinion wheels fixed to long or short threaded pins carried in couplings or cranks forming the bearings of the rods carrying the dial pointers. The latter are fashioned from scraps of aluminium sheet, cut, trimmed, drilled, and then bent to shape as required; there are no suitable Meccano parts which provide the necessary precision. The use of Bert Love's precision made brass components is recommended to ensure minimum play in the various movements. Any movement will necessarily cause loss of accuracy in the marking out.

The initial setting and correctness can be checked by setting all the scales to zero, when the telescopic arm should be perpendicular to the dial plane. This can be checked with a set square in two planes at right angles to other, or other suitable means. The short pointed rod and coupling should be removed for obtaining the most accurate observation.

EDITOR'S NOTE:
An old photographic enlarger would be ideal for providing the foundation of this useful device, which is not limited to the marking out of regular surfaces. The telescopic arm, being set to the direction of the sun's rays any particular moment in time by the calibrated dials, removes the need to carry out any calculation of any of the required lines. It is a very ingenious solution to what would otherwise be a difficult exercise in the case of curved or irregular surfaces.

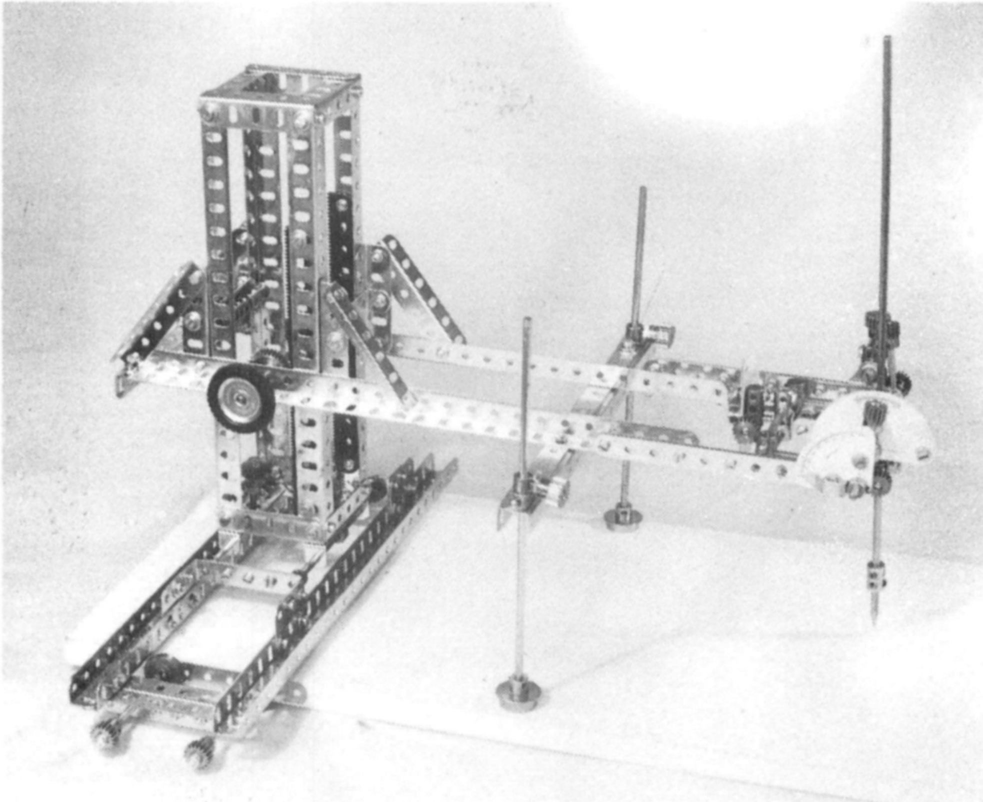


FIGURE 1 The Ta'Bois Sundial Drawing Jig set up for drawing the hour and declination lines for a horizontal plane sundial.

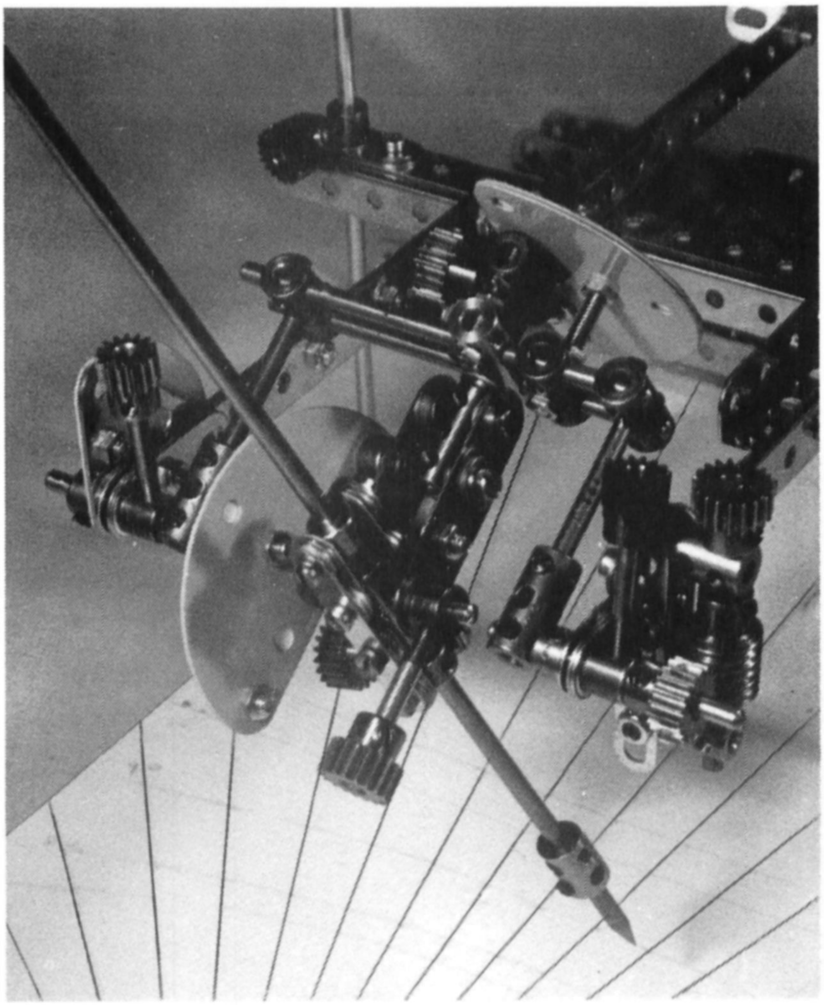
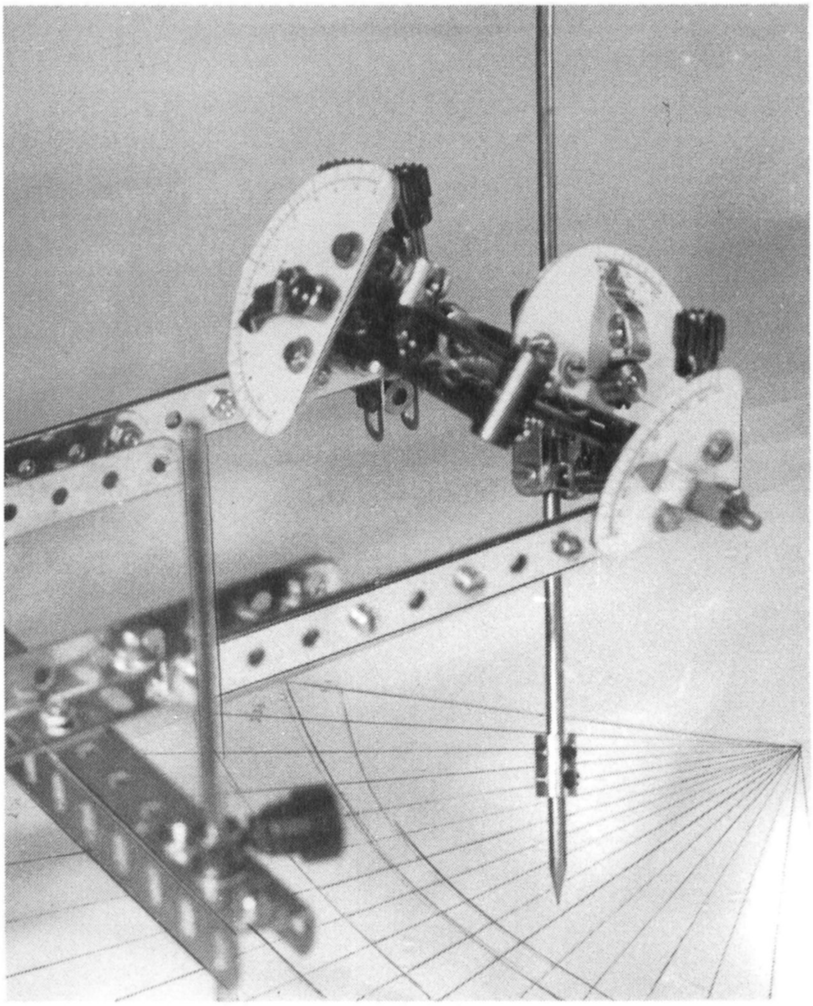


FIGURE 2 A close-up view of the setting head.

FIGURE 3
The three scales for setting the telescopic arm, the uppermost dial is for the hour angle and is marked 6-12-6 at equal angles of 15 degrees, the declination scale moves the telescopic arm 23.5 degrees on the latitude set by the dial on the right-hand side.



