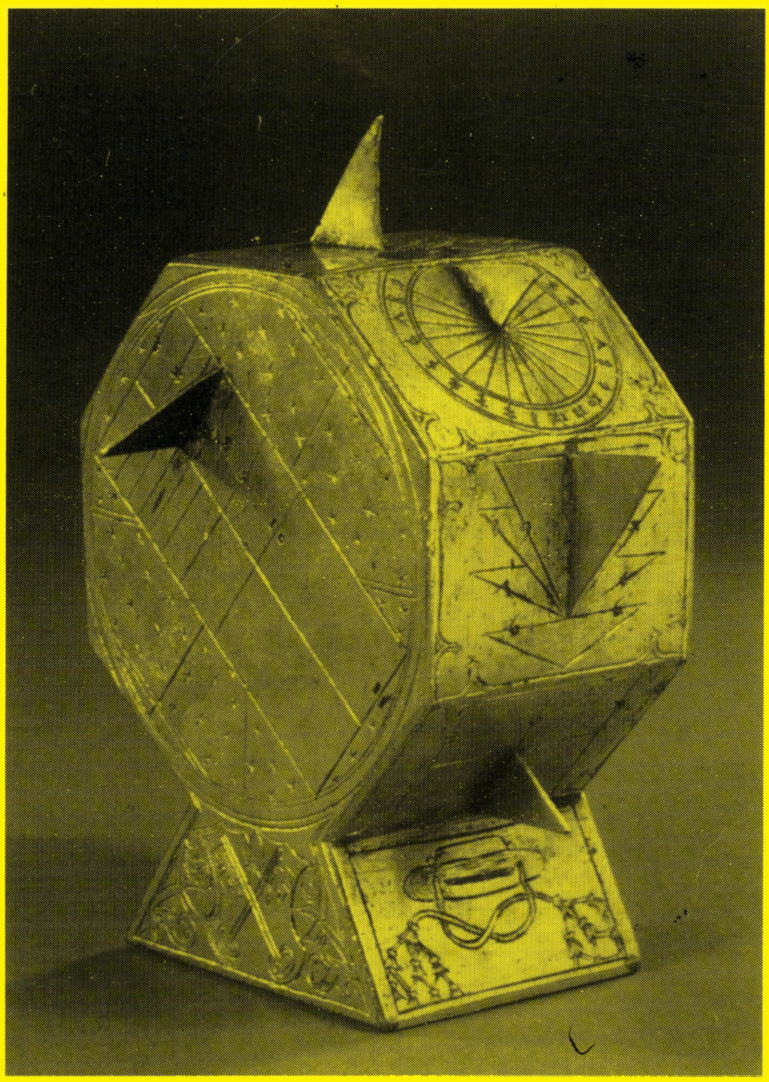
The British Sundial Society



BULLETIN

No. 94.1 FEBRUARY 1994

ISSN 0958-4315

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Cover Illustration - Polyhedral sundial attributed to Nicholas Kratzer circa 1525 and made for Cardinal Wolsey whose Arms and Cardinal's hat are engraved on the base. The instrument incorporates nine types of dial and is a portable version of the monumental sundials in stone which Kratzer designed. Height of this instrument in 100mm, including the gnomon. Now preserved at the History of Science Museum, Oxford. See also pages 28 and 42.

DIALOGUE

LA BUSCA DE PAPER

Issues number 13 and 14 for 1992 were received in late 1993. Issue 13 contains one article only and is entitled "Brief Notes on the Conservation of a Sundial in Porrera". This is of great interest although it refers to the restoration of a type of sundial rarely met with in the British Isles, that is one delineated upon stucco. This material is especially vulnerable to atmospheric pollution since it is based on lime plaster (calcium hydroxide turning to calcium carbonate by combination with carbon dioxide in the atmosphere). Generally the first requirement is to affix the loose patches to the wall itself, followed by the filling of fissures and cracks before any paint restoration can be undertaken. It is normal to use a final coat of water-proofing material to keep water out of the stucco. The writer points out that each sundial will need individual treatment so his notes give general indications only. It will be recalled from the recent article "Destruction by Decay" in BSS Bulletin 93.3 that restoration work is by far the largest task facing diallists today. In this issue also is the commencement of a most useful feature in the form of a twelve page insert listing a Gnomonic Vocabulary by Josep Maria Vallhonrat. This is a most useful contribution to the science of gnomonics since it enables translators to deal with Catalan, English, Dutch, French, German, Italian, Portuguese and Spanish dialling terms. If the reviewer must be critical the lack of inclusion of Latin is to be regretted since all the main early European dialling texts were published in Latin. Nevertheless a most splendid effort for which the author deserved much praise.

Similarly issue 14 contains one article only "Analytical Calculation of the Declination of a Wall by Observation of the shadow of a Stylus perpendicular to it at any hour of daylight". This is a very clear exposition of the method by Rafael Soler i Gayà', excellently translated into English by William Bain. On the last page is a cartoon in four illustrations where an elderly gentleman is shown checking a sundial by his watch, points out the difference to an attendant, who in the last scene is shown altering the gnomon of the dial to correct the indication. The whole sequence is entitled "Timely Humour". In the enclosed Vocabulary, the listing has got as far as [altitude of the sun] so it is going to take a very long time to reach its Zenith in the Zodiac. It is going to be a most important contribution to gnomonics when completed.

Since issue 14 there have been two further issues but these cannot be reviewed since they have not reached the Editor as yet.

ANNUARIO DELLA SPECOLA CIDNEA

This contains the annual report for 1993 of the activities of the Brescia Observatory in Italy. 1993 sees the publication of the astronomical empherides for the coming year for the first time. The section of main interest to us as diallists is that the photographic section contains illustrations of sundials which were entered in the "Shadow of Time" International Contest for sundial makers. A lady by the name of Anna Trombetta has produced an English section in the book, plus English titles for the photographs. These are in black and white and thus remove the charisma of the colour schemes employed. Mainly the dials are vertical types, with a couple of large horizontal versions and one analemmatic dial. The accent is on the artistic presentation rather than the novelty of technical design.

NORTH AMERICAN SUNDIAL SOCIETY

A Sundial Society has been proposed to cater for those living in North America who are interested in dialling. All those who would like to become members should contact either:

Mr Frederick W. Sayer III, 8 Sachem Drive, Glastonbury, CT 06033 U.SA.

or

Mr. Ross McCluney, Florida Solar Energey Centre, 300 State Road 401, Cape Canaveral, FL 32920 U.S.A.

ROUMANIA

Robert McVean the grandson of our member Colin McVean has sent in an interesting report about his group's recent visit to Roumania to help in the provision of improved science education for Roumanian orphans. One of the projects was the installation of an analemmatic sundial as part of the theme of earth, wind and sun in the educational garden of the orphanage school at Bradet some distance to the north of Bucharest. Because of pressure upon space, it has not been possible to include this report, in this issue. It is hoped to include the report in the next issue. In the meantime congratulations to Robert and his group, and to Colin McVean for providing the basic plan for the installation. Colin has also been asked to make a sundial for the Company of Apothecaries in London and we look forward the hearing about this when completed.

SARAJEVO

The Editor received a letter in October 1993 from Milutin Tadic who is trapped in Sarajevo. He has made several requests for the British Sundial Society to arrange for his safe passage out of the former Yugoslavia but efforts by the Chairman and Editor to find out how this could be achieved have come to naught. Members will recall that Tadic has made several contributions to the BSS Bulletin in the past.

To the majority of us in the West, the present turmoil and destruction in Yugoslavia seems absolutely senseless. Those who have had cheap pleasant holidays there in the past will be even more conscious of the stupidity of waging internal war upon innocent civilians.

The photograph sent is of a sundial made by Tadic and his friends in 1984 which was erected in Sarajevo. It was hit by a shell splinter in June 1993. Tadic has put at the head of his letter "A Sundial is the Silent Voice of Time" - the quotation from Robert Hegge, 1630; and so this shattered sundial is an eloquent witness to the ravages of a stupid civil war.

As the photgraph is not very good and cannot reproduce well, the figures on the lower left of the dial give Latitude 43° 52′ 24″ and Longitude 18° 25′ 50″. The motto is "SUNCANI SAT".

The letter was smuggled out of Yugoslavia by a UNPROFOR soldier. I am sure that BSS members will join with the Editor's hopes and wishes that Tadic and all those in Sarajevo will soon be freed from the present conflict. If anyone has any idea as to how he can be helped, please forward your suggestions.

(For photograph see page 43)

THE IVORY DIPTYCH DIAL PART 2
UNDERSTANDING THE MARKINGS
JOHN MOORE

When looking at these dials our attention usually focuses on the modern equal hours scales and we tend to dismiss the other scales as being rather 'old fashioned'. When we know just a little more about them we may observe that they often have scales for Babylonian and Jewish hours. Once we fully understand their markings and how to use them they become much more interesting to us, but alas, these are often of little use in the modern world.

NUREMBERG DIPTYCH DIALS

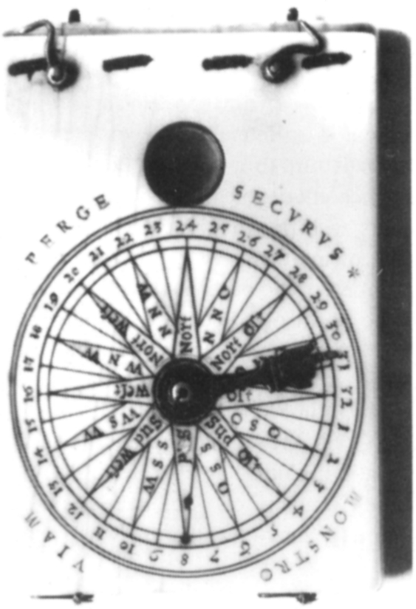


FIGURE 1. Ivory Diptych Dial by Hans Troschel. Face A

Fig 1. shows Face A of a typical Nuremberg dial by Hans Troschel. This shows a wind rose and a hand like pointer. The dial is first orientated to north by sighting the point of the compass through its small window. The hand pointer would be rotated to show the present direction of the wind, in this case East, where it could be left for later comparison. In its centre a small wind vane could be placed there to facilitate the reading. It must have been an inaccurate device, especially when held in the hand, or anywhere close to the observer's body due to the local disturbance to the airflow. Most dials of this type have a slot type pocket in the lower tablet to store the wind vane when it is not in use but in this example it has been omitted and so the estimation of the wind's direction would be done by the user, possibly by observing the motion of the clouds, some smoke, bending trees, grasses or even ripples on water. Observations of wind directions and their changes are a good guide to weather forecasting and would have been a useful feature to our forefathers. Note that the 32 points of the compass start at East and not as we now do in the North. Around the edge of the dial is the Latin inscription PERGE SECVRVS * MONSTRO VIAM. (Proceed Safely, I Show The Way.)

Face B, Fig.2, carries a standard vertical dial showing hours VIII to IIII. Above this is a pin gnomon dial with a scale of 'Tagleng', (Day's length), which shows 8 hours at the Winter Solstice when the sun is low, and 16 hours at the Summer Solstice. At the two equinoxes the line is straight, and of course, the day's length becomes 12 hours.

The shadow from the tip of the same pin gnomon will

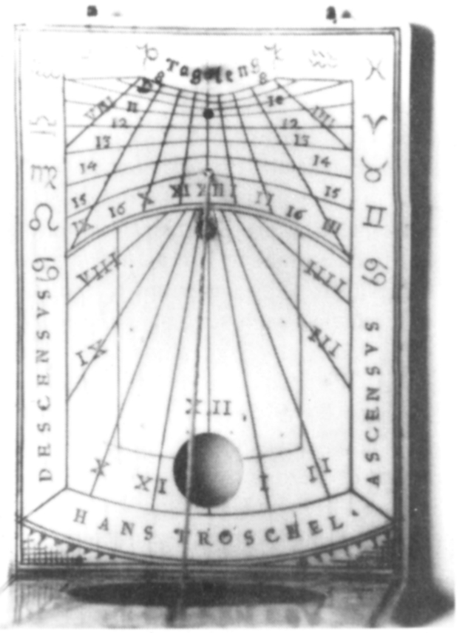


FIGURE 2. Ivory Diptych Dial by Hans Troschel. Face B

also indicate the time on this small vertical dial for the hours VIII to IIII. As the sun moves across the sky the shadow will trace out a line from left to right, and knowing the date, ie. whether it is before or after the Winter or Summer Solstice, the astrological house, or zodiac symbol may be determined. The symbols start on the right and read clockwise from the Vernal or Spring Equinox in March with Aries the ram, which is depicted by a symbol representing ram's horns, ♈. Astrological information was of much greater importance in earlier times, being used daily and its consequences often completely ruled the everyday actions of people. Face C, Fig 3, carries a

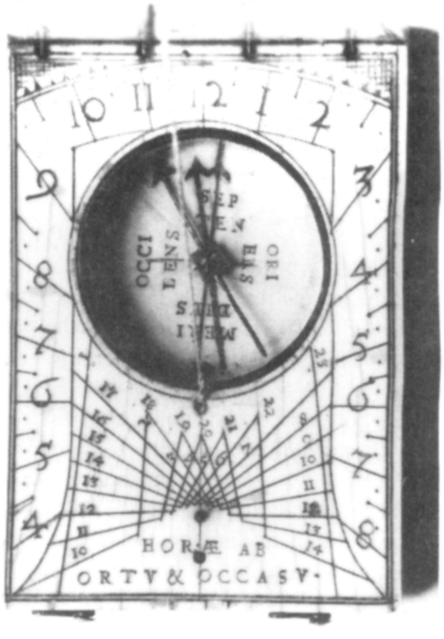


FIGURE 3. Ivory Diptych Dial by Hans Troschel. Face C

standard horizontal dial for the hours of 4 in the morning until 8 in the evening. The compass is simple, showing only the four cardinal points plus the current magnetic declination of about 5° west, being around 1700. (Ref.1.) Other compass points were unnecessary within the bowl as the wind rose on Face A could be used if they were required.

At the bottom is another pin gnomon dial with the caption in Latin, HORAE AB ORTV & OCCASV. (Hours from sunset and occasional hours.) At first sight this scale seems somewhat confused but it is actually two dials in one, each mirroring the other. Ascending clockwise from 10 through to 23 are the hours reckoned from sunset. These are known as Italian, Bohemian or 'Welsch' (foreign) hours. This form of time reckoning was also used by the ancient Greeks, Jews, Silesians and the Chinese. The other scale starting at 1 in the top left corner and finishing at 14 on the right shows Babylonian or Greek hours that begin at sunrise. When the shadow of the pin gnomon is vertical, ie. pointing North, it is midday. At the equinox, sunrise and sunset are at 6am and 6pm respectively when reckoned in modern hours. This means that midday will be 18 hours after sunset, Italian, and 6 hours after sunrise, Babylonian. Close observation will show that at a short distance north of the gnomon, the two lines for 18 and 6 cross. At the Winter Solstice we know that the sun rises at 8am and sets at 4pm in Northern Europe. Therefore midday is only 4 hours before sunset, ie. 20 hours after sunset and 4 hours after sunrise. These two lines join at a point furthest north of the gnomon. At the Summer Solstice when the sun is much higher in the sky the shadow of the gnomon tip is much closer to the gnomon giving 16 and 8 hours for noon. These scales are completely obsolete by modern standards and therefore are seldom understood.

Face D, Fig 4, has a volvelle showing AETAS LVNAE & HORAE NOCTIS, (age of the moon and night hours). This enables the dial to be used at night if there is enough moonlight. In practice this is only possible for about five days either side of the full moon, but as long as the moon is visible it should be possible to make a reasonable guess as to where its shadow would fall. The string gnomon dial on Faces B and C would be operated as it would be for the sunís shadow and the moon's time would be found. If there was insufficient light to set the compass correctly, then the pole star could be used and the dial aligned with it. It must be stressed that lunar time measurements without complicated corrections are at best only approximate. (Ref.2.) This is due mainly to the moon's cycle of 11 years, during which its altitude also changes. The time reading taken should now be converted via the lunar volvelle into solar hours. Firstly the central gilt brass disc is set to the age of the moon. The moon's age starts with zero at new moon and the relevant scale is the middle of the three outer ones. In this example the 10th Day has been set. In the days before full moon, the moon rises before 6pm and therefore would be in the South in the evening. If, for example, the time reading were 2am lunar, this figure would be read from the brass disc and converted by the adjoining scale which shows 10.15pm Solar time.

The outer scale shows a figure in hours that is the difference between solar noon and lunar noon for each day of the lunar month. Hence at full moon this is given as 12 hours. On the 10th day illustrated, this would be 8 hours. Notice that 8 is given for two consecutive days as there is no provision on this dial for giving both hours and minutes of correction and 8 is the nearest hour on both days. Some dials have two rings of figures giving more detailed information, one being for hours and the other for minutes. Therefore with only the full hours being represented some consecutive days must show the same figure because the moon's time only changes by 48 minutes per day.

It is worth noting on this dial the use of the thrush symbol in three places. This is the trade mark of Hans Troschel whose name translates as 'thrush'. Also at the top between AETAS and LVNAE is the Nuremberg 'n' symbol that was applied to dials to denote a quality product. (Ref 3).

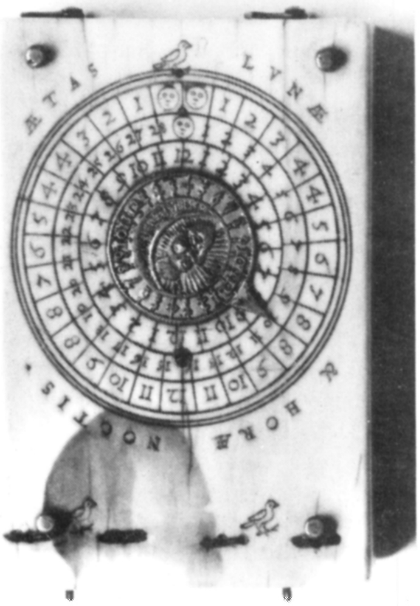


FIGURE 4. Ivory Diptych Dial by Hans Troschel. Face D

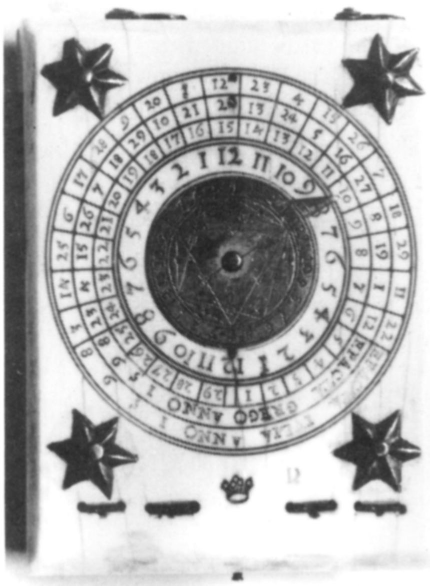


FIGURE 5. Ivory Diptych Dial by Paul Reinman. Face D

An alternative lunar volvelle is shown in Fig 5, this time on the dial by PAVLVS REINMAN. Note his crown symbol and again the 'n' quality mark. Its lunar conversion scale is virtually identical to the Troschel dial. The lunar volvelle pointer is again set for the 10th day and the 2pm lunar reading again corresponds to around 10pm solar time. Two further scales are added, viz. EPACTA IVLIA ANNO 1598 and EPACTA GREGO ANNO 1598. These are scales for the Epacts starting in the year of 1598 (which is when this particular dial was made) for both Julian and Gregorian calendars. The moon has a cycle of 19 years after which its position in the sky is virtually identical on any given date, ie. full moon will fall at almost the same time on the same date nineteen years later. This period is actually shorter by 1hr 27m 32s (Ref 4) but this only amounts to one day's error in 312 years.

Each year has 12 cycles of the moon, each of approximately 29½ days. This means that 12 lunar months are 11 days short of a solar year. The Epacts, therefore show the number of days remaining from the end of the lunar year until the close of the solar year. Many religious festivals are linked to the moon's cycle. Passover or Easter are determined from the Sunday following the first new moon after the Spring equinox. This date also determines other church festivals such as Lent and Whitsun. On this dial the year 1598 gives 3 in the Julian calendar and 14 for the following year, (1599) etc.

At this time the Gregorian calendar was being introduced into Europe. Catholic countries used it following the decree of Pope Gregory from the 5th October 1582. Since the time of Julius Caesar the calendar had accumulated an error of 11 days and Gregory had devised a new form of reckoning so that this error would not occur. Protestant states continued to use the older Julian calendar for some time. In Britain the change was not made until 1752. Germany was divided into several small states, some of which were Catholic and some Protestant, so both calendars were running simultaneously. Hence the provision for both systems on these dials.

Fig 6. (Ref 4), shows a scale of Epacts relating to the Golden Numbers. The Golden Number is the particular year of the Moon's cycle of 19 years, and the corresponding Epact is shown for each year of the cycle. This particular chart produced in 1711 interestingly contains two errors. The fifth year shows the Epact as being 24, but this should read 25, and the eighth year shows 18 where it should be 28. The latter is obviously a printing error with one Roman X missing.

Golden Number.	Epacts
1 . . .	. XI.
2 . . .	. . XXII.
3 . . .	. . . III.
4 . . .	. . XIV.
5	. . XXIV.
6	. . VI.
7	. . XVII.
8	. . XVIII.
9 . . .	. . IX.
10 . . .	. XX.
11 . . .	. . I.
12 . . .	. . XII.
13 . . .	. .XXIII.
14 . . .	. IV.
15 . . .	. . XV.
16 . . .	. . XXVI.
17 . . .	. . VII.
18 . . .	. . XVIII.
19 . . .	XXIX.

FIGURE 6. Table of Epacts from Wells' Chronology, 1725

Another interesting feature of the Reinman dial is at the centre of the gilt lunar volvelle. This shows the astrological Aspects consisting of a triangle, a square and a hexagon. The Aspects are angles formed between two or more celestial bodies as seen from the Earth. Certain combinations of planets at particular angles have different and important astrological significance. The basic aspects are Conjunction 0°, Sextile 60°, (separated by two zodiac signs), Square 90°, Trine 120°, and Opposite 180°. (Ref 5) Opposite, Square and Sextile Aspects were associated with bad luck and the Trine with good luck. Ref 6.

The dial by HANS TVCHER 1583, Fig.7, is quite unusual, in that it shows only Italian hours, (sunset at 24). Its string gnomon is obviously incorrect and has been fitted at a later stage. This type of dial can only operate from pin gnomons, which are now missing, and it shows the time on both faces, B & C.

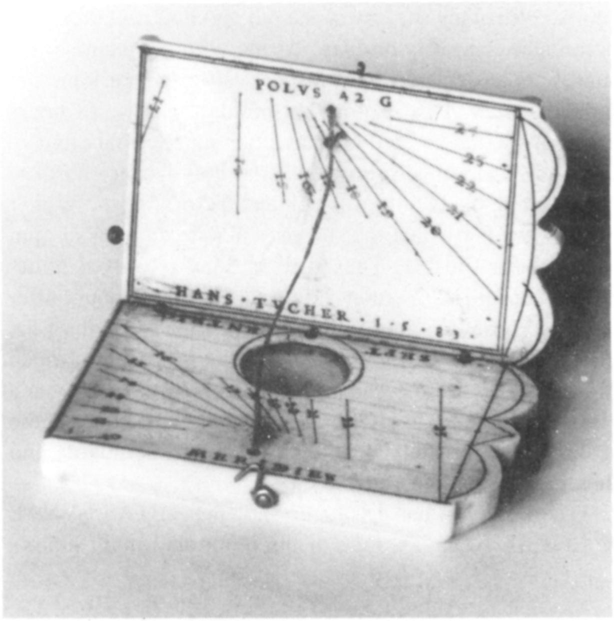


FIGURE 7. Ivory Diptych Dial by Hans Tucher, 1583

DIEPPE DIPTYCH DIALS

Dieppe dials differ in many ways from those of Nuremberg. A Magnetic Azimuth dial by Jacques Senecal is used to explain the various functions. It is typical of many dials made in Dieppe around 1660-1670 period and its design is normally attributed to Charles Bloud, the best known of Dieppe's dial makers.

Fig 8, shows Face A, which carries a Polar dial and an Equatorial dial. These two dials have been included to make it truly universal, ie. so that it could be used at any northern latitude, because the main dials on Faces B & C can only be used at a fixed latitude. To use these dials the lid must be tilted to the correct angle. The angle for setting the dial is engraved on the edge of Face B and the small lever which slots into Face C is set against the scale, Fig 9. The polar dial across its centre will be used with its face towards the south so that it remains parallel to the Earth's axis or POLES. The shadow is formed by a pin gnomon placed into the hole at its centre. The equatorial dial, on the other hand, is operated with north and south reversed so that it lies parallel to the EQUATOR. It then reads exactly like a 24 hour clock. Its main drawback is that it can only operate in the summer months when the sun is above the equator. In the winter months the sun is too low and could

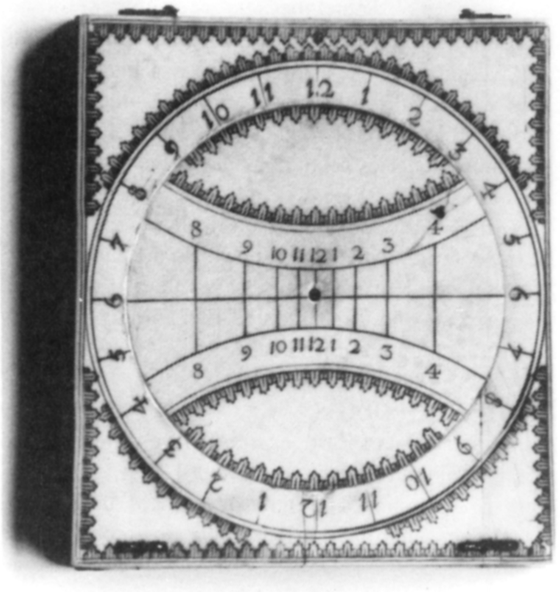


FIGURE 8. Dieppe Ivory Dial by Jacques Senecal, Face A

FIGURE 10. Ivory Dial by Jacques Senecal, Face B

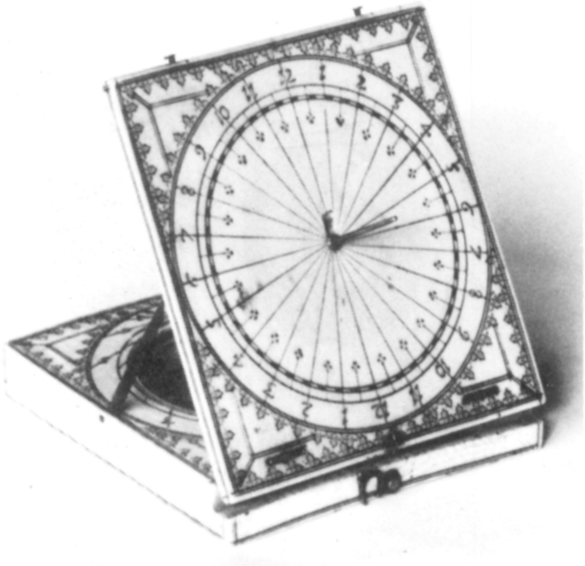


FIGURE 9. Unsigned Dieppe Dial showing operation as a Polar Dial

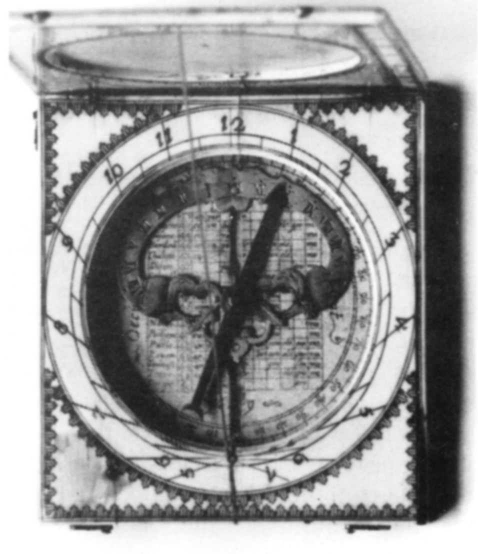


FIGURE 11. Ivory Dial by Jacques Senecal, Face C

only throw a shadow on the underside of the lid.

Face B, Fig 10, consists of a calendar and lunar volvelle. In its centre is a small volvelle that has a round cut-out representing the appearance of the moon. It would normally be used in reverse to compare the moon's form with its likeness on the volvelle and show the actual day of its cycle. In this example the moon is 7 days old, ie. around its first quarter. If the moon's shadow shows 2pm lunar time this is shown to correspond to about 7.45pm solar. If its user is unable to get a satisfactory shadow, the moon's form may be compared with the cut-out and the Pole Star may again be used for determining true north. Around the edge of this dial is an annual calendar showing the number of days in each month.

