The British Sundial Society

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BULLETIN

No. 91.2 JULY 1991

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BULLETIN 91/2 - JUNE 1991 - CONTENTS

DIALOGUE - NEWS ITEM

DE ZONNEWIJZERKRING

Bulletin 91.1 of De Zonewijzerking (Number 41) for January 1991 has 53 pages and gives much evidence of the mathematical approach to dialling. Foreign members are reminded that the subscription of f45 is now due, payment by Euro-cheque or Dutch banknotes to avoid crippling bank charges. An account of the meeting attended by 23 members at Nieuwersluis is given by F J de Vries; and a detailed balance sheet for 1990 by the treasurer. A 2½ page corrigendum is given in respect of the article "Rechte en Schuine Klimming" in *Bulletin* 90.3. There is an article "Noqmaals: De Schuine Klimmings" by W J de Bode which seems to be dealing with the effects of the obliquity of the earth's axis. An illustration showing a shepherd calculating the passage of the night in the 16th century, taken from the *Kalendrier des Bergiers* [Calendar of the Shepherds], is followed by more on "Schuine Klimming". C M La Grouw writes on the terminator on the globe, whilst van der Wyck writes on the rule for parallel displacement for the construction of declining and reclining dials - this has resulted from the correspondence between F J de Vries and George Higgs. The mathematics in this article is not at all well laid out. An article by Folkert A Visser of Spain is a more down to earth essay on sundials, with not a single mathematical symbol in sight. A Time ball description from the journal *De Terschellinger* of 25 October 1990 is given on page 34. Dr Hagan writes of the exhibition devoted to Time at the New Church in Amsterdam and mentions several instruments such as "Little Ship of Venice", a compendium by Humfrey Cole, and so on. In "Toepassen Gnomonica voor Architectuur en Bebouwing" computer generated dial surfaces for declining and inclining dials are dealt with, as does F J de Vries with a dodecahedran [shades of Leonard Digges]. The latter would make an excellent subject for a glass paperweight. Two views of the computer generated surfaces are given. Dr Hagan gives a number of small pieces, including one on the Foucault pendulum and the formula for the horizontal sundial. Under book reviews is the catalogue edited by A J Turner, and mention of the articles on sundials in *Clocks* by Christopher St J H Daniel. Another excellent issue.

Bulletin 91.2, No 42, May 1991, has a colour insert showing a sundial made by Jaap van den Berg in 1748. Details of the summer excursion are given in a separate insert; in the bulletin itself, details of a meeting for 14 September 1991; and a full page on the BSS Cambridge meeting 19-22 September 1991 in conjunction with the British Sundial Society. Congratulations are expressed to Dr Hagen on his election to Vice-President of the BSS. An article by W J de Bode includes horoscopes, followed by dials engraved on glass by Gerard Sonius. Under the heading "Sloping Azimuth Lines" is an article which was inspired by seeing the sundial made by Eise Eisinger in 1801 for Yme Fr. Tigchelaar in Yakum, written by Dr Hagen, with an English summary. In conjunction with Fer de Vries and van der Wyck, their computer modelling found that the dial should have an inclination of 91·66° and a declination of 9·19°. The vertical sundial in Albert Park, Middlesborough, England, is described by Th van Rhijn. It was made by John Smith of Stockton-on-Tees in 1872. Two pages are devoted to the details of the BSS Second Annual Conference at Edinburgh in glowing terms. The usual book reviews follow, and the final page features the DIY sundial first shown in the Bulletin of the Scientific Instrument Society, No 27 (1991). The issue has a total of i + 51 pages. A pity English readers cannot understand the language.

LA BUSCA DE PAPER

Only two issues of this journal were made in 1990, the last (Issue no 7) being received in February 1991 just as the Editor was wondering if the postal service had broken down between Spain and England. As mentioned in previous issues of the BSS *Bulletin,* the language used is Catalan, with English summaries that help the Editor no end, and occasionally allow him a wry smile. The first article is entitled "XXth Century Sundial Makers - in the mountains of Garraf" which describes the sundial placed on the front of a farmhouse built in 1799. The new dial was designed by Mr Josep Nogué i Mas, the technical calculations by Mr Jordi Norgué i Mas (two brothers). The second article is a very interesting reconstruction of an ancient Damascan sundial, and it is hoped to include this in a future issue of the BSS *Bulletin.* The request by Mr Javier Albertos about Francis Hall's work describing the dial in the King's Privy Garden is again aired but no mention is made of the description provided in BSS *Bulletin* 90.2.

Under the title "The hour of poetry - Memory of Light" a free English version of the poem of Cèlia Sànchez i Mûstich is given, alas it died in translation:

> I leave, in the memory, a sundial that registers the hours
> of love and of search and condemns to the exile of fog
> the minutes that poison the remembrance.
> A sundial of the forgetting that with the shadow of a scrap of thought
> sings [signs] the exemption of the lucidity time.

It should read more like this:

> In my memory I leave
> A sundial marking the hours of love and its pursuit
> Condemning to exile in the mist
> Those minutes that taint the remembrance.
> A sundial of forgetfulness
> That with the smallest thought shadows
> The signature of time with clarity.

A somewhat improbable solution to Problem No 4 presented in issue 6 is given.

DER STERNENBOTE

A Sundial Society has been founded in Vienna, Austria; with the same basic aims as those of the British Sundial Society. Details of the officers, etc, have not yet been received by the Editor, although the address is believed to be "Treffen Osterreichischer Sonnenuhrenfreunde" [Austrian Friends of Sundials], Freyung 6, Wien 1, Austria. An article is included in *Der Sternenbote* [the journal for the Austrian Astronomical Bureau, Vienna] for September 1990, and is short enough to include here. It has been translated from the German by Mrs. Lilli Young.

GNOMONIC: SUN CHRONOMETER IN BADEN, NEAR VIENNA

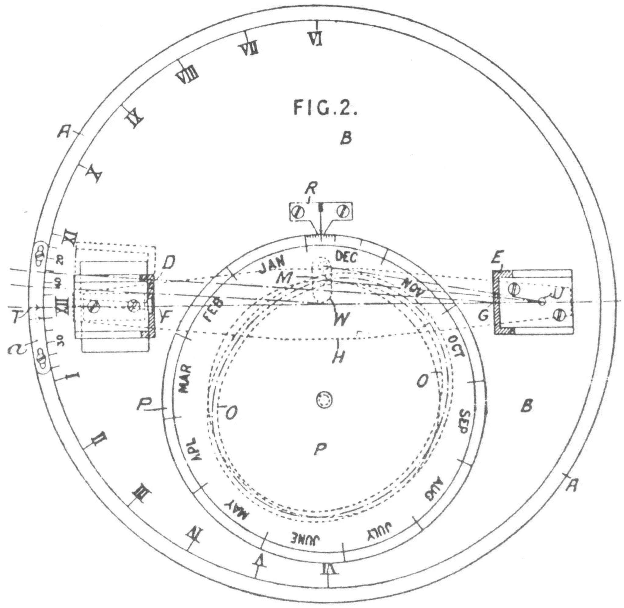
"Very shortly an instrument will be found installed in our Spa Garden, which will be a great attraction, because apart from Munich, no other example is to be found and because of its rarity, it will be a point of interest worthy of our Spa". This passage could be read in the *Badener Boten* [or Badener Messenger] of 6th June 1908.

"This is a Sun chronometer which shows the time correctly to the minute of local mean time, and was manufactured by Rainiers of Munich with the greatest precision from the original design of the Englishman Gibbs [who invented it]. The instrument is 25cm high, partly made of black lacquered cast iron and partly of matt-ground brass, standing on a pedestal 85cm in height. We have to thank the well known Court Watchmaker - Herr Alois Winbauer - for drawing our attention to this instrument. He has also been responsible for its erection and its exact alignment, which because of its construction is absolutely weather-proof, at night only it is covered with a lockable copper dome" [to protect it from physical damage].

Up to then Sun chronometer had been in the showroom of the watchmaker; it was first proposed to position it at the so-called "Zöllneraussicht" or the "Moritzruhe", until it was eventually placed near the Kaiser Joseph Monument. The solemn inauguration ceremony took place on 18th August 1908 and the then Inspector of Gardens, N. Krupla agreed to be responsible for the proceedings. As a mark of the occasion, an inscription was placed on the marble pedestal:

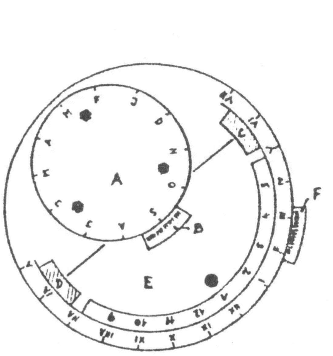
"Sun chronometer Embellishment Society, Baden 1908", this was because the Society bore most of the cost.

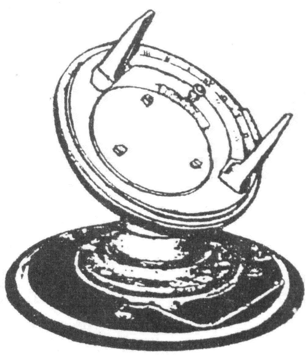
The Sun chronometer has a small and a large movable equatorial disc, each having a scale at its periphery. To read off the accurate local mean time, a few simple hand movements only are required. First the appropriate day is located by turning [by hand] the small disc A [engraved with the twelve months of the year], by using the three thumb screws, which indicate on scale B the days of the month [1-31]. This turns an inner oval brass disc [not visible from the exterior, and turns C, one of the two uprights to allow for the Equation of Time. Then C and D are grasped with both hands to turn Disc E bearing the hour scale until the sun's rays fall through the slit in C on to the inner surface of D which has a black line index. Thus the minutes and hours may be read off on the scales.



The instrument referred to here was the subject of a patent granted to G.J. Gibbs on 8th May 1906 [an example of which may be seen in the Science Museum Time Gallery, London]. The following is an abridgment of the patent:

The instrument may be used to determine Greenwich Mean Time in any longitude. The graduated hour disk B is adapted to turn in a fixed ring A in the plane of the equator, and has secured at right angles to it, a screen E having a central line G. A parallel screen D having a central aperture F is carried by an arm H which passes through an aperture W in the plate B and works in a cam-groove O in a plate P. This plate is pivoted to the disk B, and is graduated round the circumference to show the days and months of the year. To use the instrument, the plate P is first rotated until the day of the month is brought opposite the fixed pointer R, the cam groove simultaneously turning the arm H and screen D through an angle proportional to the equation of time for that day. The disk B is then turned until the light from the aperture F falls on the central line G when the time is read by means of the pointer T on the piece a. To enable the apparatus to be used in varying longitudes, the piece a is adjustably secured to the fixed ring A.





OStR.Prof.Mag.Rudolf Gamauf, Baden

THE HAMPTON COURT DIAL OF JOHN MARR, 1631 (Part 3)
A. R. SOMERVILLE

TO KNOW THE ASCENIONALL DIFFERENCE BY THE SHADOW OF THE STILE.

This ascensionall difference is onelie found in oblique spheares And is the same thing that causeth the increase or decrease of everie daie to bee longer or shorter than an Equinoctiall daie, and is thus found whether the sunne have north or south declination, follow ye parallell of the pointe to the
32 Horizon at east or west and marke what meridian passeth by ye intersection, the arch of the Equator conteyned betweene that meridian and ye equinoctiall colure (wch is ye six a clocke hower line) is the ascensionall difference, wch being coverted into time by allowinge 15 degrees to an hower and one degree to 4 minutes, and subtracted from six a clocke (the sunne having north declination) sheweth the hower of sunrisings and added unto six sheweth the hower of sunsett. Or being doubled and added to an Equinoctiall daie (wch is 12 howers) maketh ye length of the daie, and subtracted maketh the length of the night. And if the Sunne hath south declination add this ascensionall difference to six of ye clocke and it maketh the hower of sunne rising and subtracted maketh the hower of sunsett, wch time of sunsett being doubled maketh the length of ye daie and the time of sunrise being doubled maketh the length of ye night.

33 **TO SHEWE THE AZIMUTH OF YE SUNN BY THE SHADOWE (THAT IS THE HOUR THE SUNN BEARETH FROM US) HOW FARR FROM EAST, WEST SOUTH OR NORTH, ACCORDINGE TO A HORIZONTALL POSITION.**

When the Sunn shineth observe amonge the Azimuths (or verticall circles) wheare ye shadow of the upright edge of the stile falleth, and marke well what pointe of the Horizon that verticall will touch, I saie that the arch of ye Horizon conteyned betweene that south line and the East, West, South, or north, sheweth in a (Horizontal position) the sunns distance from either of them.

TO SHEWE THE AMPLITUDE OF THE SUNNE BY THE SHADOWE WHOSE PRINCIPALL USE IS IN THE ARTE OF NAVIGATION.

The amplitude of ye sunne is the arch of the
34 Horizon conteyned betweene the point of ye sunns risinge or settinge and ye true East or west, And it is called South or North amplitude accordinge as the declination is and is thus knowne. Observe wheare the parallell of the point cutteth the Horizon at East or west, And the arch of the Horizon conteyned betweene that intersection and the true East or West, sheweth the Amplitude required.

TO SHEWE THE ALTITUDE OF YE SUNN ABOVE THE HORIZON BY THE SHADOWE OF THE STILE.

The lines wch shewe ye altitude of the sunne, are those yellowe lines that are parallell to the Horizon called by ye ancient astronomers the Almicantors of ye Sunne (as hath been said). Therefore observe amounge them wheare the shadowe of the point falleth and followe that line to either end, without the Tropique of Cancer ♋.And ye nombers
35 thereunto belonginge shall answeare your desire.

TO SHEWE THE DECLINATION OF THE SUNN BY THE SHADOWE.

Observe wheare the parallel of the point will cut the meridian line and the nombers sett neere thereunto will shewe the sunns *declination*, whether it bee South or North.

TO SHEWE THE JUDAICALL (OR ECLIPTIQUE HOWER) BY THE SHADOWE OF THE STILE.

The ancient accompt of diurnall time used amonge the Jewes, Arabians, Egyptians and theire neighbouring nations (and so I take it is used by some of them at this daie) was to divide ye artificiall daie into 12 equall partes whether it were longer or shorter or equall to an equinoctiall daie, and the night into 12 likewise. The first reasonn hereof was taken from the equal ascension of the Ecliptique
36 line, wch is ye measure of the 12 signes of ye Zodiacke without having either regard or respect to the declination, length of the daie, or obliquite of the Horizon, yet nevertheless six of theise signes rise justlie everie daie, the wch beinge 30 degrees a peece, make (accordinge to an Equinoctiall accompt) two howers of time, and soe the whole six make 12 howers; Likewise manie of ye antient Astronomers (especially ye sect of the Pithagorians) did ever hould the Ecliptique to bee a more noble and honoble circle than the Equinoctiall, accomptinge alwaies the Equinoctiall to decline from the Ecliptique and not ye Ecliptique from the Equinoctiall.

Those hower lines are signified unto us by those greene lines in the concave, and the nombers proper unto them are written (in numerall letters) uppon
37 the scroll without ye Tropique of ♑ thus I, II, III etc to XII (as hath been formerlie described) Therefore observe amonge them wheare the shadowe of the point falleth, for it it fall betweene the Horizon and the first of them marked thus I, then is it the first hower of the daie, and if it fall betweene the lines marked with I and II then is it the second hower of the daie, and soe of anie other. And if it fall just uppon any of them then is it that hower compleat uppon wch it falleth.

TO COMPARE THEISE UNEQUALE HOWERS TO OUR VULGAR AND EQUALL HOWERS.

ffirst finde the Sunns parallell for the daie proposed, then see how manie of our vulgar hower lines doe crosse that parallel, between anie two of those unequall howers (for it is supposed that uppon the same parallell they are alwaies equall) and the nomber of meridians theare found shall shewe how manie degrees of equall time maketh
38 one of those unequall howers.

Example

I desire to compre theise unequall howers when the daie is at the longest.

The Parallel for the daie is the Tropique of Cancer ♋ And, I doe finde that theare falleth there betweene two of those unequall howers, 20 1/2 degrees wch is one hower and 22 minuts of an equall hower. And if you compare them at the Equator you shall find them equall to our equall howers. And if you compare them att the Tropique of Capricorn ♑ when the daie is att ye shortest Then you shall find them to bee but 38 minutes of an equal hower.

And this is ye same accompt of time that the Jewes did use as you may read in ye Gospell by St. Mathew Cap: 20 verse 3.5.6. and capit 27 verse
39 45:46 and elsewhere. Noate that theire sixt hower compleat is alwaies the middle of the daie (or the 12th equall hower) but all ye rest constant to noe certaine time.

The Italian & Babilonian howers might have been showen, but (because the proper lines belonging unto them are not actuallie donne) they shalbee referred to theire proper places.

TO SHEWE THE DAIE OF THE MONETH BY THE SHADOWE OF THE STILE.

The 12 moneths of the yeere are described two severall waies uppon the margent of the great concave and uppon either of them the daie of the moneth maie be founde by the shadowe of the stile (if it weare lost or forgott) uppon the first of them it may bee imeadiatelie found by the shadowe and uppon ye other by consequent. Those uppon wch the shadowe doth (immediatelie) pointe out the daies, and uppon the two circular segments towards
40 the East and west, (before described)

Therefore if the length of ye daies doe increase followe the parallell of the point to ye west side of the Horizon and there uppon the circular segment it shall cutt ye daie of the moneth. And if the daies doe decrease followe it unto the Horizon at the East wheare it shall cut ye daie of the moneth likewise.

The other waie is thus

Observe wheare the parallel of the point will cut ye quadrant of the Ecliptique answearinge to the present season, And the like signe, Degree, and minute beinge found amoung the signes uppon the margent, you finde the daie of ye moneth present sett right against it wch will answeare your desire.

41 To know by ye shadowe at what hower and minute of the daie the Sunn wilbee just East or West or uppon anie other Azimuth proposed.

Marke well wheare the parallel of the point will cutt the proposed Azimuth, and the meridian (or hower line) passinge by that intersection will answeare yor desire.

To find the Almicantar for anie hower proposed, or to find the Almicantar for anie Azimuth proposed, or the Azimuth for anie Almicantar proposed.

Theise and manie suchlike questions depend uppon ye intersection of theise foresaid lines one with another, whereof if theare should bee perticular examples given they would seem too tedious.

YETT BEFORE WEE LEAVE THE SHADOWES OF THE CONCAVE TO KNOWE BY THE
42 SHADOWE OF THE MOONE THE PRESENT ESTATE OF THE TIDE ATT LONDON BRIDGE.

At what time of the yeere or age of the moone whatsoever, it is alwaies ebbinge water from ye risinge of ye moone untill the shadowe of the stile showe 10 of the clocke then is it younge floud at London Bridge, and when it sheweth 11 of the clocke, it beginneth to flowe above bridge and when the shadowe cometh to 3 of the clocke it is high water, from wch time it alwaies ebbeth till ye moone goe down.

And thus much for the propositions that are onlie performed by the shaddowes.

To be continued

THE SUNDIAL SOCIETY

The following may be of interest to members of the British Sundial Society, it is taken from a report on a talk by Mr J D R Brown on social and personal activities in retirement, taken from the *Policyholder Journal* of 30 May 1975:

It was a little surprising, though certainly gratifying, to receive a letter from Miss I Williams, Honorary Secretary of the Sundial Society, referring us back to a paragraph in a 1953 issue of Policy Holder written by Oudeis, the columnist whose insurance gossip feature regularly occupied the first page in those days. Oudeis, quoting from the sundial motto which was shown on the front page of the newsletter as 'I tell on the sunny hours', remarked that his own version of the motto ran:

> Serene he stands amidst the flowers
> And only marks life's sunny hours
> For him dark days do not exist -
> The brazen-faced old optimist.

A member of the society has again come across the verse, which is presumed to be a sundial inscription, and the society have been struck by its peculiarly apt character and, possibly with a consciousness of copyright responsibilities which not all our readers possess, ask our permission to use the verse as a permanent feature of their magazine.

Permission granted, of course, - if it is ours to give! Oudeis, who alas is no longer with us to tell the source of the verse, if indeed he knew himself; but we doubt whether anyone will object, even if its author could be traced.

The Sundial Society is an association of men and women of mature age [which signifies retirement and pre-retirement years to many] who wish to extend their circle of friends and develop new ideas. It is non-profit making, has no paid staff and all its officers are honorary [Editor - "sounds familiar"]. Within the society are small groups of members having mutual interests such as reading, writing, gardening, discussion and painting. Information and ideas are circulated and members also correspond with each other outside the groups. For details, send a stamped and addressed envelope to Miss I Williams 33 Rustwick, Rusthall, Tunbridge Well [sic], Kent.

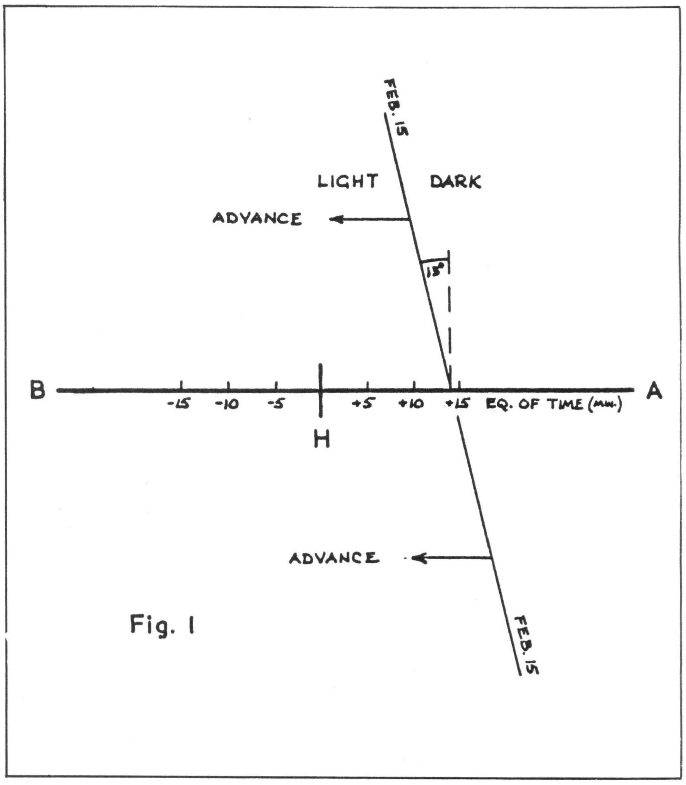
THE SPHERICAL SUNDIAL AS A MEAN-TIME DIAL

BY JAMES RICHARD

The spherical sundial, so ably described by Peter Drinkwater in *Bulletin* No.90.3, is capable of a curious trick; it can function as a mean-time dial for six months out of the twelve. (Yes! I am one of those who "would, wouldn't they").

Normally, of course the hour marks are placed on the equator of the sphere. In Fig 1, AB is a small part of the equator on the East side of the sphere, drawn horizontally on the diagram for convenience. The sun is on the left, thus the shadow is advancing. At this hour, by **sun time**, the edge of the shadow will pass through H and, as Mr Drinkwater has pointed out, it will do this regardless of the tilt (equal to the declination of the sun).

Now consider what happens at the hour H by **mean time**, for example on 15 February when the declination is 13° South and the equation of time is approximately 14 minutes. The line marked 15 February shows the edge of the shadow: it leans forward at 13°, and has 14 minutes to go before it reaches mark H. An hour mark placed anywhere on this line will indicate the hour by mean time on that particular date. If a corresponding line is drawn for another date, an hour mark placed where the two lines cross will indicate mean time on both dates. Finally, if the declination and equation of time are changing in a properly related manner in the interim, the same mark will indicate mean time over the whole period.



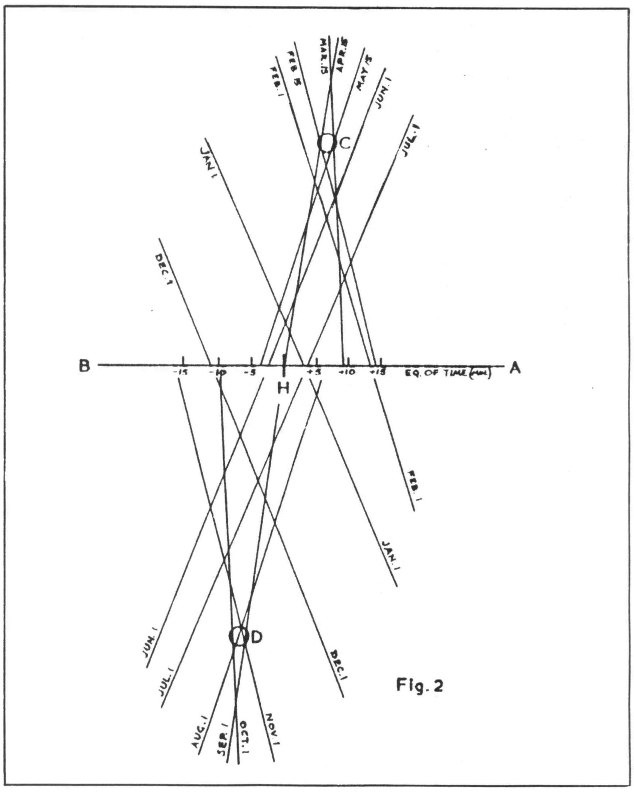


Fig 2: The edge of the shadow at the hour H by mean time has been drawn for various strategic dates and shows the lines passing through the small circles C and D, of three minutes time in diameter. The maximum distance of each edge of shadow line from the centre, at the correct time indication is therefore $1\frac{1}{2}$ minutes. See text for full explanation.