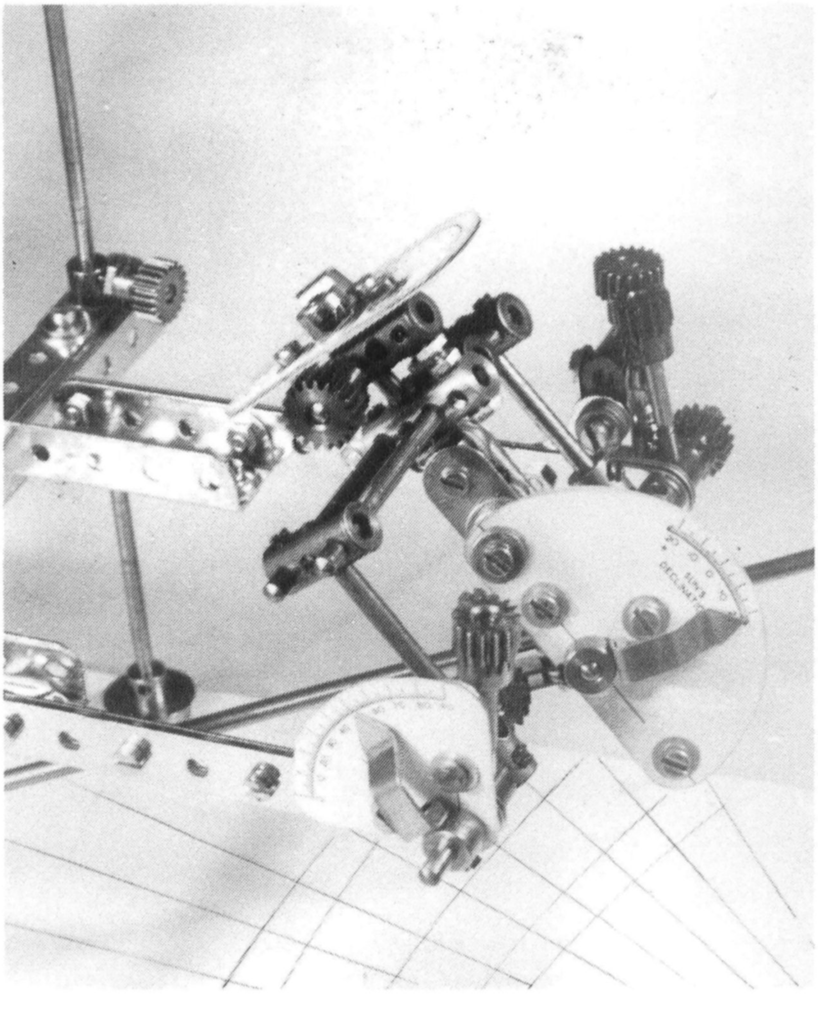


FIGURE 4 The declination and latitude scales of the setting head.

HIS MAJESTY'S DIALS IN WHITEHALL GARDEN

PART II

TEXT MODERNISED BY CHARLES K. AKED

Continued from page 35 of Issue No. 92.2, June 1992

THE
DESCRIPTION
AND VSE OF
HIS
MAIESTIES
DIALS
IN
WHITE-HALL
GARDEN.

LONDON,
Printed by BONHAM NORTON and
IOHN BILL, Printers to the Kings
most Excellent Maiestie.
MDCXXIV.

Title Page from Edmund Gunter's treatise of 1624.

3. TO FIND THE AZIMUTH OR POINT OF THE COMPASS WHEREON THE SUN BEARS, FOR ALL HOURS OF THE DAY, AT ANY TIME OF THE YEAR.

The time of the year is here represented by the red parallel lines of declination; the time of the day by the black hour-lines. First find where these two meet, and then see which of the blue lines would pass through that intersection; the distance of the blue line from the line of East or West will give the Azimuth required.

As, if the day proposed were the sixth day of April, and it is required to know the Azimuth whereon the sun bears at 9 hours 45 minutes in the morning. This month is found on the West part of the Concave, and the parallel of declination drawn up to the sixth day of this month is about 10 degrees distant from the Equator. This parallel crosses the hour-line of 9 hours 45 minutes in the middle between two blue Azimuth lines, and following this middle to the Margin, I find there that it directs me to the point N W in the inner circle; and so to 45 degrees from the West in the middle circle of the Margin, which shows that the sun is in the opposite point 45 degrees distant from the East, upon the South-East point of the compass.

4. TO FIND THE HOUR AND THE MINUTE WHEN THE SUN SHALL COME TO ANY AZIMUTH, AT ALL TIMES OF THE YEAR.

As, if it is required to know at what hour the sun would be in the East on the longest day in the year. The sun rises in the East at VI in the morning and sets in the West at VI in the evening about the tenth of March, and the thirteenth of September: but at all times of the year, it will be past VI in the morning before he comes to the East, and he will be past the West before VI of the clock in the evening. As here the Tropic of Cancer, which is the parallel of the longest day crosses the West Azimuth at 7 hours 22 minutes in the morning; and such is the time of the sun's coming to the East.

5. TO FIND THE DAY OF THE MONTH WHEN THE SUN COMES TO ANY POINT OF THE COMPASS AT ANY HOUR PROPOSED.

As, if it is required to find the day of the month when the sun shall come to due East at VII in the morning; I shall find that the hour-line of VII in the morning crosses the West Azimuth at the parallel of 18 degrees of North declination, and this parallel leads me to the first of May on the West side, and to the twenty-second of July on the East side of the Concave: which shows that the sun will be due East at seven in the morning, and due West at five in the evening, both on the first of May, and the twenty-second of July.

THE USE OF THE YELLOW LINES

The yellow lines are, all of them, lesser circles drawn upon the same centre in the bottom of the Concave; and so parallel one to the other representing the parallels of altitude, commonly called by the Arabian name, Almucantars. There are sixty-two of these; and they are numbered both at the meridian and at the Tropic of Cancer in yellow figures with 5, 10, 15, &c, according to their distance from the horizon, which is represented here by the edge of the Concave. The use of them is,

1. TO FIND THE ALTITUDE OF THE SUN ABOVE THE HORIZON.

When the sun shines, observe the shadow of the style that falls among the yellow parallel from the horizon will give the parallel of the sun's altitude above the horizon. As, if the shadow of the top of the style falls on any part of the tenth parallel, it shows the sun to be at 10 degrees of altitude above the horizon. And so in the rest.

2. TO FIND THE ALTITUDE OF THE SUN FOR ANY DAY AND HOUR PROPOSED.

3. TO FIND THE ALTITUDE OF THE SUN FOR ANY DAY AND AZIMUTH PROPOSED.

4. TO FIND THE ALTITUDE OF THE SUN FOR ANY HOUR AND AZIMUTH PROPOSED.

These and similar propositions, with their converses, depend upon the meeting of the yellow lines at the intersection of any two of the other lines described earlier.

As, if it is required to find what altitude the sun will be on the sixth day of April at nine o'clock in the morning. First find the parallel of declination belonging to the day, and its intersection with the hour of nine in the morning; there you will find the yellow line drawn through this intersection to be nearly 35 degrees distance from the edge of the Concave; and such will be the altitude of the sun above the horizon at the time proposed. The same reasoning holds for all the rest.

THE USE OF THE GREEN LINES.

It was the manner of the Ancients to divide the day into twelve hours, and the night into another twelve hours, but the hours of the day were commonly either longer or shorter than the hours of the night, and the Summer hours always longer than the Winter hours: whereupon they are called the old, unequal, and (by some) the Planetary hours. These hours for the day are here represented by the green lines, and are numbered in green figures by 1, 2, 3, 4, etc, at the Tropic of Capricorn. The use of them is,

1. TO FIND THE OLD, UNEQUAL HOUR OF THE DAY.

When the sun shines, observe the shadow at the top of the style among the green lines, the next line after the shadow will give the hour required. As, if the shadow shall fall between the horizon and the green line noted with 1, it is the first hour; if between the first hour-line and the second, it is the second hour; if it falls direct on the second hour, it is the second hour complete, according to the account of the Ancients.

2. TO COMPARE THE OLD UNEQUAL HOURS WITH THE HOURS OF THE CLOCK.

As, if it is required to know what hour of the day it would be at nine o'clock in the morning upon the longest day. First find the parallel of the day and its intersection with the hour of IX, then you will find this intersection to fall between the third and the fourth of the green lines, and so it is the fourth hour of the day. For when the days are at the longest with us, the first hour begins at III of the

A Table for the Houre and Minute of the Sunne-

Day	Ianuary Ho.	Ianuary Mi.	February Ho.	February Mi.	March. Ho.	March. Mi.	April. Ho.	April. Mi.	May. Ho.	May. Mi.	Iune. Ho.	Iune. Mi.
1	3	59	4	47	5	42	6	44	7	37	8	10
2	4	1	4	49	5	44	6	45	7	38	8	11
3	4	2	4	50	5	46	6	47	7	40	8	11
4	4	3	4	52	5	48	6	49	7	41	8	11
5	4	4	4	54	5	50	6	50	7	43	8	12
6	4	5	4	56	5	52	6	51	7	44	8	12
7	4	6	4	58	5	54	6	53	7	46	8	12
8	4	7	5	0	5	56	6	55	7	47	8	12
9	4	8	5	2	5	58	6	57	7	48	8	13
10	4	10	5	4	6	0	6	59	7	49	8	13
11	4	11	5	6	6	2	7	1	7	51	8	13
12	4	13	5	8	6	4	7	3	7	52	8	13
13	4	14	5	10	6	6	7	5	7	53	8	13
14	4	16	5	12	6	8	7	7	7	55	8	13
15	4	17	5	14	6	10	7	9	7	56	8	13
16	4	19	5	16	6	12	7	11	7	57	8	12
17	4	20	5	18	6	14	7	13	7	58	8	12
18	4	22	5	20	6	16	7	15	7	59	8	12
19	4	24	5	22	6	18	7	16	8	0	8	11
20	4	25	5	24	6	20	7	18	8	1	8	11
21	4	27	5	26	6	22	7	20	8	2	8	10
22	4	29	5	28	6	24	7	22	8	3	8	10
23	4	30	5	30	6	26	7	24	8	4	8	10
24	4	32	5	32	6	28	7	25	8	5	8	9
25	4	34	5	34	6	30	7	27	8	6	8	9
26	4	36	5	36	6	32	7	28	8	6	8	8
27	4	38	5	38	6	34	7	30	8	7	8	7
28	4	40	5	40	6	36	7	32	8	8	8	6
29	4	41			6	38	7	34	8	9	8	5
30	4	43			6	40	7	35	8	9	8	5
31	4	45			6	42			8	10		

setting for euery day in the yeere.