Face C, Fig 11, has two separate sundials on it. Around the edge of the compass is a standard horizontal dial for a fixed latitude which is operated from the string gnomon. In the centre of the compass bowl is a dial which is read from the southern tail of the compass needle. To use this dial correctly the complete diptych is turned until the shadow of the lid falls exactly along its base, i.e. the user lines the back of the diptych to face the sun. The compass needle will point to the North, generally towards the user, but its tail will cross the engraved metal hour scale in its bowl. This is the correct time. However, during the course of the year the sun's altitude and position will change and correction needs to be made. This pewter scale is arranged to slide up and down, being controlled from the calendar volvelle which is on Face D, (Fig 12.). On the back of the calendar disc is an eccentric groove in which a pin fron the back of the hour scale runs.

In the compass bowl is a paper scale and around its edge is a scale of degrees reading 0°- 90° from both North and South. This would generally be used with the compass needle to show directions. It is also marked with the four cardinal directions in Latin. In its centre is a complex table.

This has a list on the left of 18 French towns. In the second column is the latitude of each town. In the remaining 9 columns are many entries of two or three letters, each believed to give details of some of the attributes of each town.

On Face D, Fig 12, is a calendar volvelle which is rotated against the engraved hand pointer. Once the correct date is set this adjusts the hour scale as described above.

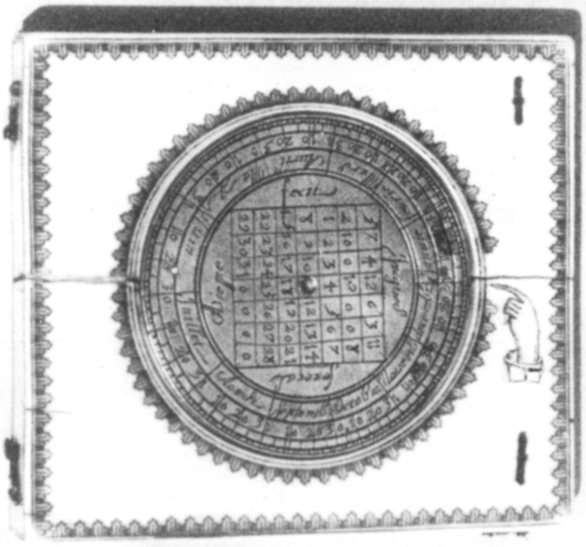


FIGURE 12. Ivory Dial by Jacques Senecal, Face D

In the centre of the disc is a square full of numbers surrounded by the maker's signature, 'Jacques Senecal Dieppe fecit'. The central table consists of 7 rows and 7 columns. It is not immediately obvious, but there are two sets of information in this square. The first two lines are for the months of the year. However, these are not the Gregorian months that we use today, but are those used in the older calendar of Julius Caesar. In his calendar the year commences in March (at the vernal equinox) and hence March is the first month, April the second, etc. This explains some of the names that we still use for our months, v.i.z. September (7), October (8), November (9) and December (10). The end of the year was, of course, in February. This made the addition of one day each Leap Year much simpler. The day, however, was not added at the end as we do now on the 29th, but, instead, 24th February was reckoned twice.

The numbers therefore in the first two lines are for the months of the year, 5 = July, 7 = September, 4 = June etc. Notice that 5 is placed above 2 (ie. July and April). If we check with a diary, or calendar, we will find that July and April always start on the same day of the week. Similarly the second column has 7 = September and 10 = December. In the three squares with zero this means that there is only one month starting on that particular day. 19 is below 12. This is not actually 19, but strictly, 1, 9. On this day of the week there are three months, v.i.z. February, March and November, with the 1 and 9 conveniently crammed into one square.

The five rows of lines below this are a standard table of the 31 days of the month arranged in groups of 7 days, ie.weeks. These two tables were used in conjunction so that if the first days of both July and April were to fall on a Thursday, as in 1993, September and December would be one day earlier, ie. Wednesday. Similarly the third column would be Tuesday etc. On the bottom row of this table are four zeros which fill the spaces that would otherwise be blank. However, on some Perpetual Calendars of this type, these four unused spaces often contain the date of the year of manufacture.

With a little knowledge it is possible to operate the calendar the determine the day of the week, the date and the year. With our modern calendar a Bisextile or Leap Year would necessitate a jump at the end of February, making calculations that bit more difficult.

OTHER DIPTYCH DIALS

Dials from other parts of Europe tend to have similar scales to both those of Nuremberg and Dieppe, but, generally were somewhat simpler. The main differences are in their decoration. The dials of Spain and Italy are probably the best known.

The unsigned Spanish dial, Part 1, Fig 7 is interesting in that it has two pin gnomon scales. On Face B is a Babylonian hour scale starting at dawn i.e. 24 or 0. On Face C (Fig 13), is an Italian hour scale ending at dusk. This is in the form of a Scaphe Dial, ie. hollowed out. The markings are quite similar to those on a flat surface but the exercise of inscribing the marks within the hemispherical bowl must have been an exacting task. The maker has obviously cut these lines by hand as can be seen from their somewhat irregular forms.

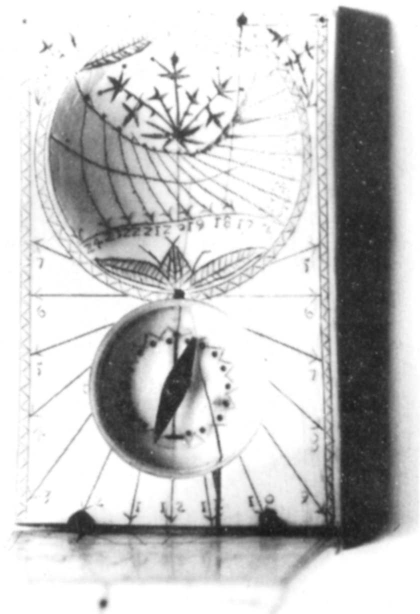


FIGURE 13. Spanish Ivory Dial, Face C

There is still much we can learn from these early diptych dials. Further research into their makers, tools and methods is still needed. What is certain is that our forefathers carried these dials in their pockets and used them. They were a prestige symbol for many. They were also precision instruments and could be used not only for time telling, but for much more important reasons connected with their lives at that period. It is quite probable that many of the users did not fully understand all the markings. We should, perhaps, compare these dials with modern pocket calculators. We nearly all use them quite regularly, but how often do we use the more complex functions such as sines or logarithms?

Continued on page 21

A method of determining the North and latitude

J. G. FREEMAN

† Originally presented at a Members' Evening held by the Yorkshire Branch of the Mathematical Association at the University of Bradford in November 1972.

1. Introduction

There are occasions when one needs to know the North and one's latitude, as for example when one is constructing and orientating a sundial, or exploring in unknown terrain.

A method of obtaining this information by observing the sun is here described, which does not possess the disadvantages of that in which one observes the sun when its altitude is greatest—namely of being useless if the sun is obscured by cloud at noon or if the sun's declination is not known. It is suitable for a classroom experiment, and is an application of stereographic projection.

2. Stereographic projection

Consider any sphere s with its centre O at the observer. Denote by Z, P and S the points in which the vertical line through O, the line through O parallel to the Earth's axis, and the line joining O to the sun meet the sphere s (see Fig. 1). We call s the *celestial sphere*. Let V be the point on s diametrically opposite to Z. If the line joining V to S meets p, the horizontal plane through O, at S', then S' is called the *stereographic projection* of S on p.

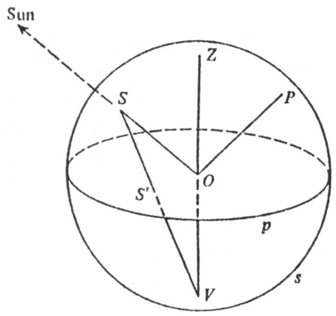


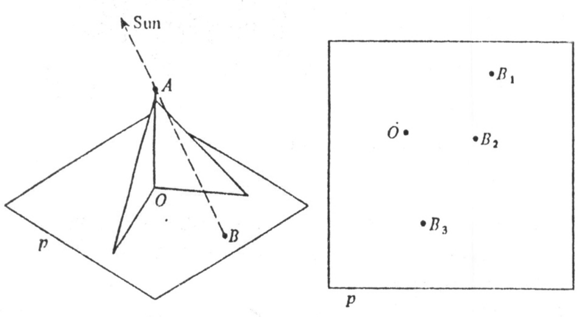
FIGURE 1. The celestial sphere.

The sun's declination is the complement of $\angle SOP$; from tables it may be seen that the maximum daily variation of the declination is about 0·4°. If our experiment lasts not more than six hours, the declination will not have varied by more than about 0·1°, and we shall therefore regard the declination, and hence $\angle SOP$, as being constant during the course of the experiment, and the path of S as being a circle c on s.

A fundamental property of stereographic projection is that all circles project into circles (with the exception of circles through the vertex of projection V, which project into straight lines). The circle c on s will therefore project into another circle c' on p.

3. The apparatus and observations

The apparatus consists of two setsquares fastened together as shown in Fig. 2a (adhesive tape may be used for this purpose), standing on a fixed horizontal board, with a pin, head A, fixed in the angle between the setsquares at their apex. We take for the point O in Fig. 1 the point on the board vertically below A; the board itself is then the plane p in Fig. 1.



(a) (b)

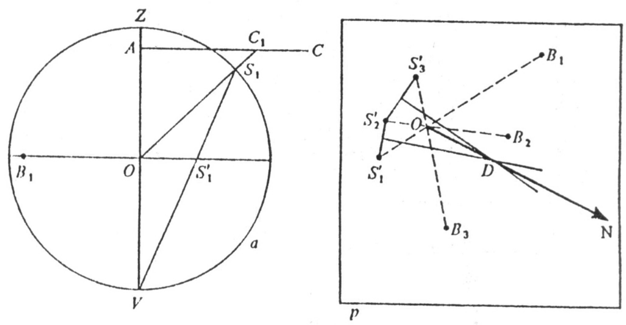
FIGURE 2. (a) The apparatus. (b) Observations.

On any three occasions during the day when the sun is shining, one marks the shadow B of A on p, obtaining three points B_1, B_2 and B_3 as shown in Fig. 2b.

4. Determination of the North

Draw a circle a with radius equal to that of s, to represent the cross-section of s through O, Z and B_1 (see Fig. 3a). Draw a horizontal line AC through A (the point representing the head of the pin in Fig. 3a). Mark the point C_1 on AC such that $AC_1 = OB_1$. Then OC_1 makes with B_1O produced an angle equal to the sun's altitude when B_1 is the shadow of A, and OC_1 meets a at S_1, the point representing the position of S corresponding to the instant when the shadow of A is B_1. Let VS_1 meet B_1O at S_1'. In Fig. 2b mark the point S_1' on B_1O produced so that OS_1' in Fig. 2b equals OS_1' in Fig. 3a. Similarly insert points S_2' and S_3' in Fig. 2b. The points S_1', S_2' and S_3' are the stereographic projections on p of S corresponding to the instants when the shadows of A are B_1, B_2 and B_3 (see Fig. 3b).

The circle c' which is the projection of the path of S passes through S_1', S_2' and S_3', and its centre D should next be obtained by finding the point of intersection of the perpendicular bisectors of the joins of any two pairs of S_1', S_2' and S_3' (see Fig. 3b). Consideration of symmetry shows that D lies in the plane ZOP; hence join O to D and the line OD points North.



(a) (b)

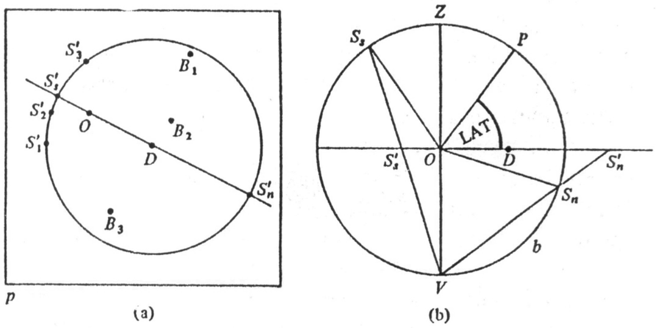
FIGURE 3. (a) Cross-section of s through O, Z and B_1. (b) Determination of D, the centre of circle c' through S_1', S_2' and S_3'.

It is advisable to separate consecutive observations by an hour or more, since, if the points S_1', S_2' and S_3' are too close together it is difficult to determine the position of D with accuracy.

5. Determination of latitude

Draw the circle c' with centre D and radius DS_1' (see Fig. 4a). Call the points where OD meets c', S_s' and S_n'. These are the projections of the points S_s and S_n, the positions of S corresponding to the instants when the sun is due South and due North respectively.

Next draw a circle b with radius equal to that of s, to represent the cross-section of s through O, Z and D (see Fig. 4b). In this figure insert the points S_s' and S_n' such that OS_s' and OS_n' in Fig. 4b equal OS_s' and OS_n' in Fig. 4a. Join VS_s' and VS_n' to meet b in S_s and S_n. Join S_s and S_n to O and bisect $\angle S_sOS_n$; this bisector will meet b in P. Since $\angle DOP$ is the required latitude, we now measure this angle.



(a) (b)

FIGURE 4. (a) Determination of S_s' and S_n'. (b) Determination of S_s, S_n and P (OP bisects $\angle S_sOS_n$).

Figure 4b will, incidentally, enable us to determine the sun's declination also. Since $\angle S_sOP$ is the complement of the declination, we may measure $\angle S_sOP$ and obtain the declination from

$$\textit{Declination} = 90° - \angle S_sOP.$$

SUNDIALS IN ILLUSTRATIONS

CHARLES K. AKED

The average artist, when depicting a sundial, usually demonstrates a complete lack of understanding of the elementary principles of dialling. As an example, the very English caricature shown in Fig 1, subtitled "The stupid servant sent by his master to set his watch, returns having dug up the sundial". Obviously this is a case of the pan calling the kettle black because the sundial is clearly meant to be a horizontal dial, yet it is marked out like a clock dial, and judging by the angle of the gnomon, could not be used as shown in England. However the position of this dial accessory indicates that the scene must be in the Southern hemisphere, for at noon in the Northern hemisphere, the shadow of the style would fall on VI and not XII. For those not familiar with the quirks of English humour, and it is an acquired taste, milord has gout in his right foot and is resting it on a footstool. If you have never had gout, first of all think yourself very lucky, secondly you cannot envisage just how sensitive to touch the affected member is; thirdly it puts you into a foul temper, and fourthly few people can afford the amount of brandy and claret required to bring about this affliction. You certainly cannot check your own watch against a sundial if so afflicted.

Figure 2 shows a crowned lady standing at the margin of a pool, this is a pen sketch by Urs Graf, dated 1514. As a sort of added detail, there is an ivory diptych dial at the lower right, but although the sun is casting a shadow from the main body of the dial, the string gnomon has none. All we can say is that it is shortly after noon. Urs Graf (1485-1529), of Soleur, was a Renaissance landscape painter who was fond of including a sundial in his works, and depicted many kinds of dial in these. The dial shown here is a poor example of his dialling delineations.

Figure 3 shows a typical Teutonic lady with very large hips, it is an allegory by Martin Zasinger and the original engraving may be seen in the Kuntsmuseum, Basle. One must suppose that it is meant to illustrate Life, Time and Death, since the lady is standing on a skull and holds a diptych dial in her right hand. The artist's initials are placed on either side of the skull. The significance of the object on the upper right is lost on the writer.Again there is no shadow on the dial, the sun appears to be high in the sky, about mid-morning. The engraving on copper was made in the early part of the 16th century, it is entitled "Memento Mori", 16th century Latin for 'Remember you must die', and is usually depicted by a skull. Some commentators state this illustration is in the style of Albrecht Dürer, personally I consider it too fussy for Dürer. In spite of the warnings today about global warming, it is clear that the weather in those days must have been quite balmy since so many ladies of this century are shown unclothed. Never having stood upon a skull, I am unable to comment on how precarious this action might be, the lady seems unconcerned, whereas the skull appears to be gritting its teeth.

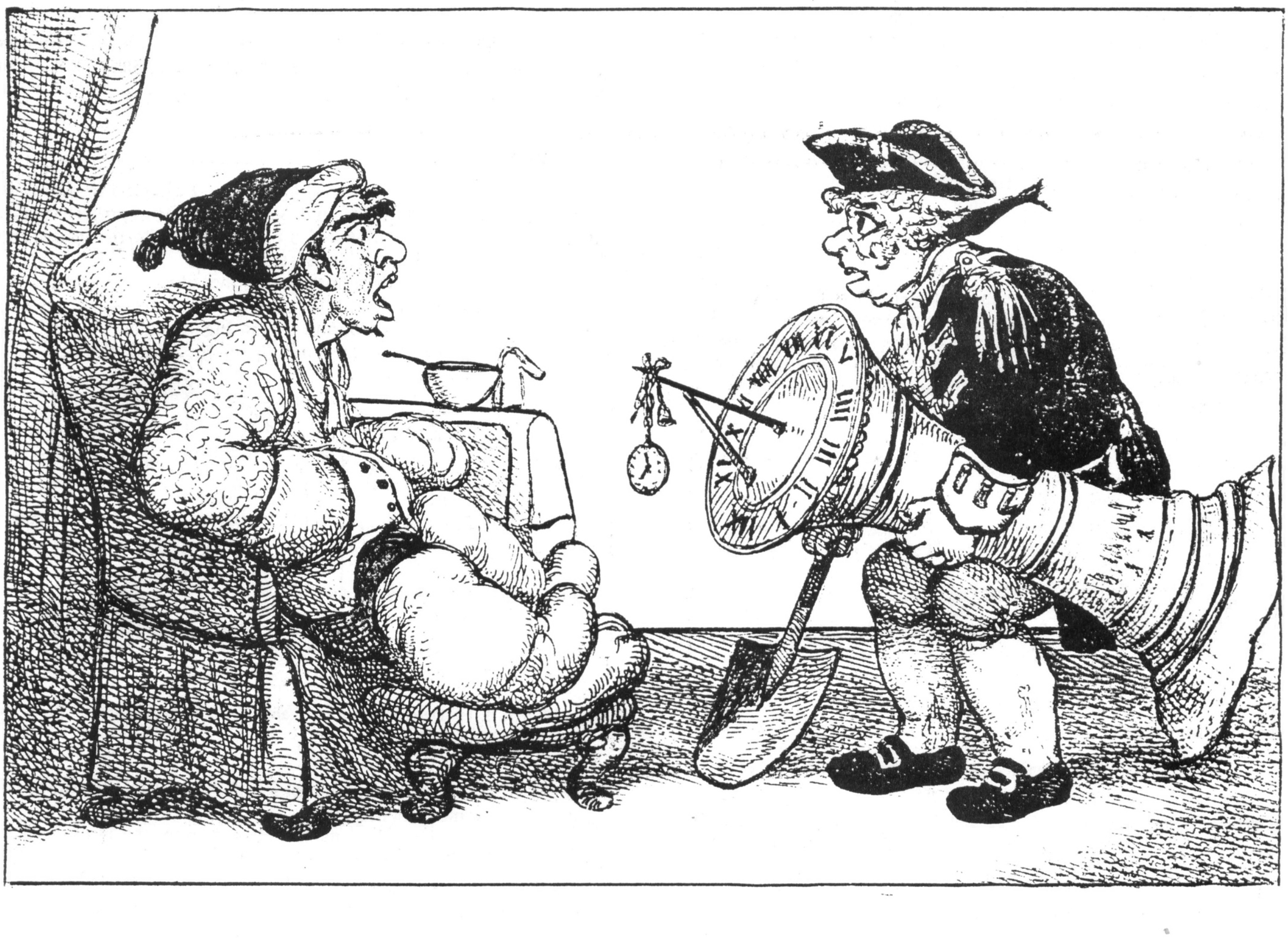


FIGURE 1: English caricature cartoon - "The foolish servant has dug up the sundial"

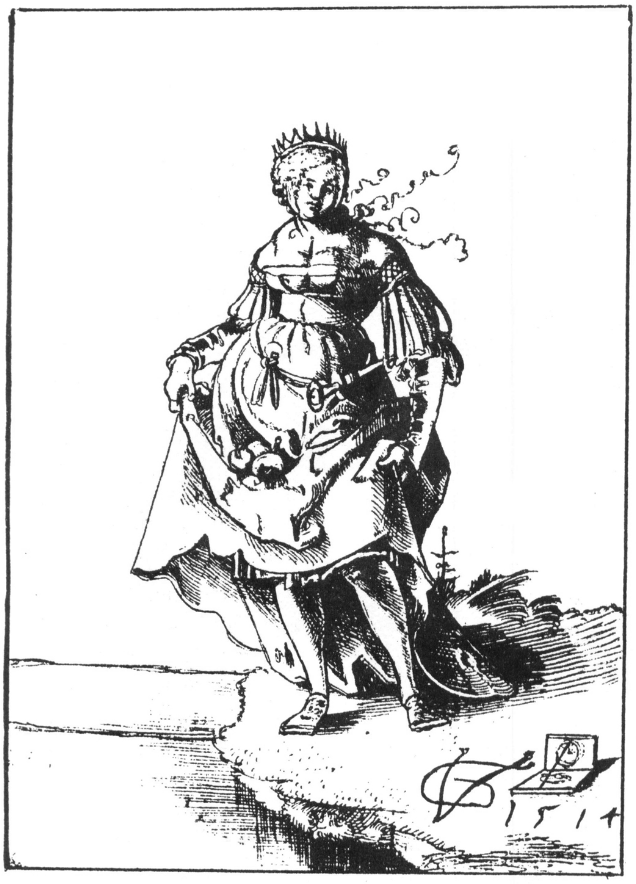


FIGURE 2: Crowned lady engraved by Urs Graf, 1514

FIGURE 3: "Memento Mori" on copper plate by Martin Zasinger, early 16th century

The next illustration (Fig 4) depicts a charming young lady with an armillary sphere, no doubt purely a decorative detail since she is not displaying much interest in it. It is not intended as a sundial since the numerals are on the outside of the ring, and in any case the indicating ring must be at right angles to the earth's axis in a armillary sphere sundial. This portrait may be seen in the National Gallery, London. It was painted by Jean Gossaert (known as Mabuse), the date is uncertain. He was a Flemish painter born at Mauberge (Mabuse) circa 1470, and in 1503 entered the painters' guild of St. Luke at Antwerp. In 1509 he went with Philip of Burgundy to Italy and his style was greatly changed by the Italian masters. This painting is still recognisable as that of the Flemish school. He died in Antwerp in 1532.

Astronomia often figures in allegorical illustrations, and in Fig 5 is used by the artist to illustrate a number of interconnected themes. Under her right hand is a star globe with the constellation of Leo prominently displayed. In her left hand she holds a cross staff of sorts and nonchalantly peers along it although the sun is directly behind her head (repeated on her right breast) and the sky is full of stars.. Meanwhile a group of savants to her left appear to be setting out a dial of some kind. Judging by the light on the figure, the sun is on the left also. Under the globe is a strange assortment of instruments. The upper one is some kind of sundial but its gnomon is set strangely and casts its shadow as though the sun was on the right hand side of the illustration. The uppermost figure is shown as 01 and not 10. The lower instrument appears to be a very crudely divided quadrant, what the divisions signify is not clear, they require multiplying by a factor of 10 to produce degrees. The final instrument appears to be a magnetic compass in spite of the annulus bearing 1-12 in Arabic figures. The use of Arabic numbers in this context can only be because Arithmetica is an accompanying allegorical figure and therefore Roman numerals would be inappropriate. This illustration is an engraving by Crispin de Passe from a sixteenth century painting by Martin de Vos, entitled "Sublime Aurea contemplating the Starry Aether". What one has to remember is that much of the allegorical detail would be clear to an observer of the period, the significance of which is utterly lost upon us today.

Robert Hegge, a Fellow of Corpus Christi College, Oxford, was a very keen sundial enthusiast. In the 1620's he sketched the famous Turnbull sundial in the College Quadrangle (more popularly known as the 'Pelican' Sundial). The perspective is deliberately distorted. The Latin inscription reads "Representation of the most elaborate Sundial in the Quadrangle of Corpus Christi College by Charles Turnbull, sometime Fellow of that College". It seems that in this sketch Hegge was trying to show all the salient features although this is a quite impossible view in reality. According to Philip Pattenden, in his book *Sundials at an Oxford College*, Hegge was probably drawing from memory, and could not be bothered to go into the quadrangle to check the details, see Fig 6. Hegge's treatise on dialling includes frequent drawings of pelicans, bishops, owls and sundials, the living objects being rather better delineated than the solar instruments. It would be difficult to recognize the Corpus Christi sundial today from Hegge's drawing but it has suffered many changes since, the column in particular being much longer and slimmer,

FIGURE 4: Young girl with armillary sphere by Jean Gossaert

FIGURE 5: "Astronomia" by Martin de Vos

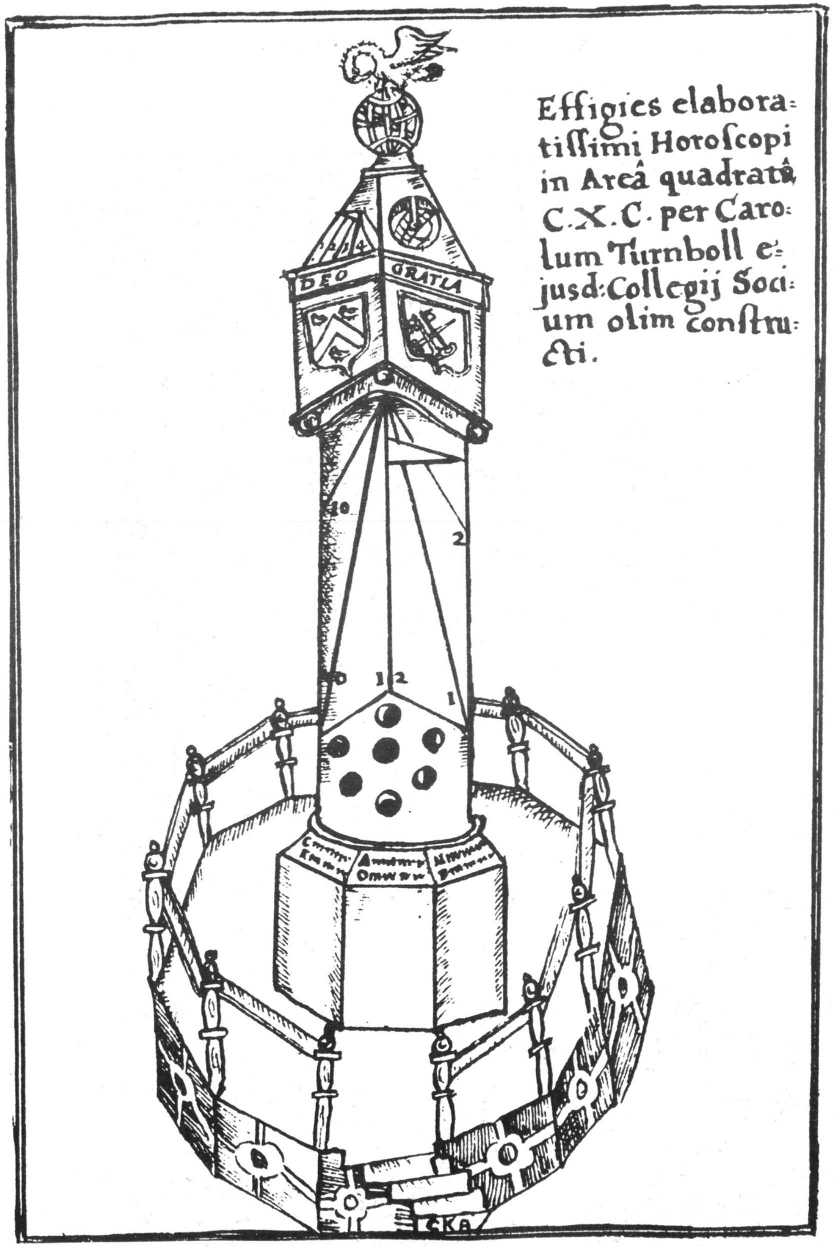


FIGURE 6: Robert Hegge's view of the Pelican Sundial at Corpus Christi, Oxford

FIGURE 7: A detail from "The Ambassadors", the most famous painting to include sundials

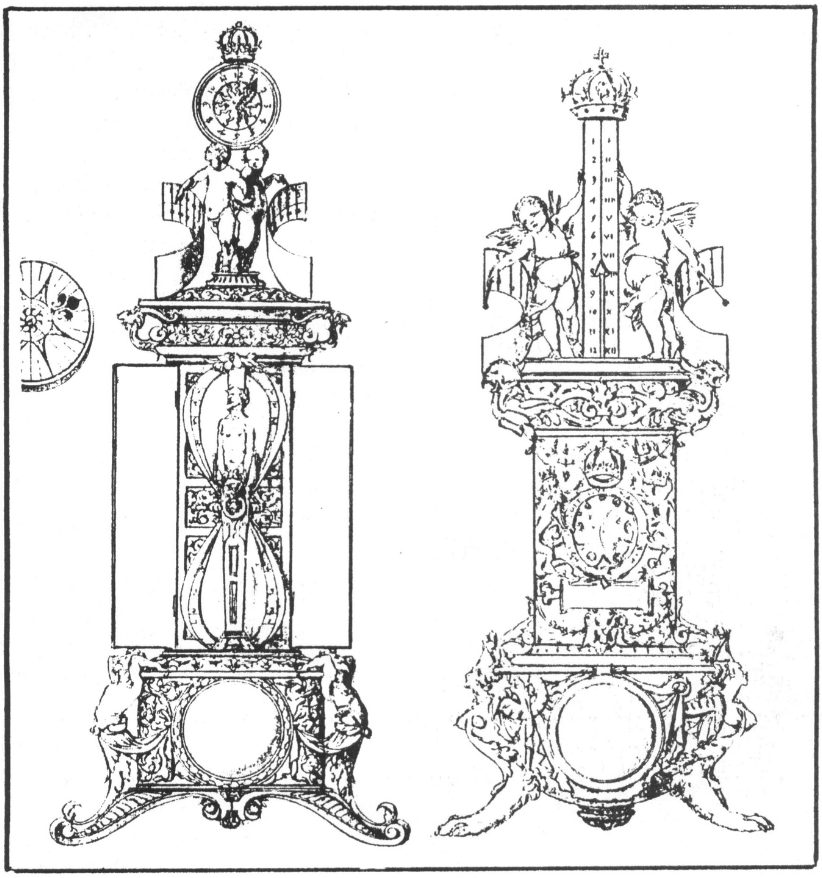


FIGURE 8: Two clock designs by Hans Holbein incorporating sundials

and accentuated by standing upon a pedestal of about five feet in height.