In Fig 2 the edge of the shadow, at the hour H by mean time, has been drawn for various strategic dates. The result is something of a cat's cradle; but it can, I hope, bee seen that the lines dated from 15 February to 15 May all cut the little circle C, and those dated from 1 August to 1 November all cut the little circle D. These two circles have been drawn with a diameter of three minutes of time, therefore the shadow lines all pass within $1\frac{1}{2}$ minutes of their centres. If hour marks are placed at the centres of these circles, instead of at point H, then mean time will be shown to within $1\frac{1}{2}$ minutes, by C from mid-February to mid-May, and by D during August, September and October, that is to say for two periods of three months, or half the year.

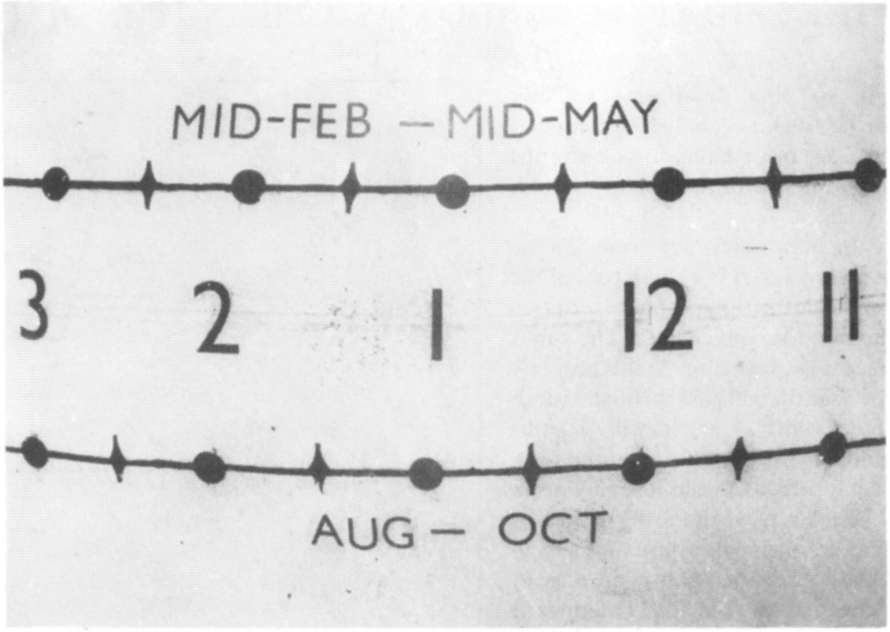


Fig 3. EAST SIDE OF DIAL, ROUND SPOTS MARK THE HOURS

The spacing of C and D is the same at every hour. C is seven minutes to the right of H, and is in latitude $8\frac{1}{2}°$ North on the sphere; or, which makes it easier to mark, it is thirty-four minutes of time above the equator, measuring vertically to the same scale as the horizontal time scale. D is seven minutes to the left of H, and $10\ \frac{1}{4}°$ South or forty-one minutes below the equator. Fig 3 shows part of a dial marked out in this way.The round spots are the hour marks and more than three minutes in diameter for easy visibility since all that matters is the position of the centre of each.

Note that this is the East side of the dial. On the West side, the sun is on the right instead of the left, and the shadow-edge leans the opposite way. As a result, the marking on this side has to be the other way up; the mid-February to mid-May marks are 34 minutes **below** the equator, and the August-October marks are 42 minutes **above** the equator. Fig 4 shows the West side of the dial.

As the two ends of the dial (if a dial may be considered to have ends), both edges of the shadow pass the same marks, at morning and evening in summer, and as these two edges lean in opposite directions, they cannot both be catered for by a single system of marking. Therefore it is necessary either to devote one end of the dial to "morning only" and the other to "evening only", or to abandon the system over the period of ambiguity, as indicated in Fig 5; ie the range of sunrise or sunset times, which is 4-5 hours long in the British Isles. This particular dial is marked in accordance with Summer Time, so the hour 7, rather than 6, occurs in the middle of the period.

What happens outside the periods mid-February to mid-May and August to October? The appropriate mark, at any particular date, is obviously somewhere between C and D, Fig 2 but where? Actually, if one imagines each hour mark to be a small beetle crawling from C to D at a uniform rate, taking from mid-May to the beginning of August ($2\frac{1}{2}$ months) and returning taking from the end of October to mid February ($3\frac{1}{2}$ months); mean time will be indicated to the same accuracy as before, ie $1\frac{1}{2}$ minutes throughout the whole year. An ingenious system of marking might serve for this, but this kind of dial calls for simplicity and this is already complicated enough. It is not too difficult to interpolate mentally between the marks at C and D.

It may seem rather academic to consider an accuracy of $1\ \frac{1}{2}$ minutes in view of the vagueness of the edge of the shadow. This vagueness is something much more serious than the familiar 2-minute width of penumbra at the edge of a definite object. On the sphere there is a gradual fading as the surface becomes tangential to the sun's rays, and we want to identify the place where the direct illumination from the sun has just ceased, although there is still illumination from the sky. On the smooth surface of a sphere, this place is pretty indefinite. However help is available - the surface need not be smooth. Fortuitiously, in the making of the dial illustrated, paint brush marks have created areas of finely ridged surface; and it is much easier to identify the last ridge touched by the sun than it is to pronounce where the illumination reaches its minimum on a smooth surface. See Fig 6 which shows some brush marks and some (more or less) smooth surface.

With this dial, which is eight inches in diameter, the brush marks have improved the precision of reading form an unreliable quarter of a hour to a confident five minutes, assuming that the geometrical standard of the sphere is up to this standard. so one's zeal in not wildly misplaced in electing for a marking system with a theoretical accuracy of $1\ \frac{1}{2}$ minutes. The precise direction of the ridges - or perhaps grooves would be a better term, is unimportant; but these must be lines and not granulations. The surface of stone, or of glass-paper for example, gives no comparable help.

Here then is a peculiar, but I hope legitimate, branch of the study of skialogy; how to produce a finely ridged or grooved surface for use on spherical dials by a method more effective and controllable than careless painting.

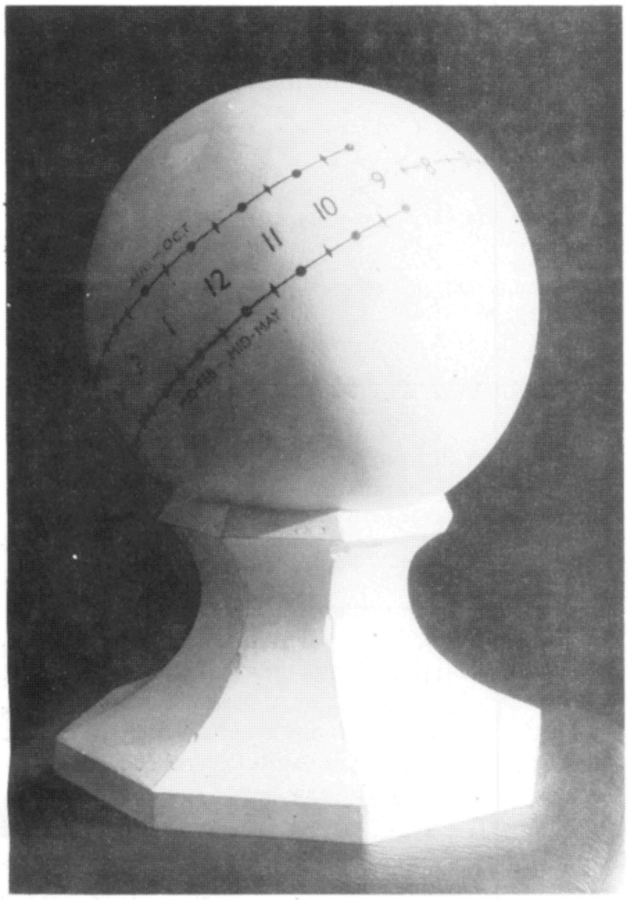


Fig 4. WEST SIDE OF DIAL

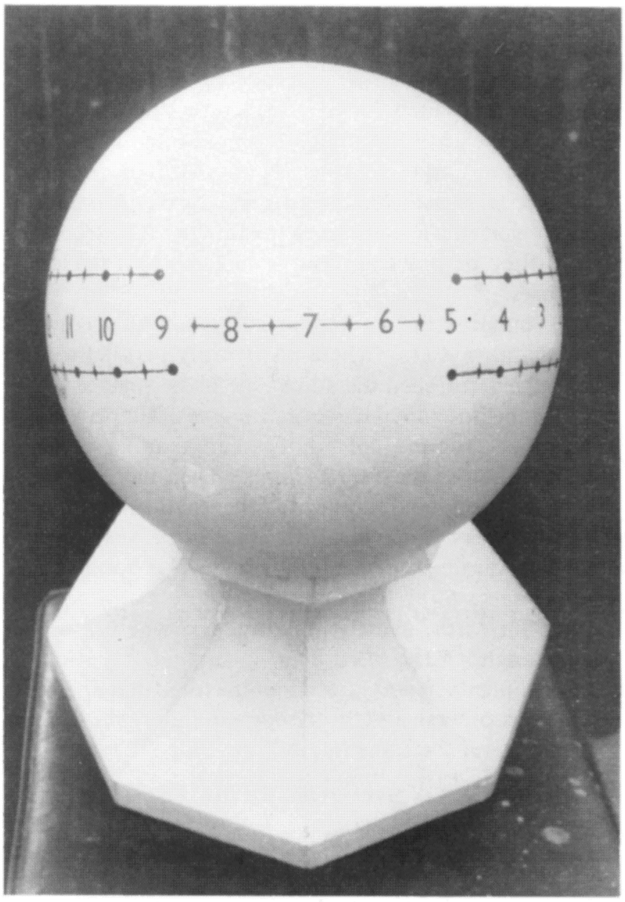


Fig 5. SOUTH SIDE OF DIAL

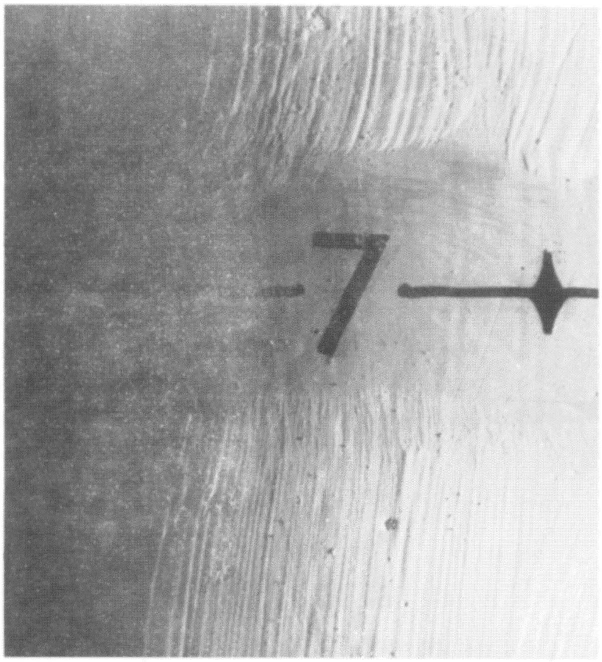


Fig 6. EFFECT OF RIDGED SURFACE

"LOOK AT IT THIS WAY" - again

BY GEORGE WOODFORD (FRANCE)

PRELIMINARIES:

My article in *Bulletin* 90.1, page 28, classified plane dials tilted one way or another from the horizontal. It has since been suggested the pros and cons of the various tilts should be examined further. Hence this article which deals with clarity, legibility, compatibility with the environment, and so on. It avoids the central controversial issue: what is the significance of sundials in modern societies? - are they historical curiosities or should they be a celebration of sun and earth? Helio-sculptures?

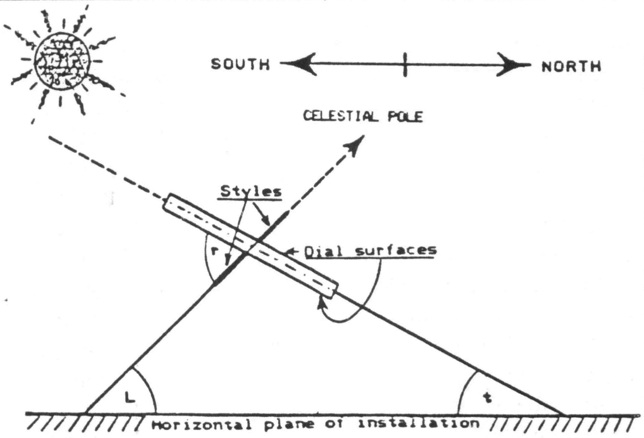
To summarise the previous article, it commenced with the style, always everywhere unalterably parallel to the axis of the earth; then the adjustable plane surface to be tilted on the horizontal base, each degree of tilt providing a distinct regime of daily sun-shadow traces corresponding to the 'regime angle'. Then there was the concept of the 'global show-case': the 'shadow regime' of the daily tracks of sun-shadows traced in a year on the tilted dial was illustrated **naturally** on level ground by the shadow traces of all fixed points of objects at a certain latitude on earth, namely at latitude r, where r is the 'regime angle' of the tilted dial.

For simplicity, it is assumed that the tilted dial does not decline east or west, and the the corresponding show-case specimen is on the same line of longitude.

A SEQUENCE OF SHADOW REGIMES

Suppose it is intended to install a dial at Penzance, latitude 50°N. What tilt should be chosen? The show-case gives examples of the shadow regimes possible, from the polar regime of the north pole, coming down the longitude (approximately) to the equator and on down to the south polar regime. Table 1 shows how the dial in Penzance would have to be adjusted. The equation from which the figures in the table are derived is:

Tilt = Regime Angle - Latitude of Installation or (t = r - L) - see Fig 1.



t = Angle of tilt from horizontal plane
L = Latitude of installation site
r = Regime angle

Tilt t = (regime angle - latitude of installation) = (r - L)

L is constant for all available regimes at a particular place of installation. To obtain such a regime, the dial surfaces must be fixed at an angle r to the styles. The tilt of the dial must then be stabilised at an angle equal to (r - L).

The fixing of the dial to the ground is not indicated, it may be at the north or south end. The free end of the style may be northerly, or for regimes of southern latitudes, southerly.

How do the regime of shadow alter on the earth's surface? The north polar regime is almost perfect in its simplicity: a daily circular track of shadow, at an infinite distance at the Spring equinox, closing thereafter to minimum radius at the Summer solstice, and then reversing towards infinity and disappearing at the Autumn equinox. At Spitzbergen, only 10° of latitude away, the pattern becomes markedly changed, or rather mutated; becoming the most complex of regimes, involving not

TABLE OF PENZANCE DIAL TILTS - LATITUDE OF INSTALLATION 50° N

Shadow regime	Tilt	Regime angle	Dial faces
North polar	40°N	90°	N - up
Spitzbergen	30°N	80°	N - up
Faroes [app]	15°N	65°	N - up
Penzance	0°N	50°	hor - up
Equator	50°S	0°	S - up
South Pole	40°S	90°	S - down

circles but ellipses, hyperbolas, a parabola and a straight line. South of the Arctic circle another mutation is accomplished (Faroes). There are no longer any ellipses; hyperbolas have taken over, those on the north few and widespread; those south of the equinox line closer together. This pattern of hyperbolas on either side of the straight line of the equinox does not mutate again until the Antarctic circle, but the slope and spacing of the hyperbolas change. In Penzance the natural regime on level ground is the same as that on the horizontal dial; with hyperbolas of medium slope. In regimes of latitudes between Penzance and the equator, the hyperbolas on either side of the straight line progressivley close together and flatten out into a new symmetrical pattern, the same on either side of the line. The whole process is reversed on the south of the equator as far as the south pole with its south polar regions.

How do these "rich and strange" variations and mutations of shadow regimes, according to tilt, affect the choice of a dial? Principally in two ways: first the time of day, in a polar regime, is a purely angular measure; that of an equitorial regime dial is linear [along the X-axis]. One gives its information like a traditional clock dial, the other similar to an ordinary thermometer scale. Again in the first case the hour lines are equally spaced, in the second they crowd towards noon and become increasingly wider towards sunrise and sunset. In this age of clear and precise timekeeping, it would seem that on a plane surface dial, the polar regime must be preferable on both counts to that on the equatorial, and more generally, regimes of high to low latitudes. However there are other relevant considerations. Two of these factors are the horizons, and the duration of the night, the 'night factor'.

IMPORTANT CONSIDERATIONS

Horizons: Every installed dial has three horizons, of which any two, or exceptionally all three, may be coincident: first, the *earth's own tangential horizon plane* which determines the time of sunset and sunrise, and so the duration of night and day. Second, the *local horizon* of land forms, buildings, trees, etc., which restricts the potential period of sunshine which would otherwise reach the dial. Third, the *dial's own horizon,* formed by the plane of which the dial surface is a part; it restricts the period of time which the dial can register. This last restriction may be referred to as the 'night factor'.

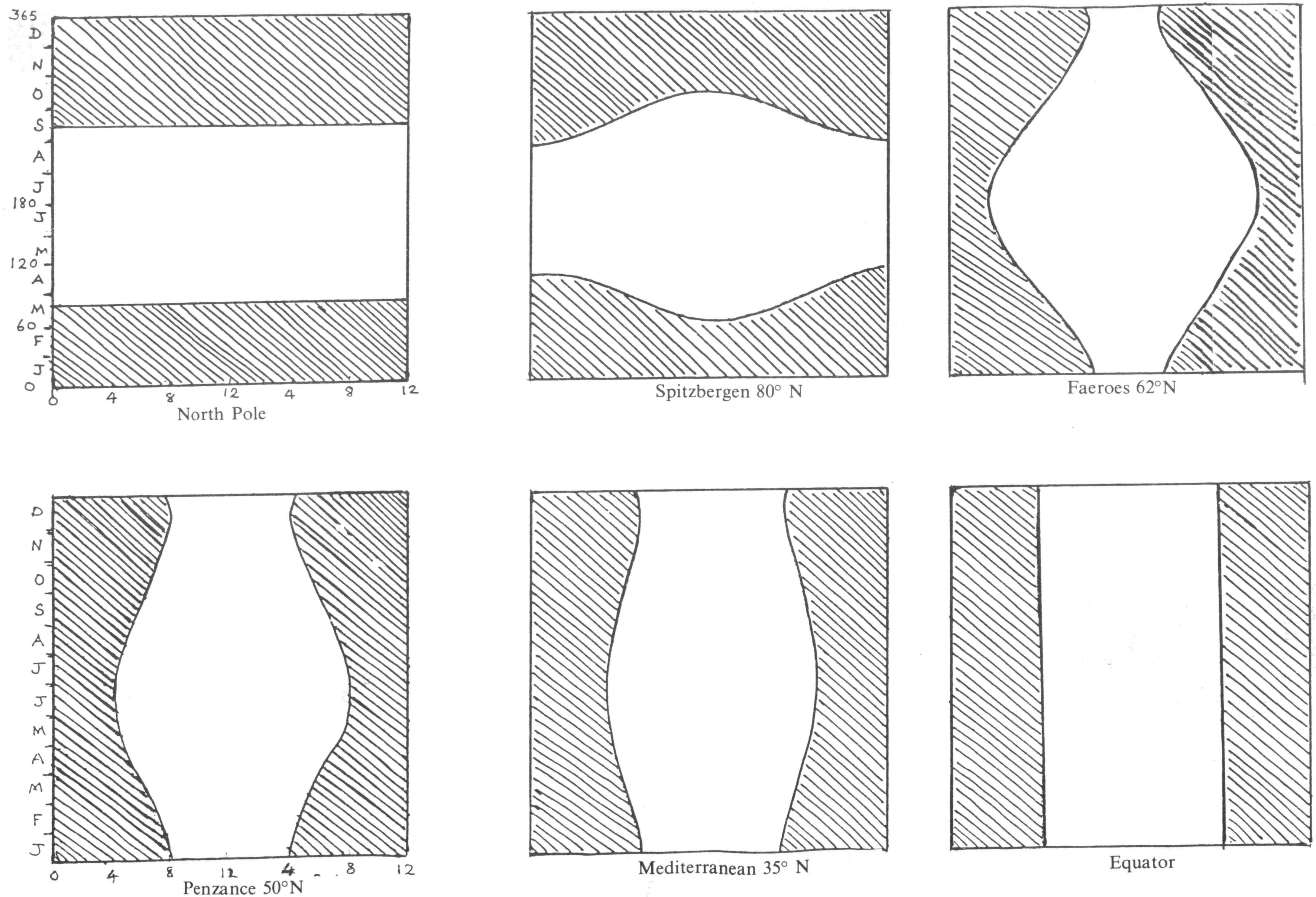
The night factor: The meaning of the next sentence may be difficult to grasp. The general rule for any tilted dial is as follows: it will not produce a time-indicating shadow after the sun has set and before it rises at the latitude r of its show-case specimen. An example should clarify this difficultly. Suppose a dial tilted north with a regime angle r is installed at Penzance on a promontory in the open sea, r being greater than the latitude of Penzance [50°]. Days are shorter in winter in such northerly latitudes; the sun sets earlier and rises later. When the sun sets at latitude r it crosses the *earth's own horizon* there, but this is parallel to the *dial's own horizon.* Hence the disappearance of the recording shadow from the dial plane [which would shortly after be sunlit on its other side for a time]. Similarly when the sun rises again in Penzance, there will be a corresponding absence of a recording shadow until the sun rises above the earth's own horizon at latitude r and the dial's own parallel horizon in Penzance. No such restrictions apply to a horizontal dial, it will register the time all day long from sunrise to sunset.

Fig 2 shows the duration of nights and days throughout the year in a selection of places at various latitudes. The night factor deprivation may be estimated by taking a tracing of the Penzance sketch [representing the potential sunlight-recording time on a horizontal dial in Penzance], and placing it over the sketch most nearly representing the regime selected and noting the months of deprivation, and the number of hours involved. The deprivation may be very great, indeed in the case of the polar regime dials [North and South] it is total for half the year, winter half for the north and summer half for the south polar regime respectively, The 'night factor' is thus one of a number of important considerations in the choice of tilted dial.

Other most important considerations are *clarity of design* and *compatibility with the environment.* The great disadvantage of polar regime dials [the Peary and Admunsden sundials of the earlier article] is that each of them can operate for only half the year. Peary in summer, Admunsden in winter. This disadvantage completely vanishes if they are *both* installed. There need be no cutting down of the *day's* recording, indeed it may be more complete. The great advantage is that each is a model of clarity. The Peary may well be circular, hour lines running from the centre, equally spaced at 15° intervals and numbered *clockwise* for the clockwise moving shadow. The small perpendicular style [to the dial plane] on the centre point does not distract attention from the always much bigger and more significant shadow, which may take the form of an hour hand of a clock, a shadow of almost unvarying length and intensity throughout a whole day of sunshine, see Fig 6. From what clearer and simpler display could a child learn to tell the time? And a child's "message understood" must surely be a criterion of success. Polar regime dials also have the advantage of clarity in the sense of being easily legible from a distance. My Peary dial stands on its own little lawn near a garden path that runs by on the north some six metres away, the time can be read, as one passes by, from the dial facing upwards to the north at 43°, see Fig 3. A horizontal dial in the same position would be illegible, like looking at a clock lying on its back on the mantelpiece. That is not to say that a place cannot be found for a horizontal dial in a garden, if there is a place where it can be looked down on, possibly a large dial at ground level in an open space or declivity.