Iuly. Ho.	Iuly. Mi.	August Ho.	August Mi.	Septemb. Ho.	Septemb. Mi.	October. Ho.	October. Mi.	Nouemb. Ho.	Nouemb. Mi.	Decemb. Ho.	Decemb. Mi.	Day.
8	4	7	22	6	23	5	24	4	26	3	50	1
8	3	7	20	6	21	5	22	4	25	3	50	2
8	2	7	18	6	19	5	20	4	23	3	49	3
8	1	7	16	6	18	5	18	4	21	3	49	4
8	0	7	14	6	16	5	16	4	20	3	48	5
7	59	7	13	6	14	5	14	4	18	3	48	6
7	57	7	11	6	12	5	12	4	16	3	48	7
7	56	7	9	6	10	5	10	4	15	3	47	8
7	55	7	7	6	8	5	8	4	13	3	47	9
7	54	7	6	6	6	5	6	4	12	3	47	10
7	53	7	4	6	4	5	5	4	11	3	47	11
7	52	7	2	6	2	5	3	4	10	3	47	12
7	50	7	0	6	0	5	1	4	8	3	47	13
7	49	6	58	5	58	4	59	4	7	3	47	14
7	48	6	56	5	56	4	57	4	5	3	47	15
7	46	6	54	5	54	4	55	4	4	3	47	16
7	45	6	52	5	52	4	53	4	3	3	48	17
7	44	6	50	5	50	4	51	4	2	3	48	18
7	42	6	48	5	48	4	49	4	0	3	48	19
7	41	6	46	5	46	4	47	3	59	3	49	20
7	39	6	45	5	44	4	46	3	58	3	49	21
7	38	6	43	5	42	4	44	3	57	3	50	22
7	36	6	41	5	40	4	42	3	56	3	50	23
7	35	6	39	5	38	4	41	3	55	3	51	24
7	33	6	37	5	36	4	39	3	54	3	52	25
7	31	6	35	5	34	4	37	3	54	3	53	26
7	30	6	33	5	32	4	35	3	53	3	54	27
7	28	6	31	5	30	4	33	3	52	3	55	28
7	26	6	29	5	28	4	31	3	51	3	56	29
7	25	6	27	5	26	4	30	3	51	3	57	30
7	23	6	25			4	28			3	58	31

Sample pages from Edmund Gunter's treatise.

clock and 47 minutes in the morning, and ends at V and 9 minutes. The second hour begins where the first ended and is complete at VI and 31 minutes. The third hour is complete at VII and 53 minutes. The fourth at IX and 15 minutes. The fifth at X and 37 minutes. The sixth hour always ends at high noon, and the rest in like order; each of these twelve hours being equal to 1 hour 22 minutes of the clock.

At the two equinoctial days, when the sun rises at six and sets at six, these hours of the day will be equal to the hours of the clock; but in the depth of winter one of these hours will be but 38 minutes of a common hour.

THE USE OF THE CIRCLE OF THE AGE OF THE MOON.

The circle drawn at the root of the style, divided with black strokes into 29½ divisions, represents the age of the moon; the other circle within it, divided with white strokes into 24, represents the hours of the day, and being continued would agree with the hour lines between the Tropics. The use of these circles is,

1. KNOWING THE AGE OF THE MOON, TO FIND THE TIME SHE COMES TO THE SOUTH.

First find the age of the moon in the outer circle, and the next hour line in the inner circle will give you the time when she comes to the South. Thus you may find that if the moon is ten days old, she will be in the South at eight of the clock in the evening. If fifteen days old, then about twelve of the clock at midnight. If twenty-five days old, then at eight in the morning. And upon this it follows:

2. KNOWING THE AGE OF THE MOON, TO FIND THE TIME WHEN IT WILL BE HIGH WATER.

First enquire what difference there is between the time of the moon's coming to the South and the time of high water, for that once known is known for ever. For example, it is commonly said that when the moon comes to the South-West, it will be high water at London Bridge; and this is about three hours after her coming to the South. And again when she comes to the North-East, which is about three hours after her coming to the North part of the Meridian. Suppose then that the moon is ten days old, then she will be in the South by the former proposition at eight in the evening, or in the North at eight in the morning, add to this three hours more, and it will be high water at eleven of the clock.

3. KNOWING THE AGE OF THE MOON, TO FIND THE HOURS OF THE NIGHT, BY THE SHADOW OF THE STYLE.

The hour of the moon from the Meridian may be found out at any time when the moon shines, by the shadow of the style, in the same way as we find the hour of the day when the sun shines. For if the moon be in the South, she will cast the shadow of the style upon the hour of XII, and if she casts a shadow upon I, or II it shows she is accordingly either one hour, or two, or more past the Meridian. Suppose the moon to be ten days old, and that she casts a shadow upon the hour of V after noon, I would then say it is about one of the clock in the morning - For the moon being ten days old, she comes to the South at VIII in the evening, and therefore when she is five hours past the South, it must be I in the morning.

THE DESCRIPTION AND USE OF THE FOUR CORNER DIALS.

The four triangular dials at the corners of the stone decline from the prime vertical and incline to the horizon. In these the black lines shew the ordinary hours, the red lines show the summer, winter and the equinoctial shadow. If the shadow of the top of the style falls upon the middle red line noted with ♈ and ♎ the sun is in the Equinoctial. It falls upon the line noted with ♋, in the height of summer, and upon the line noted with ♑ in the depth of winter.

1. The blue lines at the North-East corner, noted with 1, 2, 3, 4, etc, show the hours from the sun's rising. The shadow of the style will fall upon the line of 1 at one hour after the sun's rising and upon the hour of two when the sun is two hours high in the East.

2. The blue lines at the North-West corner, noted with 1, 2, 3, 4, etc, show the hours from the sun's setting. The shadow of the top of the style will fall upon the line of 2 when the sun is two hours high in the West, and upon the line of 1 when the sun is one hour from setting.

THE DESCRIPTION AND USE OF THE DIALS ON THE SOUTH SIDE OF THE STONE.

The South side of the stone has many dials. One great vertical dial. Two equinoctial dials where the sun never shines except in winter. One vertical concave in the middle. Two declining dials on either side of this concave. Two small polar concaves. Two irregular dials with three styles in each dial.

Of these, the equinoctial, the decliners, and the irregular dials have only black lines to show the ordinary hours, but the great vertical and the three concaves, as they have lines of different colours, so they are such as were not on the former stone [previous sundial].

The lines drawn on the great vertical may be known and distinguished in this manner. The Equator, the Tropics and the Parallels of the length of the day are all drawn in red lines; the hour-lines from the sun's rising in yellow; the Italian hour-lines from the last sun-setting in blue. And so much is there indicated in four Latin verses:

Vmbrarum metas, Occasum *Solis* et Ortum,
Et quam longa dies, *Linea rubra dabit*:
Flaua, à Sole oriente *horas*; à Sole cadente,
Cæerulea, *Italico*, Linea, *more, notat*.

THE USE OF THE RED LINES IN FINDING.

1. The Length of the Day.
2. The Time of the Sun's rising.
3. The Time of the Sun's setting.

All variety of shadows is bounded between the two extreme red lines. The uppermost noted with ♑, represents the Tropic of Capricorn, and when the shadow of the top of the style falls on this line, the sun is at its lowest and the days are shortest.

The lowermost noted with ♋, is the Tropic of Cancer, when the shadow comes to this line, the sun is at its highest and the days are longest. The other red lines, noted in the middle with 8, 9, 10, 11, 12, 13, 14, 15, 16, are parallels of the length of the day.

The straight line drawn in the middle, noted with and ♎, is the Equinoctial. Upon this line is written, 6 at one end, 12 in the middle, and 6 at the other end. This shows that when the shadow of the top of the style falls on this line, the sun is in the Equinoctial, the length of the day is twelve hours, the sun rises at VI and sets at VI. In like manner, if the shadow falls upon the line noted with 10, it shows that the length of the day is ten hours, the sun rises at VII in the morning and sets at V in the evening.

At the end of these red lines are the signs and the months, thereby to show the place of the sun and the time of the year. As, at the one end of the Equinoctial there is the sign of Aries and the month of March; at the other end the sign of Libra and the month of September; which shows that in these months the sun will be in these signs, the shadow will fall on these parallels, and there show the length of the day as before. *Et è converso.*

THE USE OF THE YELLOW LINES; IN SHOWING THE HOURS PAST SINCE THE SUN-RISE.

The straight line drawn between the blue and the white grounds represents the horizon, for when the sun comes to the horizon, either at rising or setting, the shadow of the top of the style will fall upon this line. The yellow lines noted with 1, 2, 3, 4, etc, show the hours after sunrise, according to the distance from the horizon. As, if the shadow of the top of the style falls on any part of the yellow line noted with 1, it shows that the sun is an hour high, if on the like line noted with 2, then two hours have passed between that and the sun's rising.

THE USE OF THE BLUE LINES IN SHOWING THE HOURS PAST SINCE THE LAST SUNSET.

In Italy (as travellers say) the clock strikes twenty-four at sunset, at one hour after, it strikes one, and then two, three, and so forward until the next sunset. So that if the day should be eight hours long, it will strike sixteen at sunrise, and twenty at high noon. These hours are here represented in blue lines. As if on the tenth of our April at X of our clock in the morning, you observe the shadow of the top of the style, you will find it to fall among the red lines on the parallel of 14, on the line of 5 among the yellow lines, and on the line of 15 among the blue lines; which shows that the length of that day is 14 hours, and the time of day 5 hours from sunrise, and 15 hours from the last sunset.

In vertical concave, at the middle of the South side of the stone, this verse is written: *Horæ vulgares, & Signa in culmine coeli.* [Ordinary hours and the Sign in the Meridian.]