Of course not all artists are content with a mere caricature of a dial, and for one of the most faithful reproduction of a series of sundials, visit the National Gallery in Trafalgar Square to stand before "The Ambassadors" painted by Hans Holbein the Younger in 1533, see Fig 7 for a detail from this. The writer gave a detailed account of this magnificent painting in an article published in Antiquarian Horology, Volume IX, Winter 1976, pages 70-77. It is of interest to note that the instruments depicted here were previously shown in a portrait of Nicholas Kratzer painted by Holbein (a friend of his), but were then in an unfinished state, in 1528. See BSS Bulletin 93.2, page 10, for a reproduction of this portrait. The Ambassadors will be the subject of a future article in the BSS Bulletin, so no further details will be given here.

Two of Hans Holbein's designs for clocks incorporating sundials and clepsydrae are still extant and are in the British Museum collections. These are shown in Fig 8, that on the left was actually made after the death of Holbein and presented to Henry VIII. It comprised a sandglass, clepsydra and mechanical clock turning the dial at the summit of the ensemble, it is now lost. The design on the right appears to have the sundials and clepsydra only, a float in the clepsydra moving the arrow pointer on the vertical scale. The division of the dial scales into two halves is an ingenious way of achieving a compact arrangement. The doors protecting the sandglass or clepsydra are decorated with the Royal Arms. The original sketches are annotated by Holbein.

"The Watch and the Sundial" (Fig 9) is the title of the

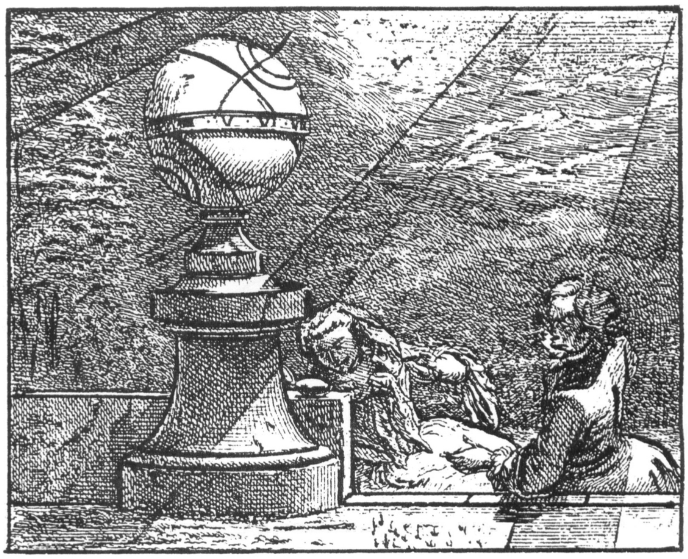


FIGURE 9: "The Watch and the Sundial" by Claude Gillot circa 1700

next vignette. It was sketched by Claude Gillot (1632-1722), who was born at Langres, France, and who taught such masters as Watteau and Lancret. He was closely connected with the theatre and ballet as a designer of scenery and costumes. This picture is an illustration of a fable of Henri de la Motte. It is difficult to make out what the message from the sundial may be. The gnomon is pointing in the general direction of the sun, the indicating shadow falls on the figure V, and the whole scene is as imaginary as the fable. Evidently the lady (near the dial) is keeping a close watch on the timekeeper, a characteristic of those engaged in clandestine meetings, torn between the yearning for another few moments of passion and the need to avoid suspicion; and not checking the watch against, nor relying upon the indication of the supposed sundial. One must infer that the sun is breaking through holes in the clouds to produce such shadows and by these it seems to be approaching noon.

Because of the edict of the Sun King Louis XIV that France would use solar time as the time regulating the country, and which continued after the French Revolutionaries did their best to get decimal time adopted; the title of the painting by Ch.-J. Traviès (1804-1859), lithograph by V Ratier is "I always go by the sun", Fig 10. The traveller seemingly is rather puzzled by the sundial which indicates half past twelve, or thereabouts. The confusion caused to travellers by the multitude of local solar times, must have been enormous. Traviès was a French painter who illustrated H. de Balzac's work. To keep a watch in compliance with solar time requires a daily correction, to indicate solar time by a watch or clock it is necessary to have a cam with an outline similar to that for

FIGURE 10: A French cartoon by C. J Traviès of the early 19th century

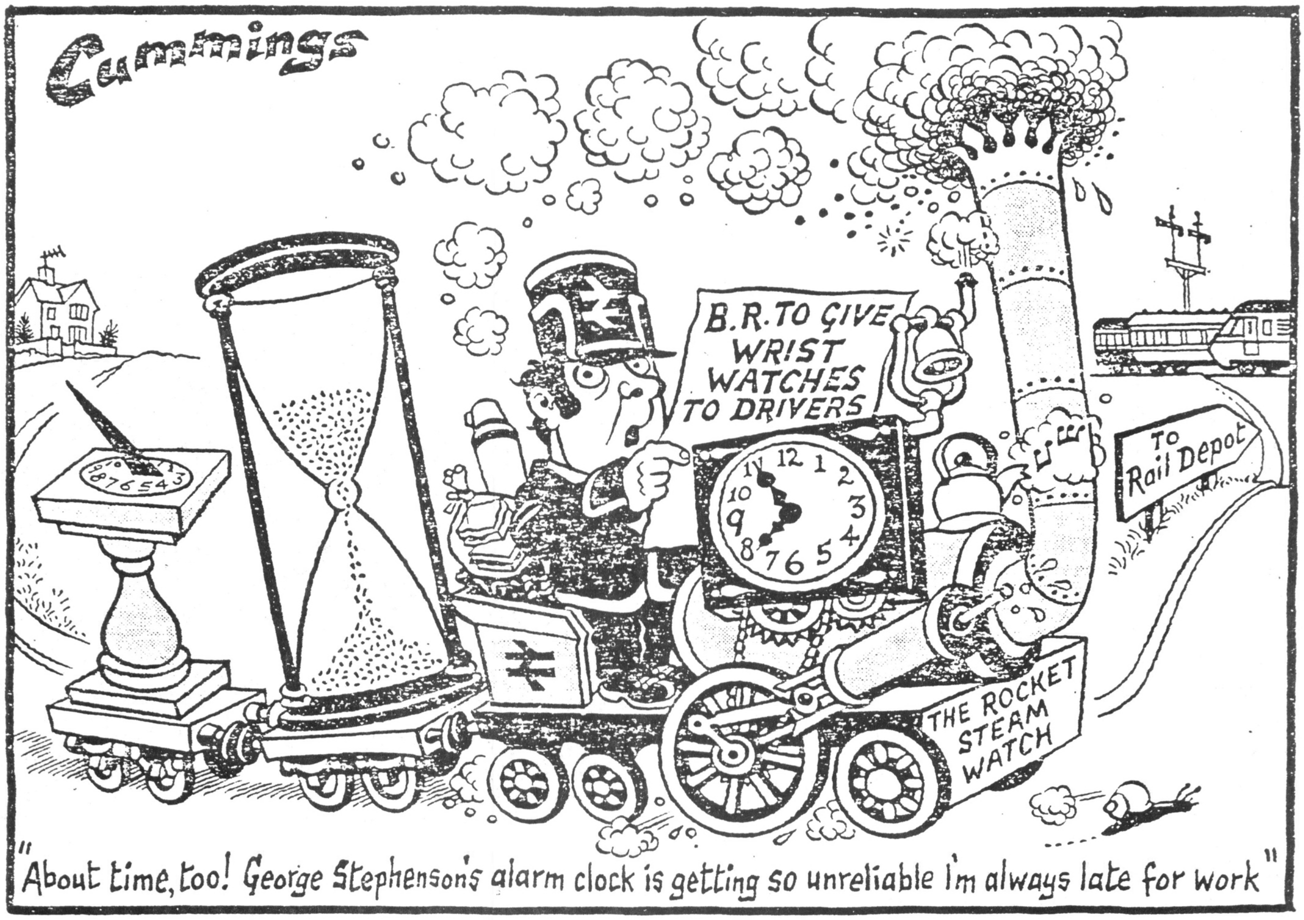


FIGURE 11: A 1984 cartoon with a sundial drawing up the rear

TIME AND TIME-TELLERS.

JAMES W. BENSON.

LONDON:
ROBERT HARDWICKE, 192, PICCADILLY.
1875.

FIGURE 12: James W. Benson's title page illustration of 1875 which became the logo for the NAWCC in the USA, the largest and most active horological association in the world

the Equation of Time analemma so that the hands may be advanced and retarded by the appropriate amount each day on the theoretical mean solar time normally indicated by the timekeeper. Not many such clock or watches were ever made. It was this mechanical difficulty which brought about the adoption of mean solar time in the place of seasonal hours. It must be pointed out that the changeover is not noted in horological records, and that the earliest clocks with a foliot regulator were adjusted to indicate noon on each and every day, the moment at which the sun was on the meridian being used as a time standard. In other words, although each day and night had equal time divisions, which was a departure from the old unequal or seasonal hours; the varying length of the day throughout the year was followed by manual adjustment of the clock. This was tantamount to ignoring the Equation of Time although the effect was known, because accurate data was not then available until the late seventeenth century, when John Flamsteed (the Astronomer-Royal) produced his first tables, and these were not particularly accurate.

The lack of understanding of the sundial is no less in the twentieth century, this example by Cummings is way off the right lines although the style is roughly at the correct angle, how it copes with the changing direction of the lines (when the engine is on them) is not clear, however its root originates at the three of the clock dial scale, so perhaps it does not greatly matter. It does give a new dimension to portable timekeepers however, see Fig 11.

The logo of the National Watch and Clock Collectors Association in America takes us back to the earliest sundial/pocket watch theme, a continuing occurrence to the present day but in reverse, for with the advent of accurate time on demand and watches which may be relied upon utterly for intrinsic accuracy, the tendency now is to check the sundial for accuracy of indication. One might just as well use an elastic tape measure to measure linear magnitudes as to compare the mechanically ground out measure of mean solar time against the perfect accuracy of solar time indication with an accurately set up sundial. This logo was first used by James W. Benson of 58 and 60 Ludgate Hill, London, in the little book Time and Time Tellers. It is also used on the front cover of the book, embossed in gilt, in which the vague shapes on the pedestal pillar are there resolved into a circle of dancing ladies, with the watch clearly showing a quarter to four on its dial, and the nondescript foliage transformed into graceful fernlike fronds. The illustration on the title page is identical to the American version. Since the NAWCC design is registered, the illustration here is taken from Benson's title page of 1872 (Fig 12), and long out of copyright. I have shown the embossed illustration, alas the gilt on a dark green ground does not reproduce well, but see Fig 13.

Of course what is presented here is a mere fragment of the vast body of sundial illustrations over the centuries, yet curiously enough the sundial was not a popular subject until the sixteenth century when the scientific sundial began to make its appearance in Europe. Before that those artists incorporating symbols of time into their pictures usually included a mechanical clock, so that St. Augustine who flourished from AD 354-430, is pictured in his study with an armillary sphere and a 24-hour dial weight-driven mechanical clock in the fresco by Boticelli in the church of the Ognissanti, Florence. This is dated 1480. St. Augustine is often quoted since he made the famous

FIGURE 13: The cover illustration of J.W. Benson's book.
(Gilt on green)

observation about time - "What then is Time? If no one asks me, I know; if I wish to explain to one that asketh, I know not". No one since then has made any significant progress in its understanding, but if he had had such a clock in his day he would have regarded it as a miracle in itself, whereas we take such devices for granted. The best that Augustine could have hoped for then was a classical hemispherium of the period.

The other symbols of Time, such as Chronos or Father Time with his Sandglass and Scythe, and indeed the sandglass itself, are recent innovations of this millenium. Whilst sundials have never really fitted into this theme easily, they have more than made up for this by the pithy and apt comments placed upon the dials themselves, putting into words the contents of many pictures such as are depicted here, ie the allegory of Life, Time and the certainty of Death. To some, these mottoes are anathema, but then none of us like reminding of the swift passage of time and the temporality of human life.

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LETTERS TO THE EDITOR

KIRCHER'S SUNFLOWER CLOCK

I refer to the interesting article by John Briggs (BSS Bulletin 93.2, pp. 42, 43), which I hope will stimulate full translation of the texts shown in the illustration. In case this is not forthcoming, perhaps the following comments will spur a knowledgeable member to provide authoritative versions.

The title at the top:

ΩΡΟΣΚΟΠΙΟΝ ΕΑΙΟΤΡΟΠΙΚΟΝ

can be transliterated:

HOROSCOPION EAIOTROPICON

An early meaning of 'horoscope' includes the idea of 'time watcher'; and 'τροπι κοσ' is to do with 'turning'. I hope that a Greek scholar will elucidate the 'εαιο' root, but I expect it means 'by itself, left alone'. Thus I think that this Greek heading means 'A Self-Turning Watch'.

It is a little difficult to decipher the Latin inscriptions, but I believe that on the scroll there is *Artis et Naturæ Coniugium*; A Union of Art and Nature.

The text at the bottom is also difficult to read, but may be as follows:

Annos circuitu Sol tempora Signat et horas
Omnia Solisequatio[?] Simid [?] Solis agit

for which (very hesitantly) I offer:

In its circuit, the Sun shows the seasons and the hours:
The uniform motion of the Sun drives everything.

W. A. DUKES

* * * * * *

JOHN ROWLEY

With regard to the article about Butterfield dials in Bulletin 92.3 (October 1992) and the list of makers, there are in fact two Butterfield dials by John Rowley at the National Maritime Museum. One was made for John Churchill, first Duke of Marlborough, and bears his coat of arms; the other was made for the Earl of Orrery and bears the Boyle family arms. The Museum has photographs of both dials.

A paper by John Appleby of Norwich on some of Rowley's lesser known activities, including his very large (29 inch) horizontal sundials made in 1710 for St. Paul's Cathedral and Blenheim Palace, will be published later in 1993 in the journal *Annals of Science*. The Land Tax Books show that he vacated his retail shop "under St. Dunstan's" about 1713. His Johnson's Court address, which he occupied in parallel with the Fleet Street one prior to 1713 and then by itself until his death in 1728, was possibly mainly residential. From 1715 onwards he was mainly concerned with large engineering projects rather than mathematical instruments.

J.R. MILLBURN

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THE TEN COMMANDMENTS

Like Mr. Drinkwater I have no desire to be "picky" over Bulletin articles but the drawing of an horizontal drawing accompanying M. J. Cowhams excellent advice to a "beginner" on buying a sundial does contain an error. In fact it illustrates another common fault on cheap "garden centre" dials. As the gnomon has substantial width the 4 am and 5 am lines should of course spring from the same corner at the toe of the gnomon as the 4 pm and 5 pm lines, not the opposite as drawn. Obviously the same applies to the 7 pm, 8 pm and 7 am, 8 pm, lines, they should be continuations of each other.

COLIN THORNE

SUN COMPASSES

BY MICHAEL HICKMAN

INTRODUCTION

What are the connections between the British Sundial Society, the Special Air Service and the flight paths of moths? To find out read on.

Earlier features[1] in the BSS Bulletin have addressed sun compasses and I do not intend to recycle the material in those. What I aim to do is to complement with new material from my researches that has already been written and to show that the mathematics are not as difficult as they may seem.

I recently visited the Royal Signals museum at Blanford Camp, Dorset and was intrigued to see there what at first sight appeared to be analemmatic sundials. Closer examination revealed that they were in fact sun compasses and that while they bear some resemblance to analemmatic dials there as significant differences.

Thanks to the kindness and willing help of the curator of the museum, Major R. Pickard, I was permitted to examine the exhibits closely, to photograph them, and to have a copy of an explanation of the use of the different types.

Later I visited the tank museum at Bovington, Dorset, where I found two more sun compasses on display. Once more the museum staff were extremely helpful and kindly allowed me to read some of their library material relating to sun compasses. They also provided me with a copy of some of that material.

I trust that members will find sun compasses as interesting as I did. I also hope that if they are in Dorset they will visit the Signals and Tank museums. Each will fully repay the effort required to get to them; being ex-Royal Navy I can claim to be unbiassed by any regimental loyalties!

THE THEORY OF SUN COMPASSES

At any particular location there is a mathematical relationship between the sun's direction relative to north and the local hour angle. (Those who are interested in the mathematics of this will find details in the appendix.)

As diallists with an analemmatic dial we use the direction of the sun to determine the time. However there is no reason why we should not work the other way round and use the time to determine the direction of the sun relative to the direction of north. This in essence is the principle on which sun compasses work.

It is relevant that the error of a warship's gyrocompass used to be checked by measurement of the sun's direction relative to east or west at sunrise or sunset respectively (the amplitude) and calculation or derivation from tables of what that direction should be. Perhaps compass error is still determined this way but I expect it has all been replaced by satellite navigation systems or ships' inertial navigation systems (SINS).

THE USE OF SUN COMPASSES

In our youth as scouts or guides we have all probably used our watches to determine south by bisecting the angle between 12 o'clock and the hour hand, with the hour hand pointing to the sun. As members will appreciate this is not a particularly accurate way of determining the direction of the north/south line and our trusty scout magnetic compasses were almost certainly better. However, for serious use in vehicles, there is one major disadvantage of such compasses and that is that they are what they say they are - magnetic.

Thus they are unusable near, for example, an army tank or a Landrover. Perhaps it is possible now with modern degaussing techniques to neutralise vehicles' magnetic fields sufficiently for magnetic compasses to be used near them[2] but it certainly was not during the last world war. This meant that vehicles in North Africa had to have some other means of determining their direction of travel across almost featureless deserts. The British Army used sun compasses for this purpose.

I thought that the Afrika Korps and the Egyptian Army might also have used sun compasses in North Africa and that perhaps the latter force still use them.

The military attaché at the Egyptian embassy in London was kind enough to contact his home country for me and found that the Egyptian army do not use sun compasses. However in a feature[3] about Ralph Bagnold, the founder of the Long Range Desert Group (LRDG), it is stated that in the early 1940's the Egyptian Army had acquired some of Bagnold's compasses and in fact lent him some of his own inventions for use by the LRDG because he could not get any from British military sources.

I have not been as successful with enquiries about the Afrika Korps, but it has been suggested that they probably did not need sun compasses as they tended to operate in large formations and close to the coast where roads and routes were reasonably well defined.

The first recorded use of sun compasses was apparently in Libya during the first world war. However, despite the authority of the publisher, I do not feel that the instruments described in the source of the information[4] can legitimately be described as compasses. The instruments described were used to indicate that a vehicle was pointing in the required direction, that direction having been found with the aid of a magnetic compass. We should be clear that the early sun compasses did not indicate north without recourse to a magnetic compass, or the use of azimuth tables and were perhaps better described as direction indicators.

Sun compasses were also used in the 1920's in more peaceful conditions by a group of British army officers, including Ralph Bagnold, in their explorations in the Middle East.[5]

EARLY BRITISH ARMY SUN COMPASSES

The Howard Sun Compass

A simple sun compass used by our army was the Howard Sun Compass, of which there were inevitably two versions, Mark 1 and Mark 2. A photograph of the Mark 2 has already appeared in the Bulletin[6] but for those who do not have the reference, and to explain the way in which the Howard Sun Compass was used, figure 1 shows the principal features of its construction.

Note that the bearing plate is calibrated counterclockwise from 000° (or 360°). This has the same effect as calibrating the time plate clockwise which is perhaps more logical and less confusing as the time plate shows the direction of north when it is positioned so that the gnomon shadow indicates the correct local apparent time.

As already suggested it is perhaps misleading to call this a compass as it was not used to find the direction of north

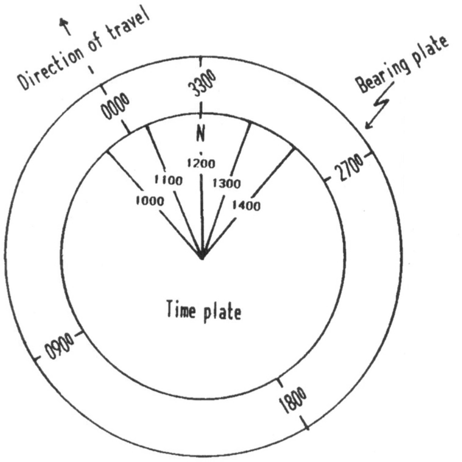

FIGURE 1: The Howard Sun Compass - principal features

relative to the direction of the sun. That was done by the use of azimuth tables and the Howard Sun compass was used to plot the resultant relative direction and then they indicate the required direction of travel. According to information from the SAS the tables were based on Davis's Azimuth Tables.

The modus operandi of the Howard compass was as follows:

a) The user selected the appropriate "shadow angle" table for his latitude. This table showed, for any given latitude and any given two-week period, the relationship between local apparent time and the sun's bearing, or azimuth. It also gave for each two-week period the value of the equation of time.
b) On the time plate radii were drawn for local apparent time at half-hour intervals. The angles between the radii and the index line were taken from the shadow angle table in use.
c) Further radii at quarter-hour intervals were drawn by interpolation. (For clarity only a few lines, at hourly intervals, are shown in the figure).
d) The compass was then mounted horizontally on the vehicle with the 000°-180° line on the bearing plate parallel to the vehicle fore and aft line and with 000° to the front.
e) The time plate was turned until its index was on the required bearing on the bearing plate. (330° in the figure.)
f) The vehicle was turned until the gnomon shadow lined up with the local apparent time on the time plate. The vehicle was then pointing in the required direction.

If a convenient distant landmark lay in the required direction then all that was required was for the vehicle to be steered towards it. However in deserts there probably wasn't a convenient distant landmark. In this case it was necessary to make constant reference to the sun compass and to use different radii as local apparent time elapsed. This meant that the vehicle had to be steered so that the gnomon shadow lined up with the local apparent time. To avoid constant resetting a suggested technique was for each period of 15 minutes to use the shadow line 7½ minutes ahead of the start of that period so that for the first half of the period the course would be to one side of that required and for the second half it would be to the other side. Thus the vehicle would steer a zig-zag course but the mean course would be that required.

A disadvantage of the Howard sun compass was that it needed supporting data tables and much preparation. Also the time plate was liable to buckle in heat and chinagraph pencils could not be used to plot the radii as they melted.

The Bagnold Sun Compass

From material supplied by the Royal Signals museum and an illustration in a description of Bagnold's journeys[7] the Bagnold compass appeared to be somewhat similar to the Howard compass already described. Material kindly provided by the SAS confirms this.

Again the navigator had to work out the local apparent time and then consult azimuth tables to find the sun's direction at that time. The Bagnold compass was then set so that the shadow of the gnomon fell on that bearing on the compass 360° scale. The compass could then be used to show any required direction, but like the Howard compass it needed constant resetting as local apparent time changed. The use of the Bagnold compass to steer a vehicle was similar in principle to that for the Howard compass.

For those of you who have been patiently awaiting an explanation of the relevance of the flight paths of moths there is an analogy between the use of Howard or Bagnold sun compasses and a possible method by which moths navigate. If one proceeds so that the angle between one's heading and the direction of a distant object such as the sun is constant then one will proceed in a straight line. Hence the Howard and Bagnold compasses. However if the object is not distant, as in the case of a moth and a candle, then one proceeds in a spiral. If the angle is less than 90° then the radius of the spiral will decrease until one ends up at the object. Thus a moth isn't actually attracted to a light; he crashes into it in his attempt to use it as a sun for his own sun compass.

(I would be delighted to discuss the maths of this if anyone is interested - moths' maths? If I've got it all wrong about moths' navigation systems are my beliefs moths' maths myths?) - To return to sun compasses.

The Universal Type Sun Compass

This appears to be the first instrument designed to obviate the need for the navigator to look up any tables, which gave it a significant advantage over the Howard compass. It also obviated the need for pencils that don't melt. The compass looked rather like an analemmatic sundial, which is not surprising as like that dial it might be regarded as a mechanical analogue computer to solve the standard equation already referred to. However it required time as an input to give north as an output, which is the inverse of the

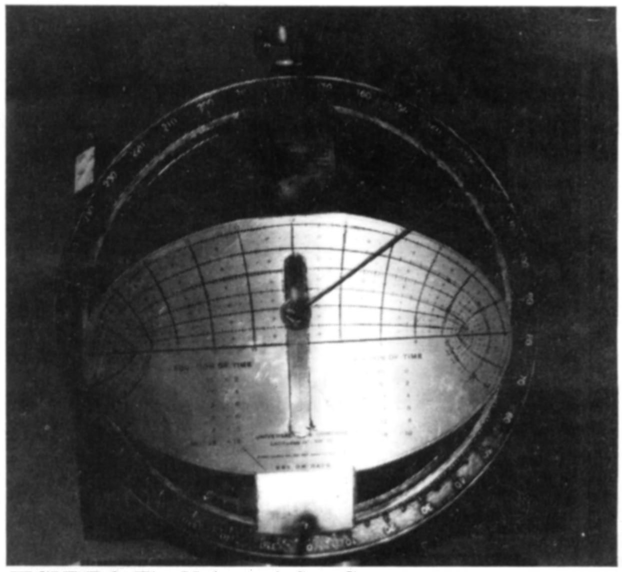

FIGURE 2: The Universal Sun Compass

function of the sundial. Furthermore the equation, and hence the design, was modified so that the compass might be used more easily at any latitude. Details of the modified equation are given in the appendix.

This instrument, shown in Figure 2, comprised five parts which were called

The vertical pointer
The shadow needle
The elliptical time plate
The rectangular date scale
The circular protractor.

The vertical pointer was fixed at the centre of the circular protractor. The date scale was also fixed to the protractor, with its major axis along the north-south line of the protractor. The elliptical time plate could be moved in the north-south direction and in use was positioned according to the date. The date scale on the time plate was calibrated so that the movement of the time plate was proportional to the tangent of the sun's declination.

The time plate was engraved with curves, one for each of several latitudes, showing the relationship between the direction of the sun and the local apparent time. In use the time plate was set according to the date, thus taking account of the sun's declination. Next the shadow pointer was positioned so that it passed through the appropriate latitude curve at the point representing local apparent time. The whole compass was then turned until the shadow of the vertical pointer lay along the shadow pointer, 000° on the circular protractor then pointed to true north.

Readers may recall that a similar American sun compass has already been described[8] in the BSS Bulletin.

The Cole Universal Sun Compass

This was similar to the Universal sun compass already described and again there were Mark 1 and Mark 2 versions. However, while the mathematics of the Cole compass were the same as those of the Universal compass the mechanical arrangement of the components was slightly different.