Some dials are on easier terms with the environment than others. For a horizontal dial the local horizon, except in the north quadrant, must be low, and ideally, very low in the east and west quadrants. By abandoning winter sunshine altogether, my north polar regime dial tilted upwards 40° towards the north is unaffected by a southern background of forest trees 20 metres high and only 25 metres away. The results of this environmental friendliness may be surprising and delightful. Gardens are unpredictable, bushes grow unexpectedly larger, trees are uprooted by wind, and in longer views the spaces disappear. From my study window, the Peary dial at 50 metres is seen as a bright ellipse in closely surrounding

Fig 2. DAY AND NIGHT REGIMES OF VARIOUS LATITUDES



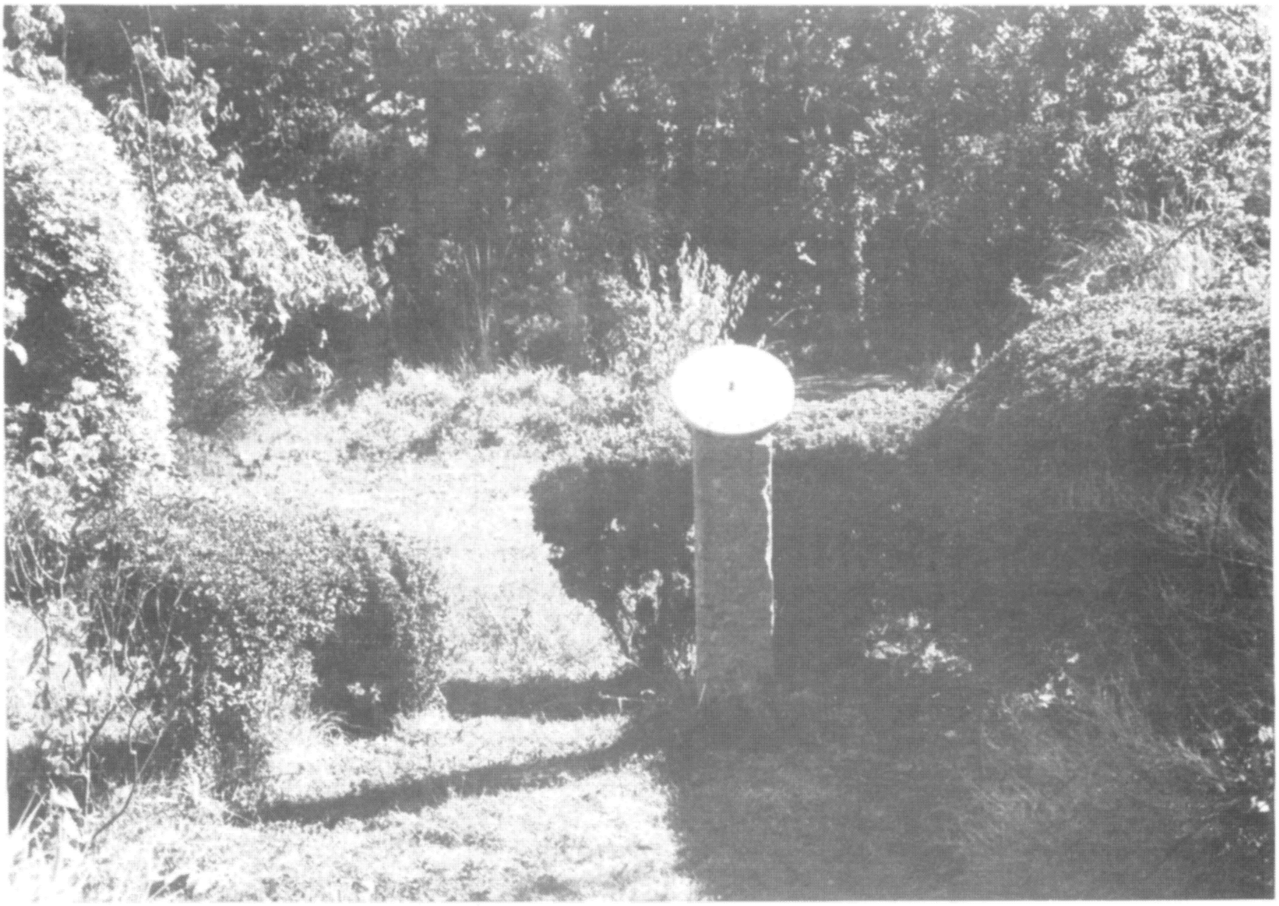


Fig 3. THE PEARY DIAL SEEN AT 6 METRES DISTANCE

vegetation, dark green bushes on either side are over-arched by a dark red Prunus tree, and a high background of tall trees completes the back-cloth - a pleasure quite unplanned for, and unforeseen, see Fig 3 and 6.

The north polar regime dial has another positive characteristic, it can easily be constructed to record clock time [pace Peter Drinkwater]. This involves an occasional slight movement of the dial in its own plane like the steering wheel of a car. The style is fixed in the underlying support as the axis of rotation [see *Sundials, their Theory and Construction* by A C Waugh, pages 25-34]. Alternatively, if precise time-keeping is not felt to be necessary [as amongst friends], the rotation east or west to compensate for longitude and hour advance of one hour for BST may be incorporated permanently when first installed; the indicated time will then be within six minutes of BST from 26 March to 18 September, see Fig 7.

JOURNEYING DOWN A LONGITUDE

Spitzbergen: A tilted dial with this regime installed in Penzance [Fig 4], has the same qualities and defects as the Peary, but less marked. The hour lines are not quite equally spaced at 15° intervals, the tilt of the dial is reduced from 40° to 30°, so one must approach closer to read the indicated time; and it is not quite so environmentally tolerant. On the other hand, the principal defect is diminished, it can register from 24 February to 11 October. It deserves to be of special interest to diallers because in this regime the circles of the poles split into a complete family of conic sections. The lowest curve in the dial in Fig 4 is a downward curving hyperbola appearing on 1 March, the straight line is the equinoctial, whilst the parabola marks the first day the sun does not set - 7 May, and the ellipse is the summer solstice. All these reappear at corresponding dates as the shadows lengthen.

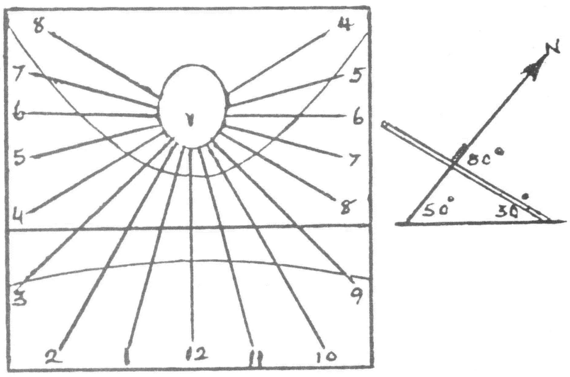


Fig 4. SPITZBERGEN REGIME DIAL IN PENZANCE

Penzance: This regime may qualify as the third most attractive in the northern hemisphere because the dial has the 'stability' of level ground and, because the tilt havng been reduced to zero, the night factor is eliminated. Up to this point the dial's operative sunlight has been restricted by this factor during the winter half of the year. From now on, proceeding south continuously to the south pole, the dial's *summer* operative sunlight is restricted.

Mediterrean: For this region the Penzance dial must be tilted towards the south at 15° to the horizontal. It must be viewed from the south but the tilt is insufficient to make the dial clearly legible from a distance. From close by, the style, at 35° to the dial plane is intrusive, particularly in the middle of the day at which time the hour lines are close to each other. It may be held that the style should be an important and decorative feature, and that the advance of a sort of blanket shadow is symbolic and should be accepted. It is, however, a real defect if there is any doubt about the interpretation of its message. There is no possible doubt if just one isolated dark shadow lies on an otherwise bright surface, a pointing-finger shadow from which even a child can tell the time.

Gulf of Guinea, equator: For this regime the tilt is 50° upwards south and the dial *is* legible from a distance. The style, also at 50°, casts a shadow parallel to itself, a north-south line pushing from left to right during the day. Hour lines can only be drawn for five complete hours before and after noon [**total 10**]. The operative part of the dial surface is twice as long east-west as north-south. The equatorial regime has advantages, but only becomes really attractive if the plane surface is abandoned in favour of a concave surface.

Tristan da Cunha: From the equator on, we are in an upside-down land [for northern hemisphere dwellers], where winter is summer and inhabitants walk about more or less upside down. Tristan de Cunha is, at 37.5° south, just about 90° south of Oxford. The vertical dials of the city (Oxford) suffer from the summer-is-winter syndrome, their operative *summer* sunlight being reduced at the summer solstice by the first three and last three hours of daylight, Fig 5. [Editor's note: The Oxford dials are so restricted by surrounding buildings that this shortcoming represents no disadvantage in practice].

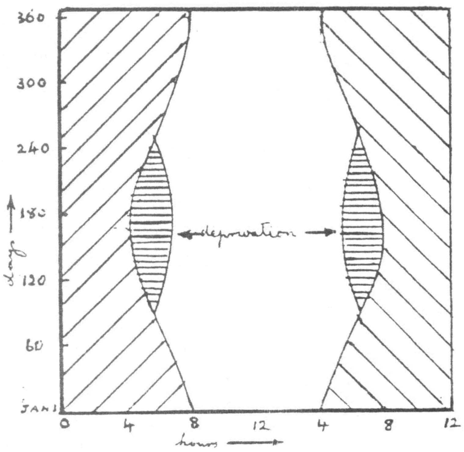


Fig 5.
Penzance day/night regime; with night factor deprivation imposed by Tristan da Cunha regime

South pole: The Admunsden dial has to be set high to look downwards from a south wall where winter sunlight can reach it. It is not tolerant of most other environments, and whilst it is not so easy to install as the Peary dial it is a perfect companion, not only in sharing the year's timekeeping, but also inviting an upward look; leaving the Peary dial to deal with level and downward glances. As the declination of the wall will generally be east or west, this has to be compensated for, and the security of the overhanging mass of the dial ensured. But its message is as clear as day, it can be large and rectangular, marked with hours 6 to 12 to 6; and it cannot be sullied by the attention of birds. Apart from its ignoring summer sunlight, it has one grave defect which is confusing for children, its moving-shadow-finger goes anticlockwise, but familiarity will soon bring acceptance.

Fig 6. PEARY DIAL SEEN AT 20 METRES DISTANCE

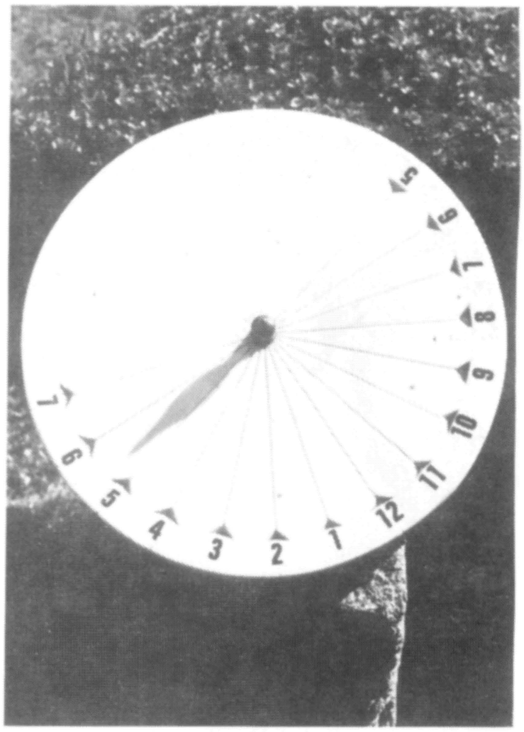


Fig 7. PEARY DIAL CLOSE UP TIME 5.20 FRENCH SUMMER TIME 20th AUGUST 1990

THE WORLD UPSIDE DOWN

BY H W VAN DER WYCK (NETHERLANDS)

SUMMARY:

An essay on the experience of people in the Southern Hemisphere, specifically concerning gnomonics.

When you put the question to someone: "What is a spiral staircase?", ten to one you will get an answer involving one hand making a clockwise movement. Screws are tightened clockwise, so too the older types of light switches to put the lights on, as do the knobs on radios and televisions, and so on. What can be the reason for all this? The fact that most people are right-handed? I think not, since I myself am left-handed, but still have the same reactions as right-handed persons. But, you might very well say, what has all this got to do with sundials?

My own opinion is that these traditions and habits stem from the fact that civilisation evolved in the Northern Hemisphere. And to those living there, the Sun, Moon and even the Stars, appear to move in a clockwise direction; and similarly the shadows of people and objects. I even think that this is why the hands of clocks are designed to move in this direction.

The whole enigma struck me when, some time ago, I had to get better acquainted with sundials for the Southern Hemisphere. This implied imagining the Sun travelling from East to West and passing through *North*, and so, facing it, travelling right to left; in other words in an *anticlockwise* direction! Ergo that also goes for the shadows on their equatorial and horizontal sundials.

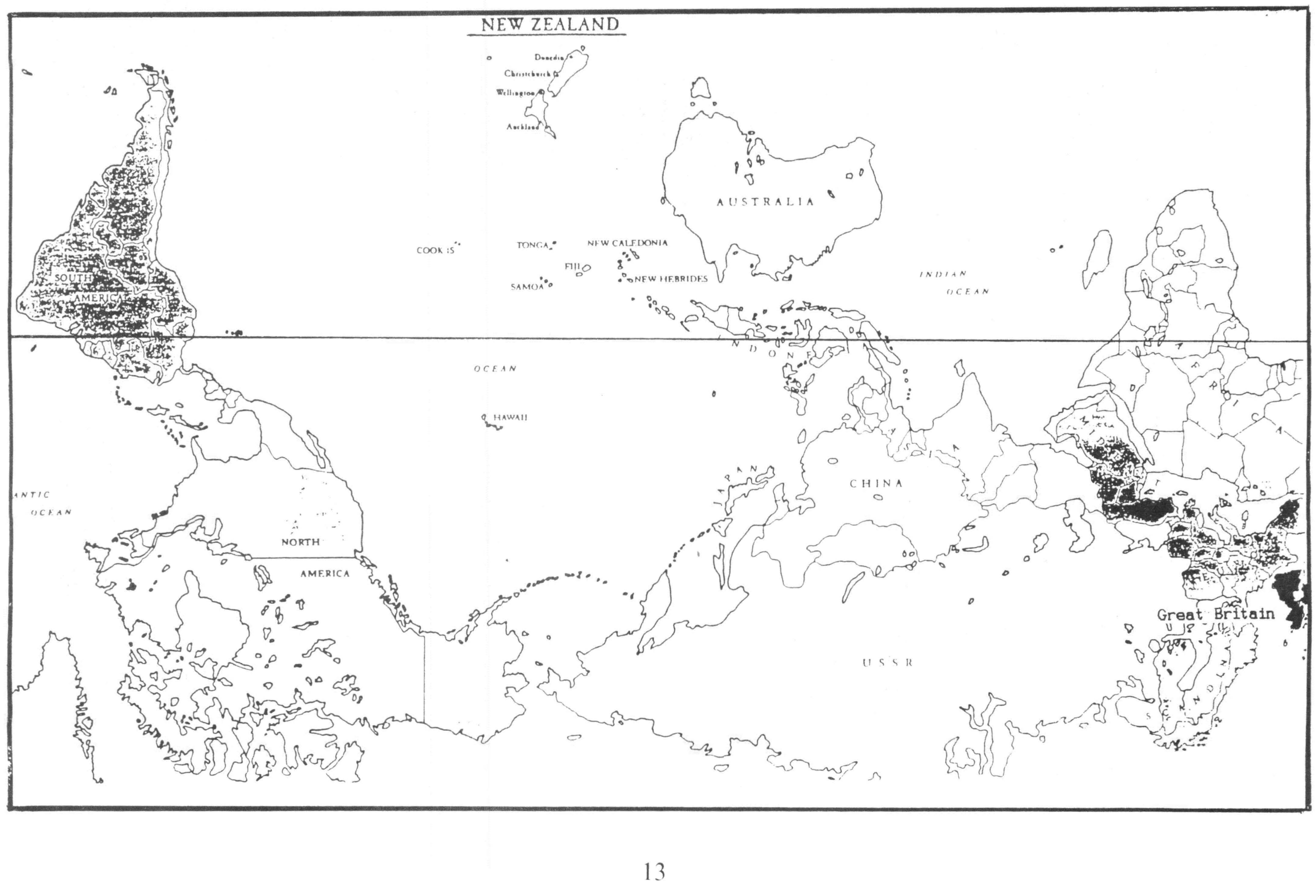
Suppose that the Primeval Man discovered by the Leakey's at Lake Victoria in South Africa had become the fount of civilisation and, having developed by spreading into more southern subtropical areas, would human perception then have opted for clockwise rotation?

But these are no more than idle reflections, and my concern is with something completely different. Whilst occupied with these thoughts I naturally reached for the dialling literature available to me: Terpstra, Waugh, Drecker, Rohr, and Schumacher [Volumes 1 and 3]. In these I could find only two references: Rohr [1982] mentions the Southern Hemisphere on pages 55-56 and page 209; whilst Waugh states, in a footnote on page 7 [American edition, 1973], that his remarks singularly pertain to circumstances in the Northern Hemisphere. Meanwhile, on being informed that Waugh is available in Johannesburg [South Africa], I am not quite clear what they want with this book there, considering this footnote. I did, however, wonder whether there was anything written or chronicled for our friends in the Southern Hemisphere!

Recently a copy of an article by William S Maddox, called "Sundials on Walls", published in *Sky and Telescope*, December 1987, came into my hands. In his introduction, Maddox expresses a view in the following words, which has become more and more my opinion too: *"Throughout this discussion we will assume a 'Northern Hemisphere Chauvinism' for clarity".*

Currently I am trying to locate a like-minded spirit in South America, South Africa or Australia in order to exchange thoughts on these matters in writing. So far I have been unsuccessful in my attempts. Perhaps a reader of this *Bulletin*, living South of the Equator, would be so inclined?

A couple with whom my wife and I are aquainted, recently visited their daughter in Buenos Aires, and promised to keep a lookout for me for sundial books; alas



none were to be found. However a few days before their return, they learned of a friend of their daughter, of Dutch descent also, who sported a sundial in her garden. - "Could we please come round and have a look at it?". "But of course. Do drop by". A sundial! Finally. An equatorial dial, no less. "And where did you buy it?". "Oh", came the unruffled answer, "we had it flown in from Holland . . ."

But to return to the matter of the revolving globe. Recently I was pondering the subject and holding a small globe, gave it a considerable push, in the 'right' direction of course, and suddenly, before realising it, I was holding it 'upside down'. And unexpectedly, it now revolved from right to left, along with *our* Sun! This had never occurred to me before! But it did bring about new questions -would they have globes for the Southern Hemisphere that are printed so that the South Pole is facing upwards? Or is the world over there constantly in an upside down state?

One of our fellow members [De Zonnewijzerkring], Mrs Hanekuyk, aware of my quandary, brought back a map for me from her trip to New Zealand, that is indeed 'upside down'.

Editor's Note: It is very disturbing to see such a map after seven decades of seeing it the 'right way' up. Is nothing to be held sacred?. Britain looks so insignificant in the lower right hand corner.

A SUNDIAL FOR THE WINDOW SILL

BY J G T M TAUDIN CÀBOT (NETHERLANDS)

My search for sundials without easily damageable parts wasn't very successful. So I started thinking and experimenting. Sitting in my chair I tried to visualise the trace the sun would leave in the sky. If I could only get that trace on my glass window! That was to be the principle of my sundial: the reading point had to be stationary and 'look' at the sky. So all I had to do was construct a sundial which I would place vertically on the glass, the travelling sun would cast its shadow over the stationary reading point, and during the whole day, the shadow pattern would move over this point.

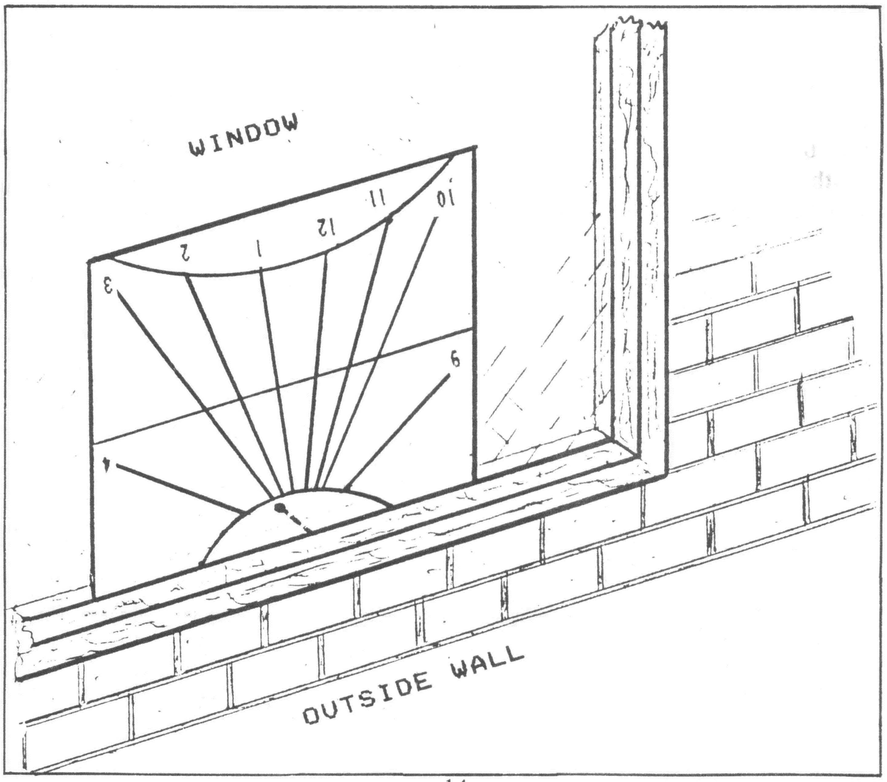
Many hours of calculating followed and finally I could draw my sundial. A very familiar pattern emerged on my drawing board which made me think again, for what I saw was a normal vertical sundial. Had I made a mistake? No. The proof is very simple. Normally you have the sun, shadow point and sundial pattern in this linear sequence, however this line remains exactly the same in space if you interchange the latter two of these points to give the sequence sun, sundial pattern, and the shadow point. Now use this point as the reading point, and there it is!

So the recipe is:

- Construct a vertical sundial as if you would if mounting it to the exterior of your window.
- Rotate the sundial 180° around the horizontal axis perpendicular to the window. The dial is now laterally inverted and upside down.
- Now mirror the shadow point to the inside of the window around the horizontal axis in the sundial surface. This is the third 180° turn made, and all is now ready.

A construction of this sundial was made using an overhead sheet and a coloured felt tip pen. When you put figures on this sundial, you have to think of constructing a vertical sundial on the outside of your window such that it is seen upside down from the outside. The shadows of the figures will be perfectly readable upon the interior horizontal surface forming your reading point.

It is even possible to create your reading point on the floor and construct the sundial as if the whole wall is one window. If that wall happens to have only three small windows, you use parts of this large sundial [the wall], and paint these on each window. A scale drawing will be of great help in this case. Enjoy this new type of dial.



THE ASTRONOMICAL QUADRANT OF SANTA MARIA NOVELLA IN FLORENCE: PLANETARY AND CANONICAL HOURS

BY GIOVANNI PALTRINIERI (ITALY)

Among the works carried out during the mathematical career of Egnazio Danti[1] is the large astronomical quadrant on the facade of the Dominican Church of Santa Maria Novella in Florence. It consists of an almost square slab of white marble [1.465m x 1.540m x 0.08m thick] fixed by one edge to the church wall, which faces almost due south. The marble slab is thus in the meridian plane, one face turned to the East, the other to the West.

The base of the quadrant, which is seven metres from ground level, rests on a bracket which both supports the weight of the slab and adds to the decorative appearance of the instrument. At the upper corner are two rods which act as gnomons: their function is to indicate the height of the midday sun on both faces of the quadrant by their cast shadows on a graduated scale almost the full width of the marble slab. This scale is engraved with marks for the summer and winter solstices, the equinoxes, and the points of entry into the intermediate signs of the zodiac.

On the west side of the supporting bracket is engraved:

COSM, MED, MAGN, ETR, DUX NOBILIUM ARTIUM STUDIOSUS ASTRONOMIAE STUDIOSUS DEDIT ANNO D. MDLXXII	This is a dedicatory inscription to the ruler of Tuscany and gives the year it was made - 1572.

On the east side, and more interesting from the astronomical point of view:

DILEGETI OBSERVATIONE PERSPECTA TROPICOP DISTANTIA G. XLVI, LVII, XXXVI, L, ET ANGULO SECTIONIS G, XXIII, XXVIII, XXXVIIII, LV	By diligent observation, the distance between the Tropics is found to be 46° 57′ 39″ 50′, and the Obliquity of the Ecliptic is thus 23° 28′ 49′ 55‴

Five pairs of dials are drawn on the quadrant, some still retain their gnomons, but those of the others are lost. These dials show morning hours on the East side, and afternoon hours on the West side.

On the upper parts of the two quadrants is carved "H. AB OCC." [Horae ab Occasu, or Hours from Sunset]. These hours, also called Italian Hours, are the twenty-fourth part of the interval between one sunset and the next. Just beneath these, other hour lines are cut entitled "H. AB ORT." [Horae ab Ortu, or Hours from Sunrise]. These are the twenty-fourth parts of the interval between two successive sunrises. In the lower segment of the quadrants, close to the wall, are lines to show the Astronomical Hours, which run from midday to midday in twenty-four hours.

On the bracket, just below the dedicatory and astronomical inscriptions, are dials for "Oltramontane" or French Hours, which differ from the preceding only in that they are divided into two groups of 12, starting from midday and midnight.

Lastly, on the wall of the church itself, divided into two parts by the marble slab, is carved "H. PLAN." [Planetary Hours]. More ancient then the preceding hours, and also called Temporary Hours, the Planetary hours of the day are the twelfth part of the interval between dawn and sunset, whilst those of the night are the twelfth part of the period between sunset and dawn. So the hours on a summer day are much longer than those of winter, though of course, the long day hour corresponds to a short night hour and vice-versa. The term "Planetary" is used because the first hour of the day was dominated by a specific planet: Monday the Moon, Tuesday (Martedi) Mars, and so on. In succeeding hours the planets followed each other in a prescribed order, readily found from tables by those who hoped to profit from a favourable moment, or avoid times unpropitious to their proposed actions.

The Planetary Hour dial has a peculiar hour-line pattern, a series of lines equally spaced which converge on the base of the gnomon fixed normal to the plane and terminate at a quarter circle line. Superimposed is a second set of lines which converge above the gnomon; they have variable angular spacing and pass well beyond the quarter circle line. The first series of lines has Roman numerals, the second Arabic.