The lines drawn there are of three kinds. The common hour-lines are drawn in black, the Equator and Tropics in red, as in the other dials. The other lines noted with ♈, ♉, ♊, etc, are the lines of the twelve zodiacal signs

TO SHOW, WHICH OF THE 12 SIGNS IS IN THE MERIDIAN.

All the twelve signs pass by the meridian in 24 hours, but unequally, some in less time than two hours, some in more. When the sun shines, observe where the shadow of the top of the style falls among these lines of signs, for that shows the sign which is then in the South, and so passing the meridian. As the sun, being in the equinoctial at IX of the clock in the morning, the shadow falls upon ♒ and ♑. If the sun is in ♈, then the sign of ♒ is in the meridian. If in ♎, then it is the sign of ♑. But when the sun comes to the Tropic of Cancer, that shadow will fall, at IX in the morning, upon the sign of ♉, and that is the sign which is in the meridian.

In the two polar concaves on the South side of the stone are lines noted with these words, *Aequalis, Dupla, Tripla, Quadrupla,* etc. The use of them is:

TO SHOW THE PROPORTIONS OF SHADOWS TO THEIR BODIES.

As, when the shadow of the top of the style falls upon the line noted with *Aequalis*, the shadow of a man, upon level ground, is then equal to his height. When it falls upon the line noted with the word *Dupla,* then his shadow is twice his height. And so for the rest. The proportions being thus known, you may take the length of the shadow and so find the height of the body when it cannot otherwise be so easily measured.

THE DESCRIPTION AND USE OF THE DIALS ON THE NORTH SIDE OF THE STONE.

The sun shines on the North side of the stone only in the summer, and then early in the morning before it shines on the South side; or late in the evening after it has left shining on the South side. And therefore I have drawn here such lines as may answer to them on the South side. In the vertical concave on this North side, the red lines show the signs and the place of the sun; the blue lines noted with *Dupla, Tripla, Quadrupla,* etc, show the proportion of shadows to their bodies. In the two side inclining dials, the red lines note with 16, 15, 14 etc, serve to show the length of the day, and the blue lines the hours from sunrise and sunset.

THE DESCRIPTION AND USE OF THE DIAL ON THE EAST AND WEST SIDES OF THE STONE.

The sun shines on the East side of the stone only in the morning, on the West side only in the afternoon, and not on both at once, and therefore I have made them one answering the other. Either side has four great dials of severall forms: a Meridan Plane, a Meridian concave, a Meridian cylinder dial, and a square hollow dial of many sides. Over the meridian plane, on one side, these verses are written, showing the use of the lines according to their colours.

Horas antiquas, *Viridis; Rubra linea,* Signa
Monstrat; Cæruleus, nautica puncta, *color.*

On the other side, these verses, to the like effect:

Cæruleo, dantur communes Azimuth; Horæ
Antiquæ, *Viridis,* Signa *colore* rubro.

The red lines here represent the sign and place of the sun. For the sun shining, the shadow of the edge of the top of the style falling among the black lines will show the ordinary hours, and the shadow of the lower point of that edge falling among the red lines will show the sign of the place of the sun, according to the characters ♈, ♉, ♊, ♋, etc, noted in the *ellipsis.* The green lines show the old unequal planetary hours, dividing the day into twelve equal parts; for the green lines which follow next after the shadow, will give the hour required. The blue lines, noted with E, E b S, E S E, etc, show the common azimuths, or (as Seamen call them) the points of the compass, whereon the sun bears from us. For if the point of the shadow falls upon the line noted with E, the sun is in the East; if it falls on the line noted with E b S, then the sun bears from us East by South.

In the square hollow dials of many sides, the black lines show ordinary hours, and the red lines represent the Equator and the parallels of declination. For here, if the sun's beams pass through the little hole in the side of the square and fall upon any part of the red line 20 degrees above the equinoctial line, the declination of the sun is 10 degrees to the southward; if on 20 degrees below the equinoctial line, the sun is 20 degrees from the Equator northward.

In the meridian concave on the East side of the stone is written this verse, Horæ vulgares, *at* ascendentia Signa. [Ordinary hours and ascending signs.]

In the meridian concave on the West side, Horæ vulgares & descendentia Signs. [Ordinary hours and descending signs.]

The lines drawn here are of three sorts: The common hour-lines are drawn in black, the Equator and Tropics in red, as in the other dials. The other lines noted with ♈, ♉, ♊, ♋ etc, are the lines of the twelve signs.

TO SHOW, WHICH OF THE 12 SIGNS IS AT THE HORIZON.

All the twelve signs rise and set in 24 hours but unequally, some are near three hours in rising, others rise in less time than an hour. Here it suffices only to observe the top of the style, for it will fall upon the sign which is rising, if the sun shines on the East Side; or upon the sign which is then descending if the sun shines on the West side of the stone.

In the meridian cylinders are two geographical tables, one on the East side of the stone of such places as are East or London. The other on the West side of such places as are West of London. And these are described according to their Latitude and Longitude in such a way, that the same lines which show the hour of the day, also show the difference longitude. The use of them may be,

1. TO SHEW THE TIME, WHEN IT IS NOON IN ANY OF THOSE COUNTRIES.

Such places as lie East from London have noon before us, such as lie West from London have noon after us. But to find the time more particularly, observe the shadow of the style which shows the hour of the day, for when that comes over any place in the chart, then it is noon in that place. Thus the shadow of the style coming to the meridian of Jerusalem at the hour of IX in the morning shows that it is noon in Jerusalem, when it is but nine of the clock in London.

2. TO SHOW THE TIME OF THE DAY AGREEING TO ANY OF THOSE COUNTRIES.

First find the meridian of the proposed place, then see where the shadow falls, so the distance in hours between the shadow and that meridian will give the time of the day required. As if, it being noon at Rome and Venice at such time as it is about eleven of the clock at London, and that there is two hours difference between the meridian of Rome and the meridian of Jerusalem, and therefore at Jerusalem it is two of the clock after noon at the time proposed.

And what is here said of the day, the same may be understood of the time of the night. It appears by the former proposition that it is noon at Virginia at such time as it is V of the clock after noon with us at London, and therefore five hours difference between the meridians of Virginia and London; so that I suppose if those in Virginia and we at London could see one the same thing at the same instant of time (as sometimes we may, either the beginning or end of an eclipse of the moon), if we see it at midnight, they should see it at VII of their clock in the evening; or if they see at VIII in the evening, we shall see it at one in the morning.

These and such like, are the uses of these dials: If too obscurely delivered your Majesty may command the Author.

F I N I S.

Note: Edmund Gunter's treatise was re-published in facsimile in 1972 by Theatrvm Orbis Terrarvm Ltd, Amsterdam; and De Capo Press, New York. It was reproduced from the copy of the work in the British Library and made available as Number 465 in "The English Experience" series. It was available at the bookstall in the Museum of the History of Science, Oxford, until recently and there may be copies available elsewhere. However the reprint is very difficult to read by those unused to archaic texts, and there are occasional words missing and some quite faint. Thus, although the presentation here is not literal, the information is accurately rendered and much more understandable.

COMPUTER PROGRAM FOR DIAL CALCULATIONS

The program prepared by Mr Fer de Vries is again available, and he has very kindly allowed it to be sold to BSS members, the proceeds going to the British Sundial Society funds. The program is no longer supplied by Mr Peter Scott (see page 4 BSS Bulletin 90.2). The program will run on IBM compatible systems, but the drawing function requires a graphic adapter (CGA, or EGA/VGA with screen dump). It is available as a $3\frac{1}{2}$in disc or two $5\frac{1}{4}$in discs. The price is £8.50, which includes postage and packing. Four pages of explanatory text prepared by Mr Piers Nicholson will be sent with the discs. The simpler program devised by Mr H C Parr is no longer available but the listing of the program may be found in BSS Bulletin 91.3, page 36. Orders to Charles Aked, 54 Swan Road, West Drayton, Middlesex UB7 7JZ. Please make cheques payable to BSS. Overseas members must include extra for air mail postage and pay in sterling as the cost of conversion at an English bank is about the same as the amount payable.

The Hon. Sir Mark L-B

THE HOLKER DIAL

BY MARK LENNOX BOYD

I am always disappointed that sundial books do not start with a description of the Hemispherium of Berossos, for an understanding of it leads directly to the understanding of other dials. Imagine the Earth reduced in size to that of an orange. Slice the orange along its axis of rotation and gouge out one of the halves. You have a half sphere of orange peel. Insert a gnomon or sharp pointer into this cup so that its tip meets the centre of the circle of the rim. Imagine the cup rotating in 24 hours along the axis down which you first sliced it. You now have the hemisphere of Berossos. The shadow of the tip of the gnomon on the inside of the cup will tell the time. The hour lines are in fact great circles through the poles, like lines of longitude, and set apart every 15 degrees.

The Hemispherium leads immediately to the equatorial dial the most apparent usual differences being that the latter has a gnomon in the form of a rod stretched between the poles, and that the unnecessary bits are cut away. It leads next to the horizontal, vertical and reclining dials for they are planes set tangentially at an approximate angle to the cup and their time lines are formed by projections from the tip of the pointer through the great circles on the cup onto these planes.

The Hemispherium was the first sundial and Berossos made his stupendous invention in about 300 BC. It swept round the Greek World. But it was tricky and expensive to gouge hemispheres out of lumps on stone and later Greek mathematicians determined the plane dials which superceded it.

I had long wanted to make a modified form of Berossos' dial in the shape of a shallow bowl, (rather than a half sphere) and when my friends Lord and Lady Cavendish asked me to design a dial to be made in turned Burlington slate, a thriving business which they own, I saw my opportunity. The Holker dial is so called by me because it is sited at Holker Hall the home of the Cavendish family (Figs 1 & 2). It is mathematically a projection of the hemispherium of Berossos onto a bowl whose cross section is a segment of a circle, with the tip of the gnomon as focus for the projection (Fig 3).