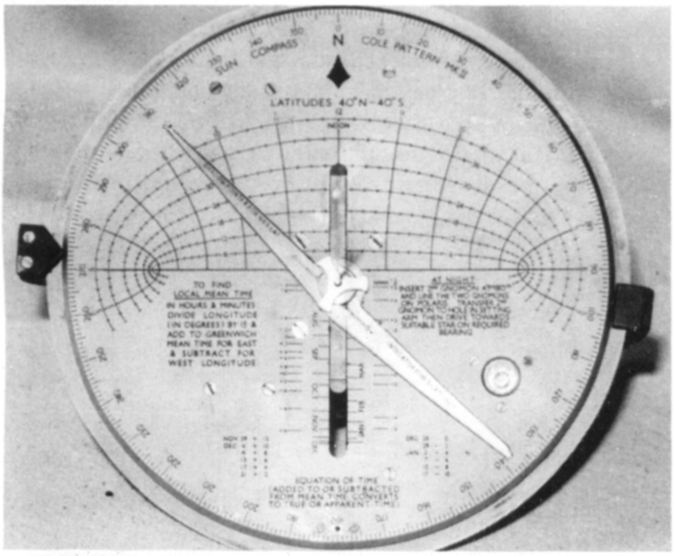

FIGURE3: The Cole Compass Mark 2

The Mark 2 Cole compass is shown in Figure 3. It comprises a circular rotatable plate around which was a 360° scale. Engraved on the plate were curves similar to those for the previous instrument ie. one for each of several latitudes, showing the relationship between the direction of the sun and the local apparent time. In this plate there was a slot in the north-south direction, and in this slot a holder for the gnomon was positioned according to the date, and hence to the sun's declination. Thus the gnomon was moved in the Cole compass whereas the elliptical time plate was moved in the Universal sun compass.

The method of use of the two instruments was basically the same, but in the Cole compass the point at which the gnomon shadow intersected the 360° scale had no significance because, except when the sun's declination was zero, the gnomon was not at the centre of the 360° circle. If the gnomon has been set at the correct date, that is it has been positioned according to the declination of the sun, and if the circular plate is rotated so that the shadow of the gnomon passes through the point determined by the latitude and the local apparent time then the north mark, or 000°, on the dial would point to true north.

No tables were required for the Cole sun compass and again the only calculation required was the conversion from mean time to local apparent time. The value of the equation of time was given from a scale engraved on the slot used to position the gnomon and the longitude needed to be known so that the usual correction for it might be applied.

The Cole sun compass Mark 2 was also capable of being used at night, by aligning two vertical pins in the direction of the Pole Star. In this context it was really being used only as a means of measuring angles between the required direction and north, in other words as a direction indicator.

The SAS informed me that the Cole sun compass is still used but that it is now at the Mark 4 stage.

In the *Geographical Journal*[9] there is a mathematical description of the theory of a universal sun-compass but it is not clear if it refers to any particular practical instrument. It is also worthy of note that in this article the author gave two alternative types of universal sun compass, one as in the Cole and the other in which the navigator needed to allow for latitude when setting the position of the gnomon. The author thus undid, I think, the good work done by Cole in eliminating the need for this allowance. However it must be said that a simple graphical method of determining the effect of latitude was described.

One effect of this modification was to make the compass appear as a series of superposed analemmatic sundials with common east-west dimensions.

The Evans-Lombe Sun Compass

This consisted essentially of two concentric circular cards free to rotate about their centre. The smaller card had a series of radial hour marks on it and at its centre was a vertical gnomon. If the card was positioned so that the shadow of the gnomon fell on the hour mark corresponding to local apparent time then the noon mark would point north. The larger card was marked anticlockwise around its perimeter from 0° to 360° and was mounted so that the 0-180° line was on the fore and aft line of the vehicle. Thus the compass was basically a Howard sun compass described earlier. However the user did not have to prepare a time plate as in the Howard; a set was provided for him.

This compass was easy to use but it had the disadvantage that separate cards were required during the year to allow for the varying declination of the sun and also sets of such cards required for various latitudes. In practice thirteen cards were used for different declinations, each card covering two two-week periods of the year. Sets of cards, thirteen in each set, were produced for each two degree change in latitude; as the Evans-Lombe system was designed primarily for the North African campaign this did not entail many sets as most of the action was between fairly close limits of latitude.

More details of the Evans-Lombe Sun compass and its use may be found in the *Geographical Journal.*[10] Your local public library will probably be able to get you a copy of the article.

The Micklethwait Sun Compass

I am indebted to the staff of the Tank Museum at Bovington Camp, Dorset, for a copy of an undated monograph[11] by E.W.E. Micklethwait. In this the author briefly discussed the Bagnold sun compass and the Evans-Lombe sun compass, and then, in more detail, explained his own sun compass. The paper contained four illustrations of the compass.

From Micklethwait's paper his sun compass seems to be the most elegant of those I mention in this article. It even functioned as a sundial at the same time as a compass, and I think that the reason for this is that it made use only of the sun's azimuth but also of its altitude. There were thus two known factors whence two unknowns might be derived.

Despite the virtues of the Micklethwait sun compass I am uncertain that it was ever in widespread use. It appears that one prototype still exists, apparently at what used to be called the Admiralty Compass Observatory at Slough. That establishment is now part of the Defence Research Agency and moved to Portland, Dorset but I do not know if the sun compass will be moved there nor if we shall ever be able to see it.

In use the Micklethwait sun compass was set for latitude, longitude and date. The declination and equation of time were derived by mechanical analogue computation and the instrument was oriented so that the shadow of the end of the gnomon fell in a particular spot. 000° on the compass scale would then point to the true north and zone time would be indicated on the time scale. There was thus no need for the navigator to make any calculations or to carry any tables. All he needed to know what his latitude, longitude, and the date. If he didn't know the time Micklethwait's compass could also act as a sundial to give him the local apparent time.

For more detailed account of this compass members are recommended to contact the Curator, the Tank Museum at Bovington Camp, Dorset, to see if they may have a copy of Micklethwait's paper. Alternatively they may like to contact the Public Records Office. The PRO may also be worth trying for access to the papers referred to in the Micklethwait monograph.

CONCLUSION

Most people nowadays probably regard sundials as merely ornamental. I hope that I have shown that, in another guise, they have a practical function.

Given the location and the date and time a sun compass such as the Cole will reliably indicate true north. Location may be easily obtained now, in terms of latitude and longitude, by using a system such as Decca and if we don't know the date and time we shouldn't be navigating, should we?

To come up to date the Special Air Service, who may be regarded as the successors to the LRDG, use sun compasses for desert navigation and were kind enough to tell me that the Howard and the Cole Mark 4 were deployed during Operation GRANBY. That has established the connection between our society and the SAS.

Thus sun compasses are still used - this is splendid and shows that the subject of our interest and enthusiasm has a practical use even at the end of the twentieth century.

As in everything we do as members of the British Sundial Society all we need is the sun!

ACKNOWLEDGEMENTS

I gratefully acknowledge the help and information willingly given to me by the following:

Mr Jack Bradshaw, of Dorchester, who drew my attention to previous material in the BSS Bulletin and other relevant material and who lent me copies of it. He also provided valued comment on this paper in its draft form.

The curators of the Royal Signals Museum at Blandford, Dorset and the Tank Museum at Bovington, Dorset, for giving me access to their material on display and to the literature in their records.

The Defence Research Agency at Slough (now at Portland Dorset) for giving me a lead for the Micklethwait compass.

The Special Air Service at Hereford for providing much useful information about the current use of sun compasses by the British Army.

The staff of Dorset County lending and reference libraries for their usual cheerful and efficient provision of published material.

APPENDIX

Like its parent article the appendix is intended to supplement earlier relevant material. Attention is particularly invited to the feature on Lambert's circles in the BSS Bulletin.[12]

The usual formula for derivation of the sun's azimuth is:

$$\text{Tan Az} = \frac{\text{Sin HA}}{\{(\text{Sin Lat} \times \text{Cos HA}) - (\text{Cos Lat} \times \text{Tan Dec})\}}$$

where Az = azimuth
HA = sun's hour angle
Lat = latitude
Dec = sun's declination

Note that this formula has been printed incorrectly on page 139 of Waugh's "Sundials: Their theory and construction".

The foregoing formula may be shown graphically as follows:

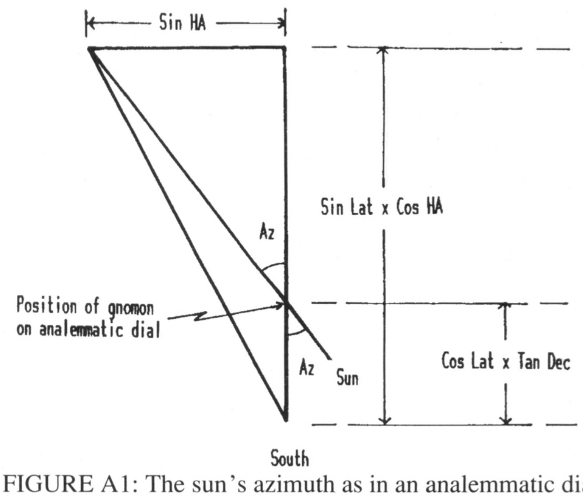

FIGURE A1: The sun's azimuth as in an analemmatic dial

and you may see from this diagram the construction of an analemmatic sundial.

In the design of the Cole compass the formula is modified so that the setting of the gnomon is a function of declination only. This avoids the navigator having to carry out the calculation of Cos Lat x Tan Dec in the previous formula before he can set the gnomon in its correct position.

Cole was not the first to do this as Antoine Parent beat him to it by over two hundred years[13] though he was attempting to find time rather than direction. In other words Parent was trying to design a universal sundial rather than a universal sun compass.

The expression on the right-hand side of the equation is divided top and bottom by Cos Lat. It thus becomes

$$\text{Tan Az} = \frac{\text{Sin HA/Cos Lat}}{(\text{Tan Lat x Cos HA - Tan Dec})}$$

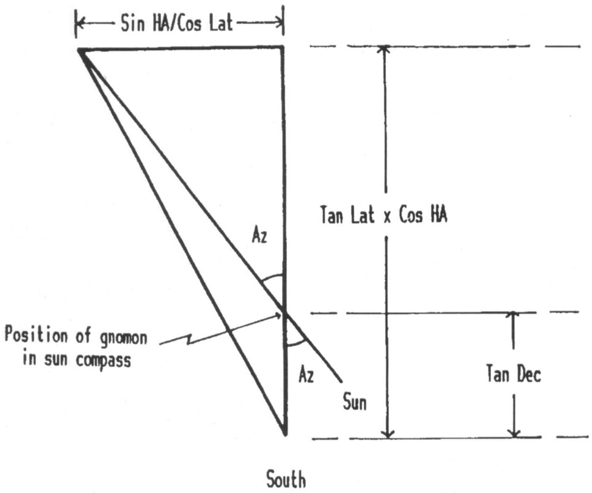

FIGURE A2: The sun's azimuth after Cole

which may be shown graphically as follows:
The co-ordinates X, Y of the hour/latitude points for the Cole compass are given by:

$$X = \text{Sin HA/Cos Lat}$$

and

$$Y = \text{Tan Lat x Cos HA}$$

A typical plot for values of latitude from 20° to 40° is shown in Figure A3.

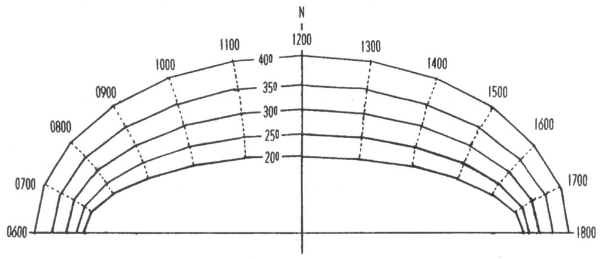

FIGURE A3: Simplified plot for the Cole compass

Mathematicians may care to note that the loci of points with constant latitude are ellipses, which is to be expected from the analemmatic dial design, which is for one latitude only. The loci of points with constant hour angles are hyperbolae.

These ellipses are hyperbolae as will be seen engraved on the dials of the Universal and Cole sun compasses.

Readers with knowledge of astro-navigation at sea may recognise Weir's azimuth diagram in these ellipses and hyperbolae. I do not know if Bagnold, Cole et al were aware of this diagram, but the author of Reference 9 was aware of its existence in 1941. Details and an explanation of the diagram may be found in volumes 2 and 3 of the Admiralty Navigation Manual 1938.

The Cole sun compass Mark 2 was designed for latitudes between 6° and 40° north or south. I suspect that the main reason for this was that as the latitude increases the values of X and Y in the foregoing equations both increase rapidly and would both equal infinity at latitude 90°. This means that if the ellipses for high latitudes are to be shown on the compass then the ellipses for lower latitudes would be inconveniently close together.

This was probably not of much importance operationally as a sun compass was most likely to be used in desert areas which occur largely in low latitudes such as in North Africa. There would be little need for such a compass in higher latitudes such as in Europe.

Having tried the Egyptian and German military attachés perhaps I should now contact the Russian military attaché to see if his army uses sun compasses in Siberia?

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Continued from page 7.

The important fact is that these features are included in the event that we should need to use them.

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ACKNOWLEDGEMENTS

The author would like to thank Prof. G. L'E. Turner and Mr. A. Turner for their help in preparing this article.

A THREE-POINT SUNDIAL CONSTRUCTION

FREDERICK W. SAWYER III, USA.

Projective Dialling, the 9th tract of William Leybourn's book *Dialling* (orig. 1682, 2nd ed. 1700), is attributed by Leybourn to the brilliant seventeenth-century diallist Samuel Foster. The tract contains several constructions, the most interesting of which appears as Chapter 11:

To draw a Dial upon a flat Superficies by means of Three Shadows of a Stile, caused by the Sun upon the same Superficies in on Day, without knowing either the Sun's Declination, the Elevation of the Pole, or Situation of the Plain.

Thus the construction posits that the diallist is given a plane, a style, and three shadow-points made by the end of the style on the plane at different times in the course of a single day. From this information one must construct a dial on the plane. To be clear about what information the diallist does not have, it should be pointed out that the construction assumes no knowledge of the geographic latitude of the dial, the reclination or declination of the plane, the date or times at which the shadows were cast, or the placement of the meridian either for the plane or for the geographic location; it is not permitted to take any more readings relating to the location of the sun.

This three-point construction is also discussed by John Collins in his 1659 work *Geometrical Dyalling*. Collins attributes this construction to M. de Vaulezard of France. The contribution which Collins makes to the discussion is the (first?) publication of a demonstration that the construction is valid. Rather than reproduce Collins' graphical argument here, we will provide formulas which mirror the construction and whose justification is somewhat easier to follow.

As will be seen from these formulas, the ingenious construction works, provided the diallist is able to distinguish, at least roughly, between the East and West sides of the plane with which he or she is working. To eliminate any ambiguity here, we will show that it suffices to record the order in which the three shadow-point observations are made.

I. NECESSARY DATA

Although we do not know the geographic latitude or the reclination or declination of the plane, we do know that it can be treated as a horizontal plane in some latitude (referred to as the plane's latitude), and at some meridian (referred to as the plane's meridian) perhaps different from the geographical meridian. The formulas do not solve for any of the first three of these quantities, but instead determine the latitude and meridian of the plane, so that the assumption may be made that we are dealing with a horizontal dial; the difference in meridians will be found by observing the meridian of the location (without further reference to the sun) and by constructing the meridian of the plane.

Given the plane's latitude and these two lines (the plane's meridian serving as the substilar line), there are any number of graphical or calculation techniques for finishing the dial. We will concentrate simply on producing these essential elements.

II. MERIDIAN OF THE DIAL'S LOCATION

Before presenting the necessary formulas, let us consider how Leybourn determines the meridian of the location. As will be shown later, if we do know the times at which the shadow-points are made, this construction (and section of the present article) is unnecessary and may be replaced by further formulas. Leybourn's technique for determining the meridian of the location is essentially independent of the graphical construction except for its reliance on knowing the position of the dial centre; the formulas below will determine the appropriate centre point for the dial.

Let a plummet drop from the end-point of the style until it hits the plane. A line drawn from the centre of the dial through the point at which the plummet meets the plane lies in the meridian of the location. If the plane is vertical, so the plummet falls parallel to it, simply drop the plummet from the foot of the style (assumed to be perpendicular) and trace the line followed by the line of the plummet; this tracing will follow the meridian. Finally, if the plummet does not touch the plane, but the plane is not vertical, then place a straight-edge joining the end-point of the style to the centre of the dial on the plane and drop the plummet from any point on the straight-edge; the point at which the plummet hits the plane is on the meridian line through the centre of the dial. As Leybourn points out, in the latter case it may occur that the thread needs to be so close to the plane that it is not feasible to make a good determination of the desired point. Should this problem arise, another possibility is to let the plummet fall from any point on the straight-edge arranged as noted earlier and then to string a thread from the style's end to the plane in such a way that it is perpendicular to the free-hanging plummet line; the point of intersection of the thread with the plane is on the meridian as before described.

III. MODERN REFORMATION OF THE SOLUTION

Let us now suppose that we are given the points A (the projection perpendicular to the plane of the style's end-point), B, C, *and* D (the shadow-points recorded at different times in the course of a single day).

Let the length AC be different from the lengths AB *and* AD; should this not be possible, then we have the special case of an equatorial dial and the construction is not needed.

Construct an arbitrary rectangular coordinate axis system with the point A as origin and with the perpendicular distance of the style's end-point above point A as the unit length. The coordinate system will be used to take measurements but neither of the axes needs to be in the meridian.

We first determine values for six angles. Select a ray of one of the axes to serve as the zero-point for measuring angles in the plane. Angles W_b, W_c, and W_d are the angles, measured clockwise, that the shadow points make with this ray. The remaining (acute) angles a_b, a_c *and* a_d are solar altitudes determined by the following:

$$\cot a_b = AB \qquad \cot a_c = AC \qquad \cot a_d = AD$$

Evaluate the quantities E, F, G *and* H as follows:

$$E = [(\cos a_c \times \cos W_c) - (\cos a_b \times \cos W_b)]/(\sin a_c - \sin a_b)$$

$$F = [(\cos a_c \times \sin W_c) - (\cos a_b \times \sin W_b)]/(\sin a_c - \sin a_b)$$

$$G = [(\cos a_c \times \cos W_c) - (\cos a_d \times \cos W_d)]/(\sin a_c - \sin a_d)$$

$$H = [(\cos a_c \times \sin W_c) - (\cos a_d \times \sin W_d)]/(\sin a_c - \sin a_d)$$

Note that these quantities are always defined because we know a_c is not equal to either a_b or a_d, and therefore the denominators in all cases are nonzero.

We now use the following standard formulas from spherical astronomy:

sin a = (sin Lat)x(sin Dec) + (cos Lat)x(cos Dec)x(cos Time), and

(cos a)x(cos Z) = (sin Lat)x(cos Dec)x(cos Time)-(cos Lat)x(sin Dec)

where *a* and *z* are the solar altitude and azimuth associated with the shadow-point, *Lat* is the plane's latitude, and *Dec* and *Time* are respectively the solar declination and hour-angle, the latter being determined with respect to the plane's meridian.

Since our shadow points are all made on the same date, we assume no change in solar declination between them; so these formulas tell us that

$(\cos a_c \times \cos z_c)-(\cos a_b \times \cos z_b)$

$(\sin Lat)x(\cos Dec)x(\cos Time_c - \cos Time_b)$, and

$\sin a_c - \sin a_b = (\cos Lat)x(\cos Dec)x(\cos Time_c - \cos Time_b)$

Hence,

$\tan Lat = [(\cos a_c \times \cos z_c)-(\cos a_b \times \cos z_b)]/(\sin a_c - \sin a_b)$

$= [(\cos a_c \times \cos z_c)-(\cos a_d \times \cos z_d)]/(\sin a_c - \sin a_d)$

We define *V* as the angle, measured at origin *A*, between the positive y-axis of the arbitrary system we have adopted and the primary (ie North) ray of the plane's meridian. We then have:

$W_b = V + Z_b$, $W_c = V + Z_c$, $W_d = V + Z_d$, and

cos W = (cos V x cos Z) - (sin V x sin Z),

sin W = (sin V x cos Z) + (cos V x sin Z).

By substituting these equations in the defining equations for *E, F, G and H,* we have:

$E = (\tan Lat \times \cos V) - (T_b \times \sin V)$

$F = (\tan Lat \times \sin V) + (T_b \times \cos V)$

$G = (\tan Lat \times \cos V) - (T_d \times \sin V)$

$H = (\tan Lat \times \sin V) + (T_d \times \cos V)$

where

$T_b = [(\cos a_c \times \sin Z_c)-(\cos a_b \times \sin Z_b)]/(\sin a_c - \sin a_b)$

$T_b = [(\cos a_c \times \sin Z_c)-(\cos a_d \times \sin Z_d)]/(\sin a_c - \sin a_d)$.

We can now achieve our goal of determining the necessary parameters for the sundial as follows:

tan V = (E - G)/(H - F), and tan Lat = (E x cos V) + (F x sin V).

The plane's meridian is the line through *A* making angle *V* with the positive y-axis. The dial's centre is located on the plane's meridian at a distance from point *A* equal to *(-cot Lat)*; the dial's equinoctial line is perpendicular to the meridian, a the distance from point *A* equal to *(tan Lat)*.

Thus, the locations of the plane's meridian, the dial centre, the equinoctial line (and gnomon) are uniquely determined by these equations. Note, however, that these formulas by themselves do not completely determine numeric values for *V* and *Lat*, since there are two values of *V (-180 < V < 180)* and hence of *Lat (-90 < Lat < 90)* which are possible solutions. The two solutions will be for horizontal dials in different hemispheres, the North dial resulting in hour-lines which progress clockwise and the South dial resulting in counter-clockwise hour-lines.

This ambiguity is handled in Leybourn's treatment simply by the following comment:

It is to be observed, that in all Dials the Morning Hours ought to be marked on the West-side, and the Evening Hours on the East.

In actual practice, the caveat may be sufficient, but our calculations do not need to rely on this tacit determination of the cardinal directions if we have noted the order of occurrence of the shadow-points. Given this order and the location of the dial centre, we know whether the hour-lines should progress clockwise or not; hence we can select the appropriate pair of values for *V and Lat* and thus correctly determine which ray of the dial's meridian line lies to the North.

We have thus determined the required values for completion of the dial, if we rely on Foster's technique or some similar method for determining the meridian of the location. Note, however, that there is also a calculation option for this placement which we will now develop.

IV. ADDITIONAL COMPUTATIONS

Consider the following standard formula from spherical astronomy:

(cos a x sin Z) = (sin Time x cos Dec).

Combining this equation with the two gnomon equations given in Section III above, yields:

tan Time = (cos a x sin Z)/[(cos a x cos Z x sin Lat) + (sin a x cos Lat)]

[NB. This formula produces local apparent time only if the plane's meridian coincides with the meridian of the location. See the discussion to follow.]

We know the solar altitude *a* and azimuth *Z (ie. W - V)* associated with each of the three shadow-points, so this equation permits the determination of a Time *(Time)* for each of the readings.

In the seventeenth century, it would not have been appropriate to assume that an accurate independent source for the correct time was available; indeed, the very purpose for performing his construction might be to produce the only such accurate source in a particular location. Today, however, it seems reasonable to assume that an independent source has given a value for the local apparent time of each reading (before the 'corrections' of the equation-of-time or standard or daylight savings adjustments).

The time values generated by the above equation may well differ from the independent values for each reading; however the differences for the three points should all be equal. A difference occurs whenever the meridian of the plane does not coincide with the meridian of the location. The difference in times *(Diff = Time from above formula - Independent Local Apparent Time)*, expressed in angular measure, equals the arc angle between the two meridians.

Draw a line through the dial's centre point, at an angle *N* measured clockwise from the primary ray of the plane's meridian, where

tan N = tan Diff x sin Lat

The line is the meridian of the location, found without resort to plummet and straight-edge.

The dial is constructed as though the plane is horizontal at latitude *(Lat)*; markings on its hour-lines are to be offset by a constant amount equal to *Diff* (angular measure). The noon-line is the meridian of the location as just determined.

Finally, given the information we have developed so far, suppose we wish to determine the reclination and declination of the plane. The following set of equations answers this question if we allow ourselves the luxury of assuming that the geographic latitude *Phi* (ie. the latitude of the location, as opposed to the plane's latitude for which we have already solved) is known.

Continued on page 29.

A TABLE OF TIME DIFFERENCES IN SPANISH CITIES

BY MASTER ANTONIO DE NEBRISSA

For many years Dr. José Luis Basanta Campos has sent copies of small early horological tracts to his friends at Christmas. There is a rich field of such writings in Spain with reference to dialling and these are but little known to diallists in England. The following is one such treatise written by Master Antonio de Nebrissa, circa 1517, and is translated from a facsimile edition of 100 examples numbered by hand which were printed in the workshop of Artes Gráficas Pontevedras issued 11th December 1986, the day of Saint Dámaso:

PROLOGUE of Master Antonio of Nebrissa communicating to readers about the table he has devised and published about the diversity of the hours and parts of an hour in the cities and places which correspond to their parallels ie situated at the same latitude.

MANY opinions are set in the common opinion of villagers who are quite ignorant of that which reason and art show to be otherwise. Most think that the lengthening and shortening of the days occur equally; and since these increase in six months of the year, and in the other six months diminish; thus as the shortest day of the year is of nine hours and the longest fifteen hours as at Toledo: these days must grow an hour in each month, and contrariwise the diminish an hour in the other six months of the year. As to the truth, only in the month of March do they increase as much as in the earlier months of January and February and in the days of the following December, after which they will begin to grow. On the contrary they diminish as much only in the month of September as they did in in July and August, and those subsequent to June, after that they commence to diminish. It is for this that the year is divided into four parts, the first from the winter solstice, which is the shortest day; up to the month of March when the nights are exactly equal to the days; which is known as the summer equinox. The second is from this point up to the summer solstice, which is the longest day of the year; the third from this solstice up to the month of September, when again the nights are equal to the days, which is the autumn equinox. The fourth from this equinox up to the following winter solstice and the shortest day of the year; and most think that such time there is from the winter solstice up to the summer equinox, that is in the first quarter; as there is from this equinox to the summer solstice, which is the second quarter. And of course that such time from the summer solstice up to the autumn equinox, that is the third quarter; so that from the equinox up to the winter solstice is the last quarter being another truth. Since the days of the year increase for 182 days and a half and three hours; and diminish again in the same time; so the first quarter which is from the winter solstice up to the summer equinox, there are two days and fifteen hours less than in the second quarter; which is from the stated equinox up to the summer solstice. Similarly in the third quarter of the year: which is from this solstice up to the autumn equinox; there are two more days and fifteen hours more than in the last quarter of the year; which is from this equinox up to the winter solstice. In the same way it appears that it is not believed that the longest day of the year with its night is longer than the shortest day with its night, when actually it is true that the longest day of summer is one so much longer that the shortest day with its night. But all the previously mentioned facts are easily proved: whereas the populace who do not judge things sensibly, thinks otherwise which we now wish to demonstrate where there is not much difference and the error is small.

RULES FOR THE USE OF THE PRINCIPAL TABLE

If you wish to know the hours and parts of hours which there are from the rising of the sun up to midday in some city, town or place in Spain, or some other place in Europe that lies at the same latitude, look in the table for the latitudes of the cities for that place you wish to know, or the nearest to it, and take the that value of latitude which corresponds and look for it in the table of the diversity of hours and minutes in the first line which proceeds from thirty-six degrees up to forty-five degrees, then look at the first two vertical columns in the first half of the table and in the last two vertical columns of the second half, all these serving for the four quarters of the year. The first column commences at the 14th September when in the autumn the days are equal in duration to the night, and in descending you will find the rest of September, the months of October and November and up to the 12th December, when the days are shorter than the nights. In the second column commencing at 11th March when in the summer the nights and days are once more equal, and descending you will find the rest of March and April and up to the 12th June: in which the days are longer than the nights. At the bottom of the last column of the second table you will find 12th December when the winter solstice has the shortest day and longest night of the year; and ascending you will find the rest of December with the months of January and February up to 21 March in which we say the that the nights are equal to the days. The penultimate column rises from 12th June when in the summer solstice it is the longest day and shortest night of the year, and rising you will find the rest of June with the months of July and August up to the 14th September: in which again we say the nights are equal to the days. After this find in one of these four lines the month and day nearest to the one you wish to find out the values for, then look at the column for the latitude where the hours and minutes will be found: if it is in the first and last columns these are the middle of the night; if the second and penultimate columns: it is the middle of the day. And so multiplying this value by two we have the entire duration of the night or day. By this one can set one's watch.