The present brief essay proposes to clarify the significance of this anomalous double line pattern and to furnish a logical explanation based on two separate gnomonic systems, one used in civil life, the other for religious purposes.

In parallel with Planetary hours, the Middle Ages also used Canonical hours and as the two systems were very similar, they eventually ended by being combined and referred to indifferently by either name. With the Santa Novella quadrant, on which all kinds of sundial are traced, we find, however, a clear testimony that Planetary and Canonical hours were two quite distinct systems, even if very similar to each other. An attempt will be made to clarify their significance in the light of the scarce literature on this instrument, and from the experience of practical gnomonics acquired by the present writer.

The bibliography of Danti's Astronomical Quadrant at Santa Maria Novella in Florence is very small. The first description of the instrument is given by the maker himself in the appropriate chapter in his *Treatise of Astrolabe*.[2] A half page diagram illustrates it schematically and assigns letters to each of the five dials which are explained in a detailed list below [Fig 1]. For letter 'G' Danti writes "place of the Planetary hours used by the ancient Hebrews and Romans, and of the Canonical hours". The text which follows then expressly states "The fifth hour system is that of King Hezekiel, of unequal, or true planetary hours, drawn on the wall of the church adjacent to the quadrant, at the sign G, with red lines on the marble stone, to which are added black lines designated Canonical hours".

Thus the author makes it sufficiently clear that in the one and same place are two distinct tracings: Planetary hours in red and Canonical hours in black. The text continues with a brief comment and shows the use of the combination of different dials to find the time of dawn, midday, midnight, the length of the day and night, etc., at any given moment.

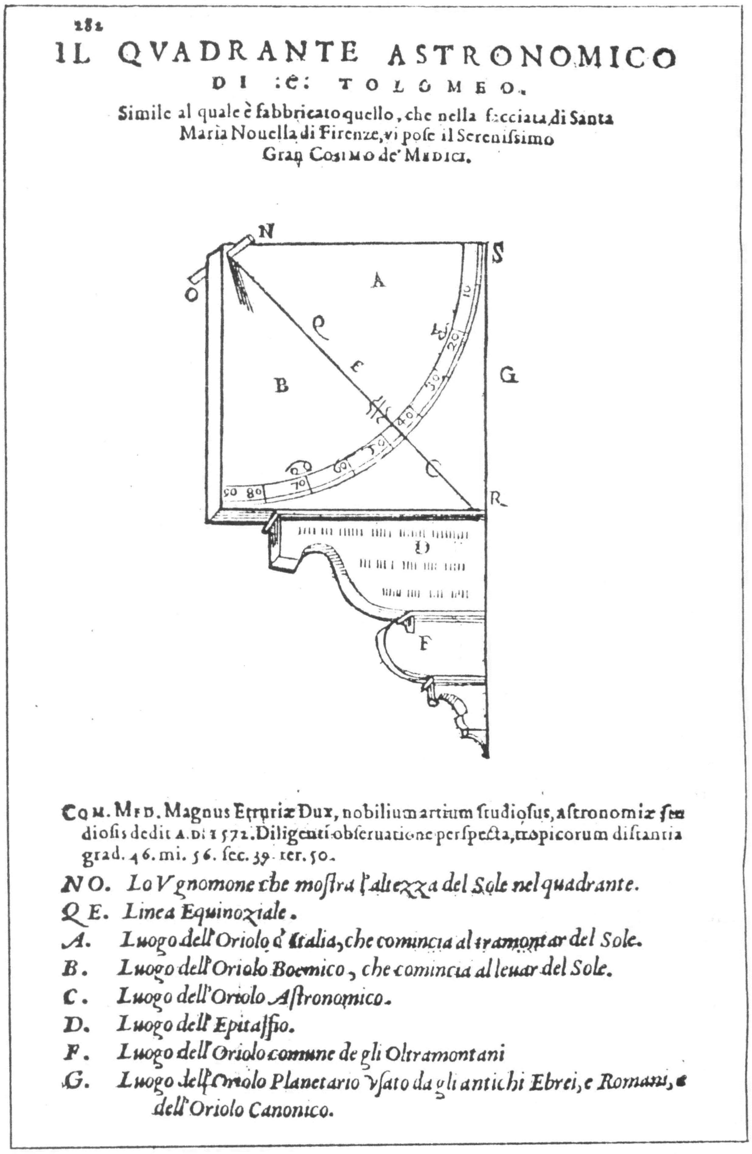
After Danti, the Jesuit P. Leonardo Ximenes wrote about the instrument in his *Old and New Gnomons of*

THE ASTRONOMICAL QUADRANT AFTER PTOLEMY

Similar to that made for the facade of Santa Maria Novella of Florence and placed there by His Serene Highness the Grand-Duke Cosimo de Medici.

The dedicatory inscription in Latin is translated in the present text.

NO. **The gnomon which shows the Altitude of the Sun on the Quadrant.**
QE. **Equinoctial Line.**
A. **Place of the Italian Hours which commence at the setting of the Sun.**
B. **Place of the Bohemian Hours which commence at the rising of the Sun.**
C. **Place of the Astronomical Hours.**
D. **Place of the Inscription.**
F. **Place of the Communal Hour or Oltramontani.**
G. **Place of the Planetary Hours of the Ancient Hebrews and Romans, and the place of the Canonical Hours [on the church wall at right angles to the Quadrant]. Note: The N S at the top does not indicate North/South.**


282

IL QVADRANTE ASTRONOMICO DI :e: TOLOMEO.

Simile al quale è fabbricato quello, che nella facciata di Santa Maria Nouella di Firenze, vi pose il Serenissimo Gran Cosimo de' Medici.

COM. MED. Magnus Etruriæ Dux, nobilium artium studiosus, astronomiæ studiosis dedit A. D. 1572. Diligenti obseruatione perspecta, tropicorum distantia grad. 46. mi. 56. sec. 39. ter. 50.

NO. *Lo Vgnomone che mostra l'altezza del Sole nel quadrante.*
QE. *Linea Equinoziale.*
A. *Luogo dell'Oriolo d'Italia, che comincia al tramontar del Sole.*
B. *Luogo dell'Oriolo Boemico, che comincia al leuar del Sole.*
C. *Luogo dell'Oriolo Astronomico.*
D. *Luogo dell'Epitaffio.*
F. *Luogo dell'Oriolo commune de gli Oltramontani*
G. *Luogo dell'Oriolo Planetario vsato da gli antichi Ebrei, e Romani, e dell'Oriolo Canonico.*

Figure 1 The engraving of the Quadrant from Danti's Treatise of the Astrolabe.

Florence.[3] In his historical construction, this astronomical scholar describes the great quadrant of Santa Maria Novella, the adjacent armillary, and the noon mark whose construction had begun inside the church, but he makes no mention of Planetary or Canonical hours. Then two centuries later than Danti is a description given by the Dominican F Vincenzio Fineschi[4] on the restoration of the facade.

Lastly, in order of date of publication, but certainly not in importance, an interesting essay was published in 1979 under the signatures of M.L. Righi Bonelli and T.B. Settle. This work, which deals with Danti's activities in Florence, especially in relation to the quadrant of Santa Maria Novella, enquires into the reasons for the dual trace in the Planetary hours section. Although Danti himself made a distinction between red and black lines, yet in another section he speaks expressly of five dials, not six; and the two authors question the significance of the double trace, on the assumption that Planetary and Canonical hours are identical.

To confuse the issue further, Fineschi thus expresses his perplexity: "This dial [ie the Planetary hours] is used by churchmen to regulate the times of services by the Canonical hours .... the lines drawn for these hours are those prolonged beyond the arc between the six o'clock line and the horizontal, not the others which terminate in the middle, confusing the first and signed with Roman numerals and whose purpose cannot now even be recalled. At this point the authors of the 1979 essay advance the hypothesis that the engravings on the facade had undergone some alteration, or that Danti's text, usually so precise, became obscure here because of a series of vicissitudes occurring in those years, which delayed the printing of his text. In support of this hypothesis they compare Danti's text, a drawing [presumably from his own hand[6]] and the actual markings. The two gnomons showing the altitude of the sun are described by Danti as being a single metal rod passing through the marble slab, but in fact they are in two parts mounted in a more complex way on the outside corner. Also the other gnomons referred to in the text do not agree with those on the drawing, confirming that between design and eventual realization, things were substantially modified.

That some modifications were made subsequently is possible, but one thing is certain, as the following part of this article demonstrates, the dial with Planetary and Canonical hours is showing the hours of two different systems.

As often happens to those concerned with historical documents, it is easier to recognise a marginal fact than a common one situated under one's nose. The chroniclers limit themselves to recording novelties, not those things which are universally known at the time, and this is true in the present case, for with the abandonment of the Planetary hours and the adaptation of Canonical hours which had survived only for religious reasons; there was a flood of ink turned to describing the Italian hours, which in the Italian peninsula replaced all the preceding types, leaving behind only a modest literature on the subject [of the earlier ones]. Thus, those who concerned themselves subsequently with the archaic systems, combined these under one title: namely that of Temporary hours.

PLANETARY HOURS

For those versed in gnomonics, the marking out of a planetary hours dial on a wall is not particularly difficult. If the wall does not decline but faces due South, the matter is even simpler. In the last century dialling experts suggested different ways to achieve this, from the very simple to the most elaborate. Without going deeply into the technical details, it is convenient to examine the fundamental aspects here.

First consider an hour completely different to the planetary hour: the equal, or common or equinoctial hour. On the two equinoctial dates, the day and night have the same duration, and each of the resulting twenty-four hours are identical in duration. The majority of the ancient time measurement systems used hourly intervals, the only difference being the different times at which the computation commenced [sunrise or noon].

The Planetary hour, as may be seen from the preceding, corresponds to a twelfth part of that period elapsing from dawn to sunset on any given day, which at the equinox has the same duration as the common hour [mean solar hour]. For any other date, the amplitude of the planetary hour measured in equinoctial minutes is obtained by multiplying the length of the day in equinoctial hours and minutes by a factor of five [since the total minutes are obtained by multiplying by 60, and there are twelve hours, therefore $60 \div 12 = 5$].

Danti stated that at Florence, on the date of the Summer Solstice, the duration of the day was 15 hours 16 minutes equinoctial. Each planetary hour therefore had a duration of (15 hours 16 minutes x 5) = 76 minutes 20 seconds equinoctial. Conversely, at the Winter Solstice, the day consisted of 8 hours 44 minutes; which multiplied by five gives a planetary hour equal to 43 minutes 40 seconds equinoctial.

From the values just obtained, a planetary hours dial may be set out by the use of the following method:

First determine the dimensions of the sun dial by fixing it normal to the meridian plane as if designing a vertical sundial which does not decline. The layout will be moreover completed from the diurnal solstice line and from the equinox (by the diurnal line that is traversed in a given day by the extremities of the shadow on the sundial). Having seen from the preceding that the planetary and equinoctial hours are of equal duration at the equinox, it will be sufficient to change the numerical indication at the points by which the last intersect the equinoctial line, and mid-day obviously corresponds to the sixth hour.

Going on to mark the diurnal line of the Summer Solstice, one commences at the vertical of the sixth hour, and using the time duration of the common or equal hour times a factor of five, the planetary hours are set out at intervals of 76 minutes 20 seconds equinoctial time [at the latitude of Florence]. This is repeated on the diurnal line of the Winter Solstice, setting out again from the sixth hour at intervals of 43 minutes 40 seconds equinoctial hours. The joining of the three points on each of the three fundamental diurnal lines will permit the arrangement shown in Figure 2.

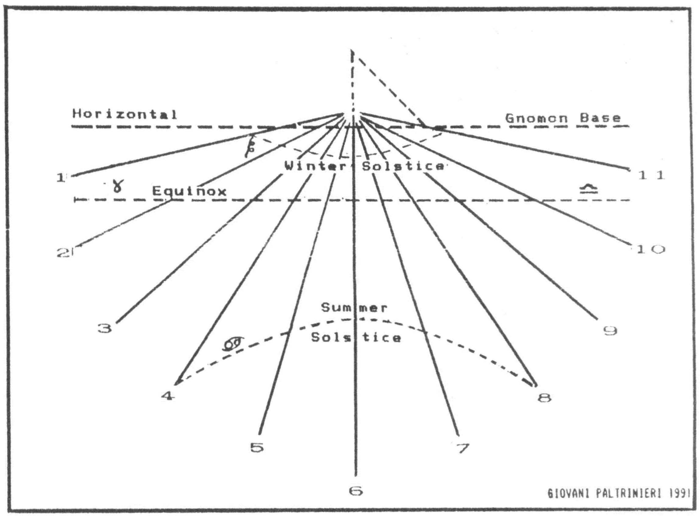


Figure 2 The Planetary hours set out for the Latitude of Florence.

From the drawing it can be seen that the hour lines converge to a point that is placed higher than the gnomon. Moreover the varying angular division is almost constant. The duration of the time interval between the hour lines will always correspond to the twelfth part of the daylight period between dawn and sunset, independent of the season.

The sundial thus described is the set of long lines marked with Arabic figures on the facade of Santa Maria Novella in Florence.

CANONICAL HOURS

Consider the Middle Ages for a moment. In every corner of Europe, religious communities founded on the principles of St. Benedict were being founded and developed. Their Rule, including the motto *Ora et Labora,* laid down precise moments for communal prayer at some significant Planetary hour, particularly with reference to the Passion and Death of Jesus Christ as spoken of in the Gospels. Nothing seems more natural to use the sun as a reference to determine these intervals, but in the absence of skilled gnomonists to provide answers to this problem, a very simple geometrical method was developed which had no astronomical or gnomonic basis.

In medieval times, churches were oriented correctly on a East-West line, the officiating priest facing the Orient, since the sun - symbol of Christ, who illuminated the world - rose in the East. Thus it was natural that one wall of the church would face due South and that a sundial should be traced on it.

This instrument, truly very simple, consisted of a gnomon of abitrary length, fixed at right angles to the plane of the wall. At its foot, a string could be tied to act as a compass to draw a semicircle below. Two lines passing through the base of the gnomon - one horizontal, the other vertical - respectively represented the lines of sunrise and sunset, and midday. The arc of the semi-circle between the points of the intersections could be further divided into twelve equal parts. The simple sundial was then ready for use, see Fig 3.

This is the dial included within the semi-circle which is seen on the facade of the Church of Santa Maria Novella, with its hours indicated in Roman figures. Only a dial of this kind could truly be called *Canonic,* being made expressly for the use of a religious community which required to know the Canonical hours, or times of prayer prescribed by the Rule.

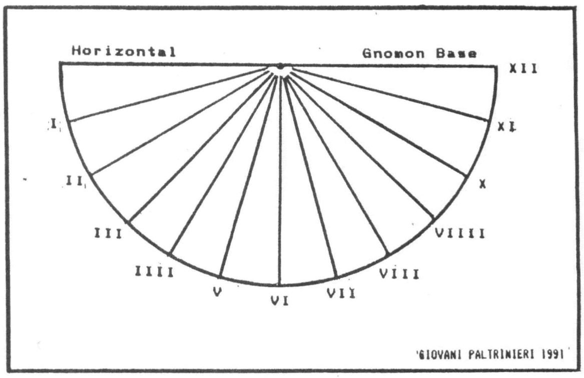


Figure 3 The Canonical hours set out for the Latitude of Florence.

Even as a substitute for the ancient and accurate Planetary hours, the Canonical hours dial as indicated by this shortened method of delineation, has an error usually less than half an hour. The noteworthy points are that this dial is independent of geographical location, the length of the gnomon, and easily made by people of little sophistication.

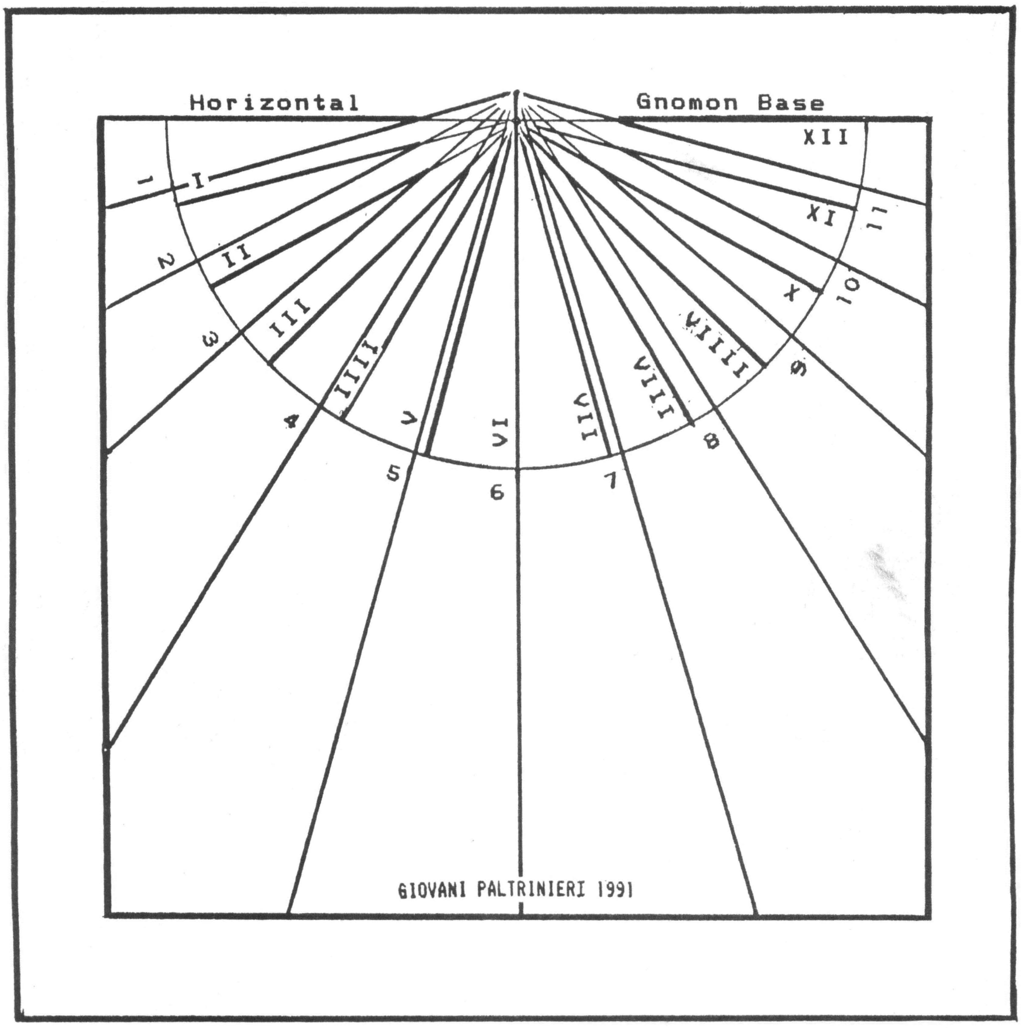


Figure 4 Superposition of the Canonical and Planetary Hours for the Latitude of Florence.

Superimposing Figs 2 and 3 gives Fig 4 showing the complete trace, cut in the marble facade of the Florentine church, in its entirety, and not divided into two parts by the centrally placed marble slab of the quadrant. As can easily be seen from the figures, the difference between the Canonical and Planetary hours lines is not great; the variation between the two being more evident half-way through the morning or afternoon. Here then is an unequivocal demonstration of the double tracing which explains why Canonical and Planetary hours have taken on different connotations although really the same, because of the different ways of construction. That people adopted one way or another unthinkingly is more than possible, given the contemporary rhythm of life and the limited precision of timekeeping.

Those who have concerned themselves with these archaic time systems until now have always confronted the problem as historians, not as gnomonists; writers of the past regarding the problem as marginal. Thus Danti's work, previously seemingly a slight anomaly only at first appearance, now takes on a more particular interest.

Danti's great quadrant, constructed to glorify the ruler of Florence, not in every language, but in every recognised manner of reckoning the hours; has finally yielded its hidden secret. Even today it is an instrument which is modern in content, and it may be considered as a symbol of tolerance and fraternity among many differing races: "It is possible to show the hour in many ways, but time is the same for everyone," see Fig 5 for an illustration of the actual quadrant dial on the facade of Santa Maria Novella church at Florence.

It is therefore demonstrated absolutely that although canonical and planetary hours are identical in theory, the difference in the method in setting out the dial, means in practice that the two indications differ substantially, see Fig 6 for a view of the east side of the Planetary and Canonical hours dial.

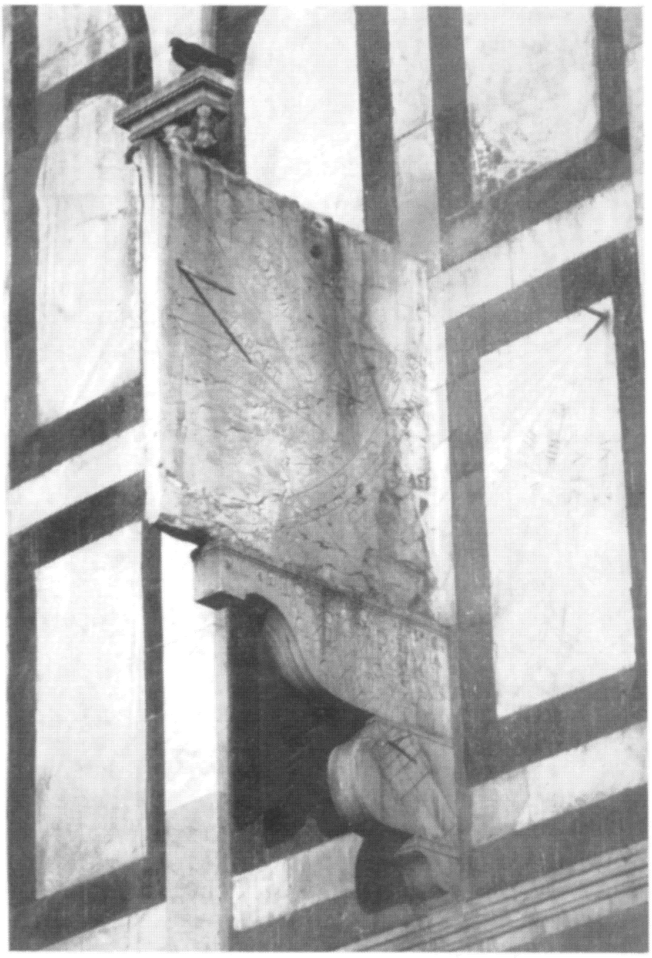


Figure 5 Danti's Quadrant Dial on the facade of the church of Santa Maria Novella, Florence.

Figure 6 The East side of the Planetary and Canonical Hours Dial.

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1. Egnazio Danti: born Perugia 1536; died Alatri 1586. Mathematician, Cosmographer and Architect.
2. Egnazio Danti: *Trattato dell Astrolabio,* Firenze, 1578. [Treatise of the Astrolabe, Florence].
3. Leonardi Ximenes: *Dell Vechio e del nuove gnomons fiorentio,* Firenze, 1757. [Of the old and new Florentine gnomons, Florence]
4. Vincenzio Fineschi: *Novelle letterairie del 1779,* Firenze, 1779. [Literary news of 1779, Florence]
5. Vincenzio Fineschi: Op. cit. coll. 146-7.
6. "Gabinetto dei disegni e delli stampe degli Uffizi", dis, 3946A. [Cabinet of drawing and printing of the Office].

EQUATION OF TIME AT NOON UT

ROBERT SAGOT (FRANCE)

translated by Charles K. Aked

Editor's Note: Robert Sagot was, up to recently, the President of the Sundial Commission in Paris; the office is now held by M. Denis Savoie who has given permission to publish the following article from the journal published by the Société Astronomique de France - *Observations et Travaux,* Number 18, 1989, pages 37-42.

In dialling, one must take account of the equation of time each time it is wished to compare the time read from a sundial to the legal time of watches. Knowledge of this equation is equally indispensible for calculating the 8-curves [analemmae] figuring on mean or legal time sundials.

According to the classic definition, the equation of time is that which must be added algebraically to true solar time in order to obtain the mean time shown on watches or clocks. For a long time, the Bureau of Longitudes Year Book carried a column entitled: Mean Time at True Noon. Thus, in the last century, at the date of 14 July 1889, one could read 0h 5m 36s.

Actually, this column exists today, headed by the caption "Meridian Passage", but as it connects the meridian of Paris and the mean time of Greenwich, the importance of the equation of time is not quite so clear as before. However, after a correction due to the difference of longitude, the result + 5m 50s is found for 14th July 1989. Note that in the passage between these two dates, exactly 100 tropical years (36524 days) has passed, during which the equation of time has increased by 14 seconds.

Independently of the previous formulae for calculating the equation of time, several procedures exist, more or less expeditious, which permit finding the values with sufficient precision for the needs of dialling. Three such procedures are described in this article.

TIME OF THE PASSAGE OF THE MERIDIAN

The simplest of these procedures consists of consulting the ephemerides time UT of the passage of the Sun at the Paris meridian and adding 9 m 21 s to obtain that of the passage at Greenwich. That given was performed for 14 July 1989.