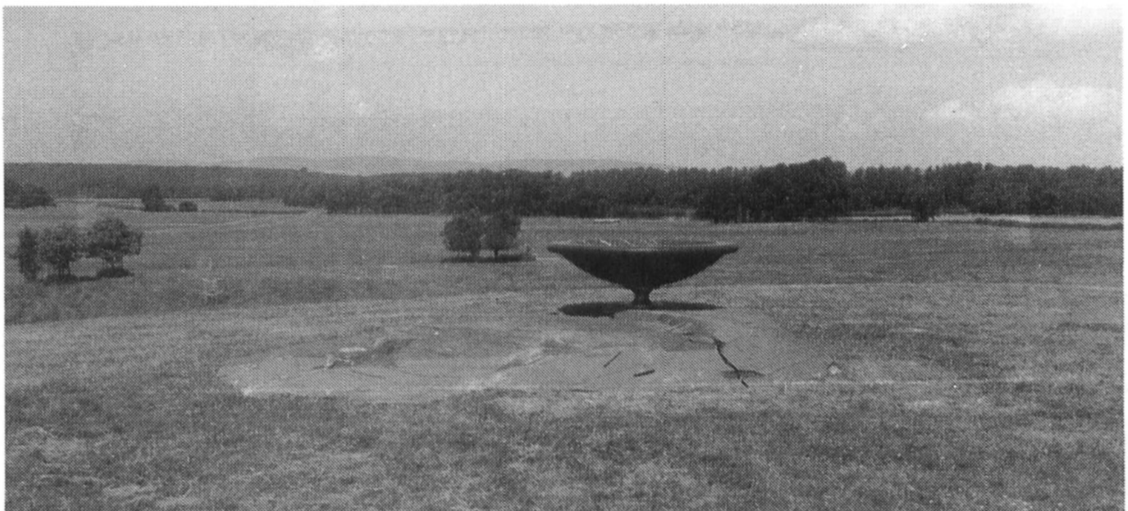
The dial is marked into 15 minutes divisions for time, and for date with the six divisions for the 12 signs of the Zodiac, from Capricorn to Gemini on the West rim as the days get longer, and Cancer to Sagittarius on the East rim as the days get shorter.

The latitude is also marked on the dial, together with a table of corrections for G.M.T. These are a combination of the equation of time and the value for longitudinal displacement and are good to within half a minute. (The dial is also, of course, provided with drainage holes!)

The dial sits on a massive bronze collar which in turn is set on a twelve ton rock of Burlington slate placed (if that be the right word for the final resting of such an object) on the brow of a low hill in a paddock. Robert Sylvester very kindly orientated it for me, for I did not have time to get it ready for the Holker Garden Festival earlier this year. The craftsmen at Burlington faced massive technical problems in making the dial. First the difficulty of turning a piece of slate weighing 17cwt and 155cm in diameter, secondly the problems of calibration, and finally the horror of moving such a massive slate rock for the base. But I judged that the harder might be their task, the greater would be their satisfaction at the result. And so it has proved.

The calibration of the dial posed a challenge to me because it is impossible to draw the curves of this dial on a flat sheet of paper. Therefore instead of a plan, the engravers had tables of computer calculated figures which gave the polar coordinates for the points of every intersection of the curves. The coordinates were: the angle subtended from the centre; and the distance from the centre along the surface of the bowl. The engravers therefore had to draw a giant 360° protractor onto a ring of paper and stick it to the rim of the bowl. They also used a purpose made ruler which stretched across the rim and had a curved section to fit snugly into the curved bowl. With this ruler they marked the angles subtended from the centre and with a flexible steel rule they measured the distance from the centre along the bowl's surface (Fig 4). The method of setting out the dial in this way had been tested by me previously on a $\frac{1}{4}$ scale model. The technique of setting out proved to be surprisingly swift and accurate. The figures the engravers used were calculated to $\frac{1}{100}$ of a degree and $\frac{1}{100}$ of a centimetre. I am sure the engraved result is pleasantly close to these levels of accuracy. Terry Armistead, David Allonby and John Penellum in particular, but all the others also who have been involved in making this dial have every reason to be immensely proud of their enormous craftsmanship.

FIGURE 1:



Holker Hall, Grange-over-Sands, Cumbria is open to the public from April to October (not Saturdays).

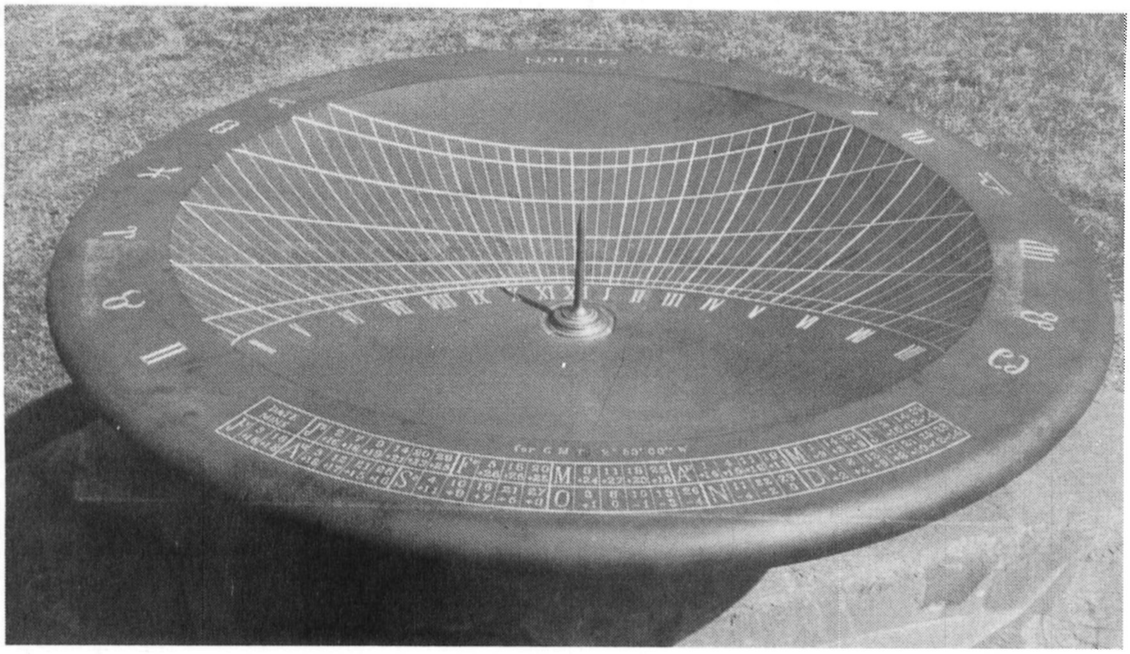


FIGURE 2:

The hour and date curves are highlighted with gold leaf.

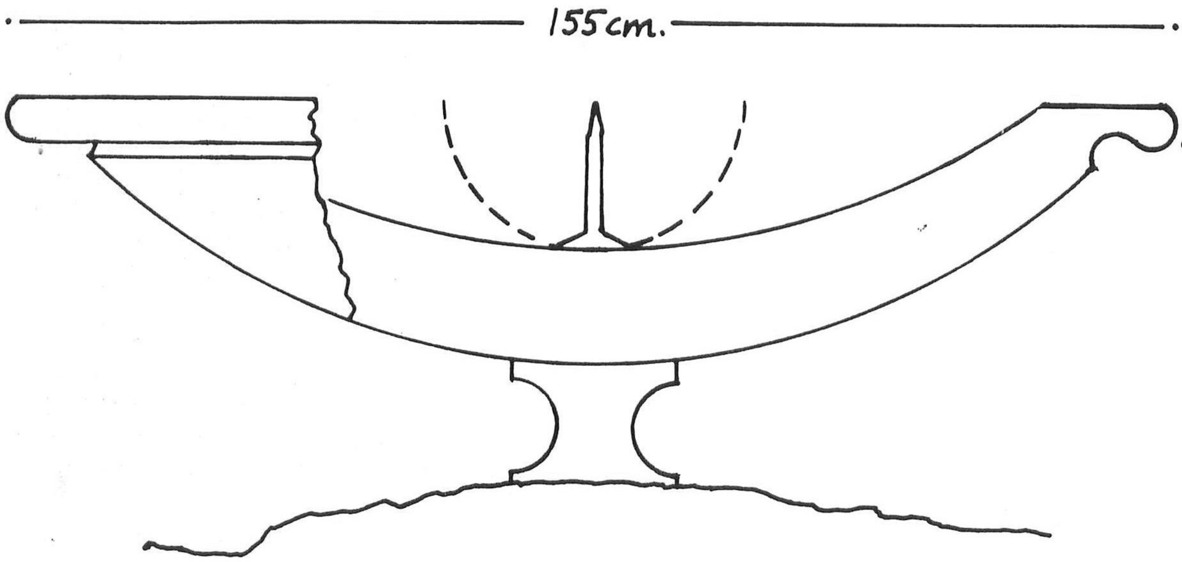


FIGURE 3:

Cross-section of dial with notional hemispherium marked by hatched semi-circle.

FIGURE 4:

Measuring with the flexible steel rule. The paper protractor can be seen round the bowl's rim.

THE PRODUCTION OF THE HOLKER DIAL

COLLATED BY CHARLES K. AKED

INITIAL CONCEPT (contributed by Mr. Harold Ogden, Sales Director, Burlington Slate Limited).

I have been involved with the slate industry since 1950 and have seen a steady growth of the application of the material from the former traditional use of slate for roofing purposes through various stages to architectural uses such as cladding, flooring, copings and sills etc; and on to what may only be described today as designer type items, eg. water features, trophies, garden ornaments etc.