For the practice of this rule I give the following example. Today is the 1st day of August, I am in the sacred town of Toledo in the hall of the Archbishop and I wish to know how many hours and minutes there are in the day. I look for it in the table of places; and not finding it but there is the town of Alcala which is two leagues to the west, and Guadalojera three to the east on the same parallel which I shall use; there is a small difference, although not enough to worry us, it is not of a significant amount. All these places are on the same latitude - 40°. Looking in the table of the diversity of the hours and minutes, I find the month of August in the penultimate column of the same table, but I do not find the first day but the second; because the table proceeds in increments of three days, and the least error which at the head of all the months in the calendar is written as a title and that day has certain hours for the day and night. It has not been possible to show the greatest discrepancy because none of the parts of the month have equality, nor the numbers of hours each day is common in all the places. In the Canary Isles the longest day of the year is thirteen hours and the night eleven, and in contrast the shortest day of the year is eleven hours and the night thirteen hours. In Tangier and mid-cities of Africa the longest day of the year has fourteen hours and one-twelfth. In Seville the longest day of the year is fourteen hours and one-third, and the night hours the night ten hours less a third. And why do we not divide after the example of Ptolemy: in the town of Coruna which was the place of the convent and under the rule of the Romans: the longest day of the year has fifteen and one eighth hours: the night has nine hours less an eighth part. And so proceeding from a half day to the north through France, Germany, Bohemia, Norway and Russia until arriving at lands where the longest day is twenty-four hours; and the night does not consist of even a fraction of one hour. I cite other days when only half the body of the sun appears: up to those where the other half sets and everything is always night. When it does not have hours or tenths of an hour: we could not comprehend the twelfth part of the day or night if it were not for the common watches we call otherwise equinoxes, because in each one of them arises at fifteen degrees of the equinoctial: And because in past times a monk took care to set the watch (clock) in his house, I ask myself that with such variation what would give him confidence to be able to regulate the clock in his charge in order to accomplish his office: he would draw up a table based on the declination of the signs and degrees from the equinoctial with the differences of the days and nights in the whole world, and because there were others who thinking as the religious man; persuaded Arno Guillen Broca, the publisher of books which can be multiplied by printing: because if others ask me for the information, they know where it may be found to get it in their minds without me having to break my head again.

DEFINITION OF SOME TERMS USED BY THE AUTHOR

Before you make use of these tables, it is necessary for you to know the meaning of certain words which astronomers use and speak of: primarily those of degrees and latitude. All the circles which are used as references in the sky, or the earth or other spherical body are; in the first place divided into three hundred and sixty degrees which the Latins call parts and the Greeks meridians. Then each degree or part is divided into sixty parts or minutes, and each minute into sixty parts or seconds, proceeding further to the smallest part or time that can be estimated or detected, which the astronomers call physics and of which they make use in measuring the movement of the planets in the fixed stars to find the times in which these movements occur. As now in the first half of the table we use the division of the hour into sixty minutes and because we do not proceed here but to satisfy popular sentiment, we do not prescribe according to halves and thirds. "Anchura" - latitude is so called in comparison with "longura"- longitude because in the sky as here on earth the distance from west to east is longitude and latitude from the north at midday and because in the sky the distance from east to west commences from the first of the sign of Aries up to the same point which we call three hundred and sixty degrees: and the distance from midday to the north takes itself from the equinoctial up to the north, which is ninety degrees, which again is a quarter of a circle; for this reason we call one longitude and the other latitude. It is the same on earth because the distance from west to east itself commences at the meridian which passes through the Canary Islands up to the same again three hundred and sixty degrees, and the distance from midday to the north takes itself from the equinoctial up to the north: which is ninety degrees, and for this reason these are also called longitude and latitude. So Ptolemy in order to show the positions of cities, towns, and places, put the longitude and latitude in degrees or parts of degrees, and when we meet with one and the other, there we can identify that place, as indicated in the table of latitudes which serves for the present argument because from the longitude one knows beforehand the time of the rise of the sun at places in the west and east. It remains to declare why solstices and equinoxes are so called, in the four quarters into which the year is divided, they are distinguished by the two terminations of the solstices, one in winter on the shortest day of the year, and the other in summer on the longest day of the year, and two equinoxes, one in summer when in the month of March the nights are equal to the days, and the other in autumn when in the month of September once again the nights are equal to the days. The solstices are so-called because in the month of December and the month of June it happens that that the sun does not make any appreciable change in the place where it rises and sets, and neither in the number of hours or parts of hours of the day. But to have a longer day in another place, the place must be situated further from the equinoctial, and to the north of it, more or less thus I take the number closest which is 2 and where one encounters the degrees of latitude with the days of August, I find 6 hours and 54 minutes from sunrise to midday, I double this which gives 13 hours 48 minutes; which is 4/5 of an hour. This day is equal to the 23rd April because it is in between the second and third quarter of the year and the same equal hours and nights occur on the 23rd October and 28th February because they are between the first and last quarters of the year. So the same number serves for the four quarters of the year.

COMMENTS

There are some small errors in these tables, for example: the first entry on the eighth line of the first part should read 6h 24m (not 6h 14m as shown), and the second entry on the sixth line of the second part should read 6h 22m (not 6h 21m). These appear to be printer's errors rather than those of the author's. Similarly there are values in parentheses which are corrections from the values indicated in the first part of the table, these may be modern corrections when the facsimile was prepared but there is no note to indicate this. In the example given to show how to use the tables, it is stated that because Toledo cannot be found in the tables, it is advised to use Alcala and Guadalajara, yet Toledo is printed just above Madrid in the list of places at 40° latitude; and Toledo is actually almost on the 40° latitude, Madrid is slightly to the north of this. Zaragoza (Saragosa) is shown under the latitudes of 37° and 42°, the latter value is the correct one. Whilst the names of the cities and towns have not been Anglicized, the reader will find no difficulty in finding these places in a modern world atlas. A glance at the map of Europe will show that the greater part of Europe lies well outside the scope of the tables. And when the author speaks of the middle cities of Africa, it hides the fact that ninety per cent of the African continent was then completely unknown and and uncharted. At least three more centuries were to pass before Livingstone made his historic exploration into Central Africa.

Considering the very early date of the manuscript and the comparatively poor standard of timekeeping by mechanical clocks at this time, it is remarkable that the author could calculate the times shown to within one minute. It would seem the original table would have been printed in one block, judging by the layout. Note also that in the text where the author mentions a watch, he means by this the timekeeping part of what we now call a clock, not a pocket watch because the pocket watch had only just been invented by this date. The clock of those days was a mechanical device which struck a bell, the watch was the timekeeping part of such a device, so-called from the "watch" kept by a man who actually struck a bell at prescribed hours, taking his time from an early mechanical device called a "monastic alarm".

From his remark "without me having to break my head again", it seems the compilation of these tables required a considerable mental effort. The text translated here seems somewhat longwinded and turgid, perhaps some of the freshness of the original has been lost in this transliteration, and of course our Continental counterparts are rather prone to flowery texts, especially in this early period.

Inspection of the principal table shows that on no day of the year is there less than (6 x 2 = 12) hours of daylight; and never greater than (7h 43m x 2 = 15h 26m); a total greatest difference of 3h 26m. These differences are of course accentuated as the latitude increases, and so such tables would have been of greater use to travellers in Northern Europe than in Spain and much lower latitudes. In view of the many recent comments about when the mean solar time of mechanical clocks was adopted in Europe, it is quite clear from this table that the equal hours system was taken quite for granted at the start of the sixteenth century.

ACKNOWLEDGEMENTS

The main text of this pamphlet was translated from the original Spanish by Mr. Ron Satchell. Kind permission to publish this translation has been given by Dr. José Luis Basanta Campos.

CHARLES K. AKED

REFERENCE

A useful source to understand early timekeeping in Spain is Perpignan 1356 -The Making of a Clock and Bell for the King's Castle by Dr. C.F.C. Beeson, Antiquarian Horological Society Monograph No 23, London, 1982. By this time there were mechanical clocks installed in many of the cathedrals of the major cities in Spain. The errors of such clocks far exceeded the daily differences between local solar and mean solar time, so the Equation of Time did not have any significance until much more accurate mechanical clocks were devised about the late seventeenth century, when the seconds pendulum with the anchor escapement was applied to clocks.

TABLE OF LATITUDES OF PLACES

36	Ossuna	Trujillo	Tordesillas	44
Arcila	Andujar	Talavera	Valladolid	El Padron
Tanger	Baeza	Toledo	Olmedo	Pont de Limia
Alcazarquivir	Jaen	Madrid	Osuna	Leon
Ceuta	Alcala la R.	Alcala de H.	Soria	Vitoria
Trapana	Cazoria	Guadalajara	Almazan	Media Navarra
Palermo	Alcaraz	Moya	Calatayud	Pampiona
37	Villena	Tortosa	Daroca	Pertusa
Tarifa	Denia de Ar.	Tarragona	Zaragoza	Huesca
Gibraltar	Cerdeña	Corcega, isla	Gerona	Nimes
Marbella	Catania	Salerno	Barcelona	Aviñon
Estepona	Mesina	Tarento	Lerida	Mantua
Cadiz	Ceutin	Brindizzi	Genova	Riminui
Jerez	39	Trento	Pisa	Ravena
San Lucar	Faro. Port.	41	Roma	Ancona
Arcos	Setubal	Lamego	43	45
Lebrija	Elvas	Ciudad Rod.	Braga	Finisterre
Malaga	Badajoz	Salamanca	Astorga	Santiago
Velez Malaga	Merida	Madrigal	Palencia	La Coruña
Salobreña	Medellin	Arevalo	Burgos	Santa Marta
Antequera	Belalcazar	Avila	Najera	Vivero
Almeria	Guadalupe	Segovia	Logroño	Lugo
Cartagena	Ciudad Real	Sigıenza	Calahorra	Gijón
Zaragoza	Almagro	Barcelona	Agueda	Oviedo
Etna de Sicilia	Cuenca	Capua	Tarazona	Santander
38	Monviedro	Napoles	Cabo de Creus	Laredo
Cabo de S. Vic.	Valencia	42	Perpiñan	Bermeo
Lepe Ayamonte	Jativa	Oporto	Monpellier	Burdeos
Lagos	40	Aranda del D.	Marsella	Lion
Frenegal	Lisboa	Zamora	Bolonia	Aquileia
Sevilla	Alcantra	Benavente	Siena	Venecia
Carmona	Coria	Toro	Livorno	Padua
Ecjija	Plasencia	Medina	Florencia	Milan

A Table in order to know how many hours and parts of hours there are in each day of the year in the cities, towns and places in Spain and in consequence in all other places in Europe on corresponding parallels.

Degrees of Latitude		36	37	38	39	40
Months		Hr Min	Hr Min	Hr Min	Hr Min	Hr Min
14 Sep	11 March	6-00	6-00	6-00	6-00	6-00
17	14	6-03	6-04	6-04	6-04	6-04
20	17	6-07	6-07	6-08	6-08	6-08
28 (23)	20	6-10	6-11	6-21(11)	6-12	6-12
26	23	6-14	6-14	6-15	6-15	6-16
29	26	6-17	6-18	6-09(19)	6-19	6-20
2 Oct	29	6-21	6-22	6-22	6-23	6-24
5	1 April	6-14	6-25	6-26	6-27	6-28
8	4	6-27	6-28	6-30	6-31	6-32
11	7	6-30	6-32	6-33	6-34	6-36
14	10	6-33	6-35	6-37	6-38	6-39
17	13	6-37	6-39	6-40	6-41	6-43
20	16	6-40	6-45	6-43	6-45	6-47
23	20	6-43	6-45	6-47	6-48	6-51
26	23	6-46	6-48	6-50	6-52	6-54
29	26	6-49	6-51	6-53	6-55	6-57
1 Nov	29	6-52	6-54	6-56	6-58	7-00
4	2 May	6-55	6-57	6-59	7-01	7-03
7	5	6-57	7-00	7-02	7-04	7-06
10	9	7-00	7-02	7-04	7-07	7-09
13	12	7-02	7-04	7-07	7-09	7-12
16	15	7-04	7-07	7-09	7-12	7-14
19	18	7-06	7-09	7-11	7-14	7-16
22	21	7-08	7-10	7-13	7-16	7-17
25	24	7-09	7-12	7-15	7-17	7-19
28	27	7-11	7-13	7-16	7-19	7-20
30	31	7-12	7-14	7-17	7-20	7-21
3 Dec	3 June	7-12	7-15	7-18	7-21	7-21
6	6	7-13	7-16	7-19	7-22	7-22
9	9	7-13	7-16	7-19	7-22	7-22
12	12	7-14	7-17	7-19	7-22	7-22

The rest of the table of the quantity of hours and parts of hours which serve for the other six months and the other 5 degrees of latitude from 41 to 45 degrees

41	42	43	44	45	Degrees of Latitude	
Hr Min	Hr Min	Hr Min	Hr Min	Hr Min	Months	
6-00	6-00	6-00	6-00	6-00	14	21
6-04	6-04	6-04	6-05	6-05	11	8
6-08	6-09	6-09	6-09	6-10	8	5
6-12	6-13	6-13	6-14	6-14	5	2 Mar
6-17	6-17	6-18	6-18	6-19	1 Sep	27
6-22	6-21	6-22	6-23	6-24	29	24
6-25	6-26	6-27	6-27	6-29	26	21
6-29	6-30	6-31	6-32	6-33	23	18
6-33	6-34	6-35	6-36	6-38	20	15
6-37	6-38	6-40	6-41	6-43	17	12
6-41	6-42	6-44	6-45	6-47	14	9
6-45	6-46	6-48	6-50	6-51	11	6
6-48	6-50	6-52	6-54	6-56	8	3 Feb
6-52	6-54	6-56	6-58	7-00	5	31
6-56	6-58	7-00	7-02	7-04	2 Aug	28
6-59	7-01	7-04	7-06	7-08	29	25
7-03	7-05	7-07	7-10	7-12	26	22
7-06	7-08	7-11	7-13	7-16	23	19
7-09	7-11	7-14	7-17	7-20	20	16
7-12	7-15	7-17	7-20	7-23	17	13
7-15	7-17	7-20	7-23	7-26	14	10
7-17	7-20	7-23	7-26	7-29	11	7
7-19	7-23	7-26	7-29	7-32	8	4
7-21	7-25	7-28	7-31	7-35	4	1 Jan
7-23	7-27	7-30	7-33	7-37	1 July	30
7-25	7-28	7-32	7-35	7-39	28	27
7-26	7-30	7-33	7-37	7-40	25	24
7-27	7-31	7-34	7-38	7-42	22	21
7-28	7-32	7-35	7-39	7-42	19	18
7-29	7-33	7-35	7-39	7-43	15	15
7-30	7-33	7-36	7-39	7-43	12 June	12 Dec

A TABLE TO SHOW THE HOURS AND MINUTES FOR EACH DAY OF THE YEAR IN THE CITIES AND TOWNS IN SPAIN

THE DIALLING INSTRUMENTS DEPICTED IN HOLBEIN'S PAINTING - "THE AMBASSADORS"

BY PETER I. DRINKWATER

Refer to Figure 7 in "Sundials in Illustrations" page 12

A CELESTIAL GLOBE: fully mounted and adjustable for Latitude. At the North Pole is a dial for indicating the time, and a movable semi-circle is provided for determining the Dominifying Circles (Celestial Houses) of Astrology. This globe will mimic the actual movement of the Sphere at any Latitude north of the tropics and can readily be used to determine all celestial co-ordinates: including the Time and observable altitude of the Sun and any marked star. With the addition of a simple device for taking altitudes it is the complete and perfect Instrument towards which Astrolabes and Quadrants are merely striving.

A SIMPLE CYLINDER DIAL: of the type illustrated in Kratzer's own Note Book (his copy of a set of Mediæval Tracts on Dialling). It tells the Time by the altitude of the Sun and is made for a particular Latitude. Around the Cylinder are six columns; each applying to two signs of the Zodiac. The Hour lines are curves representing the altitude of the Sun at each hour respective to each two signs of the Zodiac. The pointer on the turnable cap is set above the correct place in the correct column and held freely by the visible suspension thread until the pointer faces the Sun: the shadow falling directly down the requisite Column indicates the time by its tip. This same Cylinder dial also appears in Holbein's Portrait of Nicholaus Kratzer, its maker. The most accessible "modern" construction details, relating to the Instrument in its period form, are given in my Interpretation of "The Second Book of Solar Horology" by Kratzer's rival and contemporary, the Frenchman Oronce Finé.

TWO DISTINCT PORTIONS OF A CURIOUS COMPOSITE DEVICE OF A SPECULATIVE NATURE: Item 3 has a square base plate upon which stands a vertical concave semi-circle, with a plumb line for precise levelling. A captive sighting bar is free to move within the upper quadrant of the semi-circle only; it carries a pierced sight generating a spot of sunlight which must be caught on a small peg projecting from its pivot: thus determining solar altitude. Although the whole semi-circle is divided at every five degrees, only the functional upper quadrant is subdivided and numbered; from 0° at the horizontal to 90° at the top: the numbers being off-set 5° downwards to enable the altitude to be read off against the lower edge of the sighting bar. Outside of this usual scale of degrees is another degree scale extending about 30° on either side of the horizontal but drawn at an angular displacement: this is numbered from 30° to 90° and is used to set item 4 when that is in position.

On the sighting bar is a tangent scale of Solar declination, divided into two parts by a central space of the thickness of the round plate of Item 4. This scale, marked up with the Signs of the Zodiac (as usual), is repeated on the other side of the sighting bar; and probably upon the other two faces of the bar as well, the bar being square in section. This other side of the sighting bar is visible in the representation of this same instrument in Holbein's portrait of its maker, Nicholaus Kratzer. There also it is shown that the other side of the semi-circle is completely divided into numbered degrees, and there is no scale with the angular displacement. Also absent is the sight and peg.

Item 4 is essentially a circle, probably double-sided, with a square cut through the middle of it and divided into four quarters by four lines each continuing one side of the central square, each of these quarters contains six marked hours each drawn upon a quadrant centred upon a different corner of the central square. This item is shewn stored (?) upon a transpiercing spike projecting from the middle of a square base. To use with Item 3 this base and spike are put to one side. The sighting bar is removed (probably by pulling out the pivotal peg) and passed through the central square of Item 4 so that the latter lies in the centre of the Zodiac scale with the projecting slotted lug engaging the semicircular scales of Item 3, and free to track within the whole of the semi-circle when the sighting bar is replaced. The projecting lug is set to the correct Latitude on the Scale with the angular displacement and, with the back of the semi-circle (carrying the plumbline) pointing true North, the whole assemblage acts as an Æquinoctial Sundial: the shadow of the edge of the Circle gives the correct Solar Declination on the Zodiac scales marked on the sighting bar. The sighting bar can be used to take an altitude when the circle is in position: the two functions are quite unrelated, but the ray of light will pass through the same piercing in the circle as the spike in the picture.

AN HOROLOGICAL QUADRANT WITH STRAIGHT HOUR LINES: Designed for ease of construction at the loss of precise accuracy. This type of Quadrant (not the same as that referred to above) was very popular in the 16th century and is given in many sources, including Kratzer's Note Book, Finé's published tracts, and in a Portugese manuscript. Like all Quadrants shewing equal hours it is constructed for a specific latitude. The most accessible treatment of this type is to be found in my Interpretation of Finé's "Second Book of Solar Horology". In the painting, the instrument lies, largely hidden, behind No. 3.

A MULTI-FACETTED SUNDIAL BASED ON THE PROPORTIONS OF A DOUBLE CUBE: Potencial Universal, it contains two simple Æquinoctial Dials and eight facets (two carry no dials) which are canted at $23^1/_2$°. The Hour Lines upon these facets do not fit the Gnomons, which are correct for the planes. For a fuller treatment, see my article in BSS Bulletin 93.2 (June 1993 issue).

A TORQUETUM (other versions of this name are known). Full constructional details for this device and contained among the copies of old tracts in Kratzer's Note Book: it was certainly already quite obsolete when Kratzer made this example. It has a square base plate which is hidden in the painting. Hinged to this is another (visible) square plate which is to be adjusted to lie parallel to the observed Celestial Æquator at any particular Latitude. The first oblique plate is marked with the 24 hours of the Day, in the form of a circle. Free to rotate within this Circle is a disc, upon which another disc is permanently fixed at an angle of $23^1/_2$° for the obliquity of the Ecliptic. Both of these are marked with the signs of the Zodiac: it is not clear whether those on the lower disc are equated for obliquity (like the hour lines on an ordinary horizontal sundial) although they certainly should be. A balanced sighting Bar, pivoted in the centre of the upper disc, caries a thin brass disc edge on at right angles to the top oblique disc and supported upon an elaborate base. This is divided into 360°. Pivoted in the centre of this brass disc is a second sighting Bar, and, hinged loosely to this, a brass semi-circle similarly divided, with a plumbline hanging from its geometrical centre. The Instrument will give, for any observed Celestial Object, its full spherical coordinates relative to the Ecliptic; together with its observed Altitude. If the Sun is observed the Time is given.

To use the instrument as a time-teller, proceed thus:

a Rear up the hinged square plate towards the north until it lies parallel to the Celestial Æquator.

b Set the first (lowest) Sighting Bar to the Sun's known position in the Zodiac.

c Turn the whole sub-assembly of the two discs fastened together until the Sun's rays pass through the pinholes in the sighting bar.

d Read off the Time on the circular scale of hours on the lowest hinged plate against the requisite degree of the Zodiac on the lowest Disc.

To obtain Solar Altitude:

e Move the upper Sighting Bar until the Sun's rays pass through the pinholes (the whole upper assembly may need moving through 180° to allow the semi-circle to hang free).

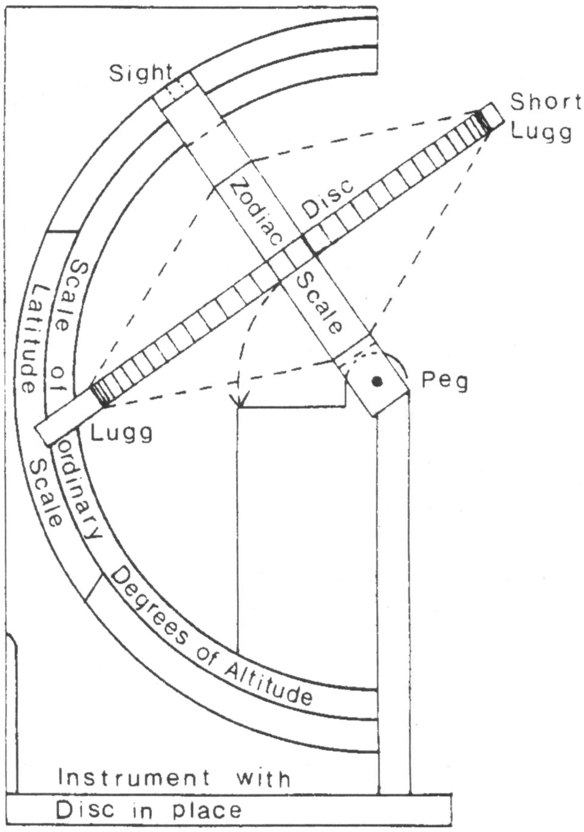
f Read off the Solar Altitude on the semi-circle against the plumbline.

g The Sun's angular distance from the Ecliptic, as shown on the full Brass Circle, will always be 0°.

If the Moon or a Planet is sighted with the second sighting bar this will frequently stand at a measurable distance from the Ecliptic. The Moon and Sun can be sighted together when the Moon is visible in Daytime.

Use of the Instrument at Night demands more complicated procedures, which cannot be exhaustively dealt with here. The fact that the Spherical Coordinates given relate to the Ecliptic, rather than the Æquator, would seem to indicate that the Instrument was used to observe the Sun, Moon and Planets, rather than the fixed stars.

Although most of the Instruments of Science as (described above), are on the upper shelf, the lower shelf, in addition to musical artifacts, also holds a Terrestrial Sphere, not mounted, but provided with a handle at the North Pole; together with a folding rule and a pair of steel (or silver) dividers.



THE COMPOSITE DEVICE

EDITOR'S NOTE: It is my intention to include an article on the painting known as "The Ambassadors" by Hans Holbein the Younger in a future edition of the BSS Bulletin. This will draw the separate items discussed here by Mr. Drinkwater into the overall meaning contained within the painting although it will not deal directly with the dialling instruments as such.

* * * * * * * * * * * *

Continued from page 23

The plane's reclination *(R)* and declination *(D)* may be determined as follows:

$$\sin R = (\sin Lat \times \sin Phi) + (\cos Phi \times \cos Lat \times \cos Diff)$$

$$\tan D = (\cos Lat \times \sin Diff) / [(\sin Phi \times \cos Lat \times \cos Diff) - (\sin Phi \times \sin Lat)]$$

$$\sin D = (\cos Lat \times \sin Diff) / \cos R$$

* * * * * *

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MORE ABOUT THE EQUATION OF TIME AND THE ANALEMMA

ALLAN MILLS
ASTRONOMY GROUP, THE UNIVERSITY, LEICESTER, LE1 7RH

THE EQUATION OF TIME

David Hughes[1] has given a clear explanation of why a correction curve - anomalously called the 'equation of time' - is required to bring the sundial and the mean-time clock into agreement throughout the year. Fundamentally the resultant of the two curves required to allow for the ellipticity of Earth's orbit and the inclination of this orbital plane to the celestial equator, the 'equation of time' becomes zero four times a year. The maximum discrepancy is around November 3rd, when the sundial is (neglecting the leap year cycle and longitude adjustment) 16 minutes 24 seconds ahead of the clock. This partly explains why November afternoons get dark so early.

Unfortunately, the convention used to denote the sign of the correction required is not always the same. the older form, used on most sundials, is:

Mean time = Time by the sundial - the equation correction

This gives rise to a curve of the form shown in Figure 1. However, the more modern astronomical usage is:

Mean time = Time by the sundial + the equation correction

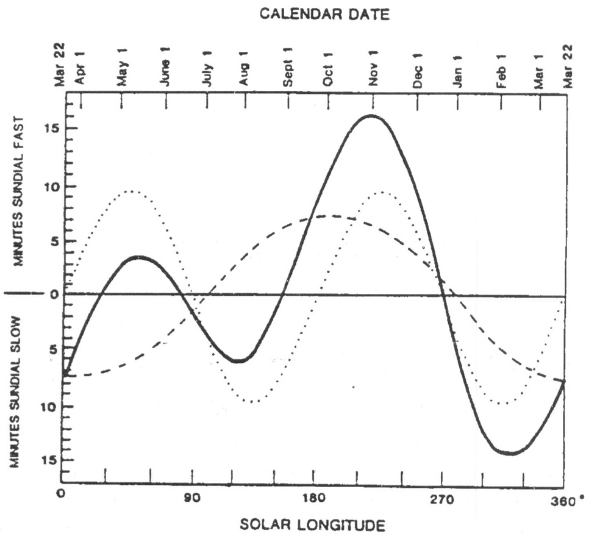

FIGURE 1: The 'Equation of Time' in the form commonly represented on sundials is shown by the heavy continuous line. It is the resultant of discrepancies introduced by the eccentricity (dashed) and the obliquity (dotted) of the Earth's true orbit around the Sun.

The sign preceding the correction is reversed, so the curve must be drawn as the mirror image of Figure 1. This is the convention illustrated in Hughes[1] Figure 2. Both conventions give the same result provided that the corresponding signs are properly observed, including the double negative leading to a positive in the older convention. The easiest check is to remember the 'rule of n':

"The sundial wins at the beginning of November"

The most convenient source of the accurate equation correction for each day of a given year is *'Whitaker's Almanac'*,[2] but a mean curve or table[3] is perfectly adequate for sundials.

HISTORY

It will be appreciated that if the absolute duration of the apparent solar day were to be measured with an independent timekeeper over the course of a year, then it should prove to vary in such a way that the cumulative daily discrepancies would build-up the equation of time. However, the maximum difference between the longest apparent solar day and the mean is only about 30 seconds, so precise and accurate methods that can be relied upon over a long term are necessary to disclose the variations.

Nowadays, accurate and independent timekeepers are provided by a variety of quartz and atomic clocks, but historically the first satisfactory alternative to become available was time measured by the stars - SIDEREAL TIME. The stars are so far away that, when observing them over a year, the annual motion of the Earth in its orbit merely adds one extra turn to the $365\frac{1}{4}$ turns made about its spin axis - ie the stars appear to execute $366\frac{1}{4}$ turns in the $365\frac{1}{4}$ day year. Thus, the interval between successive re-appearances of a given star on the cross-hairs of a transit telescope is 23 hours 56 minutes 4.0982 seconds[4] - some 4 minutes less than the mean solar day. This is why we can see a procession of all the constellations visible from out latitude if we look out of the same window at the same clock time each evening. Sidereal time is free from the complexities that bedevil solar time, and so astronomers have always preferred to obtain accurate time data from stellar observations. Also, of course, the pinpoint stellar image facilitates accurate setting, and hopefully several 'clock' stars are visible each night.