Another example. In the *Ephemerides SAF* for 1989, page 104, column 9, for 2 November, one reads: 11h 34.2m UT. In consequence it will be true noon at Greenwich at 11h 34.2m UT + 9m 21s = 11h 43m 33s UT, that is to say mean time UT - 16m 27s. Whence the equation of time equals -16 m 27 s, with a divergence which can be up to 3 seconds more or less, one result of which is that the times of passages are not given to the tenth of a minute.

Of course, in the same way in the less favourable cases, as in December, it would be futile to take account of the variation of the equation in the course of the 9m 21s which the sun takes to go from Paris to Greenwich, which would not equal a fifth of a second!

EQUATION OF TIME AT Oh UT

In place of calculating the equation of time for a time oscillating about 15 minutes around mean noon, it is more rational to operate from noon UT, which coincides to less than one second with the mean noon of Greenwich. In this case use can again be made of the *Ephemerides SAF.* The calculations will be a little longer but will give precision of the order of a second. The principle is as follows: calculate the equation of time at Oh UT and at 24h UT, ie Oh for the following day, then take half the sum of the two results. Read from the *Ephemerides SAF* the time given in column 6 (Right Ascension of the Sun) and in column 5 (Sidereal Time at Greenwich at Oh UT). After estimating at 12h the smaller of the two numbers, one obtains the equation of time at Oh UT in subtracting the right ascension from sidereal time.

Example: for 16th December 1988. First read, page 106, in the order indicated: 17h 34m 58s and 5h 39m 25s. These numbers will give as the difference: 17h 34m 58s - (12h + 5h 39m 25s) = - 4m 27s. On the following line, for 17h to Oh UT = 16h to 24 h, the numbers become 17h 39m 24s and 5h 43m 21s, where the equation of time is - 3 m 57s. The average of these two results (-4m 27s - 3m 57s) / 2, is equal to - 4m 12s, and supplies the equation for 16th December at 12h UT, with an uncertainty of the order of one second.

TABLE OF MEAN VALUES

Not all amateurs have access to *Ephemerides SAF* or the Year Book of the Bureau of Longitudes. Those who are so denied generally have recourse to the tables of the equation of time inserted in the majority of gnomonic works. These tables furnish the mean values for the 365 or 366 days of any year. The majority of those actually available are out of date by many decades and need amending, and sometimes corrected of systematic errors. It may be noted that, in English and American works or in the extracts made from these works, the equation of time can be calculated as in France (for example N. and M. Mayall, A. Waugh) or, on the contrary, changed in sign (for example F. Cousins, P. Ricou and J.-M. Homet).

CONSTRUCTION OF A TABLE

Since the return of the Sun to the vernal point each year is accomplished in an entire number of days, the same equation is found at the same dates for a number of years at the very least. But as the actual year is really composed of about 365 1/4 days, that is the end of 1461 days (three ordinary years and a bissextile year), the equations vary a little from their initial values. From this comes the idea of constructing tables of mean values and taking a quarter of the sum of four consecutive years. With these tables, whilst admitting that they should not be too out of date the uncertainty affecting the value can attain 11 to 12 seconds in December, in a table generally given to the nearest second.

A close examination of the evolution of the equation of time in the course of four years shows that it is not necessary to take the mean of the four values which occur in the course of the cycle. It is more important to know which are the two extreme values, from which can be taken the mean value to insert in the table. In principle it suffices to make use of the values gone through in the course of 731 days centred on 29 February, going for example from 1 March 1987 to 28 February 1989. One can, at the same time, in default of the *Ephemerides SAF,* directly calculate the required mean values. This has been done for the cycle centred on 29 February 1992 and allows the establishment of the adjoined table. This can serve until 1996 and also a little beyond.

UTILISATION OF THE TABLE

The median values of the table rarely coincide with the particular values which one may require. Also it is necessary to indicate here how to find them with a precision comparable to that obtained through the use of the values for right ascension and sidereal time.

Let E be the equation of time sought, Δ the difference between the median M tabulated and that which follows it, R the row occupied by the considered date in the cycle of 4 years following 29 February, one has:

$$E = M + (0.06 - 0.24\ R)\Delta$$

The corrections in the median M will therefore be, respectively, along row R of the date, $+ 0.36\ \Delta$, $= 0.12$ D, $-0.12\ \Delta$ and $-0.36\ \Delta$

By way of example take the case of 16 December 1988 already treated above. From the adjoined table, the values in the December column may be found: M = -4m 23s for the 16th and -3m 54s for the 17th; from which Δ=+ 29s. This 16 December is the first of the cycle of four years having commenced on 1 March 1988, the applicable correction will be +0.36 Δ =+ 10s. Finally this gives the value E=-4m 23s = 10s =-4m 13s. The use of the *Ephemerides SAF* would have led to a value of -4m 12s. The two results are therefore identical to the nearest second.

Unique case: The value given in parentheses for 29th February is not a mean value but a unique value. This is not used for calculating the corrections to the days 28 February or 1 March.

8-CURVES

The various procedures which have been shown permit knowledge of the equation of time for any determined date. When it is required to trace the indications of mean or legal time, the adjoined table can be used without corrections, assoicated with a table of the same kind for the declination δ of the Sun.

One can also be independent of the date and choose the longitude λ of the Sun, which will give all the arbitrary values that one wishes from 0 to 360 degrees. The formulaes to be used were presented at the reunion of the Commission (The Commission of Cadrans Solaires, Paris), and are given below:

$\sin\ \delta = 0.3978 \sin \lambda$
$K = 77.39° - 0.0172\ (1980)$
$E = 2.365° \sin 2\lambda \sec \delta + 1.916° \sin(\lambda + K) - 0.012$
$\sin 2(\lambda + K)$

The equation of time E is expressed here in degrees. These relations will be valid up to the year 2000, with 1.915° instead of 1.916° and taking K = 77.05°.

EQUATION OF TIME AT NOON UT

	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
	m s	m s	m s	m s	m s	m s	m s	m s	m s	m s	m s	m s
1	+ 3 28	+ 13 34	+ 12 23	+ 3 55	+ 2 54	+ 2 13	+ 3 48	+ 6 18	0 0	- 10 19	- 16 23	- 10 58
2	+ 3 57	+ 13 42	+ 12 11	+ 3 37	+ 3 01	+ 2 04	+ 3 59	+ 6 14	- 0 19	- 10 38	- 16 24	- 10 35
3	+ 4 24	+ 13 49	+ 11 58	+ 3 19	- 3 08	- 1 54	+ 4 11	+ 6 08	- 0 38	- 10 57	- 16 25	- 10 12
4	+ 4 52	+ 13 55	+ 11 46	+ 3 02	- 3 14	- 1 44	+ 4 21	+ 6 04	- 0 58	- 11 15	- 16 24	- 9 48
5	+ 5 19	+ 14 01	+ 11 32	+ 2 44	- 3 19	- 1 34	+ 4 32	+ 5 58	- 1 18	- 11 34	- 16 23	- 9 23
6	+ 5 46	+ 14 05	+ 11 18	+ 2 27	- 3 24	- 1 23	+ 4 42	+ 5 52	- 1 38	- 11 51	- 16 21	- 8 58
7	+ 6 12	+ 14 09	+ 11 04	+ 2 10	- 3 28	- 1 12	+ 4 52	+ 5 45	- 1 58	- 12 09	- 16 18	- 8 33
8	+ 6 37	+ 14 12	+ 10 50	+ 1 53	- 3 32	- 1 01	+ 5 01	+ 5 37	- 2 19	- 12 26	- 16 14	- 8 06
9	+ 7 02	+ 14 14	+ 10 35	+ 1 37	- 3 35	- 0 49	+ 5 10	+ 5 29	- 2 40	- 12 42	- 16 09	- 7 40
10	+ 7 27	+ 14 15	+ 10 19	+ 1 21	- 3 37	- 0 37	+ 5 19	+ 5 20	- 3 01	- 12 58	- 16 04	- 7 13
11	+ 7 51	+ 14 16	+ 10 04	+ 1 05	- 3 39	- 0 25	+ 5 27	+ 5 11	- 3 22	- 13 14	- 15 57	- 6 45
12	+ 8 15	+ 14 15	+ 9 48	+ 0 49	- 3 40	- 0 13	+ 5 35	+ 5 01	- 3 43	- 13 29	- 15 50	- 6 18
13	+ 8 37	+ 14 14	+ 9 32	+ 0 33	- 3 41	- 0 00	+ 5 42	+ 4 51	- 4 04	- 13 44	- 15 42	- 5 49
14	+ 9 00	+ 14 13	+ 9 15	+ 0 18	- 3 41	+ 0 12	+ 5 45	+ 4 40	- 4 25	- 13 58	- 15 33	- 5 21
15	+ 9 21	+ 14 10	+ 8 58	+ 0 04	- 3 41	+ 0 25	+ 5 55	+ 4 28	- 4 46	- 14 12	- 15 23	- 4 52
16	+ 9 42	+ 14 07	+ 8 41	- 0 11	- 3 40	+ 0 38	+ 6 01	+ 4 16	- 5 08	- 14 25	- 15 13	- 4 23
17	+ 10 02	+ 14 03	+ 8 24	- 0 25	- 3 39	+ 0 51	+ 6 07	+ 4 03	- 5 29	- 14 37	- 15 01	- 3 54
18	+ 10 22	+ 13 58	+ 8 07	- 0 38	- 3 36	+ 1 04	+ 6 11	+ 3 50	- 5 51	- 14 49	- 14 49	- 3 24
19	+ 10 41	+ 13 53	+ 7 49	- 0 52	- 3 34	+ 1 17	+ 6 16	+ 3 37	- 6 12	- 15 00	- 14 36	- 2 55
20	+ 10 59	+ 13 47	+ 7 31	- 1 04	- 3 31	+ 1 30	+ 6 19	+ 3 23	- 6 33	- 15 11	- 14 22	- 2 25
21	+ 11 16	+ 13 40	+ 7 14	- 1 17	- 3 27	+ 1 43	+ 6 22	+ 3 08	- 6 55	- 15 21	- 14 07	- 1 55
22	+ 11 33	+ 13 33	+ 6 56	- 1 29	- 3 23	+ 1 56	+ 6 25	+ 2 53	- 7 16	- 15 30	- 13 52	- 1 25
23	+ 11 48	+ 13 25	+ 6 38	- 1 40	- 3 18	+ 2 09	+ 6 27	+ 2 37	- 7 37	- 15 38	- 13 35	- 0 56
24	+ 12 03	+ 13 17	+ 6 19	- 1 51	- 3 13	+ 2 22	+ 6 28	+ 2 22	- 7 58	- 15 46	- 13 18	- 0 26
25	+ 12 18	+ 13 08	+ 6 01	- 2 02	- 3 07	+ 2 35	+ 6 29	+ 2 05	- 8 18	- 15 54	- 13 01	+ 0 04
26	+ 12 31	+ 12 58	+ 5 43	- 2 12	- 3 01	+ 2 47	+ 6 29	+ 1 48	- 8 39	- 16 00	- 12 42	+ 0 34
27	+ 12 44	+ 12 48	+ 5 25	- 2 21	- 2 54	+ 3 00	+ 6 29	+ 1 31	- 8 59	- 16 06	- 12 23	+ 1 03
28	+ 12 55	+ 12 37	+ 5 07	- 2 30	- 2 47	+ 3 12	+ 6 28	+ 1 14	- 9 20	- 16 11	- 12 02	+ 1 33
29	+ 13 06	(+ 12 30)	+ 4 49	- 2 39	- 2 39	+ 3 24	+ 6 26	+ 0 56	- 9 40	- 16 15	- 11.42	+ 2 02
30	+ 13 17		+ 4 31	- 2 47	- 2 31	+ 3 36	+ 6 24	+ 0 38	- 9 59	- 16 19	- 11 20	+ 2 31
31	+ 13 26		+ 4 12		- 2 22		+ 6 21	+ 0 19		- 16 21		+ 3 00

EQUATION OF TIME AT NOON UT

A GLASS DODECAHEDRON

A note on a new computer program has been received from Mr F J de Vries, a copy of which has been sent to Mr Peter K Scott, the BSS computer representative and adviser. Mr de Vries has prepared an interface to the professional drawing Program ACAD, details of which are given in the text below:

DODECAHEDRON

Figure 1 shows a three-dimensional dodecahedron which may be imagined as being made of glass, although it is difficult to see how the dial faces lie and what lines there are on each dial plane. To help understand and delineation, the following lines are drawn:

1 Solar hour lines, 2 Anelemmas, 3 Italian and Babylonian hour lines, 4 Lines for the height and azimuth of the sun, 5 Declination lines on most of the dial faces.

Figure 2 shows the same dodecahedron rotated approximately 60° around its vertical axis and showing the lines on a solid body so the lines on the unseen faces are not shown, simplifying its understanding.

Figure 3 shows a cube dial with solar hour lines, and Figure 4 shows the addition of declination lines and horizons.

Mr de Vries has made an interface from his dial program ZONWPLT to the professional drawing program ACAD, using release 10 to draw the three-dimensional dodecahedron by conversion of the ZWNPLT files to import the dial designs into ACAD. For the dodecahedron shown, 11 files were imported and about 70 minutes of computer running time was required to carry out the required calculations. The ACAD release 2.6 can also be used.

Mr de Vries has now stopped further development on this program as he has a new project, that of preparing a program for drawing an astrolabe. Mr Peter Scott's address may be found on the inside back cover of this issue, any queries on this program to him please.

The Editor thanks Mr de Vries for sending the information and an English translation of the data.

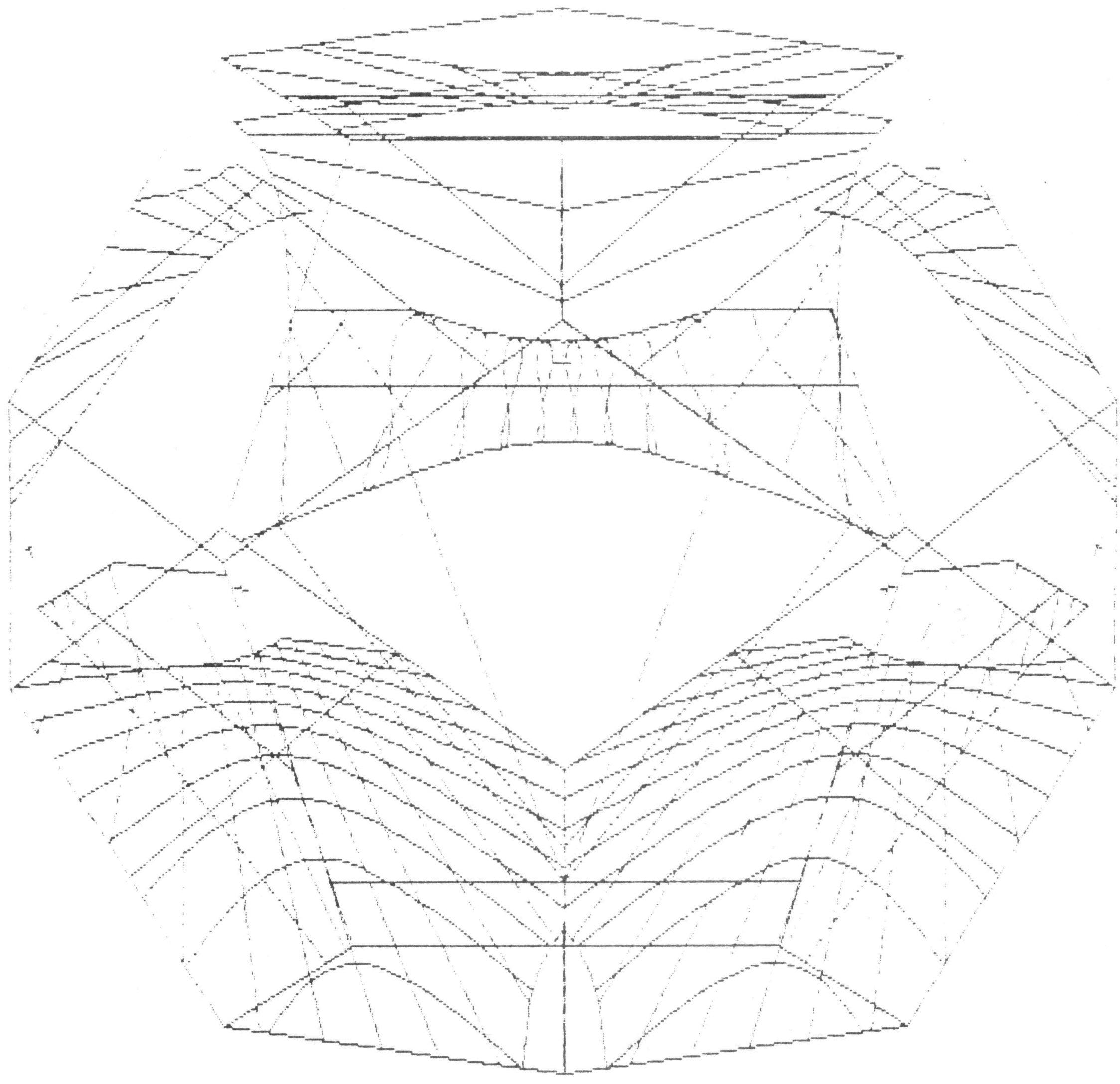


Fig 1. THREE-DIMENSIONAL DODECAHEDRON MADE OF GLASS

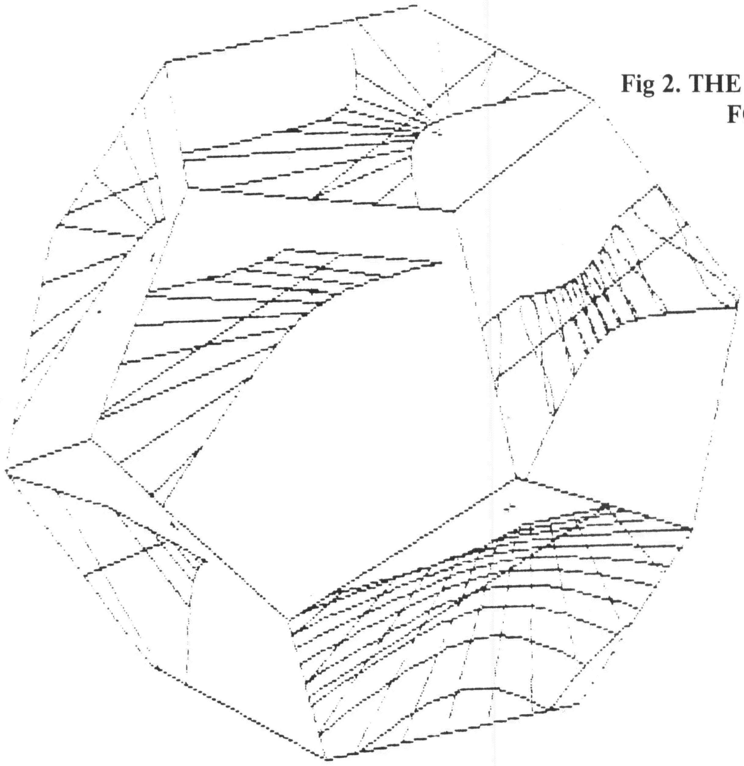


Fig 2. THE DODECAHEDRON OF FIG 1 IN SOLID FORM, TURNED THROUGH 60°

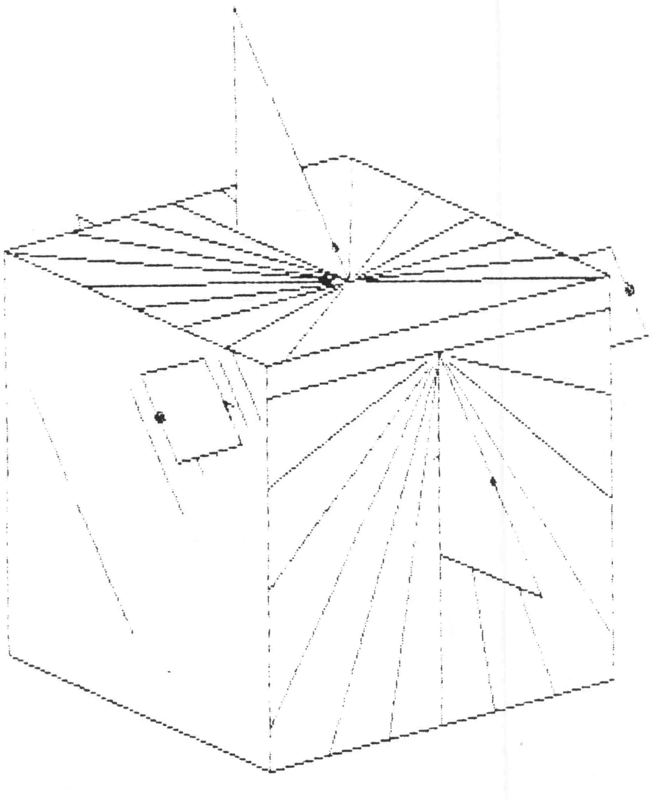


Fig 3. CUBE DIAL WITH SOLAR HOUR LINES

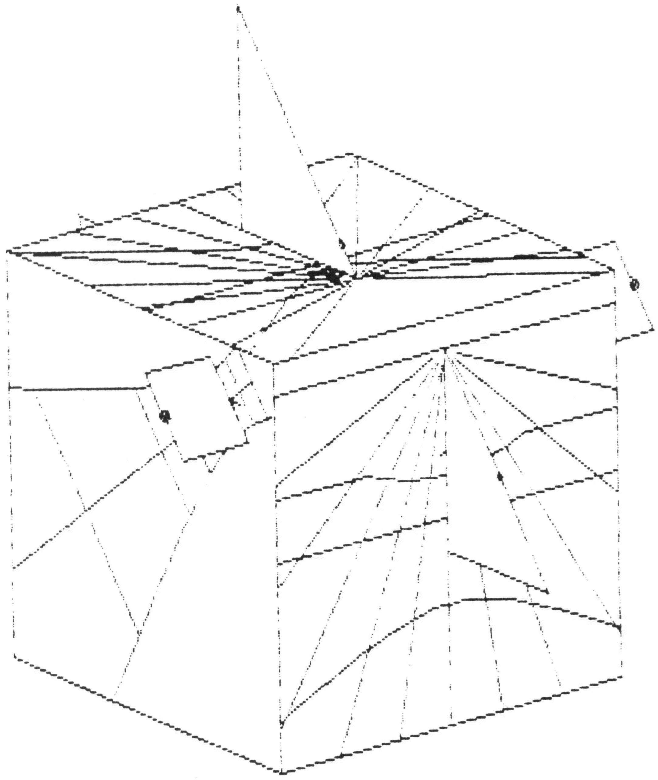


Fig 4. CUBE DIAL WITH SOLAR HOURS AND DECLINATION LINES

THE ANALEMMATIC DIAL

MARK LENNOX-BOYD

Frustrated that I found it hard to understand the proof of the Analemmatic Dial as demonstrated by René Rohr in his books, I decided to try to prove the three formulae on simple trigonometric principles. The proof was made possible by drawing a diagram which related the equatorial, horizontal and anelemmatic dials, and applying it to a somewhat involved construction. It is not very elegant but I submit it for all those who like me cannot remember much more than O-level mathematics. It must have been done before, but I have not seen it published. Others may have. The diagram is interesting also in that it provides a proof for the horizontal dial as well.

From the diagram, ABC is a semi-circle of the equatorial dial of radius a and perpendicular to the edge of the gnomon EF which is set at an angle of Ø, the latitude, to the horizontal dial; EG is the vertical edge of the gnomon. The arc IBJ is the orthographic projection of ABC onto the horizontal dial.

Therefore IBJ is half of an ellipse whose major axis is of length 2a and whose minor axis 2b is of length 2a sin Ø.

∴ (1) THE DIAL IS AN ELLIPSE WHOSE MAJOR & MINOR AXES ARE IN THE RATIO 1 : SIN Ø

Consider the shadow cast by the gnomon of the horizontal dial (plane EFG) for any hour angle H and any declination D, the tip striking the horizontal dial at K, the plane EKF striking the equatorial dial along EL.

Construct: LM perpendicular to EL; MN perpendicular to the horizontal dial; LO perpendicular to MN; LP perpendicular to the horizontal dial and which also intersects IBJ at P; PQ parallel to NG; and QR the analemmatic gnomon.

Now ML is parallel to EF and MO is parallel to EG.

Therefore OL and NP are parallel to GQ.

Therefore GQ = NP = OL = ML cos Ø = a tan D cos Ø.

∴ (2) THE DISPLACEMENT OF THE VERTICAL GNOMON ALONG THE MERIDIAN OF THE DIAL IS a TAN D COS Ø.

If x be the distance of L (& P) from the plane EBF and y the distance of L (& P) from the plane ACJI and α the angle GP makes with the meridian.