In April 1991 I came across a book on sundials which indicated that natural stone had long been used in the past, with the occasional small dial being made in slate. I thought it would be rather nice if one could produce the largest slate sundial in the world, formed from a single piece of slate. With this in mind, it was necessary not only to find a client with a suitable site but one able to commission such a costly project. Fortunately Lady Cavendish of Holker Hall, whose family control the Burlington Slate Quarries, thought it was an excellent suggestion and could offer a site in the Wild Flower Meadows in the grounds of Holker Hall, Cumbria.

Lady Cavendish asked her close friend Mr. Mark Lennox-Boyd MP if he would be good enough to design a suitable sundial, with a view to testing the capabilities of the Burlington Slate Quarry. The final result is a splendid 5 feet diameter polished blue/grey slate dish, weighing almost a tonne, engraved with hour, declination lines and date, highlighted in gold leaf; which is mounted upon a natural 12 tonne rough slate slab from the same quarry.

The finished result was duly unveiled during the Grand Garden Festival at Holker Hall on June 5th 1992, attended in person by His Royal Highness the Duke of Edinburgh. He was presented with a model of the actual sundial as a memento of his visit.

ACTUAL PRODUCTION (contributed by Mr. T.H. Southward, Production Director, Burlington Slate Limited).

The decision to manufacture the Holker Hall Sundial was decided upon at a meeting at Holker Hall in early February 1992. Terry Armistead, the Architectural Department Manager, was given the task of directing the operations, ably assisted by John Penellum, a most experienced man, both being Cumbrian born and bred. The proposed dial was regarded as a real challenge as it was going to be a very difficult task to bring it to perfection, nothing like it ever having been attempted before.

The initial step was to select a suitable block of slate from the quarry which was large enough to allow the finished size of 1.55 metres diameter and 380mm depth to be achieved, and which did not contain any flaw whatsoever, it had to be 100 per cent fault free.

After an initial search, a block which appeared suitable was located and brought from the quarry floor to the Primary Sawing building. Here the block was sawn into cubic form, 1.7 metres square and 0.5 metres in thickness, before being transported to the Secondary Saw building where the circular shape required was created by rotating the table on which the block rested, and slowly sinking a diamond tipped circular blade until the circular block was formed, see Fig 1.

Next the top of the circular blank was ground flat, Fig 2, leaving the thickness approximately 75mm over the finished design dimension. In Fig 3, the next stage of scooping out the material from the required bowl shape is shown. This difficult task was achieved by using the largest saw with a 2-metre diameter blade, with three men rotating the block on the table by hand, playing water on the blade cut from a hosepipe, and lowering the blade down the central axis of the block approximately 1mm per revolution of the block until the designed depth was reached. The waste material can be seen emerging as a fine spray on the right hand side. Figure 4 shows the block as it emerged after this operation.

The next stage was to profile the under surface to the design created by Mr. Lennox-Boyd. The block was inverted and the desired shape obtained from his drawings by computer control of the cutting tools, Fig 5. Once this had been achieved, the block was machined to the final thickness of 380mm, and the circular sink for the bronze base carved out, Fig 6, before turning the block over again and a hole drilled through the centre to take the bronze gnomon. At the same time a drainage channel was formed, with three weep holes, to enable rainwater to drain from the bowl of the sundial.

The sundial bowl was now very carefully polished by employing small hand-held air-powered polishers using a very fine diamond grit, see Fig 7 for the appearance after this operation. All that now remained to be done was the engraving of the hour and declination lines.

This final operation was undertaken as a two-man task led by Burlington Slate's master stone mason, David Allonby, ably assisted by John Fletcher. This demanding task took a period of two weeks continuous work (see Mr. Mark Lennox-Boyd's outline of the operation, and Figs 8 and 9. Following the hand carving of the lines and letters, these were carefully picked out with gold leaf, see Fig 2 of Mr. Lennox-Boyd's outline.

Meanwhile Lady Cavendish and Mr. Lennox-Boyd had visited Burlington Slate quarry to select a suitable natural piece of stone for the proposed base for the sundial. This posed a further problem as it weighed approximately 12 tonnes, and much too heavy to transport and handle easily on the soft ground at the site at Holker Hall. This problem was solved by cutting the stone into three parts to make it more manageable, before carefully transporting it to Holker Hall. Here the three parts were put back to the original shape on a bed of sand. A flat pad was secured to the surface of the rough rock and the bronze base of the sundial affixed to this, the sundial itself being firmly fixed to the bronze base to prevent any possible movement from people leaning or sitting upon the rim.

The final photograph shows the Duke of Edinburgh being presented with a model of the sundial by Lady Cavendish. Because of the considerably smaller dimensions, the Equation of Time table is not engraved upon the rim, but this illustration clearly shows the elegant lines of Mark Lennox-Boyd's design complemented by the Zodiacal signs. Unlike the usual stone employed by dial markers, slate can be expected to withstand the weather and atmosphere pollution with little change.

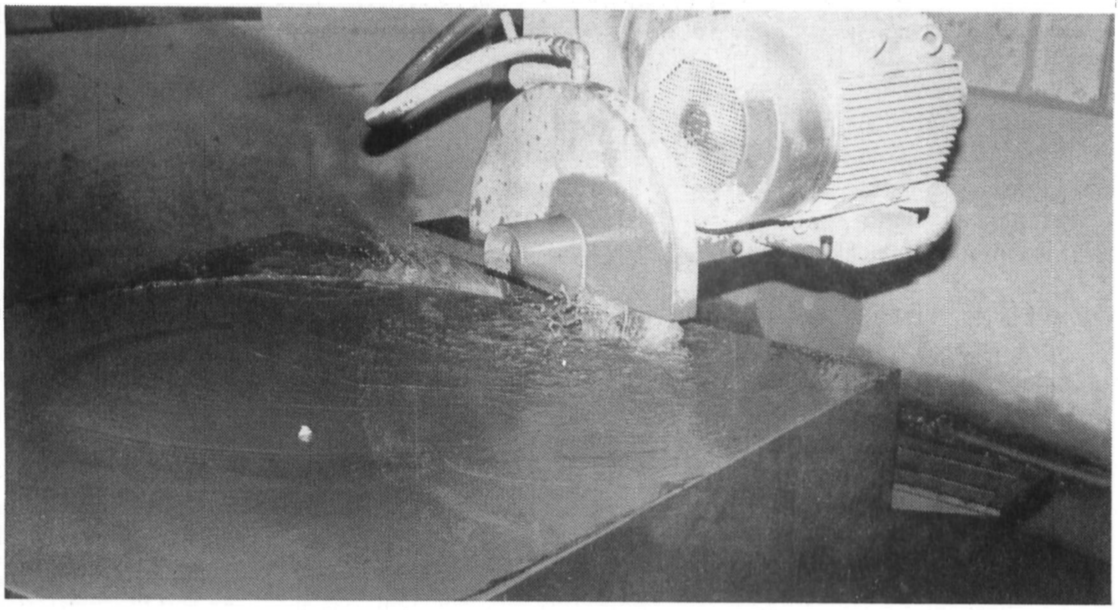


FIGURE 1

Cutting the circular blank by means of a diamond tipped circular saw, the block being rotated slowly against the saw.

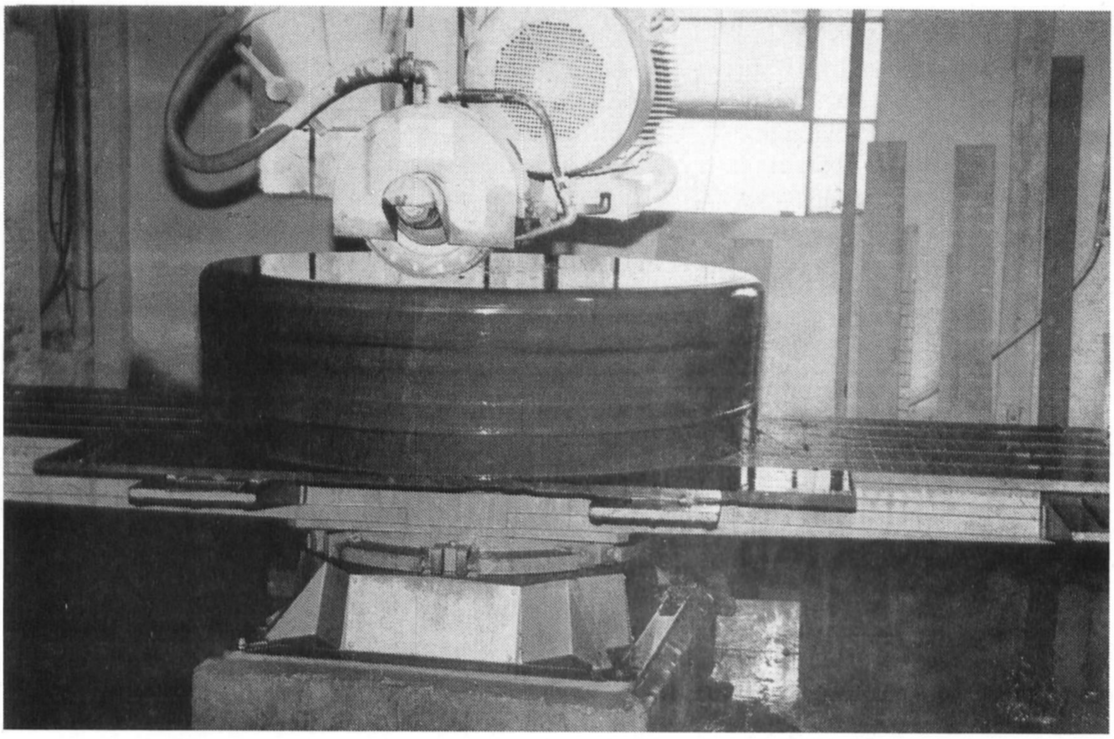


FIGURE 2

Grinding the upper surface of the circular block.