The first Astronomer Royal, John Flamsteed, equipped himself with clocks and sighting instruments of sufficient quality to make observational checks on the expected variation in the length of the apparent solar day[1]. By 1666 he had used a Tompion clock regulated against sidereal time to establish the sign and general magnitude of the discrepancy. He called his results 'The Equation of the Natural Days', and this is probably the origin of the expression 'equation of time'. Independently, Christiaan Huygens was also concerning himself with this matter.[5] However, not for another 50 years did clocks in general improve to the point where they warranted having an 'Equation Table' fixed inside the case to enable them to be accurately regulated against a sundial.[6]

THE ANALEMMA

THE BASIC ANALEMMA

The inclination of the ecliptic to the celestial equator results in the declination of the Sun varying from $+ 23\frac{1}{2}°$ to $- 23\frac{1}{2}°$ during the course of the year. A plot of these values versus the equation correction for the same data has the form shown in Figure 2. This characteristic 'figure 8' shape is called the ANALEMMA.

It will be noted that:

a. The upper and lower extremes of the figure are reached in June and December respectively.
b. The larger bottom loop stretches from September of one year to April of the next, so that the crossover point is well above the zero of the declination axis.
c. The figure is not symmetrical about the vertical axis

either.

d. The crossover point does not fall exactly on the vertical axis through the origin, although it is not far away.
e. Nevertheless, it is possible to construct a slightly inclined axis of symmetry that does divide the figure equally down the middle, and does pass through the crossover point.

It is the basic analemma that used to be pictured on

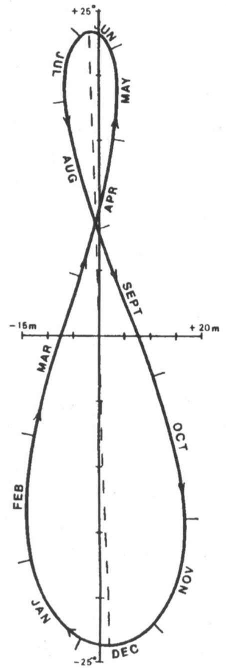

FIGURE 2: The basic analemma, as defined in the text. Plotted from the mean data tabulated by Cousins.[3]

terrestrial globes (usually in the Pacific) to indicate graphically the latitude where the Sun would pass through the zenith on the indicated date, and the mean clock time at which it would do so.[7] The figure should therefore stretch between the Tropics of Cancer and Capricorn (Figure 3). It will be seen that the equinoctial Sun never passes through the zenith at 12 noon mean time at any site on the equator: it is always about $7^1/_2$ minutes early or late.

Particularly beautiful and informative analemmas have been created photographically by Di Cicco[8] and Arnold.[9] Their technique was to photograph, on a single frame of colour film, the real Sun at the same clock time (it does not have to be noon) at weekly intervals throughout an entire year (Figure 4).

Hughes, Yallop and Hohenkerk[10] have shown how the equation of time may be calculated. It changes very slowly with time, and therefore the shape of the analemma also will vary on a long timescale. This has been investigated by Oliver.[11]

THE PROJECTED ANALEMMA

An analemma may be incorporated in a noon mark to give a built-in correction for the equation of time. However, as the length of the projected distance from the tip of the gnomon will vary with both solar declination and time, this analemma will not be of exactly the same proportions as the basic analemma. That for a vertical noon mark is shown by Hughes in his Figure 3: note that the 'December' portion of the '8' is at the top.

There is no reason (other than the labour of

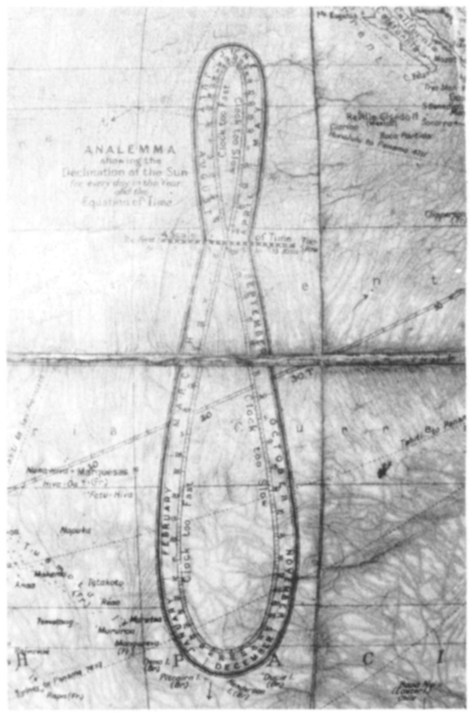

FIGURE 3: The analemma on a terrestrial globe (Philips' Challenge Globe, believed to date from the 1920s). The curve is represented by the innermost line of the '8', but the bold border (a common style) can cause confusion.

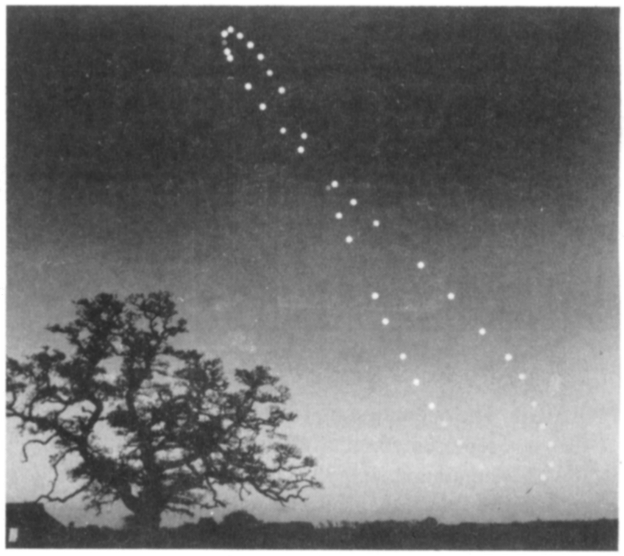

FIGURE 4: The natural 'analemma in the sky' traced out by the real Sun. Image copyright H.J.P. Arnold/Space Frontiers Ltd.

computation) why an analemma should not be drawn around every hour line of a vertical or horizontal dial. A dial pattern of this nature is illustrated by Cousins,[3] whilst a method of calculation is given by Waugh.[12] The simplest method is practical calibration: a mark is made at the apex of the shadow at clock noon on every sunny day of the year.[12]

As an alternative to analemmas on the dial, it is possible to employ specially shaped gnomons. This is the basis of the Oliver and Schmoyer dials.[3] (This Oliver is not the author of Reference 11.)

Continued on page 40

THE 'EQUATION OF TIME FOR THE MOON'

ALLAN MILLS

Reference works[1] list the duration of the lunar day - the mean period between successive passage of the centre of the Moon across the meridian - as 24 hours 50 minutes 28.2... seconds. Thus, the Moon appears to rise about 50 minutes later each night.

However, the incredible number of places of decimals to which figures such as this are quoted should not blind us to the fact that these are MEAN values, averaged over centuries. The actual day-to-day behaviour of the Moon is a long way from uniform, for with only 2% of Earth's mass it is by far the smallest body in the Sun-Earth-Moon system: an example of the notorious 3-body problem in gravitational theory. Modern computers need an expression with several terms to predict its position to better than 0.01 arcsecond.[2]

The difference in time between the motion of the real Moon and an imaginary mean moon moving at a uniform average velocity may be said to constitute the EQUATION OF TIME FOR THE MOON, although this expression will not be found in the astronomical literature. It will be applicable to any device - lunar dial[3-6] or astronomical clock[7] - where the dial pattern or gear train is (directly or indirectly) based on the mean lunar day quoted above. The situation is analogous to the way in which ordinary clocks simulate the motion of a fictitious 'mean sun' rather than the real Sun across the sky,[8] and so sundials must be 'corrected' by application of the 'equation of time for the sun'.[9, 10]

I have derived the correction curve for the Moon for 1986 from the lunar positions tabulated in the *Astronomical Almanac*[11] for that year (Fig. 1). The eccentricity and obliquity of the Moon's orbit about the Earth come in strongly, but the presence of the Sun (and even of lesser factors such as the non-spherical shape of the Earth) are continually modifying and displacing the resultant. It will be seen that in 1986 the discrepancy between mean and real moons varied by up to ± 0.7 hours about the mean line. Thus, a clock running at a uniform average lunar rate would be up to 0.7 hours (10.5°) in error twice in each lunation. This illustrates how the ingenious efforts of famous horologists to obtain 'exact' mechanical ratios between solar and lunar gear-trains were, in fact, rather misguided.

Indeed, the error could be even worse, for this example represents the optimum situation. Apart from plotting the curve in advance for every year (it does not repeat itself nearly as closely as that for the sun) there is no way of knowing when the real Moon crosses the zero axis; and so when to start a lunar clock, or align a lunar dial, at the optimum instant. An unfortunate choice could lead to a maximum discrepancy of 1.4 hours in 1986. Setting at any random point in time, one would be lucky if the markings on a lunar dial were never more than about an hour away from 'clock time'. This conclusion concurs with the usual experience of lunar dials.[3-6] Perhaps it is just as well that, unlike the inter-tidal creatures of the seashore,[12] we do not keep lunar time!

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3. F.W. Cousins, *Sundials*, Baker, London, 1969.
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5. G.C. Shephard, *Queens' College Dial*, Cambridge, 1972.
6. P. Pattenden, *Sundials at an Oxford College,* Roman Books, Oxford, 1979. The 'Pelican' dial at Corpus Christi College.
7. A.A. Mills, 'Monumental Astronomical Clocks', Parts I - V. *Horological Journal* 1990 132 (7) 226-230 , (8) 278-281, (9) 304-308, (10) 340-346, (11) 379-384.
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11. *The Astronomical Almanac* is published annually by HMSO, London.
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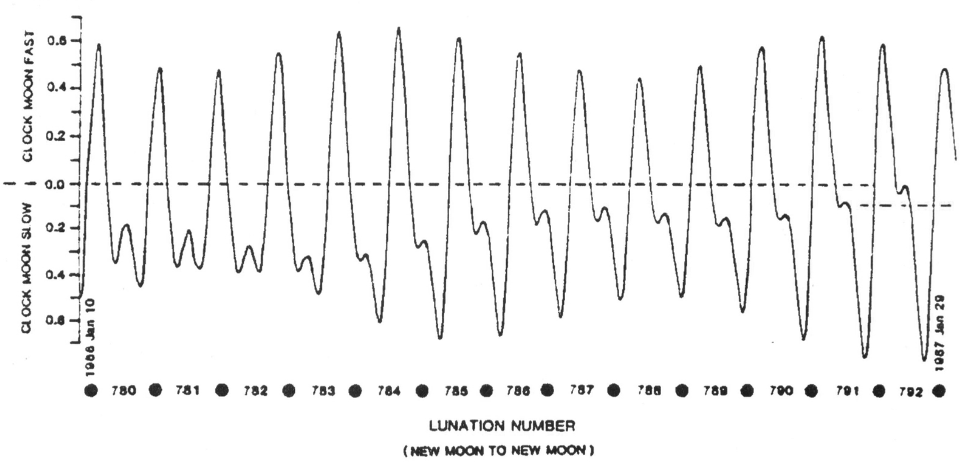


FIGURE 1: The 'Equation of Time' for the Moon in 1986: a mean moon is assumed to move at a uniform average velocity along the dashed line. In 1987, somewhat smaller swings would be produced by a revised choice of 'mean moon'

CURIOSITIES OF DIALLING - 2
TO MAKE ECCENTRIC SUNDIALS
BY P. I. DRINKWATER

This curious little tractate is preserved among the notes of the diallist Nicholaus Kratzer (MS CCC 152: Bodleian Library). It stands quite alone in the book and is totally unrelated to the much more sophisticated dialling material which precedes it; it is followed by "Another Eccentric Dial", which turns out upon study to be no more than a particular, and probably early, laying out of the usual tangent line method of drawing hour lines, in such a way as to give spurious logic to the off-centre placement of the root of the Gnomon on a horizontal sundial. There is not the slightest indication that either piece influenced Kratzer, he had plenty to go on elsewhere. Both pieces shew marked signs of lying at the end of repeated disinterested copying, and the diagram to the second piece is quite badly garbled, although readily corrected from the written instructions. Our piece, however, has not suffered in this way, and what it says is quite readily followed.

"A plan for the construction of this Sundial and all Sundials. Suppose AB to the (meridian) line (on a horizontal plane) with its centre C. Upon that centre C draw your prime circle to A and B. A being to the south, pitch point D halfway between A and C. Upon point D draw a small circle (not passing outside of the larger one) and divide it into quarters (from line AB), lettered E F G H. A line drawn through EDF (and therefore at right angles to ACB) is the six o'clock line, both in the morning and in the evening. Take ED and set this (along the six o'clock line) beyond E to determine point K. Take DF and set this (along the six o'clock line) beyond F to determine point L. Divide the space between D and K into six equal parts. Similarly divide the space between D and L into six equal parts. Place one foot of your compasses on L and extend the other to the fifth part towards L beyond D. Sweep an arc from that fifth part towards the Meridian Line until it meets the Meridian Line at M. Divide the arc from K to M into six equal parts and also divide the arc from L to M into six equal parts. From point D as a centre draw lines through all of these points. The eccentric lines thus drawn are those of

TABLES

SYENE 24°

CONSTRUCTED		CALCULATED	
12	0.00°	0.00°	12
11	5.65°	6.22°	1
10	12.54°	13.22°	2
9	21.72°	22.13°	3
8	35.22°	35.15°	4
7	57.02°	56.62°	5
6	90.00°	90.00°	6

2nd Climate

ALEXANDRIA 31°

CONSTRUCTED		CALCULATED	
12	0.00°	0.00°	12
11	7.45°	7.86°	1
10	16.37°	16.56°	2
9	27.67°	27.25°	3
8	42.82°	41.77°	4
7	63.66°	62.81°	5
6	90.00°	90.00°	6

3rd Climate

RHODES 36°

CONSTRUCTED		CALCULATED	
12	0.00°	0.00°	12
11	8.61°	8.95°	1
10	18.72°	18.75°	2
9	31.09°	30.45°	3
8	46.77°	45.51°	4
7	66.64°	65.49°	5
6	90.00°	90.00°	6

4th Climate

ROME 31°

CONSTRUCTED		CALCULATED	
12	0.00°	0.00°	12
11	9.43°	9.97°	1
10	20.35°	20.75°	2
9	33.36°	33.27°	3
8	49.22°	48.65°	4
7	68.36°	67.78°	5
6	90.00°	90.00°	6

5th Climate

BORYSTHENES 45°

CONSTRUCTED		CALCULATED	
12	0.00°	0.00°	12
11	10.06°	10.73°	1
10	21.55°	22.21°	2
9	34.98°	35.26°	3
8	50.90°	50.77°	4
7	69.49°	69.25°	5
6	90.00°	90.00°	6

6th Climate

RHIPHÆAN MOUNTAINS 45°

CONSTRUCTED		CALCULATED	
12	0.00°	0.00°	12
11	10.56°	11.43°	1
10	22.48°	23.54°	2
9	36.21°	37.04°	3
8	52.12°	52.58°	4
7	70.29°	70.45°	5
6	90.00°	90.00°	6

7th Climate

the Artificial Hours."

To the modern mind this whole passage screams for elucidation. What about latitude? What about the Gnomon? Upon what supposed principle is this construction based? How can it apply to "all sundials", and what, anyway, is meant by this sweeping term?

To the brilliant and practical mediæval mind which devised this construction, probably none of these questions would occur. Only one sort of sundial can encompass the whole day on a plane, this is the horizontal dial."All Sundials" are horizontal sundials at all places. "All Places" are encompassed in the seven climates of the Geographers:

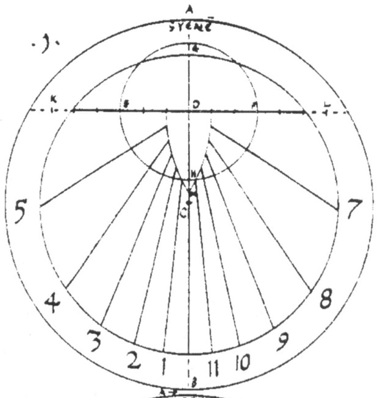
Meroë at 9° (North of the Equator), where the longest day has 12½ hours.
Syenë at 24°, with 13 hours.
Alexandria at 31° with 13½ hours.
Rhodes at 36°, with 14 hours.
Rome at 41°, with 14½ hours.
Borysthenes at 45° with 15 hours.
The Rhiphæan Mountains at 49° with 15½ hours.

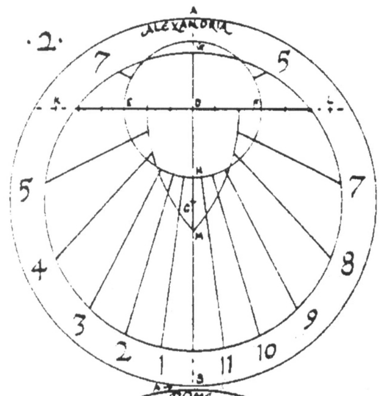
This knowledge not only gives us the angles of the Gnomons, but also the number of hours to be included at each climate. The little scale of six parts (and seven points: the useless common point D standing for Meroë), on each side of the eccentric of our dial, covers all places between the Tropics of Cancer and what, to a Mediterranean, is the last stop before desolation reigns. Failure to go further north argues an early date for the construction, probably in the Arab world. The originator clearly perceives the work as an orthographic projection of the sphere from which (as was usual in mediæval time) all potential ellipses are excluded, being replaced by applications of the Vesica: formed from the arcs of two perfect circles (such as may readily be seen in the artwork of the period), with its own geometrical logic quite thoroughly worked through.

The secret of "Universality" lies in the choice of point from which the two arcs are to be swept: their centres always being at K and L. The example specified yields a dial for the "climate of Borysthenes", exactly as in diagram 5. The other points yield dials for the other five climates catered for, with the possibility of easy interpolation in between. What happens above 49° north can only now be pure speculation, perhaps the centres of the arcs would begin to move inward, and their origins remain fixed at K and L; so that we would reach a semi-circle at climate 13: who knows!? The cold light of trigonometrical analysis is surprisingly kind to what is inherent in that which we actually have. The following tables give first the hour angles produced by the construction; then those calculated "correctly; the results are very close, certainly close enough for practical use.

Perhaps we should get out our dividers and start pacing out those arcs!

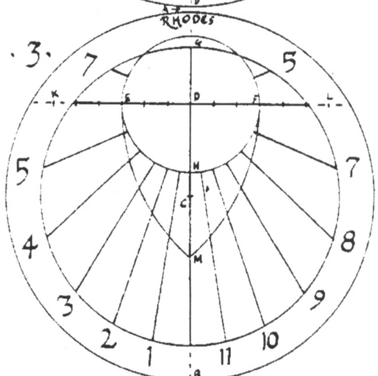
SYENE
2nd Climate
24° N

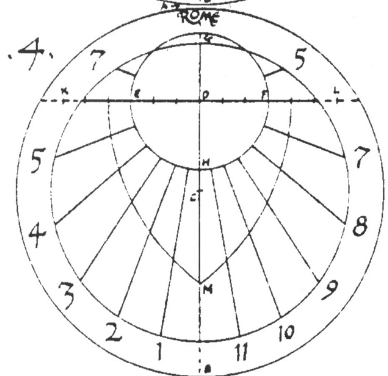




ALEXANDRIA
3rd Climate
31° N

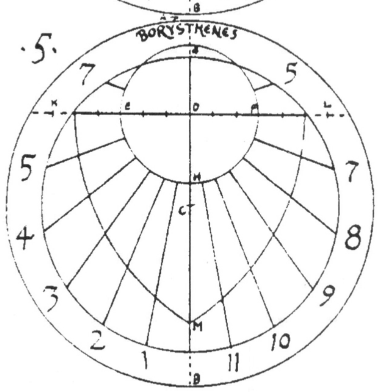
RHODES
4th Climate
36° N

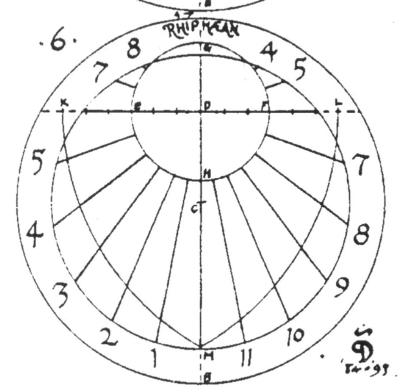




ROME
5th Climate
41° N

BURYSTHENES
6th Climate
45° N





RHIPHÆN
7th Climate
49° N

THE DECAY OF NATURAL BUILDING STONE AND ITS EFFECT ON STONE DIALS AND THEIR CONSERVATION

R.A. NICHOLLS

The Society's catalogue of fixed dials in the UK is proceeding well, but it is clear from the work completed that existing vertical dials are generally in poor condition. Of the dials catalogued, 53% are vertical and 77% of these are in stone or slate. Of dials delineated on stone, 60% are in "fair to awful" condition. These results are country-wide, and the sample size is large enough to assume that they will apply to those dials not yet catalogued.

Mass dials present as bad, if not worse, a picture. Charles Aked has drawn attention in the October 1993 Bulletin to the damage caused to our dialling heritage by the poor condition of so many dials, and he has correctly named the cause - decay of building stone. This decay is caused by physical and chemical changes in the stone, the same changes that cause "weathering", which is so often seen as desirable. One man's weathering is another man's decay.

BUILDING STONES

The physical, chemical, mechanical and geological properties of building stones in the UK have been widely studied. Much has been done by the Building Research Establishment (BRE) and information has come also from the large UK road building programme. Stone suitable for buildings is also suitable for roads.

South of Glasgow and Edinburgh, the great majority of natural stone buildings (and therefore of dials) are of limestone and sandstone. This is partly because the stones are where they are in the ground - moving building stone over long distances is uneconomic, and partly because these two stones are easier - or relatively easier - to cut and shape than the harder rocks such as granite. Sources of these limestones and sandstones have been examined, quarry by quarry, and information on their properties and behaviour is freely available.

DECAY (WEATHERING) OF BUILDING STONE

The physical and chemical changes in building stone labelled as weathering (that is, decay) are well known, but have come under more intensive scrutiny in the last few years with the increased awareness of the effects of atmospheric agents on those changes. These atmospheric agents are generally labelled as pollution, but there never has been and never will be a "clean", "pollution-free" or "neutral" atmosphere that is benign to buildings. Our atmosphere consists of gaseous chemicals plus airborne and aerosol particles arising from nature's and man's activities. This cocktail of chemicals has adverse effects on buildings and has always done so. These atmospheric chemicals cause the decay in building stones. They also cause damage to other building materials and to dials of other types, but this discussion is confined to stone dials, and to UK conditions.

There now exists an official body called the UK Building Effects Review Group (BERG) to "review the state of knowledge of the effects of acid deposition on buildings and building materials in the UK". The discussion below relies heavily on their published findings.

AIR POLLUTION

The primary chemicals in the atmosphere thought to cause decay are:

- sulphur dioxide
- smoke particles (of widely varying constituents)
- chlorides (especially near coasts)
- oxides of nitrogen (probably)

All these can dissolve in water to give acids, as well as other chemicals. The problem is therefore one of acid deposition on buildings, and its effects.

Only the last pollutant (nitrogen oxide) is obviously modern, as it arises from car exhaust fumes. Soot and sulphur dioxide existed in far greater concentrations in the 19th century than at present. Although the major atmospheric gas carbon dioxide can form acid in water it is not thought to cause damage on its own.

ACID DEPOSITION ON NATURAL STONE BUILDINGS

The pollutants can be deposited on buildings in dry or wet conditions. The quantity of pollutants available depends on the location of the building relative to pollution sources. The amount deposited in dry conditions is governed by wind speed, and in wet conditions by the quantity of rainfall, mist and fog. In both conditions the building shape controls the distribution of acid over the building surface.

The general conclusions of BERG are that acid deposition has increased in recent times from levels earlier this century, but the variability of deposition is very large indeed. The rate of damage also seems to be increasing. The following factors produce variations in the rate of damage.

- local geography
- wind speed and direction
- temperature variations
- humidity conditions
- precipitation rates and periodicity

These factors, themselves highly variable, produce such large variations in rates of damage that no general picture for the UK as a whole can be seen. There is some (but not conclusive) evidence that recent damage differs from previous decay patterns partly because of the changed nature of the pollutants.

HOW ACID DEPOSITION DAMAGES BUILDINGS OF NATURAL STONE

The decay caused by acid deposition has been well studied in limestones and sandstones, but very little work has been done on slate. Personal observation had led me to believe that slate resists decay longer than limestone or sandstone. The figures from the dial listing contradict this. Perhaps the slate dials are generally older?

The following remarks concentrate on the first two stones because there is not enough known (by me at least) about the behaviour of slate.

On limestone, dry deposition forms crusts, often black with soot, of gypsum. These crusts flake off, taking with them the original surface. Wet deposition forms gypsum and other chemicals in the pores, and these wet up and dry with the seasons. The consequent volume changes break up the stone, as does the freezing and thawing of the water itself. Rain washed limestone looks clean and less damaged, but this is an illusion. The acidic rain degrades the chemical bonds between particles and these are washed away.

These chemical changes very quickly penetrate two or three inches into the stone. If pollution declines, the primary changes still exist as a type of "memory" and can be re-activated by other pollutants or by moving the affected stone. The resulting damage can be greater than in new stone.

Within sandstone, the chemical changes cause the mineral cement holding the particles together to leach out into clay minerals. These have a bigger volume than the original minerals and the consequent volume changes flake off the stone, as does, once again, the freezing and thawing of the water in the pores.

The processes of decay are complex, and when allied to the enormous variations between and across quarries and the quarrying and building methods it becomes impossible to predict the amount or rate of damage in any building. Dials provide added complexities. They are in the front line of attack - damage proceeds from the building face inwards. They are also a small fraction of the building surface and may be either worse or better shielded than the remainder.

STONE CLEANING AND ITS RELATIONSHIP WITH CONSERVATION AND REPAIR

Cleaning damaged building stone is often the first suggestion made for dealing with decay. Not a year passes without an international conference or two on conservation and repair of stone buildings. Many papers describe methods and examples of stone cleaning. (There is a school of thought that if all the papers devoted to stone cleaning were made into umbrellas they could cover all the historic buildings in Europe, which would not then require stone cleaning.)

Stone cleaning is offered either as urban regeneration or as conservation. Most completed projects are immediately denounced as architectural and historical vandalism. The quicker - and more cost efficient - methods use physical or hydraulic forces, sometimes with chemicals, and they remove all dirt and some stone. They have no relevance to conservation of dials. If a building needs this type of cleaning, any dials are probably beyond repair, and will certainly be so after cleaning.

The slower methods generally thought of as successful, eg. Wells Cathedral, involve chemical methods. They cannot replace lost stone however.

CONSERVATION AND REPAIR OF STONE DIALS

Before conservation and repair methods can be discussed, we need to decide what must be conserved. Charles Aked also raised this point in his article. We need to have listed dials similar to listed buildings, based upon scientific and historical importance. The more important the dial, the greater the conservation effort. Two things seem inevitable - firstly, many dials are beyond repair and if owners require a dial they will have to have a replacement. Secondly, some important dials can only be conserved by removal to a safe place, with, if possible, replacement by replicas (not in stone).

ACCEPTABLE METHODS OF CONSERVATION AND REPAIR FOR STONE DIALS IN-SITU

There is as yet no proven method of conservation and repair applicable generally to stone dials. Published conservation studies on stone which seem to have most relevance to dials are those on statuary. Statues and dials are similar in that surface damage quickly destroys their worth. Valuable work in the UK on conservation has come from BRE, English Heritage and the Society for the Protection of Ancient Buildings (SPAB).

Work at Wells Cathedral employed the "lime method" of conservation. Statues were cleaned with lime poultices, sometimes over several weeks. This was shown not to damage the already fragile surfaces. Where necessary repairs with colour matched lime mortar or new stone were made. Lime water was then applied to consolidate the surfaces. Up to 40 applications were made - this is not a quick or cheap process. The final results were good, but it seems unlikely that a restored dial surface would accept re-cutting, although it might accept re-painting.

Finally, the conserved areas were painted with a "sheltered coat" of lime mortar wash, also colour-matched. This coat acts as a sacrificial layer against acid pollution, much like galvanising of steel. The coat needs maintenance at intervals. The reports indicate it is working well. This shelter coat has interesting connotations - if, as some experts believe, mass dials were limewashed, this may account for their longevity compared to younger scientific dials.

Another surface treatment has been developed by BRE, called Brethane. This is a chemical which penetrates up to 2" into the stone and forms a gel. Both sandstones and limestones can be treated. This gel is said to significantly reduce "frost damage", but this is not the only cause of damage in stone. Brethane needs skilled labour and stringent safety precautions in its use.