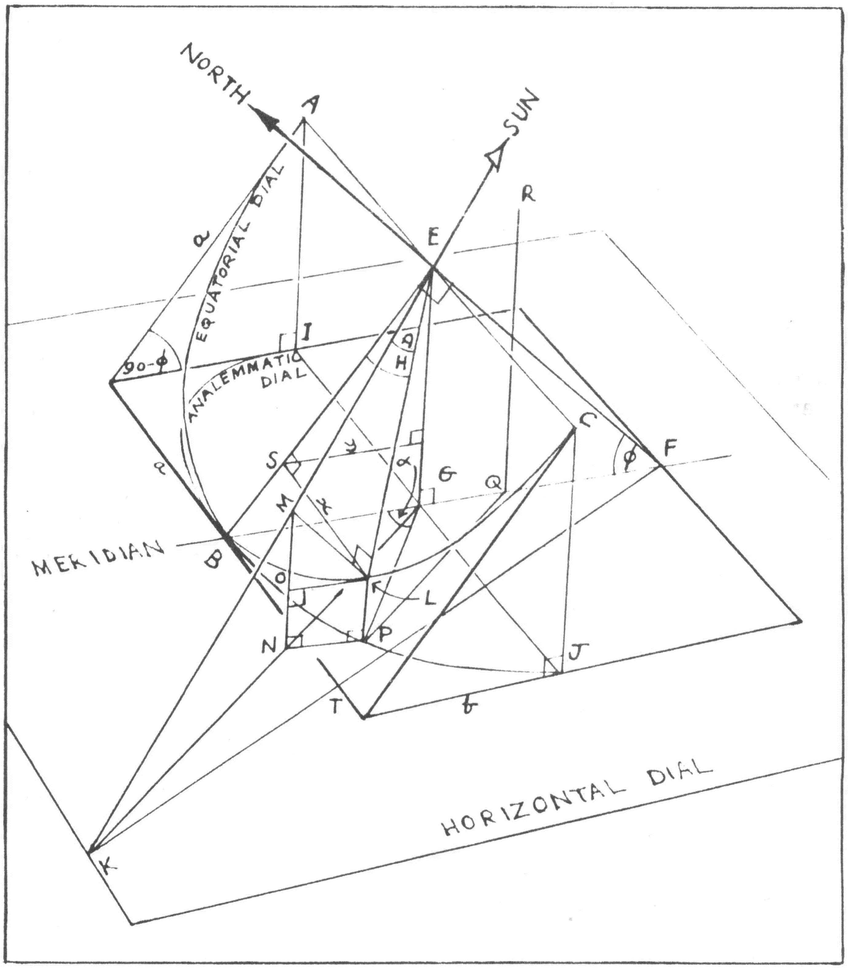
Now x = a sin H

and y = ES sin Ø = a cos H sin Ø.

Therefore tan α = x/y = tan H/ sin Ø.

∴ (3) THE TANGENT OF THE ANGLE FORMED BY THE MERIDIAN WITH THE LINE FROM THE HOUR POINT TO THE CENTRE OF THE DIAL IS TAN H/SIN Ø.

The diagram also demonstrates the proof of the horizontal dial, for if EL is extended it will strike KF at intersection T. From this construction it can be proved that tan $B\hat{F}T$ = sin Ø tan H.



A SPLENDID EFFORT

Some time ago, Mr S W Amos wrote to the editor enclosing the photograph shown here, showing a splendidly executed sundial and pedestal, and explaining his role in the matter. In December 1988 he had a telephone call from a young lady who introduced herself as Ms Linda Lack, a student at the local High School, and asking if she could come along to see him about making a sundial. Mr Stocker, the Headmaster, had a copy of the pamphlet *The Scratch Dials of Norfolk* written by Mr Amos, and so had recommended him as an adviser. Mr Amos was so taken with Linda's enthusiasm that the gave the explanations necessary to make a horizontal sundial. How well Linda absorbed that instruction and how well she accomplished her chosen project is quite apparent from the photograph,doing all the work herself, including the engraving of the lines and numerals. Not only that, she found a large piece of pine and turned the pedestal on the lathe at school. The whole assembly is now mounted on a brick plinth to bring it up to a suitable reading height.

In the photograph Linda is eighteen years of age and is seen in the grounds of Sprowston High School, Norwich. Mr Amos was eighty when Linda first met him, but obviously there was no generation gap in the collaboration. As a confirmed dialler himself, He has been greatly encouraged to find such enthusiasm in one so young.

In these days it is so easy to criticize the young, forgetting that the majority are good members of the community who make little news. It is nice to see a young person meet the challenge of materials and science to produce something as artistic as Linda's sundial and pedestal. Congratulations Linda on a fine piece of work, may you always have time on your hands with such creations.

BOOK REVIEWS

BIZKAIKO EGUZSKI-ERLOJUAK RELOJES DE SOL DE BIZKAIA [Sundials of Biscaya], written in the Basque and Spanish languages by a group of 42 authors, published by the Departmento de Cultura, Bilbao; 84 pages, 160 black and white illustrations, 9 plates and 27 illustrations in colour plus map, 24 x 24 cm.

This book is the first in a planned series dealing with collections and inventories of Biscayan riches. It is bilingual and presented with each page having the first column in the Basque language, the second being in Spanish. The presentation and layout of the material is faultless, and it is unusual to find a written text in Basque [these provincial languages being prohibited by Franco].

The pages of introduction give the names of the authors and prologue and lead to a chapter of easy readable account of life and time, soon merging into matters of the old and new ways of measuring time, including studies of the division of time, the history of the calendar from Stonehenge, via the Tower of the Winds in Athens, and on to the present day. Concurrent events in Egypt, China, Arabia, the Jewish and other civilizations are duly mentioned.

There follows a detailed and well illustrated history of the sundial, the distribution of these in the province of Biscaya, and their classification. The catalogue of the Biscayan dials begins with a map giving the locations of the more important dials. This fills 16 pages and illustrates 79 dials, each being shown with one or more photographs, these are not of a uniform quality.

For more than one reason, the book radiates an attractive aura; and with its views on Art, Gnomonics and Exotics, succeeds excellently in its approach.

René R.-J. Rohr

GEORG HARTMANN OF EGGOLSHEIM (1489-1564), LIFE AND WORK OF A FRANCONIAN MATHEMATICIAN AND ENGINEER, By Hans Gunther Klemn, published 1990.

In this study, a very important figure in Nuremberg scientific circles is dealt with in detail. Eggolsheim itself is a small village some 40 km north of Nuremberg, Germany. He was a learned practitioner in the fields of Mathematics and Physics. In addition he excelled in the field of astronomical instrument construction, including sundials. Amongst his many friends he counted Willibald Purckheimer and the great artist Albrecht Dürer, he also corresponded with many other scientists and intellectually inclined Princes. He was born 9 February 1489 in Eckoltsheim, Bamberg; and died 8 April 1564.

There are numerous objects relating to Georg Hartmann in collections, libraries and museums throughout the world, but especially in Europe and the USA. The Eggolsheim Jubilee Exhibition, to mark the celebration of the 500th anniversary of his birth, gave the most instructive opportunity until now of viewing his life and work in the perspective of a forerunner of the modern engineer.

The present study is a comprehensive revision of the introductory article in the catalogue prepared for the 1989 Exhibition and gives much detail of his life's achievements.

Unfortunately the Editor has no details of the price or where this little work can be obtained, no doubt the usual booksellers will be able to obtain it. Some details of Hartmann may be found in "Astronomical Instruments" by Zinner, and he is of such importance that an article on him will have to be included in a future issue of the BSS *Bulletin*.

K.A. MacKay.

BOOK REVIEWS

SUNDIALS BY R. NEWTON MAYALL AND MARGARET W. MAYALL, SKY PUBLISHING CORPORATION, 1989. ISBN O 933346 60 3. Pp xvi + 250, $9.95 (paperback)

Since this reviewer cut his gnomonic teeth on the first edition of this book (and is now long in the tooth!) he looked upon this copy as an old friend, even if it has had a facelift. The first edition was in 1938, the second in 1973, and this is now a second printing.

So, what has changed since 1938? I seem to remember one or two errors in that edition which are no longer present - good! The plates are no longer printed on glossy paper but are illustrations on the same paper used for the text so that they are not so clear. The list of illustrations states that eight of them are in colour - there are no colour pictures in my copy. However, a number of new illustrations have been added and these certainly help to modernise the book. The text has been revised in a number of places and new chapters have been added on the construction of variable centre dials, portable dials and heliochronometers and also on the classification of portable dials.

After giving a history of the development of sundials from the earliest times the authors give some very useful advice on how to design and construct a dial and also consider the suitability of various materials - something many other books on the subject omit. It is a pity that this section has not been revised since 1938 since new materials, such as plastic, are now available. A useful discussion of time follows though readers should note that the equation of time is defined as apparent time minus mean time and NOT the other way round as stated on pages 71 and 86. To be fair the correct definition is given on p.194.

Both projection methods and formulae are given to enable readers to delineate their own dials. In addition, a feature seldom given in other books is that there are instructions for constructing (by projection) the lines of declination (of the Sun) on equatorial, horizontal and vertical dials.

Readers in the U.K. will be interested to note that the famous sundial at Queen's college. Cambridge gets a favourable mention since it can also be used as a moondial. There is an example for finding the time when a five-day old Moon casts the shadow on the 9am line. This reviewer would be interested to hear from any reader who can explain (a) how this could actually be observed (even if the moonlight was strong enough to cast a shadow) and (b) how it was possible for the writer to deduce that the time was 5am. It is amazing that this howler has survived from the 1938 edition without being detected.

Any purchaser should check their copy carefully on receipt. The reviewer has seen two copies and both had (different) page binding mistakes.

"Sundials" is written for the intelligent layman, who does not need to be well versed in mathematics. Summing up, overall it is a useful book for students of gnomonics, but lack of care in the production has reduced its value somewhat.

Gordon E. Taylor

Reprinted, with permission from the Journal of the British Astronomical Association.

A new Sundial Group has been established in Austria, forming a part of the Austrian Astronomical Society.

A catalogue of fixed dials has been published and contains a preface by René R-J Rohr, an introduction and a history of sundials in Austria. After this comes a description of dialling with illustrations and some statistical tables together with a map of Austria. The list of dials occupies 130 pages, each province being dealt with separately, and is followed by photographic illustrations of a number of important dials and a bibliography. The text is, of course, in German.

There is an invitation to join the group which embraces membership of the Austrian Astronomical Society and at present costs ö.s. 60 per annum. The address is Astronomisches Büro, Hasenwartg. 32, A-1238 Wien.

Karl Schwarzinger. Katalog der ortsfesten Sonnenuhren in Österreich. 21 x 14½ cm. 176 pp. paper. Price not quoted.

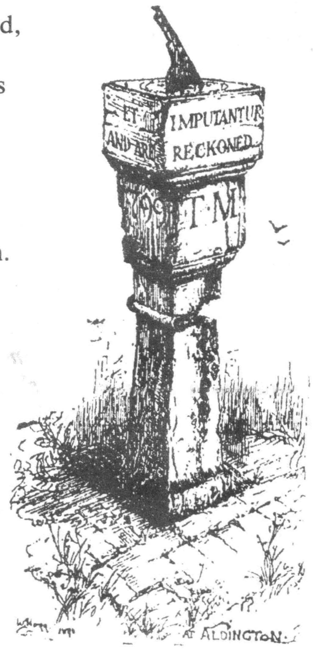
E. J. Tyler

THE SILENT STILL FORM
BY JESSICA E. SAWYER (Age 13)

The sun waltzes slowly
Through the endless blue sky,
Starting off low,
Then climbing up high.

And down on the earth,
A silent, still form,
Clocks the sun's passing,
As the days are reborn.

Its gnomon reaches upward,
While rooted to the base,
And produces the shadows
Displayed on its face.



Marking the shadows are
Lines etched in stone
That call everyone
And make the time known.

People and animals
Pass it each day,
To look at the shadow
As it goes on its way.

Cities are built,
And then are torn down,
But the sundial still rests
Proudly on the ground.

As time flies
By in a whirl,
It quietly sits there,
Ruling the world.

Time is the essence
Of the life that we lead,
So one must pay attention
To the sundial's heed.

The silent, still form,
All the world's Lord,
For awhile forgotten,
But never ignored.

LETTERS TO THE EDITOR

DIACHRONIC?

For many years, whilst on the staff of the Royal Greenwich Observatory, I used to deal with any queries on sundials sent to the Observatory. On one occasion I had a telephone enquiry from a builder/stonemason commissioned to construct a sundial for a school. The conversation went as follows:

Builder: "I've inscribed a sundial with hour lines on a block of stone, just like the face of a clock. All I need to know is how to mount it on the wall of a school".

Myself: "Well if it is to go on a wall the numerals will increase in an anticlockwise direction and will not in any case be equally spaced. Also the hour lines cannot be calculated, nor the gnomon be erected until the orientation of the wall has been determined."

After a long period of time the telephone went dead.

Does any BSS member know of a school in South-East England that may have been lumbered with a non-sundial.

Gordon E Taylor

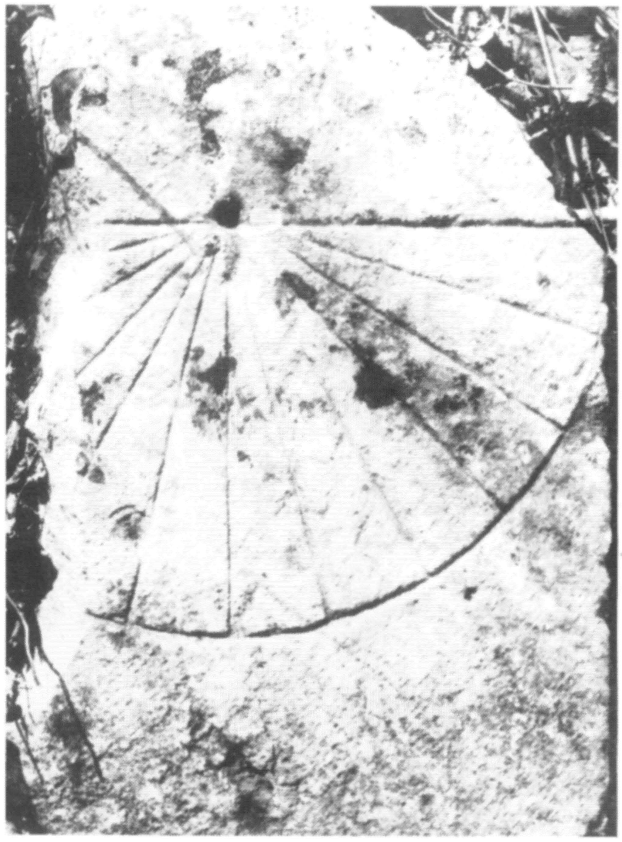
Editor: I had a similar experience with a lady architect, who with a few days to go before the grand opening ceremony of a building project with a sundial as a focal point, was asking how to delineate a sundial and did not even know if it was to be a vertical or horizontal type, nor even the latitude of the site, or if sunlight fell on the proposed location of the dial. When I told her she needed a professional diallist to advise her on the work, she enquired if payment would be required! I asked her if she worked for nothing, but evidently she did receive a salary. I was glad to put her in touch with the BSS Chairman who is more qualified to deal with these logistic matters.

THE DILUNTUM SUNDIAL

Temporal hours on ancient sundials are read according to the edges of gnomon shadows, the reason why the ancient diallers attempted to invent constructions of sundials to cover all possible gnomon shadow angles. The Roman sundial found at Diluntum had cut front edges originally. If all other constructional elements are taken into account, it can be seen that the sundial cannot capture the edges of all the shadows. *It was not actually used for this purpose: time indication was performed according to the gnomon shadow direction.* The Diluntum sundial is not a single product of ancient "naive gnomonics."

There are also a few more examples, an extreme case of which is a Roman sundial recently discovered near the Yugoslavian village Šarića Struga ($\varphi = 43° 03'$, $\lambda = 17° 30'$), on the ruins of a rustic villa. The sundial is still in situ, and although the site has not been properly surveyed by archeologists, the sundial can be tentatively dated to a period between the I and IV centuries. The circle is of radius 25 cm and divided into twelve equiangular sectors, which again dictates a special division of the day. An indication of the time of day is given by a horizontal gnomon. This kind of sundial is older than those constructed in Greece and also survives them.

Dr Milutin Tadić, Yugoslavia



TIDAL DIAL

For a long time I have wanted to thank you for your letter with Finés Book but have waited until finishing my tidal dial.

Furthermore, in remarking of an error in the last Bulletin 91-1, on page 5, I now reply that I appreciate A.R. Somerville's competence too much, and especially in respect of tidal dials, to believe he had made a mistake.

First I have discovered an error with the moon, late the 7th day of the moon but this error continues about the hour of high tide, I think that it is not the 7th day but the 11th for the values of the moon late (9h) and the hour of high tide (12h) are correct. The "Establishment" at London Bridge is known to be near 2h 30m. On the 5th day of the moon, the solar component of the tide advances the tide and on the 11th day of the moon, it delays it, but I suppose that John Marr gave only the tidal delay average.

I have read that a table dated circa 1213 about tides for this location for each age of the moon exists in London but I am unaware where it is preserved.

Your proposal for me to write an article about moon dials - I will do that later with pleasure. Compliments to B.S.S.

Denis Schneider, France

LETTERS TO THE EDITOR

P.S. On my tidal dial, 671 harbours are engraved on the lateral area of the cylinder according to their establishment.

Editor's note: The material referred to is contained in Andrew Somerville's interpretation of John Marr's manuscript of 1631, and one of the last discussions with him was in respect of the reproduction of this manuscript in the *Bulletin.* He was most insistent that it be reproduced exactly as in his rendering. This has caused the Editor a great deal of work is ensuring that his wishes were carried out to the letter because of the various archaic signs and conventions. Any errors are produced exactly as written in the original manuscript, and these would have been commented upon at the end of the series. Unfortunately Andrew Somerville did not have time even to conclude the last parts of the manuscript, never mind the analysis and comment. But it is safe to say that of all the people the editor has known, Andrew Somerville made the least number of errors in his research work. The association of the moon with dials is difficult enough, the association with tides remains a mystery to the editor, in spite of working on behalf of the Navy for forty years.

ORIENTATION OF WALL

In the Bulletin for February 1991, Richard Thorne requested a formula to ascertain the orientation of a wall using the device he described.

In the diagram below, O and M are the points where the vertical and inclined strings meet the plane of the protactor. The orientation of the wall is θ measured west of south, and the Sun's bearing is A measured west of north. If the reading on the protractor is R, then

$$R + A + \theta + 90° = 360°$$

$$\text{i.e. } \theta = 270° - R - A$$

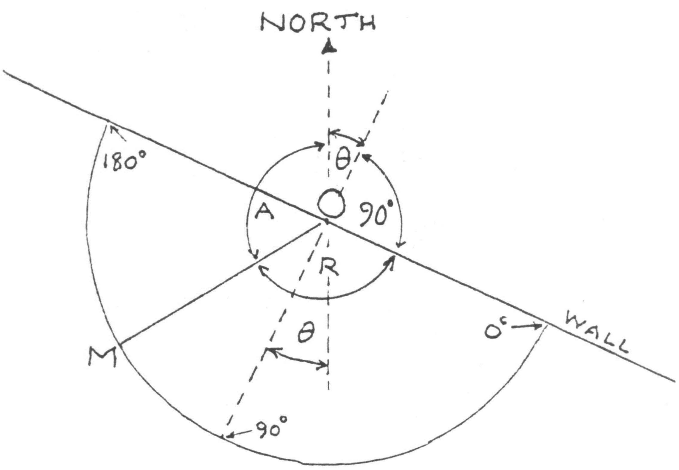
giving θ when A is known.

The value of A may be determined from the formula

$\cot A = \tan \delta \cos \phi \operatorname{cosec} H - \sin \phi \cot H$

where δ is the Sun's declination, ϕ is the observer's latitude, and H is the Sun's hour angle given by $H=15n°$ where n hours is the local solar time minus 12 hours.

Yours sincerely,
J.G. Freeman



THE SPHERICAL SUNDIAL

Peter Drinkwater's article[1] drew attention to this rather neglected form of sundial, but prompted Woodford[2] to point out an ambiguity associated with hour numerals positioned on an equatorial band., This is that twelve noon indicated by the shadow, (the terminator) is 90° from a 12 noon mark in the 'common sense' position below the Sun. This problem may be obviated by a small change in design.

The radius of the earth is neglible by comparison with its distance from the Sun. Therefore, so far as illumination is concerned, a model Earth placed in the open air with:

a Its axis pointing at the celestial poles, ie with the northern end pointing at *Polaris.*

b The location of the actual site at the very top of the model globe.

behaves exactly as if it were fixed at the centre of the real earth[3]. It is rotated once a day by the planet itself: no additional mechanism is required. As a result, parallel rays of sunlight produce an illuminated hemisphere displaying the dawn and dusk terminators, and showing where the noon Sun is directly overhead.

Polar extensions of the model's axis thus act as gnomons of 24-hour sundials. The northern dial is operative in summer, when it can be seen the Antarctic is in perpetual darkness, whilst the far North is enjoying the 'midnight sun'. With a changeover at the autumnal equinox, the opposite regime applies for the duration of the northern hemisphere winter.

The accompanying illustration is of a preliminary 'mock-up' for a globe sundial exhibiting the above phenomena. The model is made from a beach ball, and in reality is only some 10 inches in diameter. However the montage gives some impression of what a five feet diameter sculptured stone sundial might look like at this site. Whether the latter will actually be built depends (as usual) on the availability of funds.

Allan Mills

1. P.I. Drinkwater, *Bulletin of the British Sundial Society,* 1990 3 12-13.
2. G.P. Woodford, *ibid,* 1991 1 34.
3. R.M. Sutton, *Scientific American* 1959 201 No. 2 (August) 137-144.

"MOCK-UP" of proposed globe dial for Leicester University.

LETTERS TO THE EDITOR

GEOMETRIC PUZZLE

Having got down to a detailed study of *Bulletin* 90.3, page 28, I regret to say that we have still failed to get Mr de Vries' typescript mathematics correctly translated into print. The enclosed copy of part of page 18 shows the correct version:

To calculate: φ' [new latitude] d' [new declination] t_{s} [longitude correction]

$$\cos(90°-\varphi') = \cos(90°-\varphi).\ \cos(90°-i) + \sin(90°-\varphi).\sin(90°-i).\cos d$$

$$\sin\varphi' = \sin\varphi.\sin i + \cos\varphi.\cos i.\cos d \qquad \text{So } \varphi' \text{ is known}$$

$$\sin(180°-d')/\sin(90°-\varphi) = \sin d/\sin(90°-\varphi') \quad \dots \quad \dots$$

Yours sincerely,
George Higgs 24.10.1990

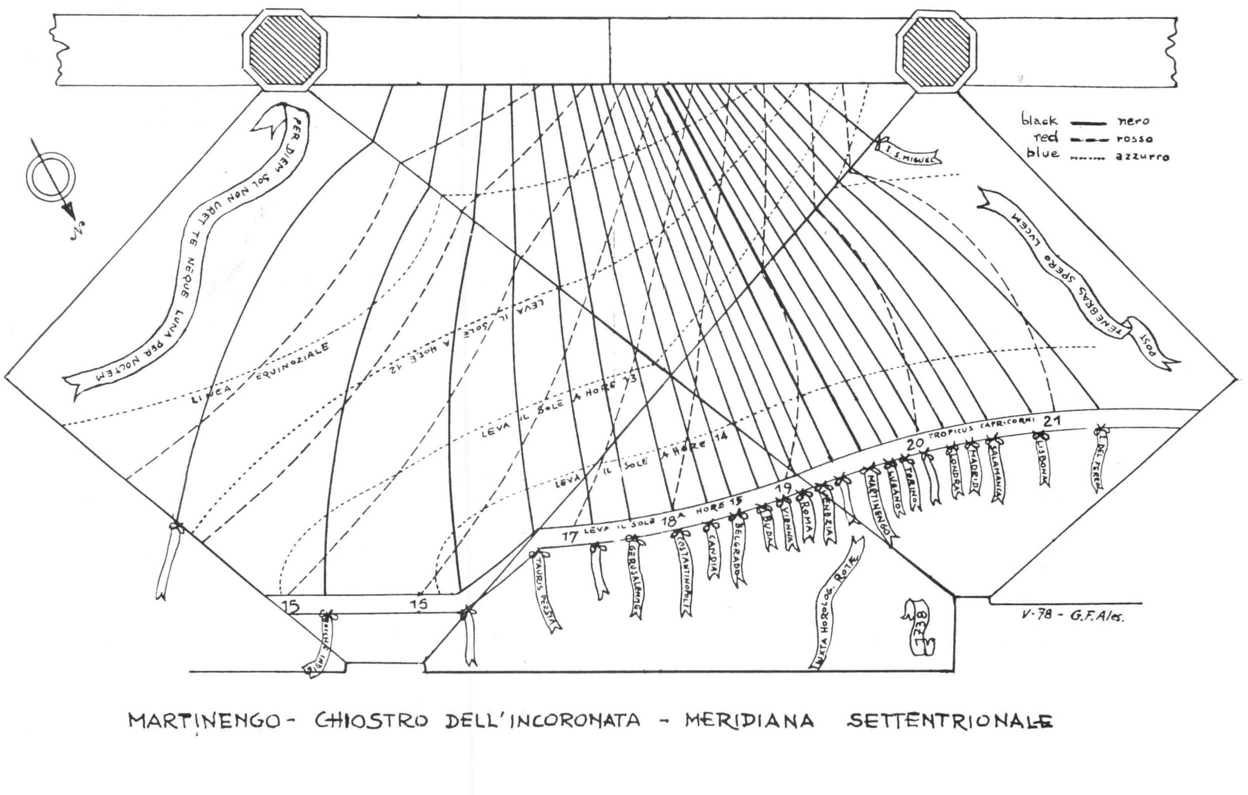
The Editor apologizes for omitting this from *Bulletin* 91.1. Mathematically inclined members will no doubt have recognised the errors, the proofs were correct when sent to the printers but alas there is many a slip...