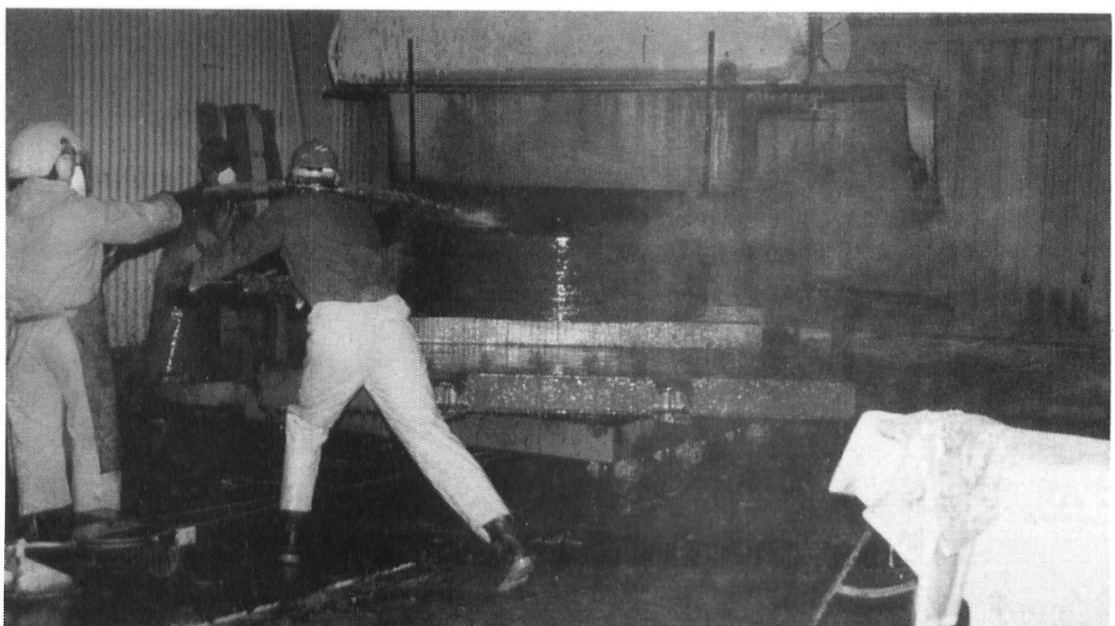


FIGURE 3

Forming the centre of the bowl by means of a large circular saw blade to scoop out the hollow.

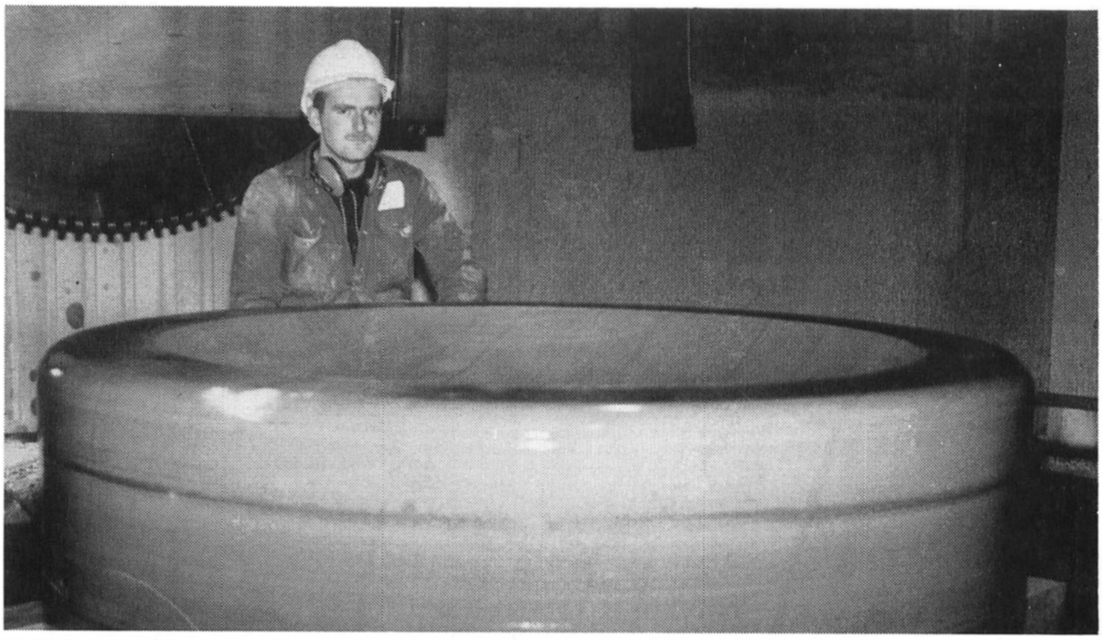


FIGURE 4

The excavated bowl after completion of the hollowing-out operation.

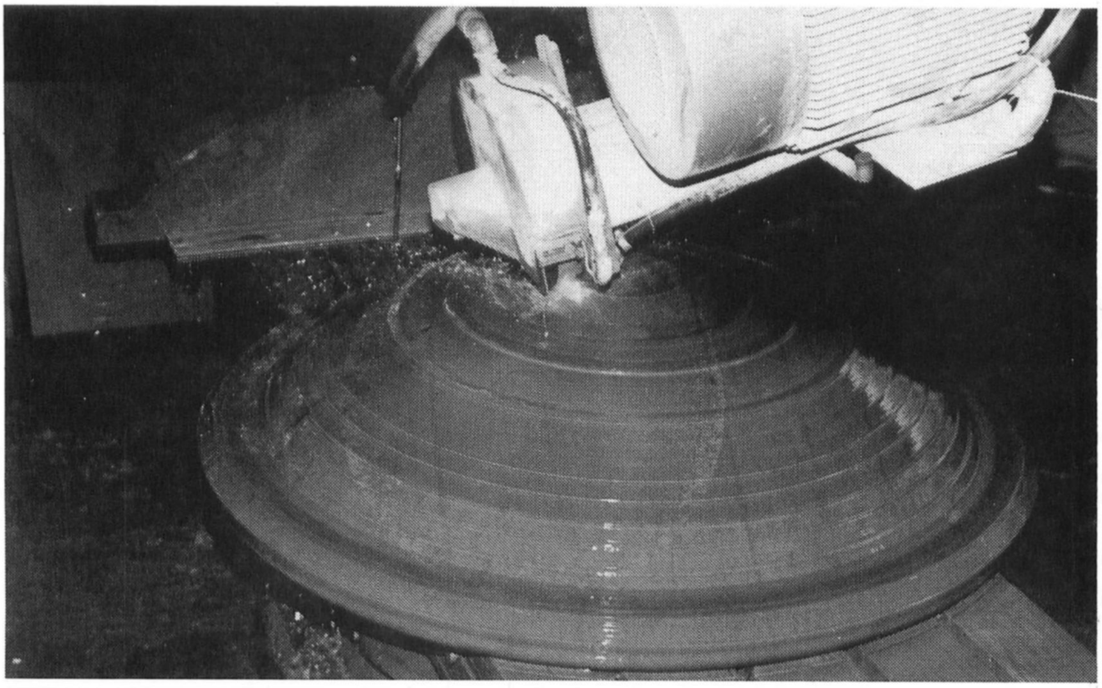


FIGURE 5

Creating the profile of the bowl on the underside.

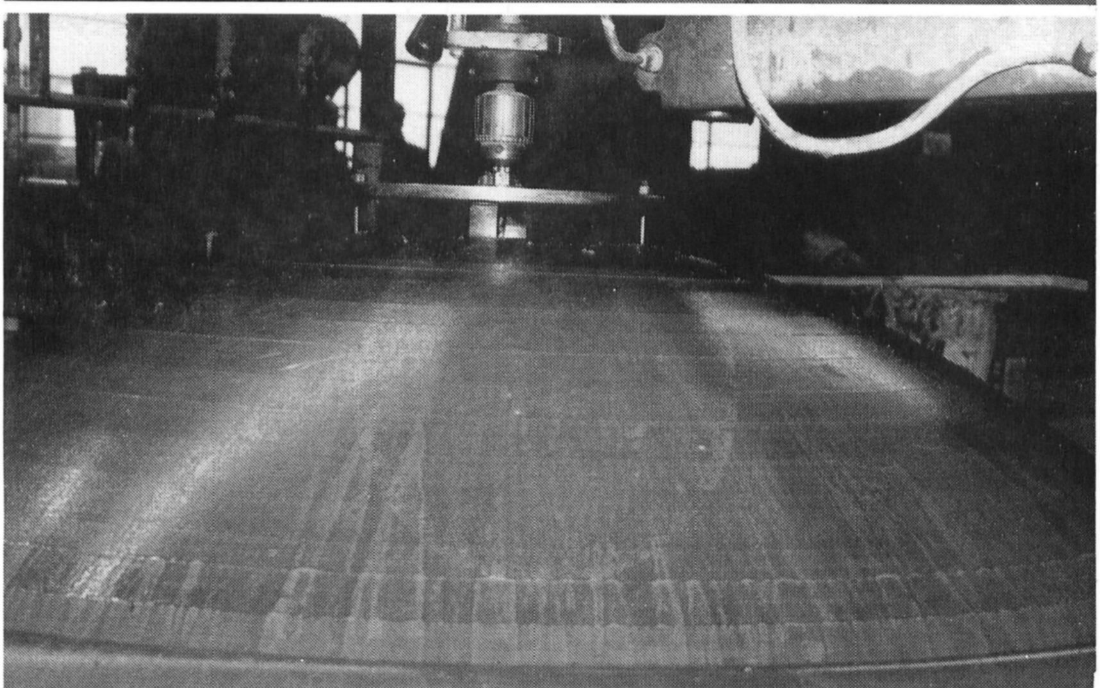


FIGURE 6

Cutting the sink for the bronze base of the sundial.