Neither method gives new for old - damage may be halted but not reversed. Both treatments might benefit new dials more than old - and the "shelter coat" principle for new dials on buildings with stone facades seems promising. It may be that all such dials should be delineated on a mortar base applied to the facade. Repair and replacement would be greatly simplified.

WHAT NEXT?

The need for coherent conservation techniques for all dials is very great. This Society seems the correct body to start looking for such techniques, in collaboration with such as BERG, BRE and SPAB. It is hoped to discuss this at the 1994 April A.G.M. and Conference and to form a conservation section in the Society. Please come forward if you are interested.

EDITOR'S NOTE Preservation and of old sundials are among the most urgent of the problems in the dialling world. These problems have been inherited from the past through decades of indifference and lack of maintenance. The sooner we get to grips with this major menace to sundials and correct the present situation, the better will be our contribution to the preservation of the unique dialling tradition in England. The dialling survey has already given us an inkling of the magnitude of the task that lies ahead. The British Sundial Society can only give a lead, for the cost of such remedial work is going to be enormous.

MANCHESTER SUNDIAL SOIREE

An Evening Dialling Soiree was held at Didsbury on 10th October 1993 at which a varied collection of portable sundials was exhibited. The attraction was in having their functions explained by experts and in handling the examples. The dials were not set out in a museum but the home of our hosts, Judi and Malcolm Jayson at Didsbury.

This gathering, held for about a dozen members in the Manchester area, had the privilege of closely examining about two dozen portable dials of all types. The collection of dials included two silver Butterfield type dials, several equatorial dials, some with mechanical adjustments; a very elegant brass horizontal/elliptical double dial, and an Augsberg dial.

Two dials were of types I had not seen before, one a self-orienting horizontal dial, the magnetic needle being adjustable for magnetic declination, protected from damage by a shallow glass dome. For travelling this fits into a round brass case and an outer leather carrying case. The next was the most interesting of those shown - a brass quadrant, finely engraved with scales and tables on both sides. One side carried a folding gnomon which allowed this to serve as a horizontal dial. Providing certain values were known, the instrument could also be used for surveying.

Many old dials were adjustable and with their engraved tables had many additional functions. Someone at the meeting compared them with today's pocket calculators, multifunctional with many buttons, most of which remain unused by the average owner. These additional dial functions were mainly included to show off the art and skill of the maker, and were probably never used or understood by most owners.

A small horizontal dial was made for use in the backwoods of Canada, its owner had written an equation of time table which fitted neatly into the lid, so it was a dial intended for practical use.

Several modern sundials were on view, educational toys, conversational pieces or advertising gimmicks, cardboard cutout models, a "Mary Rose" replica in a pomander and credit card dials in several versions. The Dutch Sundial Society - De Zonnwijzerkring has produced what I consider to be a spot dial. It is a 5cm square of plastic 2cm thick with a spot on the top surface which indicates the time on the lower surface.

A member who could not be present sent a photograph of a walking stick, the handle of which concealed a vial for spirits and also had a sundial. No doubt this was essential equipment for the Victorian gentleman explorer. I was unable to determine if the dial was engraved with licensing hours for various latitudes.

A fine spread of refreshments provided by our hosts, and an opportunity for discussion, complete the soiree. Thank you Judi and Malcolm, and those who brought dials along, for a most interesting and enjoyable evening.

ROGER BOWLING, Macclesfield

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CANADIAN SUNDIAL

In the *Sunday Times* of 20th March 1938 was a letter from Mr. N.D. Blagdon Phillips of Vancouver B.C. Canada, as follows:

I have seen the letters in your issue of January 30th with regard to the possibility of making a sundial to keep mean-time. All the methods that have been used to accomplish this depend either upon some mechanical device for sighting or altering the reading arrangements periodically.

Many years ago I devised a sundial which keeps mean-time all the year round, without any needing any alterations or re-adjustments, and it has no moving parts. When plotted for a certain latitude, it may be used anywhere on, or near to the latitude, either in the north or the south hemisphere, and only a watch and a level are needed to set it up. It is capable too of being used over a wide range of latitude north or south of that for which it was plotted.

A further interesting feature is that it can show the date, or the seasons; and, if desired, it can be marked to show any special anniversary that we may wish to commemorate.

These functions are accomplished by my having used the apex of a triangular gnomon for my indicating shadow. The hours are marked out in the figure of "eight" [analemmas]. But I use two colours for these, red and black. The red half of the "eight" is used for the first half of the year, and the black is ignored; and vice-versa for the latter half of the year.

It should be mentioned that the face of my dial is curved in order to "catch" the shadow of the apex at the early and late hours of the day. I am enclosing some photographs which will serve to make clear the principle. [Only one was published and is too indistinct to reproduce here.]

If anyone is interested in this, I shall be pleased to send drawings of a model which can be made for two or three shillings, the only proviso being that people will use them and report their findings. Cooperation in the tropics would be particularly welcome, and a keen interest in this study is more to be desired than a deep knowledge of the subject.

N.D. BLAGDON PHILLIPS

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The latter half of the last sentence is particularly applicable to us as members of the British Sundial Society. The Editor intends to obtain copies of the earlier correspondence since there was little activity in dialling in the thirties. Any information from this period will help us to understand why dialling had declined to such an extent although patents had been taken out earlier in the century by several independent inventors. Any other scraps of information from earlier newspapers would be of interest for possible publication. If you have any, please forward copies to the Editor.

TABLES OF TIME RELATING TO WATCHWORK
BY WILLIAM DERHAM

THE ARTIFICIAL CLOCKMAKER

In Chapter XI, under the title shown above, in the book with the title of The Artificial Clockmaker, written by William Derham in 1694; is the procedure for correcting a mechanical clock by the stars. No mention is made of using a sundial for the purpose, nor of the Equation of Time which was known by then and indeed several people had published tables showing the discrepancies between solar time indicated by sundials and the mean solar time intended to be indicated by clocks. These early tables were not very accurate but were more so than early clocks.

The method outlined has no need to take account of the Equation of Time, hence is inherently more accurate and the standard could be consulted nightly with very little equipment required. It used the diurnal rotation of the earth directly as a standard, and this is so constant compared with the accuracy of any known sundial, that it could be regarded as a perfect time measurer in that age. Those clockmakers, and ordinary people, using the new-fangled long pendulum clocks with an anchor escapement, who were not conversant with the irregularities of the motion of the sun, could not reconcile the regular going of the clock with an ordinary sundial, and as the sun could not be wrong, ergo the clock must be so. Of course most people of those days did not even subscribe to the earth turning round the sun in any case, and this conception was forbidden to all Roman Catholics of that age. The method about to be described was the only way that human beings of the time could demonstrate the difference in the sun's motion over the annual cycle compared with that of an accurate clock. The account opens with the division of the year into its component parts, as shown in the table.

A TABLE OF TIME

Seconds						
60	Minutes					
3600	60	Hours				
86400	1440	24	Days			
604800	10080	168	7	Week		
2592000	43200	720	30	4	Month	
31536000	525600	8760	365	52	12	Year

Note: The figures shown are based on a month of 30 days and a year of 365 days only.

The foregoing Table will be of good use in calculation, for the ready means of finding the parts of time: which is thus. Find the parts of time you seek for, the number in the concurrence of squares, is the answer to your question. Thus, suppose you seek the number of seconds in a year: in the square under Seconds, and in the same line with Year (which is the lowest square on the left hand) is the number sought, viz 31 536 000. Similarly the minutes in a month are 43 200 (based on a 30-day month).

If you would know any number, where there is the addition of an odd number to it, as the seconds in a month and one day: add the seconds in a month (which are 2 592 000) and the Seconds in a Day (which are 86 400) and you have the number sought, viz 2 678 400.

A TABLE TO SET A WATCH BY THE FIXED STARS

Night	Hour	Minute	Second	Night	Hour	Minute	Second
1	0	3	57	16	1	3	20
2	0	7	54	17	1	7	17
3	0	11	51	18	1	11	14
4	0	15	47	19	1	15	11
5	0	19	44	20	1	19	8
6	0	23	41	21	1	23	5
7	0	27	38	22	1	27	1
8	0	31	35	23	1	30	58
9	0	35	32	24	1	34	55
10	0	39	29	25	1	38	52
11	0	43	26	26	1	42	49
12	0	47	23	27	1	46	46
13	0	51	29	28	1	50	43
14	0	55	26	29	1	54	40
15	0	59	23	30	1	58	26

[This table is based on the difference between the sidereal day and solar day of 3 minutes 57 seconds to the nearest second, the accepted mean value today is 3 minutes 55.9 seconds approximately or 3m 56 s. The values are more conveniently obtained by changing the previous value +4 to the minute column and -3 from the seconds column for each successive night rather than sum the actual figures. All thus goes well in the above table until night 13, this should read 51m 20s, and although this is easily explained as a printer's error, ie 9 for 0, this error is continued into the later readings, for night 14 should read 55m 17s, and this error of +9 seconds continues onwards to night 29. At night 30 another error creeps in, this should read 1h 58m 37s if the table had continued in the same way, but it reads 1h 58m 26s, the erroneous reduction of 14 seconds almost equalling the first error of +9 seconds plus the correct reduction of three seconds between each second's entry; the correct value by calculation should be 1h 58m 30s since 30 x 3m 57s = 1h 58m 30s. Any early clockmaker making use of this table would have experienced some problems in regulating his clock at certain intervals in the above table. A good clock with a seconds pendulum has an error of less than a second a day under constant conditions.

EXPLANATION OF THE TABLE

This table shows how much the sidereal day goes faster than the solar day, in any number of nights in a month. So by observing your watch, the nice time when any fixed star comes to the meridian, or any other point of the heavens: if after one revolution of the same star to the same point, your watch goes 3m 57s slower than the star; or after two nights 7m 54s; or 16 nights 1h 3m 20s, etc; then does your watch keep time rightly with the mean motion of the sun. If it varies from the table, you must alter the length of your pendulum to make it so keep time.

[It will be noted in the previous statement that the table error of +9 seconds is continued into the text, fortunately for the clockmakers of those days, this error spread over sixteen to twenty-nine days is within the normal daily error of the clocks of the time and is therefore not of great significance. Note also that where William Derham quotes "watch", he is merely referring to the timekeeping part of a clock, not a pocket watch; hence the later reference to regulating the rate by means of adjusting the length of the pendulum].

To observe the time nicely, when the star comes again to the same point of the heavens, it is necessary to make the observations with a telescope, (Derham was a keen astronomical observer) that has cross threads in the focus of the object glass; and so leaving the telescope fixed in the same position, until a second observation. You may do this with the telescopic sights of a quadrant, or sextant, and so leaving it standing until another night of observation. Or for want of this more nice way, you may do it by looking along by the edge of two strings, suspended by plumbets, in a room, at some distance from one another. Or by looking at the edge of a chimney, etc, as Mr Watson has directed at the end of Mr Smith's Horological Disquisitions [as was done by John Harrison whilst he was adjusting the rate of his first precision clocks]. But to make a tolerable observation in any of these last ways, it is necessary to have a candle to shine upon the edge of the furthermost string, or chimney; without which you cannot see exactly when the star comes thereto. This is a rare mention of the need to illuminate the furthest sighting point if it is small in width and in darkness

[William Derham next proceeds, in the same chapter, upon the effects of refraction in connection with reading a sundial. It would seem obvious that this is so a mechanical timekeeper can be corrected by taking the reading of a sundial as a reference, however, as will be seen from the text, he nowhere mentions this].

A TABLE SHOWING THE VARIATIONS MADE IN THE TRUE HOUR OF THE DAY, BY THE REFRACTION OF THE SUN IN THE EQUATOR, AND BOTH THE SOLSTICES

Sun's Altitude in Degrees	Sun's Refraction m	s	Variation at the N. Solstice m	s	Variation at the Equator m	s	Variation at the S. Solstice m	s
00	33	00	4	34	3	32	4	38
1	23	00	2	34	2	28	3	19
2	17	00	2	24	1	49	2	32
3	13	30	1	46	1	27	2	3
4	11	30	1	29	1	12	1	40
5	9	30	1	12	1	1	1	33
6	7	30	0	56	0	49	1	17
7	7	00	0	52	0	44	1	16
8	6	00	0	43	0	39	1	8
9	5	00	0	36	0	34	1	2
10	4	40	0	25	0	29	1	2

REMARKS UPON THE TABLE

The column of the Sun's refractions, I owe to that accurate observer of the celestial motions, Mr Flamsteed. Which refractions, although shown the same in the table, yet these differ at different seasons of the year, nay perhaps according to the different temperature of the air sometimes, in the same day. Thus Mr Flamsteed found the refractions in February very different to those in April: and it is observed that the refractions are commonly greater when the mercury is higher in the barometer,

The table therefore does not show what the refractions always are, but only the mean of them, at every degree of the first ten of the Sun's altitude. And accordingly I have calculated the variations thereby made in the hour of the day.

These variations of the hour are greater or lesser, according as the angle of the Sun's diurnal motion is acuter with the horizon. The reason is plain; because the sun appears by refraction higher than it really is; so this false height affects the hour in Winter more than in the Summer half year.

There is no ray indeed of the sun, but which comes refracted to a sundial, and consequently, there is no dial but which goes more or less false (except at noon in dials that cast a shade, where the refraction makes no variation). But the refraction decreases apace as the sun gets higher, and causes a variation of not above half a minute, at ten degrees of the sun's altitude; except when the sun is in, or near the southern tropic. Nearer than half a minute, few common sundials show the time. And therefore, partly for this reason, and partly because Mr Flamsteed's observations reach not much further, I have calculated my table to only 10 degrees.

The table needs a little explanation. For having the sun's height, you have against it in the next column, the refraction: and in the next three columns the differences of the hour at the three times of the year. Taking therefore by a quadrant the sun's altitude, and observe at the same time, the hour of the day by a sundial, by the table, you may see how many minutes and seconds the dial is too fast. As at the sun's rising a sundial is 4 minutes 34 seconds too fast about June 11; 3m 32s too fast about March 10 and September 12; and 4m 38 s about December 11.

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COMMENTS

It is to be understood here that the indications here are local solar time and would need the Equation of Time correction to be of value in setting a mechanical clock. Such a check would only be approximate since the reading of the sundial could be no better than to the nearest half-minute, but better than nothing if the clock has stopped for some reason. The differences quoted for the dates are merely those caused by refraction effects and have nothing to do with the Equation of Time, although the effect of the latter is of much greater magnitude and importance. Why this is not given a mention in the book is hard to understand. at this time there were many claims by clockmakers that their clocks kept true time, and the sun went fast and slow, an assertion which was ridiculed by the ordinary man - how could the sun go fast and slow? An anonymous verse epitomizes this attitude:

There is the cottage of Peter
That cunning old fox,
Who kept the sun right
By the time of his clocks.

This was written in reference to Peter Clare, a Quaker clockmaker who lived in the village of Hatton, Cheshire, and who was laughed at for declaring the sun time was wrong and his clocks were right, but of course this was the greater error caused by the clock being in advance of the sun by more than 14 minutes on 11th February; and correspondingly slow by more than 16 minutes about 3rd November: caused by the variations in the earth's orbit around the sun and the tilt of the earth's axis, amongst other things; whilst the clock timekeeping was, or intended to be, uniform in rate.

For those who are interested in these matters, a good treatise which deals with these matters in depth is Foundations of Astronomy by W M Smart, published 1942.

It is strange that Derham does not include the explanation of the cycle of events which lead to the Equation of Time which allows the calculation of mean solar time from local solar time indications, for this is dealt with at length by John Smith in his Horological Disquisitions published only two years earlier in 1694, a book familiar to William Derham. About this time John Smith was in trouble with his religious beliefs, or rather his publishing of tracts about these, which eventually were burnt in public; so it may be that a prominent churchman like William Derham had to distance himself from such an heretic. Smith's book demonstrates that he is much more familiar with this aspect of timekeeping than Derham, in spite of the latter being an enthusiastic astronomer with one of the best telescopes available at the time. The outline of John Smith's career is given in Horological Dialogues by J. S. Clockmaker 1675, transcribed for the modern reader by Charles K. Aked, published 1986. He was by far the most accomplished of the horological writers of the period but failed to detail the practical working aspects of the craft, his emphasis being on satisfying the needs of the clock user.

The edition of The Artificial Clockmaker used here is the first, published London, 1696. For a biography of William Derham and some details of the later editions, consult the writer's three articles in Antiquarian Horology, March to September, 1970. These included some of the results of the writer's research into the subject over a period of about a year, for anyone interested in this aspect, the articles merely represent the tip of the iceberg of the possible material available, of which the horological part is quite small.

The practical application of taking successive star transits is outlined in the article "A Short Epistle to the Longitudinarians" in Antiquarian Horology, Spring issue 1991, page 297, by Charles K. Aked. This indicates the use of this application a few years after the first edition of William Derham's treatise, but it is the method devised by Samuel Watson, originally of Coventry.

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Continued from page 31

MORE ABOUT THE EQUATION OF TIME . . .

OTHER ANALEMMAS

Since 'analemma' originally meant 'construction' (and specifically 'projection') the term applied rather generally by ancient writers. Thus, Ptolemy's analemmas were orthographic and stereographic projections of the sphere.[13] Sundial enthusiasts are likely to come across the analemmatic dial[3, 12] which, by projection of the equatorial dial upon the horizontal plane of the observer,[14-16] gives rise to an elliptical outline complementing a vertical gnomon adjusted in position with the date. Such a gnomon may well be the observer him (or her -) self, for the direction of the shadow is all that matters, not its length.

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EDITOR'S NOTE: Please note that the Editor regrets that he is no longer able to do research on behalf of members, nor to supply photocopies of material, obtain patents or provide information on reference sources. Such enquiries must be directed to the BSS Secretary, who will forward these to the person most appropriately qualified to deal with the request. Mrs. Anne Somerville deals with sales of BSS Bulletin's, ties and badges.

BOOK REVIEWS

THE ART OF SUNDIAL CONSTRUCTION, Peter I. Drinkwater, pp x + 74 + Appendix of 8. Third edition, Shipston-on-Stour, 1993, ISBN 0946643 09 1. A5 format, thin card covers. Price £6, which includes post and packing from the author.

[Orders to: Peter I. Drinkwater, 56 Church Street, Shipston-on-Stour, Warwickshire CV36 4AS].

This little book has been a best-seller in the dialling world since its first appearance and is printed by the same printer as the BSS has for its Bulletin. In essence it is the first edition with some additions and slight changes. On the cover is the solution to the mystery objects in Holbein the Younger's painting "The Ambassadors" which the reviewer cannot remember having being attempted anywhere before, and one must admire the tenacity with which Mr. Drinkwater has teased this problem until it has been unravelled and forced to reveal its secrets.

The use of red in the text has been discontinued, but one of the complaints made by some purchasers in the past that the text was too small for comfort is now becoming apparent to the reviewer with advancing age. Additionally one is forced to read through Mr. Drinkwater's texts in order to understand what he is about, they cannot be skipped over lightly without losing contact. The changes and additions in the book are relatively minor in respect of the main thrust of this little work. It is the cheapest complete work available on the practical art of delineating sundials, there is no outline of the history of the art to pad out the book, nor an array of illustrations of sundials found in England or elsewhere. If the treatment in this book is ingested properly, it will be a sure foundation on which to understand the how and why of sundial delineation.

The book proper opens with a Foreword from our Chairman which ends:

"Peter Drinkwater might be described as something of an eccentric: he walks where others would drive, he sees what others would miss, he is a man who lives his life close to nature, who loves and understands the past whilst being fully aware of the present. Furthermore, Peter Drinkwater loves sundials, he has studied them and constructed them through the medium of the early diallists, from their various published works. He is an author, artist and publisher, who has produced a number of beautiful books on local social and historical subjects. He has now, I am glad to say, produced this delightful book on The Art of Sundial Construction, which not only fulfills a current need for a clear, simple and modern work on the subject, but which also has the charm of those books produced by the great diallists of the past".

This is fullsome praise indeed from someone who also has spent a great deal of time on the study of sundials. However, the reviewer must point out that the word "Construction" in the title is not in the sense that many practical people think of it, namely physically building or making; rather it is meant in the sense of geometrical construction practised by the earlier diallists. There is a section under the heading of "Aesthetics" which deals with the practical aspects of realising a sundial which is intended to help the budding diallist to actually select suitable materials and avoid the many pitfalls not readily apparent to those without a long acquaintanceship with sundials.

The book may, of course, be obtained from Rogers and Turner at Greenwich, or Mrs. R. K. Shenton, 148 Percy Road, Twickenham, Middlesex.

* * * * * * * *

SLONECZNY POMIAR CZASU, Piotr Maciej Przypkoski, pp10 plus pp16 of plates. Polish text.

This is a catalogue of the dialling instruments in Panstwowe Museum, Poland, plus a few exterior dials at other locations. It was brought to the attention of the reviewer by Mr. Mike Cowham who visited the museum earlier in the year. It is impossible to read more than a few words of the explanatory text, however the illustrations are readily understood and the major part of these cover a very wide range of portable dials, the remainder are of public dials delineated in this century. There are 33 illustrations in total, so it is rather a pictorial record.

The blue wrapper to the card covers carries a beautifully engraved gnomon for latitude 490, it bears several legends to indicate the polar axis, equinoctial, etc. and shows a large and small cherub amongst free-flowing foliage. Closer examination reveals that the larger cherub is holding a quadrant in his right hand and a large pair of dividers in his left, whilst his smaller brother holds a triangular instrument. Since the quadrant is not held in the correct working position, it is difficult to understand why the cherub is looking so intently at it. A short note on the inside rear cover indicates that this is a XVI century Nuremburg example preserved in the museum.

The catalogue becomes more interesting the longer one looks at it for plate 14 shows a horizontal dial signed Thomas Kilner 1649, it is English with a dolphin holding the style, which seems designed for northern climes. The reviewer looked at plate 15 for some time because the numerals proceeded counterclockwise. Was this a dial for the southern hemisphere? No, just the fact that the photograph had been printed in reverse. It is signed Gribelin and so must be of French provenance, looking at its reflection in a mirror converts it back into its normal self.

Most of the sundials depicted turn out to be examples mainly from England, France and Germany, with a few from Spain and Austria.

* * * * * *

EDITOR'S NOTE: Members are reminded that Mssrs. Rogers and Turner have recently issued a catalogue (Catalogue 96 for Autumn 1993 - The Measurement of Time) which has a good selection of dialling treatises both new and old (approximately 56). A copy may be obtained by writing to:

Rogers Turners Books, 22 Nelson Road, Greenwich, London, SE10 9JB. Tel No: 081 853 5271.

Mrs. R.K. Shenton has also issued a catalogue, for her address see the end of the first book review above.
Tel No: 081 894 6888.

NICHOLAS KRATZER

Because of the emphasis on Nicholas Kratzer in this issue it seems apposite to include some details of his life and career in order to give substance to the shadow. Thanks to Mr. J. R. Millburn who supplied the material, the first part deals with the entry in the Dictionary of National Biography.

FIRST PART:

NICHOLAS KRATZER (1487-1550?), mathematician, was born at Munich, Bavaria, in 1487, and studied in the universities of Cologne and Wittemburg, graduating B.A. at the latter place. Coming to England he made the acquaintance of Richard Foxe, Bishop of Winchester, who on 4th July 1517 appointed him to a Fellowship in his newly founded college of Corpus Christi, Oxford, and on 20 February 1522-3 (Old Style Calendar) he was incorporated B.A. He proceeded to M.A. 18 March of the same year when he was described in the University Register as 'Notissimus and Probatissimus et in Mathematicis in Philosophicis'. Kratzer lectured on astronomy in Oxford, and soon afterwards was appointed mathematical reader there by Cardinal Wolsey.

Kratzer was skilled in the construction of sundials and erected two in Oxford, one in the garden of Corpus Christi, reproduced in Fowler's *History of Corpus Christi College* on page 84, and another in the south churchyard of St. Mary's Church (it was removed in 1744). After the assembly of Bishops and Divines which met at Wolsey's house in 1621 had condemned Luther's doctrines, 'a testimony was sent to Oxford, and was fastened on the dial in St. Mary's churchyard by Nicholas Kratzer, the maker and contriver thereof'. Leland refers to this dial in his *De Economiis.*

In 1520 Kratzer was at Antwerp on a visit to Erasmus, where he met Albert Dürer, then on his famous journey to the Netherlands. On 12th October 1520 Tunstal wrote to Henry VIII saying he had met Kratzer at Antwerp, 'An Almayn [German] deviser of the King's Horologes' and he asked that he [Kratzer] should be allowed to stay until the pending election of the Emperor was over. 'Being', Tunstal added, 'born in High Almayn, and having acquaintance of many of the Princes, he might be able to find out the mind of the Electors touching the affairs of the Empire' (Letters and Papers Henry VIII, III,i.1018).

In the same year among Henry's payments appears the quarterly salary of 100s, to 'Nicolas Craser and Estronomyer' (ib. p 408). Dürer drew Kratzer's portrait, but it is not known to be extant. On 24 October 1524 Kratzer wrote to Dürer from London asking him to draw him a model of an insrument for measuring distances, which is in the collection of Herr Lempertz at Cologne; the reply from Dürer to Kratzer is in the Guildhall Library in London. When Hans Holbein came to London, Kratzer was one of his earliest friends. Holbein painted a magnificent portrait of Kratzer at a table on which are many mathematical instruments; this picture is now at the Louvre, and was painted in 1529 (see BSS Bulletin 93.2 page 10) when Kratzer was forty-one years of age. A good copy was lent by Viscount Galway to the Tudor Exhibition, 1890 (No. 129). In 1529 Kratzer was sent with Hugh Boswell and Hans Bour to search the king's woods and mines in Cornwall and to try to melt the ore (ib, v. 314). Among Cromwell's 'Remembrances' for 1533 is an item 'To send to Nicholas Cracher for the conveyance of Christopher Mount's letters'. Nicholas Bourbon, the French poet, in a letter to Thomas Soliman, the king's secretary, prefixed to Bourbon's 'παιδαwειον' Lyons, 1536, sends greetings among other friends, including Holbein, 'D. Nicholas Cratzero regio astronomo, viro honestis salibus, facetiisque ac leporibus concreto'. Payments to Nicholas, the king's astronomer, frequently occur in the accounts of the royal household.

In the preface to Guido Bonatus's treatise on astronomy (Basel, 1550) Kratzer is praised as a mathematician, 'qui ita bonus & probus est ut majore quam mathematicorum fortuna sit dignus'. He dies soon after 1550. Many of his books came into the hands of Dr. John Dee and Richard Forster.

Kratzer left two books in manuscript, copies of which are found in Corpus Christi (clii) and the Bodleian (MS 504) libraries at Oxford. First, Canones Horopti', dedicated to Henry VIII, with a concluding note to intimate that the subjects of his Oxford lectures were 'Astronomiam super sphæram materialem Johannis de Sacro Bosco, compositionem astrolabia, & geographium Ptolemmi'. His second work, 'De Compositione Horologiorum' contains 1 'Compositio & utilates quadrantis; 2 'De arte metrica sive mensurandi'; 3 Compositio cylindri & aliorum instrumentorum mathematica per N. Kratz'. In the Cottonian MSS is a letter from N. Kracerus to T. Cromwell, dated London, 24 August 1538, conveying information received from Germany about the Turks.

SECOND PART:

This is a translation from *Deutsche und Niederlandische astronomische Instrumente des 11-18 Jahrhunderts* by Ernst Zinner, Munich, 1956 by T. E. Rüssaak [Dutch and Netherland Astronomical Instruments of the 11th to 18th centuries]. This extract will be found on pages 419-420 of the book together with full references.

NIKOLAUS KRATZER

Born in Munich 1487, studied probably first in Vienna and then probably in Cologne where he met Heinrich Glareanus. In 1517 he became a professor at the Corpus Christi College in Oxford; at the same time he was clockmaker to King Henry VIII. As such he was also Royal Mathematician and Astronomer. In 1520 he was in Antwerp and was painted by Albrecht Dürer (1). In 1524 and about 1550 he was in London, when he sent greetings to Heinrich Glareanus through Josef Maaler (2). His later fate is unknown.

His activity in England became important through his lectures on the making of various instruments and sundials, and through his own production of intricate of intricate sundials. He introduced the polyhedral sundial, popular in Germany, in England; from his time such sundials can be localized in England (3). V.C. and Humphrey Cole were probably his pupils (4). In Oxford he gave lectures on sundials (5), ring sundials (6), the celestial sphere (7), the cross staff (8), the astrolabe (9), general sundials (10), the torquetum (11), and devices for the planetary movements (12).