M. Rohr, the author of the article "Reflected Ceiling Dials", *Bulletin* 90.3, October 1990 has received information from Eco di Bergamo, 27 June 1978, about two reflecting dials in an Italian monastery at MARTINENGO in the province of Bergarmo. One is oriented SW, see the attached drawing; the other is oriented SE. It is rumoured that in the same province there exists three more of these interesting reflecting dials, ie five in all. Mr. Rohr is researching into these matters and will send reports when he has further news. It is quite exciting to find that there are more of these reflecting dials to be discovered, if other B.S.S. members have any further information, please send details to the Editor.

The two mottoes on this dial of 1738 read:

Left: *Per diem sol non uret te neque luna per noctum* - The sun shall not burn thee by day neither the moon by night.

Right: *Post tenebras spero lvcem* - After darkness I hope for light.



MARTINENGO - CHIOSTRO DELL'INCORONATA - MERIDIANA SETTENTRIONALE

CORRECTIONS BY NOEL C TA'BOIS

Sundials, Their Theory and Construction, by Albert E. Waugh

Page 12 Rules 1, a and b. Transpose "Add" and "Subtract". Rules 1 and 2 as printed are identical. The equations are correctly summarised on page 201.

Page 21 Footnote. For "one" read "two minutes". The sun (and the moon) subtend an angle of half a degree to the observer, which at four minutes/degree, is equivalent to two minutes.

Page 60 Fig 7.2. The hour lines for 4 and 5 pm, and 7 and 8 am, should radiate from opposite sides of the gnomon, ie they should be continuations of the 4 and 5 am and 7 and 8 pm lines. The style, or shadow casting edge of the gnomon, changes from one side to the other at 6 o'clock. The change in the reverse direction, takes place at noon, which of course is not relevant on this dial, which is north-facing. It is of importance on a south-facing dial or a horizontal dial when there are two noonlines which are separated by the thickness of the gnomon.

Page 111 Table 13.3. The values of Z are correct for the latitude 39° 50′ and not as stated: 40° 43′.

Page 182 Fifth line from bottom. Delete "two or". As can be seen in Fig 18.4 the shadow will take **exactly** three hours to traverse this face.

Page 183 As in Fig 7.2 on page 60, the 5 am line is incorrectly positioned and should radiate from the opposite side of the gnomon (the sloping surface of the headstone). In fact, as shown, there is no horizontal surface on which this line could be scribed. One wonders whether this illustration is of a real dial or just a figment of the imagination of the author!

Page 196/7 Figs 19.5 and 19.6. Although not an error some confusion might be caused by the use of the letter "E" and "F" for points which do not correspond.

Page 216 Table A.9. Again not an error but care must be taken in positioning the square for a dial with a thick gnomon. The unit square must be positioned against the side of the gnomon acting as the hour style in question. See remarks against page 60 above.

CALCULATIONS

The use of electronic pocket calculators have made the use of logarithms unwieldy. The inverse functions of cot, sec and cosec may be obtained from tan, cosine and sine values by using the 1/x function key.

THE FAMOUS "DOLPHIN" SUNDIAL AT THE GREENWICH MARITIME MUSEUM TO MARK QUEEN ELIZABETH'S SILVER JUBILEE IN 1977, DESIGNED BY MR. DANIEL.

PROFILE: CHRISTOPHER ST. J.H. DANIEL - CHAIRMAN

In 1964, after a thirteen year career at sea, mainly with the P & O line, Christopher Daniel joined the curatorial staff of the National Maritime Museum, Greenwich, where, in 1979, he became Head of the Department of Museum Services. He left the Museum in 1986, and since has specialized in sundial design and as a consultant authority on sundials.

From 1967 onwards, during his museum career, Christopher Daniel made a particular study of sundials and their history. In 1972 he designed the armillary sundial symbol for the Nautical Institute, and in 1977, to mark the Queen's Silver Jubilee, the now well-known equinoctial mean-time 'dolphin' sundial, sculpted by the leading British sculptor Edwin Russell, for the National Maritime Museum at Greenwich. Similarly, he designed the vertical sundial, also sculpted by Edwin Russell, for the new premises of the Marine Society and Nautical Institute at Lambeth, which was unveiled by Her Majesty the Queen in December 1979. He also delineated the horizontal garden sundial which was presented to Her Majesty the Queen Mother, on the occasion of her 80th birthday in August 1980, by the Victoria Cross and George Cross Association. Some of his other most notable designs include the four vertical sundials for St. Margaret's Church. Westminster (1982), the analemmatic 'human' sundial for the Liverpool International Garden Festival (1984), the reconstruction of the 17th Century wall dial at H.M. Tower of London (1987-1988), and the modern armillary sundial, in the Victoria Embankment gardens at Savoy Place, marking the centenary of the Savoy Hotel (1989). In the field of restoration and reconstruction, he has also designed the various necessary components for a number of historically significant sundials, e.g.: the 17th century stained-glass window sundial - thought to be the work of John Oliver - for the Worshipful Company of Weavers at Wanstead, the re-delineation of the early 18th century mural dial at Castle Bromwich, the 18th century horizontal sundial by Benjamin Martin at East Grinstead, and another horizontal dial by Thomas Tompion at Hampton Court. His most recent work includes the design of five wall dials for Larne, Northern Ireland, made by Brookbrae Limited of London (1990), and, this year, the Andrew Somerville memorial sundial for the Bollington Arts Centre, Macclesfield, in Cheshire.

It is probably well-known that Mr Daniel has an especial interest in historic stained-glass window sundials and their preservation. However, he has an even greater and a much longer standing concern for the preservation of the nation's sundial heritage as a whole. As long ago as August 1975, he discussed his proposals for a British Sundial Register with Mr. Gordon E. Taylor, the Registrar of the Society, who had similar ideas. It was about this same time also that he first seriously considered the formation of a British Sundial Society to carry out the onerous task of recording the unknown multitude of noteworthy sundials located throughout the country. One of our members, Mr. H. Robert Mills, in a letter to Mr. Daniel, dated 28th May 1976, refers to the contemplated 'British Sundial Society', seemingly with some awe of this impending authoritative body!

Christopher Daniel's publications concerning sundials and related instruments, include the National Maritime Museum monograph No. 28 - **Sundial on Walls** (1978), and the popular Shire album No. 176 -**Sundials** (1986), reprinted in 1990. He has also written numerous articles on the subject, including a spectacular article on stained-glass sundials, which appeared in **Country Life** (26 February 1987) and another which was published in **Clocks** magazine (April, 1988). Since August 1988, following the sad death of Noel Ta'bois, he has been the author of the regular monthly feature, 'The Sundial Page', in **Clocks** magazine.

Christopher St. J.H. Daniel, Chairman of the British Sundial Society.

In 1973, Mr Daniel had a remarkable break from his museum career, when he was given sabbatical leave to join the reproduction of Francis Drake's famous ship, the **Golden Hinde,** as second-in-command. During the voyage from Plymouth to San Francisco in 1974-75, he carried out a programme of observations using period navigation instruments.

Christopher Daniel is a member of two other sundial organisations, namely the Commission des Cadrans Solaires de la Société Astronomique de France and the Dutch sundial society, De Zonnewijzerkring. He is also a Fellow of the Nautical Institute, the Royal Institute of Navigation, the Royal Astronomical Society, and the Society of Antiquaries of London. A liveryman of the Honourable Company of Master Mariners, he was elected Senior Warden of the Company for the 1988-1989 term and subsequently held the office of Deputy Master for the year 1989-1990, during the two year tenure as Master of His Royal Highness the Prince of Wales. He is also a Foyle's list lecturer, has lectured in the United States of America and lectures extensively throughout the United Kingdom. Despite his passion for the **art of dialling,** Chistopher Daniel still has an intense love of ships and the sea, a great interest in the history of navigation and a fascination for the submarine. He enjoys a broad spectrum of music - popular as well as classical, reading, walking, driving, and, not surprisingly, the pleasurable 'sport' of hunting sundials-!

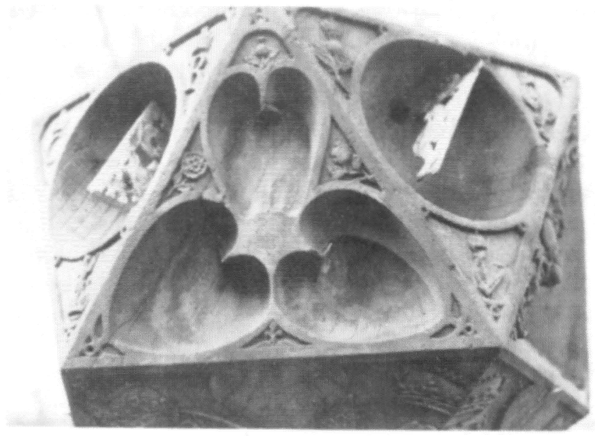
THE BRITISH SUNDIAL SOCIETY ANNUAL CONFERENCE AND A.G.M. EDINBURGH 3-7 April 1991

In his introduction to the Andrew Somerville Memorial Lecture on the last day of the Conference our new Chairman, Christopher St J H Daniel, expressed the view that our late founding Chairman was surely with us in spirit. If Andrew was indeed with us he could not have wished for a better gathering in the country whose sundial studies he had made his own. The atmosphere of these four days, when rather more than eight members gathered together, was warm, friendly, full of interest and altogether a memorable experience of good fellowship and rewarding sharing of ideas and information.

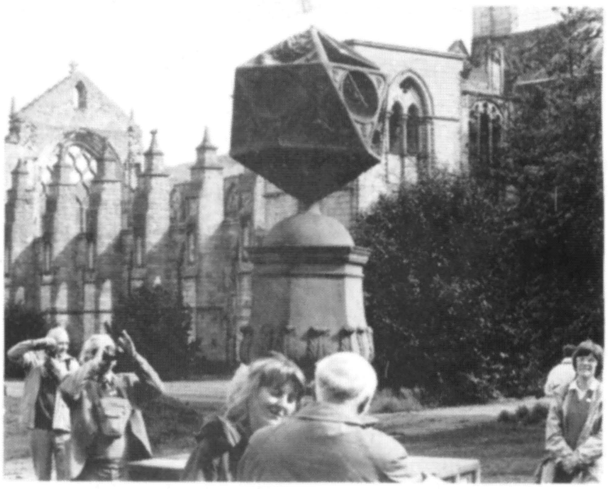
About thirty members arrived early to take advantage of a coach tour organised by Mrs Anne Somerville, to see several Scottish dials in the region of Edinburgh. The first dial we saw was a lectern dial at Inveresk Lodge (1644) recently restored by Mr George Higgs, where our Chairman's eagle eye instantly spotted that the north face gnomon had been fitted upside down, to the hilarity of the group and consternation of George! However the problem was solved by George explaining that after restoration he had sent the dial back with its gnomons loose, to be fitted on site by someone not altogether conversant with these things! Two more vertical dials by Handasyde on Inveresk Church, then on to Newbattle Abbey near Dalkeith to see a splendid pair of matching faceted dials about 5 metres high, chalice-shaped with elaborate finials above, reflecting in profile silver-gilt wine cups of the early 17th century, popular in court circles at that time. The Newbattle Abbey dials of 1635 were not seen under ideal conditions, but it was an extraordinary sight to observe wildly enthusiastic members clambering about them to find every detail in the pouring rain! Across the Forth into Fifeshire to see the dials at Aberdour Castle with its cube dial surmounted by a globe dial, a vertical dial and a 24-hour, fully marked horizontal dial from Aberdour House. Finally a splendid visit to see the facet-head dial at Fettes College on the outskirts of Edinburgh, which looked magnificent in the late afternoon sunshine against the background of the extraordinary College buildings. The whole day was a tribute to Anne Somerville's enthusiasm, dedication, energy and inspired leadership.

To describe in detail all the lectures and demonstrations which took place from the first evening to the last morning would take too much space, but they must all be mentioned because there was never a gap in the constant flow of fascinating and informed material which members clearly enjoyed. David Young got things off to a fine start with his informal and entertaining review of dials he had noted of particular interest; Dr Allan Mills introduced us to the dials made about 1660 by the young Isaac Newton on the wall of Woolsthorpe Manor in Lincolnshire, where he was born, and with incredible detective work filled in the background against which Newton must have made his calculations at that time; Gordon Taylor showed us and described the slate equatorial dials of John Bonar made in the 1620s and 30; Jane Walker and David Brown of the BSS Education Group presented the details of the new handbook they have prepared to help teachers to deal with dialling in the

Anne Somerville standing on the pedestal of Queen Mary's dial at the palace of Holyroodhouse to review her BSS troops.



Detail of Holyroodhouse Palace Dial



Queen Mary's dial against the background of the ruins of the nave of the Abbey Church at Holyroodhouse Palace.

The unique dials on John Knox's house in Edinburgh.

The facet-head dial at Fettes College, Edinburgh.

Lecturn with star plane and polar hemi-cylinder at Inveresk Lodge Gardens, dated 1644.

new National Curriculum, and illustrated many of the basic principles of the art using models made from cheap and simple domestic materials - a most praiseworthy effort; George Higgs, at over ninety years of age, amazed us with his lucid and anecdotal accounts of Scottish dials on which he had done restoration work in recent years; Robert Sylvester of Cumbria talked informally at an evening session about dials he had recorded in his area. The final lecture was by Chris Daniel on English polyhedral dials, taking us back to the origins of such dials in the Early Renaissance, through the work of Nicholas Kratzer and others, and describing many English dials of polyhedral form. This talk on predominantly Scottish types in England, presented in Scotland, formed an admirable counterpart to Andrew Somerville's talk on Scottish dials, presented in England, at our last Annual Conference in Oxford.

To the above impressive list of talks both formal and informal must be added an afternoon's walk to see the dials in the City of Edinburgh, taking in, amongst several others, the marvellous facet-head dial at the Palace of Holyrood House, known as Queen Mary's dial because it is reputedly said that it was made for Queen Henrietta Maria, wife of Charles I on the occasion of his coronation in Scotland in 1633.

Another afternoon's visit was made to see the splendid collection of dials (and superlative collection of 17th and 18th century scientific instruments) in the National Museums of Scotland in Chambers Street, guided by the Curator David Bryden after a general introduction to the history of the museum by its Director, Dr R Anderson, earlier in the day. After the museum visit those who still had the energy went to see the sad remains of a polyhedral dial and eleven pairs of diptych dials of 1631 at George Heriot's School. In addition to all of this there was the most enjoyable BSS Annual Dinner held at the Scandia Crown Hotel, attended by our Patron, The Rt. Hon. the Earl of Perth P.C., and throughout the conference displays of amateur and professional dials, brought to the meeting by members, were available for study. An interesting section amongst these displays was a group of 'wrong' dials, challenging members to test their ability to spot the mistakes.

The last item of the long weekend was the Annual General Meeting at which reports on various aspects of the past successful year of our new society were given. Nothing could have given a better indication of the firm ground on which the BSS has been established than this second annual conference in Scotland, which will long be remembered by those fortunate enough to attend. A word of thanks is due to the staff of the Pollock Halls of Residence at Edinburgh University which provided most hospitable accommodation, and special thanks must, of course, be offered to David Young, Mike Cowham and other members of the BSS Committee for making such impeccable arrangements.

Alan Smith

Editor's note: The last photograph on this page shows Mr. George Higgs on the left, and Dr. Marinus J. Hagen, Vice-President of the British Sundial Society, on the right, of the Inveresk Lodge Gardens sundial.

All photographs provided by - Mr. Mike Cowham.

AN EQUANT SUNDIAL

BY FREDERICK W. SAWYER III

The classical horizontal sundial has the disadvantage that the hour-lines are not equi-spaced, so that it is difficult to adjust the dial manually for the equation of time. Ironically, in order to address this situation the diallist may benefit by reviewing ancient Ptolemaic astronomy. In constructing his planetary models, Ptolemy managed to reduce non-uniform angular motion about a point G to uniform motion about a separate point *E*, generally referred to as the equant point. The same approach may be adopted for a horizontal dial in the following manner.

Let *E* be the desired equant point and origin of our coordinate system with the y-axis lying along the meridian. Let the gnomon lie in the meridian plane with an inclination above the dial face equal to the geographic latitude *Phi*. The gnomon intersects the dial face at the point *G* with coordinates *(O, -m)* for some constant *m*.

Let *(X,Y)*be the coordinates of a point *S* on the gnomon's shadow for some particular date and time. Then the standard equation for a horizontal dial yields:

$$X/(Y+m) = (\tan t) \times (\sin Phi)$$

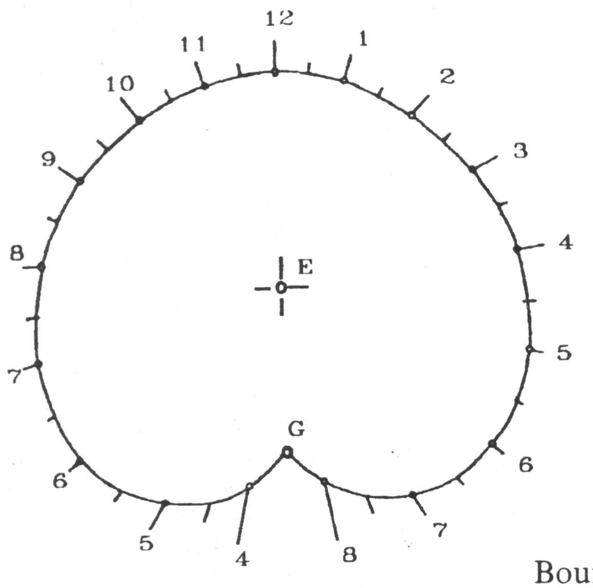
In order for *E* to be an equant point we must have the angle between the meridian and the line *GS* equal to *Kt* for some **constant** *K* and all values of *t*. The values of *K* which will be of primary interest are $1<K<2$.

We then have:

$$X/Y = \tan Kt$$

Together these equations determine the point *(X, Y)*, independent of the solar declination:

$$X = m \times \sin Phi \times \tan t \times \tan Kt / (\tan Kt - \sin Phi \times \tan t)$$
$$Y = m \times \sin Phi \times \tan t / (\tan Kt - \sin Phi \times \tan t)$$



Now instead of drawing hour-lines on the face of the dial, draw a curve determined by the points (X, Y) for values of t ranging from earliest sunrise to latest sunset and a selected value for the constant K. The dial face should lie on top of a rotatable circle of equi-spaced straight hour-lines with 15k degrees for each hour.

The centre of the circle is the equant point *E*. To read the time, find the point of intersection of the gnomon's shadow and the *(X,Y)* curve. This point will lie among the hour-lines visible on the portion of the circle extending beyond the curve - portions of the dial face beyond the curve should be cut out so that the hour-lines will in fact be visible.

Since the hour-lines are equi-spaced , all time corrections can be made by a simple rotation of the hour- circle, leaving the gnomon and *(X,Y)* curve untouched.

A suggested value for *K* is 24/C, where C is the total number of hours into which the rotating circle is to be divided.

If instead of using the suggested value for *K*, we were to set K=1, the *(X,Y)* curve would degenerate into a straight line, which is easy to draw but which has the disadvantages of reduced precision in the extreme hours and an inability to register values of *t* with absolute values greater than or equal to 90 degrees. The dial resulting from this special case was discussed by Dr. C. Macrez in "Correction manuelle des cadrans pour l'equation du temps", (*l'Astronomie,* 90:368-371, Sep 1976).

The more general case for which $K>1$ has been discussed by Dr. Macrez in (*l'Astronomie,* 97:463, Oct 1983), and by Thys J. de Vries in "Zonnewijzers met instelmogelijkheid voor tijdsvereffening en zomertijd", (*De Zonnewyzerkring voor belangstellenden in de gnomonica - Bulletin,* 5: 185-189, Feb 1980). Both authors acknowledge the idea and equations to have originated with the present writer; Mr. de Vries goes on to consider the case of an equant point selected off the meridian.

Finally, let us point out an alternative case, suggested by T.J. de Vries in Nov 1980 correspondence. Consider the following curve, where *t* is expressed in radians rather than degrees:

$$X = Kt \qquad Y = Kt / (\tan t) \times (\sin Phi)$$

This curve may be laid over a linear scale, with the hours denoted by parallel, equi-spaced north-south lines separated by a distance of .2618K per hour (i.e. 15K degrees converted to radians). This linear scale can simply be moved back and forth to account for the equation of time and any other longitudinal or seasonal adjustments to the dial. Time is read by seeing where the intersection of the gnomon's shadow with the curve falls among the equi-spaced hour-lines.

Boundary Values

Case	X	Y
t = 0 degrees	0	m x sin Phi / (K - sin Phi)
t = 90 degrees	-m x tan Kt	-m
Kt = 90 degrees	m x tan t x sin Phi	0
Kt = 180 degrees	0	-m

THE SUNDIAL IN THE MANUSCRIPT 225 OF RIPOLL

BY EDWARD FARRÉ I OLIVÉ, SPAIN

In August 1835, nearly a thousand years after its foundation, the monastery of Ripoll was savagely assaulted, all the monks were murdered, graves desecrated and the buildings burnt down. In that fire a large part of the library was destroyed, so that only a few hundred of the works in the great book collection were saved through being deposited in the *Arxiu de la Corona d'Arago*·[Crown of Aragon Archives]. Amongst these survivors there was a manuscript successively titled *Liber de Horis,* later *Tratado de Astronomia y del Relox* and today is known as *Manuscript Rivipullensi 225.*

The manuscript 225 is from the second half of the 10th century and contains a miscellaneous compilation of several older treaties collated from previous essays, translations and transcriptions of other manuscripts, many of Arabic origin and all of them having a scientific content.

The writing of this type of compilation, often used in the 10th century, originated with the need to have manuals of the didactic kind which could be used by instructors and their students when teaching or learning subjects such as astronomy, geometry, surveying, mechanics and gnomonics. The practical aim of these subjects was, amongst others, the measurement of distances, heights and depths, forecasting eclipses and other astronomical phenomena, to determine the hours by day or night, and the construction of appropriate devices to accomplish these aims such as quadrants, water-clocks and sundials.

Thus manuscript 225 has the undeniable character of a practical manual. Its size of 13 cm height by 11 cm width makes it look like a book for consultation which can be slipped easily into the pocket, it contains slightly more than two hundred folios of parchment which give a combined thickness of 2 cm. In contrast with its appearance, the contents are of a very great cultural importance.

The main subject appearing in ms 225 is on the astrolabe, an instrument known only by the Arabs at that time. They had inherited it from the Greeks through such treatises as those of Johannes Philopon (4th century), Theon of Alexandria (4th century) and Claudius Ptolemy [c AD 90-168] (2nd century); and through Catalonia it was introduced for the first time to occidental Europe.

This was the very important thesis formulated in 1935 by Dr Josep Maria Millàs i Vallicrosa from his study of ms 225, published in his *Assaig d'Historia de les Idees Fisiques i Mathemàtiques a la Catalunya Medieval* [Historical Essay of the Ideas in Physics and Mathematics in medieval Catalan], and its impact has not yet disappeared.

Three of the chapters of ms 225 entitled: "Astrolabii sententiae, De nominibus laborum laboratorum in ipsa tabul", and "Capitula horologii regis Ptoiemei", together form a treatise of the use of the astrolabe which appears to be a direct translation of an original Arabic text, the transcription of which is attributed to Sunifred Llobet, Archdeacon of Barcelona, who was involved with the cultural activities at Ripoll.

A further chapter, entitled "De Mensura astrolapsus" complements the previous chapters and gives some ideas about the construction of the astrolabe; it seems to be the summarized version of another original Arabic text which was included with the previously mentioned texts. The translation and summary of this fragment is attributed by Millàs to the aforesaid Llobet from Barcelona. The following chapters entitled "De utilitalibus astrolabii" and "De mensura astrolabii" form another treatise on the construction and use of astrolabes but written in a more accurate and literary style, it looks like a review, with modifications, also by Llobet, of the translations previously mentioned. That is to say we have before us two complete treatises on the astrolabe from Sunifred Llobet's hand; the first being a direct translation from the Arabic text, whereas the second is revised to be more suitable to occidental usage and with a more accurate text but still based upon the orginal Arabic text.

Another chapter of ms 225 which is of interest with its relation to the measurement of time is the so-called "Componitur orologium cum astrolabii quarta parte" which is a direct translation from the Arabic in respect of the astronomical applications of the quadrant with the cursor, amongst which it is remarkable to find the determination of the temporary hour as a function of the date and height of the sun. Without completely exhausting the contents of the ms, and before confining this article to the main subject, it may be mentioned that there is a chapter devoted to the description of a water alarm clock with mechanical features. It was commented on by Maddison, Scott and Kent in "An Early Medieval Water Clock", *Antiquarian Horology,* Vol III, No 12, September 1962, pp 348-353.