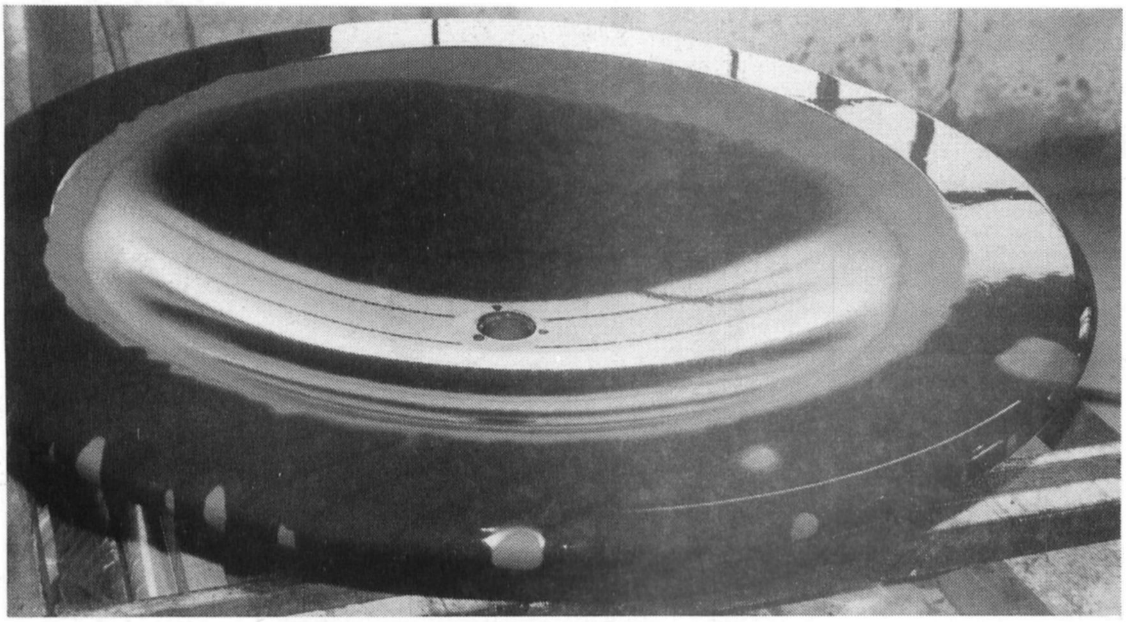


FIGURE 7

The upper surface of the bowl after the polishing operation, the three weep holes for drainage are visible in the centre.

FIGURE 8

Setting out the hour lines by Mssrs Allonby and Fletcher.

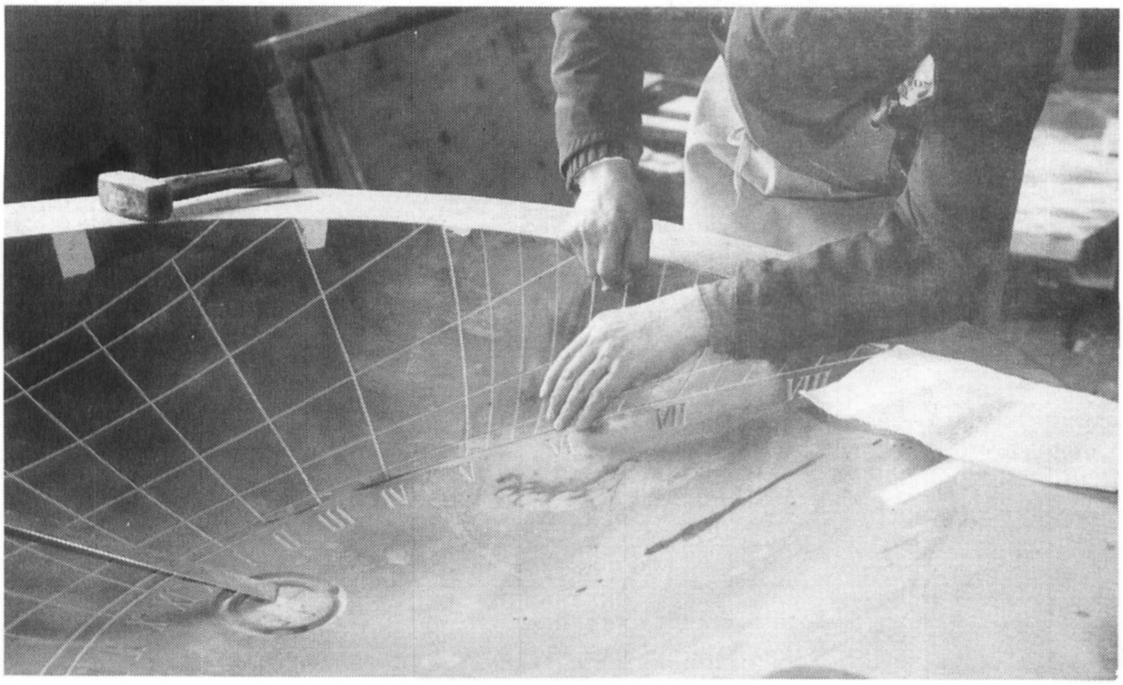


FIGURE 9

Cutting of the various lines by Mr Allonby.

FIGURE 10 Lady Cavendish presenting His Royal Highness the Duke of Edinburgh with the miniature reproduction of the Holker Hall sundial.

THE SECRETARY'S NOTEBOOK

Having recently returned from yet another of our conferences, I am amazed that so many of us with different backgrounds can happily mix together with that one common interest, sundials! Unlike a local society we cannot meet at regular weekly or monthly intervals and apart from contact with each other through the pages of our journal, coming to our meetings is really the only chance of getting to know each other. I am therefore pleased to be able to tell you about three events which are in the pipeline for 1993.

SPRING CONFERENCE

Earlier this year we decided to make our Annual General Meeting into a one day event in London with the aim of attracting a record number of our members. However, although the venue, HQS Wellington moored in the Thames, was ideal and the event was in itself a great success, we actually had slightly less members attending than at our weekend conferences. For 1993 therefore we are returning to a combined AGM and conference in the Spring as we did at Oxford in 1990 and Edinburgh last year. As a National organisation we feel it essential to hold our meetings in different parts of the country and next Spring it will be the turn of the north west of England, Manchester to be precise. You may not think Manchester very exciting, but we plan a sundial safari coach trip and an extended visit to Jodrell Bank which is not far away. We will be able to see the fascinating exhibits at the Visitor Centre and Arboretum and after it is closed to the general public, we shall stay on for lectures, a buffet supper and hopefully a private 'viewing' at the planetarium. Altogether a pretty full day! We will be arranging talks on Friday evening and Sunday morning (including the Andrew Somerville Memorial Lecture) and we will close with the AGM in the early afternoon. I understand that the date has now been fixed for the last weekend in March, that is two weeks from Easter. Details will be sent later but jot that date down now - this is not an event to be missed!

NEWBURY IN THE SUMMER

Following last years successful one day meeting at Newbury organised by David Pawley he tells me that he intends to repeat his efforts again next year probably in June. You will not need to book for this event - just turn up on the day. Again details will be announced later.

AN AUTUMN BREAK IN HOLLAND

Members will remember that last year we invited Dutch members to Queens College, Cambridge. We have now had an invitation for a return visit probably in September. No plans have yet been made, but we are thinking of hiring a coach for a long weekend trip, travelling by overnight ferry to the Hook and giving us three days in Holland. We could tour various sites to see interesting dials/museums as well as spending a day with our Dutch friends at their meeting. If things progress as we hope we will be able to let you know more information, including dates, cost, accommodation, departure points etc. at the beginning of next year. However it is almost certain that we will only be running a single coach limiting our party to 40/50 members and from the show of hands at our Bath meeting, when this possibility was announced, it would seem that we will have no difficulty in filling the coach. In order to make sure of your seat please write to me now, saying you are interested in coming, there will be no obligation on your part but you will be given priority when we later take your booking.

DAVID YOUNG

SUNDIALS AT NEWBURY

It was David Pawley's idea to hold at 'bring and show' day at Newbury, Berks., on Saturday 30th May. The venue was the Baptist Church Hall and approximately forty members, plus wives, husbands and grandchildren attended.

Exhibits varied from the range of Connoisseur dials in brass and bronze to paper, string and chipboard models as encouraged by the Education Group. Computer enthusiasts ran programmes for calculating hour angles, wall declinations, and listing mass dials. Gadgetry on display included a device for measuring altitude and azimuth, and a 'sun simulator' for delineating sundials without the benefit of sunshine.

After lunch there was a short tour of the town dials, followed by an outdoor demonstration in the Baptist Hall car park, for which the sun obligingly shone. There was a chance to try out Allan Mill's light polarization dial as shown at the BSS Annual General Meeting, whilst the Singleton brothers brought a large version of their helical dial mounted on the back of a small truck.

The afternoon session ended with a series of short talks by members on topics as varied as 'How to ensure that a fixed dial remains fixed', and 'Application of astronomical concepts to dialling', followed by questions and general discussions.

Members made their was to Newbury from as far afield as Derby and Coventry. In view of the success of this venture it is hoped that more members will organise events in their own locality. Publicity will be arranged if details are sent to the Editor.

Thanks are due to David, and his wife Beatie, for the planning and organisation of the exhibition which made the day such a success. In response to popular request, the event will be held again in 1993.

EXHIBITION OF SUNDIALS AT JODRELL BANK

The sun shone all day for this event which took place on Sunday 21st June 1992.

The Society has been working with the staff at Jodrell Bank, the site of the large radio telescope in Cheshire, to set up sundials in the Aboretum. A Sunclock designed by David Hunt is already in place, and there are two others which are used for teaching purposes but are normally kept indoors for security reasons.

Dials and models were kindly brought by several members at short notice and set up on the terrace in brilliant sunshine. Dialling books were on show, with information leaflets available in the Environmental Discovery Centre. BSS members were on hand to answer visitors' questions, and to chat amiably about the Society and about sundials in general.

Children, in particular, enjoyed making a sundial from a matchbox and then rushing outside to see if it worked! I am sorry that the event could not be more widely publicised because of shortage of time, but for those members who were able to attend, and for many of the visitors to the Centre, it was an enjoyable occasion.

JANE WALKER

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