As stated in his work on the sundials he had taken over many instructions from an old book belonging to the

Carthusian monastery of Mauerbach near Vienna. Obviously he took from this also various figures, for his drawings of polyhedral block sundials are in fact designed for a latitude of 48°, and undoubtedly taken from the old book, even though they show the accommodation to England's northerly position in the dials for 3-12-9 o'clock (13). Even the block sundial made for Cardinal Wolsey is calculated for the Viennese and not the Oxford latitude. Consequently he appears more as a successful communicator than as an independent scholar. Nevertheless his devices met such a response that Hans Holbein pictured Kratzer's sundials not only in his portrait of Kratzer, but also in his painting 'The Ambassadors'. His fame as a clever maker of sundials was so great that Tiedemann Giese, Bishop of Ulm, obtained a painted sundial, made of stone and for 550 latitude, from him hefore 1539 (14). It must have been made, therefore, for the latitude of Könisberg; consequently Kratzer must have liberated himself later from the Viennese model, designing his sundials independently. He probably made the first polyhedral sundials in the form of a four-sided pyramid truncated at the top. Likewise, the wooden vertical device with a plumb on one side and a semi-circle cut away on the other side, visible in his portrait of 1528, would appear to be his own invention. From these few facts then we are able to conclude that in time he freed himself from the Viennese model, taking his own course before 1528, becoming the famous mathenatician whose works were in demand.

As clockmaker to Henry VIII it is likely that he had made some of the clocks recorded as being in the Westminster Palace in London in 1542 (15). It seems that most of these were weight-driven clocks.

PORTRAITS

Albrecht Dürer's of 1520 has been lost. Holbein's of 1528 shows Kratzer in his workshop and is situated in the Louvre, Paris.

INSTRUMENTS

Polyhedral block sundial in gilded brass circa 1518 made for Cardinal Wolsey (16). This block in the form a prism with eight sides, the lower side resting on a base, has 9 dials: one horizontal for 5-12-7 o'clock, each one for South, East, North and West dials, 2 polar and 2 equinoctial dials calculated for 49° and is very like the figure shown in his lecture notes. It is conserved in the History of Science Museum, Oxford, [see the cover illustration].

Kratzer lectured on the Celestial Sphære of Johannes de Sacrobosco, on the making of astrolabes and the geography of Ptolemaios at Oxford. He designed a polyhedral sundial in 1520 which was executed by the mason William East and erected in front of St. Mary's church at Oxford, This sundial has not survived; the only remnants are a drawing and a description which does not fully correspond. So much can be made out: a four-sided block. resting on a short round column, was surmounted by a four sided pyramid, which in its turn carried on its tip a sphere with a surmounting cross. The East side of the block exhibited the green hour lines commencing at sunrise; the West side showed the blue lines of the hours since sunset; whereas the South side displayed a semi-circular dial, and below this a net of curved lines representing hours since sunrise and sunset; and the North side contained a net of lines showing the orbits of the Sun and Moon. The South face of the pyramid may have carried a Polar dial (17).

Circa 1520-30 Kratzer designed the polyhedral block sundial for the garden of Corpus Christi College at Oxford. This monument too is lost, it was very like the sundial belonging to Cardinal Wolsey, being based likewise on a eight-sided prism lying one one side, but showing two additional plane dials. A concave sundial replaced the horizontal dial; over this there was a sphere with a dial-plate resting on iron arches (18).

Two dial instruments of parchement circa 1546: 'organum aestivum maris' and 'organum motuum humorum humani corporis', were recorded in 1559 in the library of Ottheinrich, Duke of the Palatinate (19).

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15. Alte Uhren und ihre Meister, Ernst v. Bassermann-Jordan, Leipzig, 1926. (pages 51-52).

3, 13. The book of Sun-Dials, Mrs. Alfred Gatty. New Edition by Eden and Lloyd, London, 1900.

4. 16, 17, 18. Early Science in Oxford, R. T. Gunther, Oxford, 1923-29. Volumes I, II and V. (4, vol. II, pages 279 and 284; 16 vol. II, illustration facing page 106; 17, vol. II, pages 103-105, with illustration, 18, vol. II, pages 105-106 with illustration).

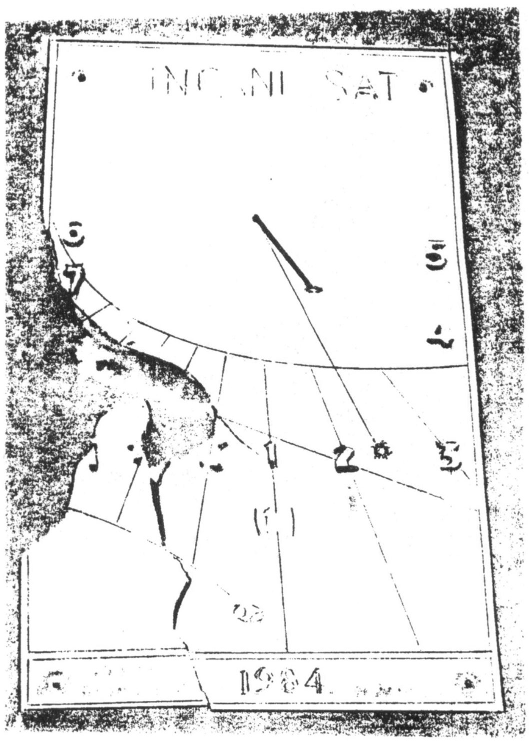
19 Ottheinrich und die Kunst (Mitteil z. Geschicte des Heidelberger Schlosses, V), Hans Rott, Heidelberg, 1905. (page 211).

2. Biographien zur Kulturgeschichte der Schweisz, R. Wolf, 1858-61. (Vol. I, page 13).

5, 6, 7, 8, 9, 10, 11, 12. Verzeichnis der astronomischen Handschriften des deutschen Kulturgebietes, Ernst Zinner, Munich 1925.

1. Die Fränkische Sternkunde im 11 bis 16 Jahrhundert, Ernst Zinner. (XXVII Bericht d. Naturiorschenden Gesellschaft), Bamberg, 1934. (pages 23-25).

14. Entstenung und Ausbreitung der Coppericanischen Lehre, Ernst Zinner. (74 Sitzungsterbericht d. Physikalischmedizinischen Sozietat), Erlangen, 1943. (page 418).



Broken Sarajero Sundial

SUNDIAL PLATE

The National Trust for Scotland has produced a new sundial plate (first edition limited to 500 examples only) to complement the National Trust for Scotland Plate Collection, and this can be ordered as a separate item from:

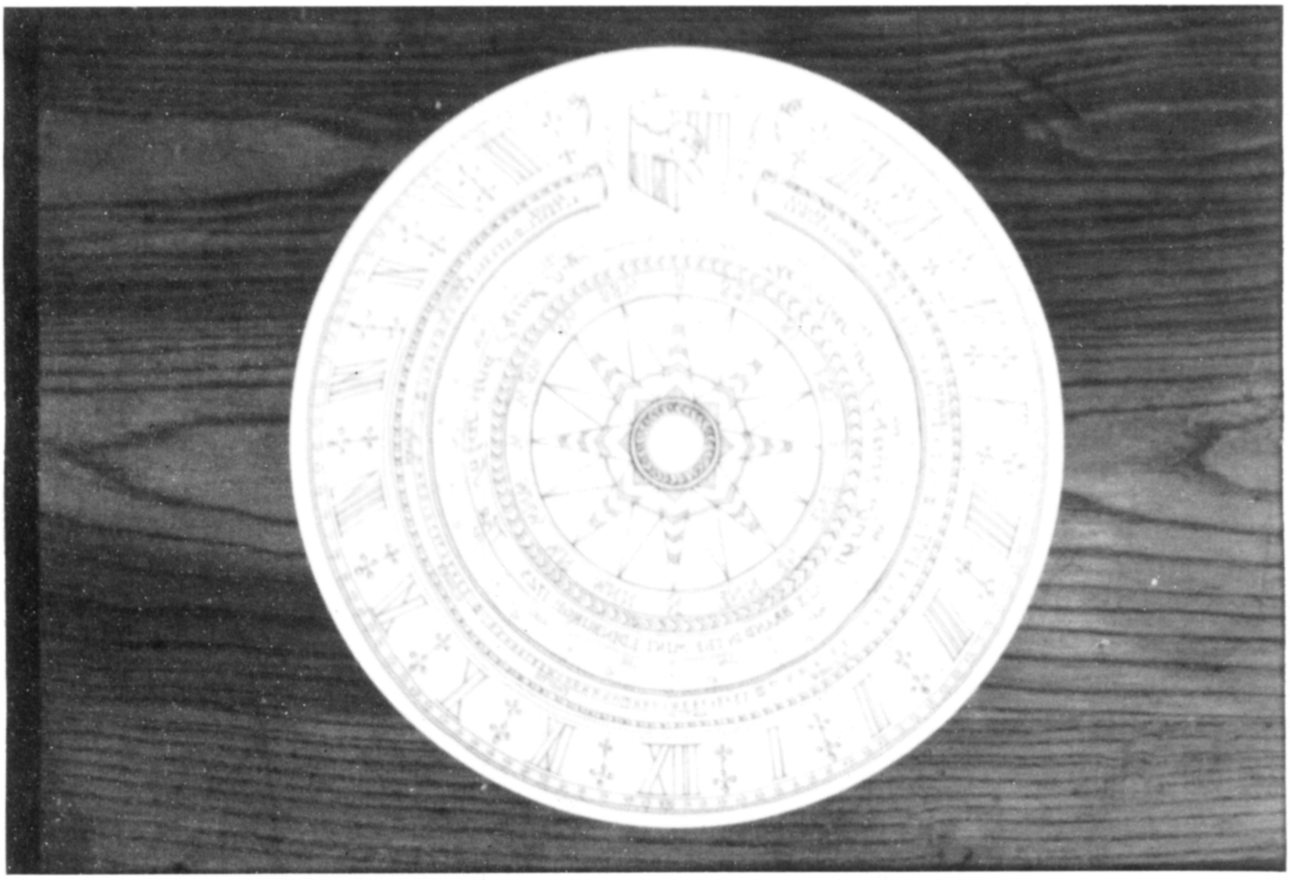
The National Trust for Scotland, 5 Charlotte Square, EDINBURGH EH2 4DU.

It is item number 88 in their recent catalogue, and is 23 cm in diameter and is printed in shades of grey. Sundials in the Trust's care are the inspiration for this design which carries the arms of David Erskine "one of ye Lords of Session and Judiciary". The centre is the usual compass and rose, with "ALX BRAND IN THE MINT EDINBURGH 1723" in a surrounding border. Alas someone not familiar with sundials has placed "WATCH EASTER" in lieu of "WATCH FASTER" in two places, there being an Equation of Time engraved in another border between the centre compass and external hour scale delineated from 4 am to 8 pm. On the back of the plate is a miniature of the compass and rose with "Design by Deborah Phillips inspired by sundials in the care of The National Trust of Scotland" - Fine Bone China". This is described as an exclusive backstamp. If the number on the back is a serial number, the plate obtained is number 5.

The cost is £15.95 plus £3.25 postage and package, cheques and postal orders payable to "The National Trust for Scotland Trading Company Limited"; or by credit card. Allow up to 28 days for delivery, any enquiries telephone 031-243 9399. The plate is delivered in a well-packed container which ensures the plate arrives in good condition. Of course purchasers who can call can save the £3.25 cost of delivery.

The Editor has a number of order forms for those who wish to obtain one or more of these plates, or a catalogue containing an order form can be sent by post by application to the address above. He would like to express his thanks to the member of the staff of the Royal Scottish Museum who first wrote to him in respect of this sundial plate.

Whilst on this aspect, there is a circular tile sundial available at the Science Museum, Exhibition Road, London. It is called the "Sun Tile" and has a plastic gnomon which can be bent to the correct latitude. It is doubtful if it could be left outside permanently since the porous ceramic body absorbs water which then destroys the tile if it exposed to freezing conditions. It would be perfectly alright placed on an inside window sill. However is is ideal as a table mat since it has a cork pad fitted to the underside and would make an excellent dinner table display for the keen gnomonist. The sun displayed in the centre has a very bright cheery face, there is a hole in the dial to accommodate a plastic rod gnomon.



NEW COLOUR POSTCARD SERIES

A. V. SIMCOCK

The Museum of the History of Science, Oxford, launched a new series of colour postcards in July 1993, and has just added a further five cards to the series which represents a broad selection of themes from the Museum's wide and varied collections.

Postcards are one of the most viable ways of projecting any public institution and the most universally popular type of souvenir for the visitor. This was well understood by the first Curator R. T. Gunther, who at the opening of the Museum in 1925, launched the famous 'Old Ashmolean Series' of postcards, which are now valued as collector's items. The Museum is located in the Old Ashmolean Building in Broad Street, near the Sheldonian Theatre. There were at least 75 'titles' in the Old Ashmolean series: and in fact several of them are still available and on sale at the Museum's bookstall.

A new series of postcards was issued in the 1960's, including the perennial best-seller, Einstein's blackboard (still available). The present third series consists so far of the following:

'The Dodo, an oil painting by Louis Gunther, circa 1877 (copied from a seventeenth century painting).

'The Measurers', an oil painting formerly attributed to Hendrik van Balen, circa 1660 (showing numerous instruments and procedures involving mathematics and measurement).

'Polyhedral Sundial', attributed to Nicholas Kratzer, circa 1525, made for Cardinal Wolsey.

'Compound Microscope', attributed to John Marshall, circa 1710, made for the Earl of Orrery.

'Verge Alarm Watch' by unknown maker, probably French, circa 1600.

"Experimental Cyanotype' by Sir John Herschel, 1842. (this represents the invention of the blueprint by Herschel).

It is intended that the new series will be added to from time to time. The postcards are 20p each if purchased at the Museum bookstall, or they can be ordered by post (postage being extra [47p] for the minimum mail order of 20 cards). The quality of the postcards in the new series is excellent.

In 'The Measurers', number 2 of the series, which purports to show the instruments and practices which are meant to illustrate the words of the Roman poet Horace. It is doubtful if Horace would have been able to interpret the dialling instruments from his words since they are far removed from his time.

The postcard illustrating Kratzer's portable sundial (number 3 of the series) is an essential addition to any diallist's collection..

Please note that although the 'Verge Alarm Watch', number 5 of the series, contains a sundial and magnetic compass, only the underside of the case of the compass is visible in the view given of the watch (see accompanying illustration). Compare the elegant engraving of this watch to the crude decoration of the Kratzer sundial.

The address of the Museum of the History of Science is:

Old Ashmolean Building
Broad Street
OXFORD OX1 3AZ

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EDITOR: A visit to the Museum of the History of Science at Oxford will prove well worth while as it houses the largest collection of portable sundials in the world and also has what is probably the most comprhensive dialling library situated in one building. Mr A. V. Simcock is the Librarian in charge of this impressive library.

SUNDIAL MAKERS

All makers listed are members of The British Sundial Society.

RAY ASHLEY (Dialmaker & Silversmith) • 2 Blythe Hill Lane, Catford, London, SE6 4UH. (081 690 5007)
Designer/maker of Vertical, horizontal and portable sundials. All dials carefully calculated for location and installed. Can use metal. painted wood, slated, stone etc. Public or private commissions.

BROOKBRAE Ltd (Oliver Gero) • 53 St Leonards Road, London, SW14 7NQ. (081 876 9238)
Designers, makers and installers of architectural sundials and armillary spheres for buildings and open spaces. Also available, an attractive range of horizontal dials and plinths for private gardens.

CONNOISSEUR SUN DIALS (Silas Higgon) • 19 Ridgeway Avenue, Coventry, CV3 5BP. (0203 415250)
Traditional dials in brass or bronze including horizontal and vertical (any declination). Armillary spheres; equatorial, elevation and analemmatic dials. Plinths available. Enquiries welcomed.

JAMES DRIVER • Elm Tree Cottage, Rushwick, Worcester, WR2 5TB. (0905) 420080)
Dials made to customers' requirements. Unusual dials using non-traditional materials a speciality. Enquiries welcome.

DAVID GULLAND • The Old Coach House, 5 Rotchell Road, Dumfries, DG2 7SP. (0387 51492)
Glass engraved sunidals to hang in window or free standing. Made to customers' location and window direction. Dial furniture (motto, design etc) can be added as desired.

W.J. HAZELL • 15 Pinkwell Lane, Harlington, Hayes, Middx., UB3 1PQ. (081 573 8710)
Dials can be made to a variety of designs following discussion with potential customers, including erection on site and plinth if required.

SALLY HERSH (Sculptor and Lettercarver) • School Lane, Lodsworth, W. Sussex, GU28 9DH. (07985 248)
All sizes of vertical and horizontal dials designed, hand carved in a variety of stone, either plain carved, painted or gilded finish. Dial furniture designed or to clients' specification. Installation service.

IRONSTONE FORGE (David Sim, Artist Blacksmith) • 1 Melrose Avenue, Reading, Berks., RG6 2BN. (0734 667531)
Horizontal in brass or stainless steel. Vertical, wall mounted or on a pillar. Portable dials, ring dials. All individually designed to customers requirements. Plinth and installation service available.

BEN JONES • 16 Rosebery Road, Mount Pleasant, Exeter, Devon, EX4 6LT.
Dials in stone, slate and wood. Dials and plinths can be made to customers' design. Installation service available. Workshop in Chudleigh, Devon open to the public weekends.

COLIN McVEAN • Gearings, London Road, Fairford, Glos., GL7 4AW. (0285 712 309)
Many types of dial, in slate, copper, brass, wood or marble can be made on request, installation possible. Enquiries welcome.

MERIDIAN SUN CLOCKS AND PLAQUES • Barnacle Cottage, Back Lane, Meriden, Nr. Coventry, CV7 7LD. (0203 465634)
Cast bronze dials of various sizes, horizontal, vertical and equatorial, also transportable wooden educational design. Vertical dials have adjustable orientation and three designs of gnomon.

MODERN SUNCLOCKS (D Hunt) • 1 Love Street, Kilwinning, Ayrshire, DA13 7LQ. (0294 52250)
Specialising in individually-printed plans for a vandal proof ground level 'Sunclock' using a person's own shadow to tell the time. Approved by 'WHICH' magazine and ideal as a school project.

ALEX MONROE, SILVERSMITH • 401½ Workshops, 401½ Wandsworth Road, London, SW8 2JP. (071 627 2513)
Sundial designer and maker, most interested in challenging commissions for both fixed and portable dials. Happy to supply plinths and will install.

OUGHLEY DIALLERS AND WEATHERCOCKMEN • 71 Killynure Road, W. Carryduff, Belfast, BT8 8EA. (0232 813186)
Horizontal, Wall - (any aspect), Armillary, Equatorial supplied, other types we will undertake. Dials can be made to customers' design. Pedestals supplied in natural or reconstituted stone and installation service available.

PHOENIX SUNDIALS (C.J. Thorne) • Trafalgar Lodge, Newport Road, Barnstaple, Devon, EX32 9ED. (0271 76720)
Vertical dials in traditional slate or painted wood. Horizontal slate dials. Commissions invited for design, construction and installation of all types of dial. Repair, restoration and conservation of existing dials.

SOLAR TIME (H. Franklin) • 4 Harveys in Town, Samford Courtenay, Oakhampton, Devon, EX20 2SX. (0837 82848)
Wall and horizontal garden dials in Welsh or Delabole slate with brass gnomons. Customers' name, house name, motto, date etc can be added. Other dials considered on request.

SOUTH WEST SUNDIALS • Sundial House, 15 Chesterfield Road, Laira, Plymouth, Devon, PL3 6BD. (0752 227582)
Standard range of dials: engraved brass horizontal, Delabole slate vertical, S, E & W facing. Commissions to produce traditional or unique dials undertaken. Plinths can be supplied.

TANGIBLE INNOVATION • Faraday Road, Newbury, Berkshire.
'Druid' Universal (helical) dials. This is a special type of Equatorial, which is operational at any time of day or year and in any location.

UPPER HOUSE DIALLERS • Upper House Farm, Dilwyn, Herefordshire, HR4 8JJ. (05447 245)
Horizontal and wall dials. Dials can be made to customers' design, plinths can be supplied and there is an installation service available.

SUNDIALS BOOKS

PUBLISHED THIS CENTURY IN ENGLISH

AKED, Charles	Dialling References, 'Antiquarian Horology'. Privately published, pp. 19.	1990
ANNO, Mitsumasa	The Earth is a Sundial, pp. 32.	1986
BOTZUM, R. & C.	Scratch & Sundials on Hereford Churches. Privately published, pp. 48.	1988
BROOKS & STAINER	Cambridge Sundials. Privately published, pp. 56.	1991
BRYDEN, David	Sundials and Related Instruments Cat. No. 6. The Whipple Museum, Cambridge, pp. 108	1988
COLE, T.W.	Various small booklets on Scratch Dials. The Hill Bookshop.	1930's
COUSINS, Frank	Sundials A Simplified Approach, John Baker, London, pp. 247.	1969
CROSS, Launcelot	A Book of Old Sundials and their Mottos. T. N. Foulis, pp. 102.	1914
DANIEL, Christopher	Sundials on Walls. National Maritime Museum, pp. 25.	1978
DANIEL, Christopher	Sundials. Shire Books Ltd, pp. 32.	1986
DRINKWATER, Peter	The Art of Sundial Construction. Privately published, pp. 80.	1987
EARLE, Alice Morse	Sundials & Roses of Yesterday. Macmillan Co, London & New York, pp. 461.	1902
GATTY, Mrs. Alfred	The Book of Sundials, (Eden & Lloyd ed). George Bell, pp. 546.	1900
GREEN, Arthur	Sundials, Incised Dials or Mass Clocks. SPCK, London, pp. 203.	1978
HENSLOW, Geoffrey	Ye Sundial Book. W. & G. Foyle, London, pp. 422.	1935
HERBERT, A.P.	Sundials Old and New. Methuen & Co, London, pp. 198.	1967
HORNE, Ethelbert	Scratch Dials, Their Description & History. Simkin Marshal Ltd, pp. 72.	1929
JENKINS & BEAR	Sundial and Timedials. Tarquin Publications, pp. 15.	1987
MAYALL & MAYALL	Sundials. Sky Publications, USA, pp. 250.	1973
PATTENDEN, Philip	The Pelican Sundial. Corpus Christi College, Oxford, pp. 52.	1980
PATTENDEN, Philip	Sundials at an Oxford College. Corpus Christi College, Oxford, pp. 100.	1979
PRICE, Laurence	Scratch Dials. Sun & Harvest Publications, pp. 92.	1991
ROHR, René R.-J.	Sundials, History, Theory and Practice. University of Toronto Press, pp. 142.	1965
SOMERVILLE, Andrew	The Ancient Sundials of Scotland. Rogers Turner Books Ltd, pp. 104.	1990
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DAVID YOUNG

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THE SECRETARY'S NOTEBOOK

WE ARE FIVE!

In May this year the British Sundial Society will be five years old, not a great age and hardly a milestone to be celebrated or a history to be written, as indeed it may be in twenty-five or fifty years time. However many members have asked me how the Society came about and who was responsible for its formation. I will therefore try to answer this question as briefly as possible but of course it is from a very personal viewpoint.

My own association with sundials started through my lifelong interest in photography. I had been giving illustrated talks to local societies and was looking for a new subject with pictorial interest. Like my fellow members I had never met anyone who knew anything about sundials despite living only a mile away from Noel Ta'bois who was, unknown to me, writing "The Sundial Page" in the *Antique Clocks* magazine. Later I was to meet Andrew Somerville through reading an article of his in the *Scots Magazine*, and later still met Christopher Daniel at the National Museum, Greenwich. In both cases I was to realise the advantage to be gained by meeting others who had a much great knowledge of the subject than myself. Both Andrew and our present Chairman were interested in the idea of a Sundial Society but both of them were busy on various projects and could not spare the time to take the initiative, although they did have a number of contacts, here and abroad in the sundial world. As Andrew said at our first meeting, "we are all waiting for somebody else to make a start!"

There the matter was left for some two years when, out of the blue, I received a call from a gentleman with a blunt Yorkshire accent who said he had contacted Dr. Somerville about the possibility of forming a society for those interested in sundials and that Andrew had referred him to me, "so what about making a start?" The voice over the telephone was none other than that of our worthy Editor Charles Aked, and after some initial correspondence I travelled to Cheshire to see Andrew Somerville who had by this time all but completed the work on his book *The Ancient Sundials of Scotland*. He made two long distance calls to Charles Aked and Christopher Daniel, upon which agreement was made to send out a letter to be published in *Antiquarian Horology*, the journal for those interested in the older methods of timekeeping; and all those people and societies whom we thought might be interested. Charles Aked's suggestion that we might make a start by becoming a group within the Antiquarian Horological Society had to be abandoned on learning of the restrictions which would be imposed upon us and also many prospective members did not wish to join the AHS. The AHS was not prepared to accept articles on modern sundials and there would be no space set apart purely for sundial topics, so it became inevitable that a new independent society would be preferable. When some forty replies had been received from prospective members, and only one or two of these were AHS members, we decided to call an initial meeting on 4th May 1989 at my home in Chingford to make a decision.

After some discussion it was decided to inaugurate the society although one member of the four people present expressed the opinion that the time was not yet quite ripe and he wanted to wait another year. Andrew agreed to take on the Chairmanship and act as Secretary with the help of his wife Ann, Charles was to produce a newsletter or bulletin to circulate to members; and I agreed to act as Treasurer and Membership Secretary. We recorded our aims on paper, together with a draft constitution, and decided upon the very modest sum of £7.50 for the membership contribution.

Most importantly there as the name for our new society; several suggestions were put forward, amongst others *The Sundial Club of Great Britain, The Sciagraphical Society and The British Gnomonics Society*. The last suggestion was hastily scrapped after a remark was made that it might be thought of as a society for the preservation of garden gnomes! At the time we were envisaging a membership of about fifty academicals and the circulation of a duplicated newsletter. Little did we realise that in little over a year we would have a membership approaching two hundred, have held a very successful conference at Oxford attended by seventy of our members, and produced the first of our properly printed journals. The events of that first year is another story that must wait until another time.

There is no doubt in my mind that Andrew Somerville was the architect of the BSS Society. The framework he laid out proved to be a sound rock on which we have steadily built and will continue to build. It was a very great blow to the infant Society when he passed away and the first page of our very first printed Bulletin had to be devoted to his obituary. He was a very fine man and both dedicated and knowledgeable in the science and history of dialling.

The BSS Society obtained its title only when Andrew Somerville discovered a defunct gardening society which agreed to relinquish its title of Sundial Society to him for our newly formed society. It was he too who made the final decision on the format and typeface for the printed form of the Bulletin although sadly he was never to see the first copy. He would have been delighted in the progress made in the last few years towards building up the society he did so much to foster himself.

However if asked <u>who</u> started the Society, then my vote would be for Charles Aked who came upon the scene at the right time and gave us all the incentive to go ahead.

USEFUL ADDRESSES

Mr. Charles K. Aked 54 Swan Road WEST DRAYTON Middlesex UB7 7JZ	[Editor]	Tel: 0895 445332
Mr. C. St. J.H. Daniel 57 Gossage Road PLUMSTEAD COMMON London SE18 1NQ	[Chairman]	Tel: 081 3178779
Mr. R.A. Nicholls 45 Hound Street SHERBORNE Dorset DT9 3AB	[Treasurer]	Tel: 0935 812544
Mr. P. Nicholson 9 Lynwood Avenue EPSOM Surrey KT17 4LQ	[Sponsorship]	Tel: 037 27 25742
Mr. Alan Smith 21 Parr Fold WORSLEY Manchester M28 4EJ	[Northern Liaison]	Tel: 061 790 3391
Mrs. Anne Somerville Mendota Middlewood Road HIGHER POYNTON Cheshire SK12 1TX	[Library, Archival Records & Sales]	Tel: 0625 872943
Mr. Robert B. Sylvester Barncroft Grizebeck KIRBY-IN-FURNESS Cumbria LA17 7XJ	[Membership]	Tel: 0229 889716
Mrs. Jane Walker 31 Langdown Road Little Sandhurst CAMBERLEY Surrey GU17 8QG	[Education]	Tel: 0344 772569
Miss R. J. Wilson Hart Croft 14 Pear Tree Close CHIPPING CAMPDEN Gloucestershire GL55 6DB	[Council Member]	Tel: 0386 841007
Dr. I.D.P. Wootton Cariad Cottage Cleeve Road GORING-ON-THAMES Oxon RG8 9BD	[Registrar]	Tel: 0491 873050
Mr. D.A. Young Brook Cottage 112 Whitehall Road CHINGFORD London E4 6DW	[Secretary]	Tel: 081 529 4880

Printed by: Stratford Repro, 42 Greenhill Street, Stratford-upon-Avon, Warwickshire. Tel: (0789) 269650