Another chapter, in which are given instructions for the construction of a sundial, will now be dealt with immediately. Within the length of seven pages of ms 225, [folios 94 to 97], is a text describing a sundial, with necessary instructions being given for its layout and construction. The sundial described is a horizontal type with hour lines engraved for temporary hours on a circular flat stone, in the centre of which the gnomon stands vertically.

The text commences by giving the instructions to lay out the dial on the stone, with six concentric and equally spaced circles to represent the twelve months of the year, plus a diametrical line called the "meridian line" which cuts all the circles in half. As this text still has didactic clarity after nearly a millenium, which was the author's main intention for his disciples' use, I offer the reader a direct translation of the main paragraphs from the original Latin text:

> *In the nearest circle to the centre and at the left of the meridian line we will engrave the name of the month of June at one side, and at the other the month of July. In the second circle we will engrave May on the left of the line and August on the right, and so on until the sixth circle, where we will place the months of January and December.*

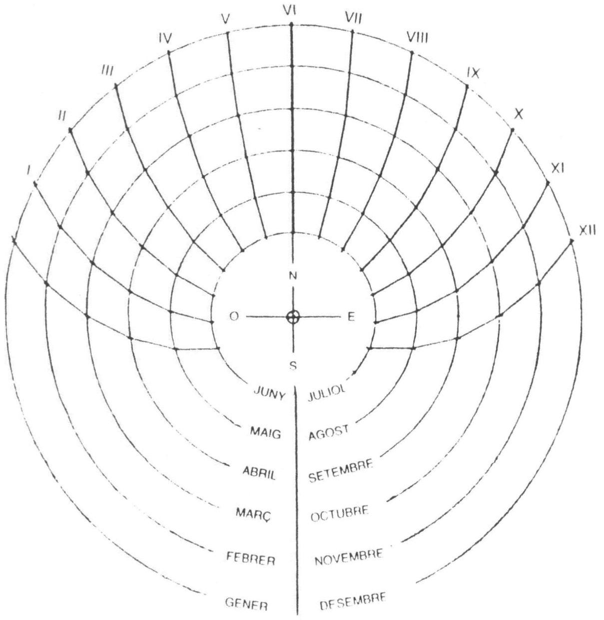


FIG 1 Reconstruction of the sundial described in ms 225, according to the explanations in the first part.

Later on, the ms indicates how to inscribe the hour divisions circles for each circle according to the relative duration of daylight hours in comparison with the night hours. [Seasonal or temporary hours where the day and night are divided into twelve parts of differing duration throughout the year].

We will divide the circle of the month of June and July in 24 parts starting from the meridian line, we will give 15 of these parts to the day time, whereas the others will be given to the night. The 15 parts corresponding to the day will have to be equallly divided on each side of the meridian line, that is to say, seven parts and half at each side. The arc of the middle [circle] formed by the 15 parts will be divided into the 12 diurnal hours, thus, six will be placed each side of the meridian line. We will have to repeat this same operation with all the other circles, taking into account, that the daily sector of the May and August month will include 14/24 parts of the circle. This sector will be divided in 12 hours, as in the previous case. the diurnal sector at the months of April and September will include 13/24 parts, and so on until the last circle, that will be equally divided in 12 parts. We must not doubt of awarding 10 hours to the diurnal space of the month of December, since the first days of this month have 10 hours and only the last ones have 9 hours. The same happens to the month of January; at the beginning of the month the days have 9 hours but at the end of the month they have 10 hours.

Following this, the symmetry of the duation of the days is discussed, starting at the winter solstice, the shortest day of the year which takes place on the twelfth day of January [resulting from the error in the reckoning by the Julian calendar by this time].

Consequently, the days eleven and twelve will be of the same duration, the same for the tenth and thirteenth, in this way, they will be increasing their duration by pairs until the arrival of the summer solstice, the longest day of the year which is the twelfth day of the calend of July, starting from it, the days will begin to progressively become shorter during the other six months.

In order to position the stone correctly, we will determine exactly at midday on any day, which is the moment when the sun reaches its maximum height. This moment will have to be fixed with the astrolabe [horoscope], and the stone will have to be moved until the meridian line coincides with the shadow of the gnomon. If we do not have an astrolabe we can orient the sundial with the help of the polar star, although it is much better to do it with the astrolabe.

Later we find another version of the layout of the hour divisions but over 7 monthly circles instead of the six just discussed.

If a man wishes to engrave seven circles on the stone, the first circle must be divided according to the 15 hours which is the length of the day in the month of June, the second according to the 14 day hours in May and July, the third according to the 13 day hours for April and August, and so on until the seventh circle, which must be divided according to the 9 day hours of December.

According to the author, the division of the sundial into seven circles has no advantage over the previous one. He ends his text relating to the sundial, advising us to note that, in order to distinguish them from the rest, the hour lines corresponding to the ends of the hours are marked with I, III, IX and XII (prima, tercia, sexta . . .), and also to do the same with the hour line that separates the night from the day, which is the line of the start of the first hour, that is to say, the hour lines are directly related to the religious services of the Church at that time.

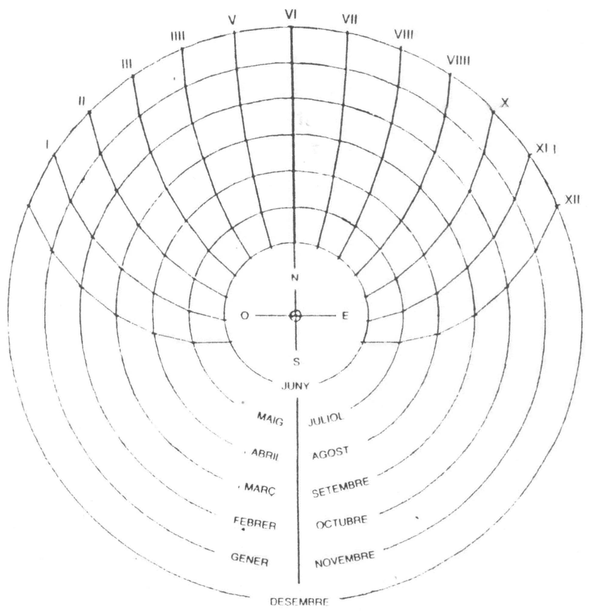


FIG 2 Reconstruction of the sundial described in the second version of ms 225, with seven circles in lieu of six.

There is no diagram accompanying the text, therefore two illustrations made according to my interpretation are attached. It must be said that they are substantially different to the sketch published by Dr Millàs (1931, p 205) to complement the brief presentation of this text.

At first sight, it might seem to be a difficult instrument to interpret, however on any day of the year there was only one hour circle applicable, the others were ignored as if they were not there. Once the correct hour circle was selected, according the time of the year, the observer would see that at sunrise the shadow of the gnomon over the first hour division on the west side [the only one not numbered] and which the ms call *the line which separates the day from the night.* As the sun begins to rise, the shadow of the gnomon, besides shortening, moves towards the next hour division, that marking the start of the second sector, in this way one can express the time by the fraction of the arc that the shadow has passed over. If the shadow has already covered the first quarter part of the segment, it could be said that it was a "quarter of the second hour", or a "quarter of two"; this could be the origin of the way of understanding the hours (in modern Catalan), in a logical way, whereas in other languages one would say that "it was a quarter past one".

The third hour correspond to the middle of the morning, the end of the sixth hour being midday, the none hour being in the middle of the afternoon, and the end of the twelfth hour coinciding with sunset, and similarly for all the days of the year.

This system was in general use until the appearance of mechanical clocks and the divisions of the day and night were called "Temporary" hours in contrast to equal parts. "Temporary" hours, resulting from dividing the daylight period from sunrise to sunset into 12 equal parts, vary in duration according to the changing duration of the day and night throughout the year, and only equal the "Equinoctial" hours at the time of an equinox. "Equinoctial" hours, before and even during medieval times, had a more limited application than temporary hours until the use of mechanical clocks became universal.

The sundial described in ms 225 was planned to be sited at a place where the longest day of the year (summer solstice) lasts 15 hours, and so the shortest day (winter solstice) lasts 9 hours. These conditions apply in all locations around 41° of geographic latitude. Consequently, in Ripoll which is sited at 42°, the sundial would have functioned perfectly, although the interpretation of "perfectly" must take into account the technical limitations of those far-off days and the primitive design of this sundial.

The author of the ms gives pre-eminence to the instructions for constructing the sundial with only six monthly circles, discarding the nine hours circle because, as he points out, there are only a few days in the year when this value needs to be taken into account. One must also state that the 15 diurnal hours of the summer solstice also can only be used a few days a year, whereas he includes a circle which will be in use for a period of two months. The second version of the sundial, that with seven circles, can be considered to be more rational, although in the ms it explicitly states that it does not have any advantage over the first. In practice, both designs would give quite acceptable results based upon the requirements of those ages.

The characteristics of this sundial has nothing in common with Arabic sundials, so we are led to suppose that the orginal sources of this text must be Latin, unless the idea originated in the culture of Ripoll, since no other sources of information are known with descriptions of sundials of similar characteristics.

The sundial, for many centuries, was the time measuring instrument *par excellence,* much easier to read than the astrolable or quadrant, and it could be used as a guide when graduating the hour divisions of candles or correcting the time shown by clepsydrae, and all the other contemporary instruments designed to preserve solar time during the night or during cloudy days.

Eduard Farré i Olivé

This article was first published in the Catalan language in Issue No 2 of *LA BUSCA DE PAPER,* the Bulletin of the Societat Catalana de Gnomonica, and is reproduced here by the courtesy of the Catalan Society of Gnomonics and the author Eduard Farré i Olivé. The Editor has slightly altered some parts to produce a more idiomatic text, and takes the responsibility for any errors thus introduced. It is a most valuable addition to the dialling information available to those who use English as a working language, and one must also salute the original author of the treatise for his clarity of description and constructional instructions.

AUSTRIAN SUNDIALS

Austria has a large number of beautiful sundials and for the first time these have been brought together in a catalogue by Karl Schwarzinger, the Chairman of the newly founded "Arbeitrsgruppe Sonnenuhren" - Sundial Group, from his sundial data base. Approximately 1,940 examples of fixed sundials are included, with the location and the most important features listed, together with the history of Austrian sundials and the basic details of gnomonics to facilitate the use of the catalogue. The format of the book is A5 (similar to the BSS *Bulletin* folded into half), it has 176 pages, and includes 40 photographs. The regular price is AS 185.00, including the mailing costs but the advance sale price is 135.00, if transferred by Eurocheque then Austrian Schillings must be specified, payable to **Osterreichische Postscheck-Konto No. 7270.125** of the Osterreicherischer Astronomischer Verein", specifying "Sonnenuhr-Katalog" on the money transfer form, and making certain your return address is clearly legible.

Further information may be obtained from: Karl Schwarzinger, AM Tigls 76a, A-6073 Sistrans, AUSTRIA. Telephone: 0512-78868 (09.00-19.00).

See also BOOK REVIEWS, and "The Secretary's Notebook", page 39.

SUNDIAL CALCULATIONS FOR COMPUTER PROGRAMMING

BY HECTOR C. PARR

In *BSS Bulletin* 90.2 dated June 1990, the Editor mentioned that I was making available a program designed to run on Acorn equipment, which calculates the hour lines for any dial in the Northern hemisphere, direct or declining, vertical or reclining or inclining. In fact the disc contains two main programs, one for the general case and one for a dial who plane is parallel to the earth's axis, and whose hour lines are therefore themselves all parallel. This second case is easy to calculate, and so this article describes the theory behind the calculations for the first case. It should enable anyone with some programming experience to write a program for his own equipment, and I believe also that it explains the best method for anyone designing a sundial with a calculator.

Firstly, I give a description of the theory, and follow this with an abridged version of a program in BBC Basic. This has been shortened for publication by omitting such features as validation checks, and by printing the hours as numbers - 11 to +11, rather than in Roman numerals.

The diagram shows the visible half of the Celestial Sphere. P is the North Celestial Pole and Z the Zenith. The Great Circle RTQF is the projection of the plane on the dial, which declines at an angle α West of South, and reclines at an angle β. α can take any value from -180 to +180 degrees, and β from -90 to +90 degrees, where negative values refer to an **inclining** dial. The style is not shown on the diagram, but it will lie either along the direction OP or in the directly opposite direction **depending** on whether the inscribed face of the dial is that facing the North or the South Celestial Pole. (For convenience, the dial is called "North Facing" in the first case and "South Facing" in the second).

The unknown elements of the spherical triange RTZ are calculated, using these formulae:

$\tan x = \tan\beta / \cos\alpha$, $\sin y = \sin\beta / \sin x$, and
$\sin z = \sin\alpha . \sin x$

We next calculate the angle between the style and the plane of the dial, represented by the arc PQ on the diagram and denoted by γ, and the inclination of the sub-style to the "vertical", or "line of greatest slope" on the dial, represented by arc QR and denoted by ε. We find:

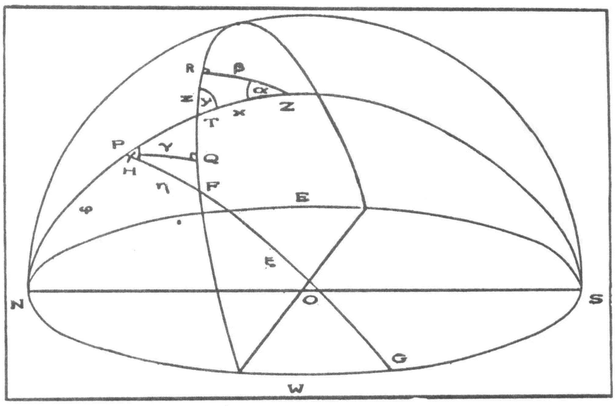
$\sin\gamma = \sin y . \cos(\varphi + x)$ and $\tan(\varepsilon - z) = \cos y / \tan(\varphi + x)$ where φ is the latitude.

For each hour of the day, if H is the Sun's Hour Angle, then on the diagram the Sun lies on the great circle PFG, and the shadow of the style must lie along OF or along the line directly opposite OF. If θ is the angle made by the shadow with the line OR, is the "line of greatest slope" on the dial, then θ is the length of the arc RF, and

$\tan(\theta - z) = \cos(\varphi + x) / [\sin(\varphi + x).\cos y + \sin y.\cot H]$

from which θ can be found for that particular hour.

To determine whether a particular Hour Line should appear on the dial we proceed as follows. The Sun lies on the great circle PFG and its distance from P will always lie



between 66.5° and 113.5°; if any point with this range is both (i) above the horizon, and (ii) on the correct side of the dial, then the Sun will cast a shadow at that hour on at least one day of the year, and the corresponding Hour Line should be drawn.

This can be coded as follows. If we represent PF by a φ and PG by ξ, then for a North Facing dial we can draw the Hour Line provided both these conditions are satisfied:

a) $\eta \geqslant 66.5°$ b) $\xi \geqslant 66.5°$

for a South Facing dial we require:

a) $\eta \leqslant \xi$ b) $\xi \geqslant 66.5°$ c) $\eta \leqslant 113.5°$

The two angles are calculated as follows, using T to stand for (θ - x):

$\cos\eta = \cos T.\sin(\varphi + x) + \sin T.\cos(\varphi + x).\cos y$

And $\tan\xi = -\tan\varphi / \cos H$

There are two main difficulties in programming these formulae. Firstly it is necessary to trap any situation which could lead to a program crash, such as division by zero or an attempt to obtain an invalid inverse trig function; and note that this latter can be caused by rounding errors in previous calculations. It is best for the program to reject the data if the plane of the dial lies within about half a degree of the earth's axis, and to request that the other program be used. *Secondly, care* must be taken to eliminate the ambiguities that arise (i) because of the limited range of the "principal value" whenever inverse trig functions are calculated, and (ii) because any two great circles intersect at **two** points, only one of which is correct. Members writing their own programs should be able to devise suitable checks by examining the version printed below.

It would be possible, of course, to write them much simpler programs to deal with Direct or Vertical Dials, but this would be pointless as the present program copes with all cases. For a Vertical Dial the value of β is zero, while for a Horizontal Dial it is best to take $\alpha = O$, $\beta = 90°$

To be continued

THE SECRETARY'S NOTEBOOK

Having just returned from our conference at Edinburgh, my wife and I were struck by the friendly spirit shown by all who attended. What a pity that as our membership is so scattered about the country it is not easy for us to meet together. Apart from the obvious pleasure in being able to talk about a subject of mutual interest we can all learn a lot from each other - it is surprising the great range of interests that individual members have in dials; from photography to collecting mottoes, from researching history to mathematics, from astronomy to craftsmanship in wood, metal, stone, slate etc., the list is almost endless.

I would like to see more local meetings in different parts of the country. Mike Cowham has organised and is continuing to organise very successful meetings on behalf of the Council but we would welcome it is just a gathering of half a dozen members in someone's house or a larger meeting in a hired hall. In either case we would be pleased to offer any help required, ie. we can provide you with up to date addresses of local members, provide speakers and even defray initial expenses, although we expect any such meetings to be self-financing. If you are thinking of making a start on these lines please let Mike, myself, or a Council member in your locality know.

AUSTRIAN SUNDIAL SOCIETY

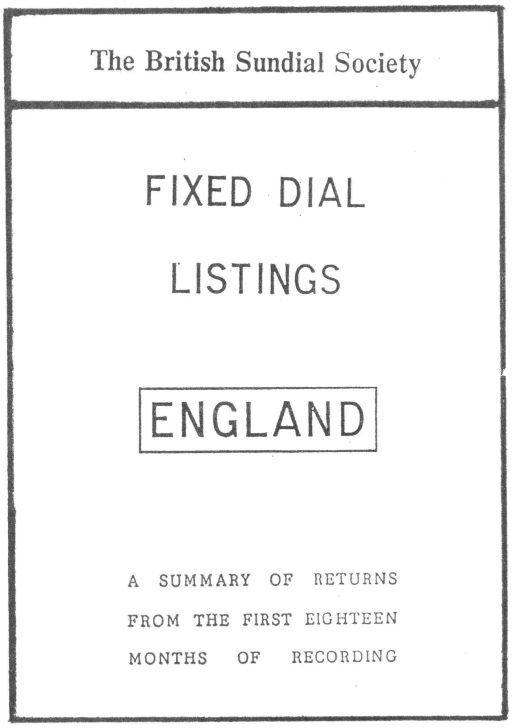
I heard a few months ago that our member Karl Schwarzinger from Austria has successfully convened a meeting of enthusiasts in his own country and formed a new sundial group, 'Arbeitsgruppe Sonnenuhren'. We have sent good wishes for the new society and he has since sent us an advance copy of a book cataloguing nearly 2,000 Austrian dials. It will be reviewed later, but I can say it appears very comprehensive and must have been the result of a great deal of painstaking work on the part of Herr Schwarzinger and his colleagues. Anyone wishing to purchase a copy of his book or join his group should write to me in the first instance.

MEMBERSHIP

Janet Thorne has told me that applications for membership are still arriving regularly and I must say that there seems to have been a revival in enquiries received here. It appears that copies of one of the magazines that came out in the Autumn, which featured a sundial article have now found their way to dentists' waiting rooms. I know of at least two members who have recently joined through this route!

FIXED DIAL RECORDING

We have recorded over 1,000 dials since we first started 18 months ago and I have now produced a summary of these records in two booklets, one for England and one for Scotland. Brief details of each and special feature. Although we still have a long way to go to record all the dials that exist these lines will prove invaluable for any member who likes looking out for sundials or wants to see or photograph a specific type of dial. Both lists can be obtained from me at £2 each booklet. Please make cheques etc. payable to The British Sundial Society.


The British Sundial Society

FIXED DIAL

LISTINGS

ENGLAND

A SUMMARY OF RETURNS
FROM THE FIRST EIGHTEEN
MONTHS OF RECORDING

DAVID YOUNG

CONFERENCE - QUEENS' COLLEGE, CAMBRIDGE

The BSS is holding a joint Conference with De Zonnewijzerkring, Netherlands, at Queens' College, Cambridge, 20-22 September 1991.

This is an ideal venue for all lovers of sundials as Cambridge has a very rich heritage of dials. The venue, Queens' College, boasts one of the world's most famous dials, dating from 1642 and carrying complex markings, with a correction table to allow use as a moon dial.

The date chosen for the Conference programme will be spread over a three-day period, with resident delegates arriving on the Thursday evening.

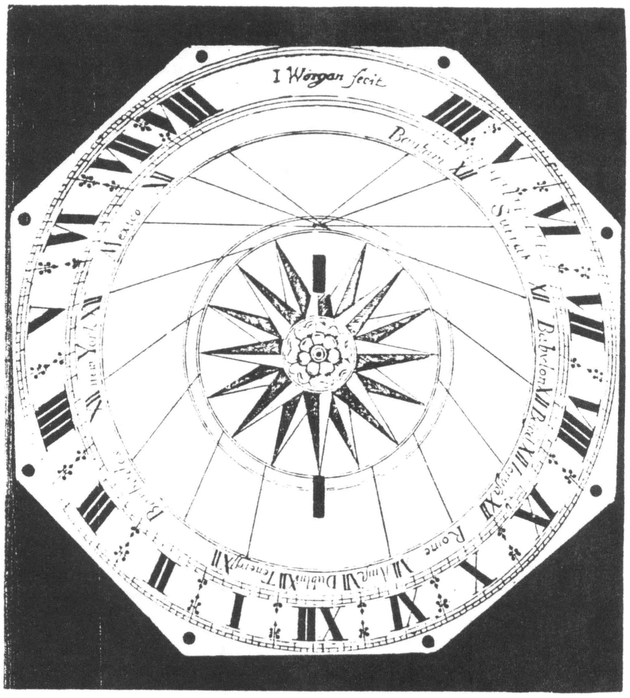
Dr. Margaret Stanier will be leading the group on a walking tour of the more interesting Cambridge sundials on Friday afternoon (21st September), whilst on Saturday afternoon the Whipple Museum will be open for a private viewing by the BSS Conference members.

Costs, including accommodation are anticipated to be in the region of £200 per person. Please send bookings, with deposit of £20, to the Conference Organiser:

Mr. Mike Cowham
The Mount, Toft
Cambridge CB3 7RL.
Telephone (0223) 262684

Bookings will be taken on a first come/first served basis in view of the limited accommodation available. For details of charges without accommodation, please enquire of Mr. Mike Cowham.

WORGAN IN AUSTRALIA



An enquiry about sundials by a lady in Australia, Mrs. Faye Starkey, included the photostat of a dial made by John Worgan, shown here. The crudeness of the signature is the result of the Editor rescuing it through the use of correction fluid from a black stain which almost obliterated it, and reveals his lack of talent in the artistic field. The story of how it came into her possession reads like a novel and is too long to repeat here. The details sent to her on John Worgan are given here, perhaps some member can enlarge on these.

JOHN WORGAN

The dates of birth and death are not known but he was working in London at least from 1686 to 1714 and called himself a "mathematical instrument-maker", with a shop 'under the Dial at St Dunstan's church in Fleet Street. There were no addresses in those days, so tradesmen gave a landmark to those seeking them, and in those days St Dunstan's church was famous for its clock with a double-sided dial hanging out over the pavement, with two giants striking bells on the hour, which attracted gawping crowds below (and attendant pick-pockets).

A number of Worgan's instruments are in the Museum of the History of Science, Oxford, including a Quadrant Dial, Surveying Compass, Plane Table, and a Circumferentor, the latter being used to measure linear distances. Worgan also made surveying instruments for other instrument makers such as John Love. He claimed that he was "able to make any mathematical instrument whatsoever".

Worgan wrote a number of pamphlets explaining the use of his instruments, a common practice of the time. A leaflet explaining the use of the Universal Ring Dial, then in popular use, is entitled "Use of a Ring Dial", and was sold from his shop. A copy of this pamphlet is in the British Library. Another of his surviving pamphlets is "Short Treatise of the Description of the Sector".

The dial shown here has the word "New" engraved on the back of it, an engraver's doodle. Mrs. Starkey's great-grandfather - William Furlong - who was a master mariner may have brought this dial out to Australia, but her grandfather, Augustus Furlong had a shop in Soowong, Brisbane, which was a used goods shop and it may have come into that. The sundial has been in the family since at least the early nineteen-hundreds, and it has been used as a plaything by fourteen children in the family. This has caused a certain amount of damage through perpiration corrosion (this is why the signature was masked by corrosion) and the children have picked out the wax from the engraved lines. Mrs. Starkey's mother states that the inner rose was red years ago. Obviously the sundial has seen very little use, and of course, is perfectly useless in the Southern hemisphere. Unfortunately the gnomon has been lost, the family cannot recall ever having seen it.

The dial has been washed to remove the surface soiling and prevent further corrosion damage. However, even the faint engraving of the name endings above the large letter abbreviations such as Amsterdam and Jerusalem is still perfectly clear, proof of the little use the dial has undergone. The engraving looks as if it has been carried out by an engraver with considerable experience in engraving clock dials. The dial is engraved for the latitude of London, with two noon marks to allow for the thickness of the gnomon, this causes the lines for the hours at twelve hour opposition not to be quite in alignment, eg 4-4, 5-5, 6-6, 7-7 and 8-8. Noon marks are provided for each of the named locations.

CHARLES AKED

MWS

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