The British Sundial Society

BULLETIN

No. 97.3

JULY 1997

BULLETIN 97.3 - JULY 1997

CONTENTS

Front Cover: Countess's Pillar, Penrith - Chris Daniel
Back Cover: Goblet Dial - A.A. Mills

Printed by Fieldfare Publications 01223 311334

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BULLETIN

OF THE BRITISH SUNDIAL SOCIETY

ISSN 0958-4315

ISSUE 97.3 - JULY 1997

EDITORIAL

Embarking on my duties as editor of the B.S.S. Bulletin, I am fully conscious of the heavy responsibility of the task. The status of the Society depends largely on the Bulletin, which has already been well-established in high regard. A tribute to Charles Aked the retiring editor appears in this number.

My aim is to maintain and enhance the reputation of the Society and its journal. I am viewing the job also with a sense of joyful anticipation. I recently attended the Society's Annual General Meeting at Newton Rigg, Cumbria, (reported herein); so I am reminded again of the enthusiasm and skill, erudition and ingenuity, of my fellow members of the Society. These qualities will ensure that there will never be a shortage of material for the Bulletin. Keep it coming!

The cosmopolitan nature of our contributions and readership is a delightful aspect of the Bulletin. The present issue has articles from France, Italy, Israel and Turkey. The next issue will, I hope, carry articles from Australia and Germany. All the world is our stage - a happy thought!

The Bulletin carries much material of a technical nature, full of interest to the designers among us. Other articles have a historical or literary context, such as the Stephenson Dial in the present issue and the Thomas Hardy Dial in a recent one. I also welcome contributions which could be called 'snippets'. So when you come across an unusual dial, or figure out a new design, or construct a brand new sundial or grieve over a derelict one, or even see a 'thingey on a whatsit' - please put pen to paper, eye to viewfinder or finger to keyboard and send the Bulletin a snippet.

THE ZODIAC

COLIN McVEAN

Many many years ago there was a round island in the sea which had a curious collection of animals, people and things living on it. It was completely circular and was happily divided into twelve equal parts like a cake which had been cut into twelve equal slices. To describe who lived there you have to begin somewhere so let us begin with the Ram, then going round the island clockwise you come to the Bull, the Twins, the Crab, the Lion, the Virgin, the Scales, the Scorpion, the Archer, the Goat, the Water-Bearer and the Fishes.

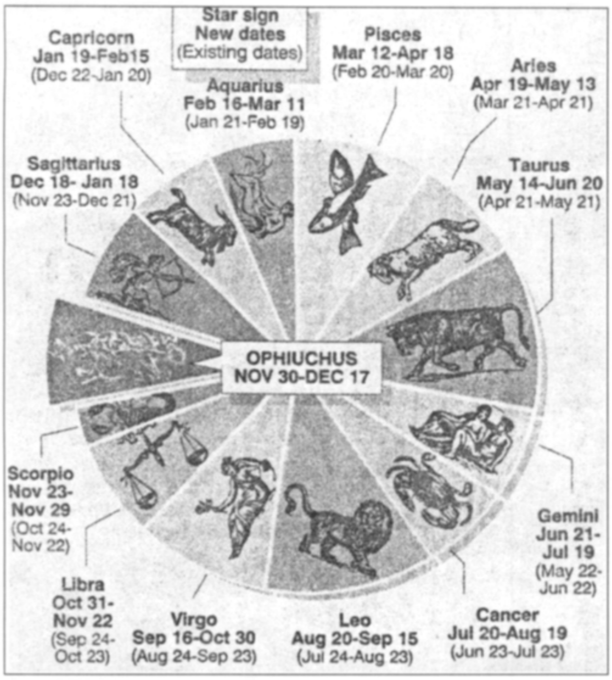
One day the Ram decided he would do a tour round the island and visit everybody, so he jumped over the fence into the Bull's field. The Bull was very large and uncommonly strong. His strength was sometimes called on to push unruly stars back into their proper places. Like many large and strong animals he was very gentle so it was no surprise to find the Twins sitting on his back. Then they all went down to the beach to see the Crab. The Crab had just completed his new skin so he did not have any barnacles on it yet. His mother had kept all his skins since he was a baby and had them all nicely arranged in the sand outside her lair. The Crab always knew what was going on all over the world because he could live on land or under the sea. All the sea animals except the very smallest who were rather nervous of him would bring him news. He told his friends that the Lion had not been very well, probably through gorging his food without chewing it properly. After some further chat the Ram went on to see the Lion who was by now feeling much better as the Virgin had given him a draught prescribed by the Scorpion and weighed out on the Scales.

The Virgin was always very kind to everyone and she even got on well with the Scorpion who was a hundred years old, very short-tempered, knew a great deal and did not mind saying so. The Virgin had once been engaged to Orion, but she got so tired of his boasting and showing-off that she left him. She kept a general eye on everything, weighing the baby stars on the Scales to see that they put on weight. She was very pleased to see the Ram; she scratched his head and found him some delicious clover with the dew still on it. They discussed local matters for a time, then the Ram said he must be getting on. The Virgin told him to be careful of the Scorpion who was in a bad mood because he had been told that he would have to share his area with the Serpent-Bearer who had lost his job with the circus. So the Ram went on, past the Scales. You could not talk to the Scales because they were not alive, but it was always an interesting place to be because all the island's records were kept there. Anyone was allowed to use the Scales it they were careful and kept them clean and polished.

The Ram came to the Scorpion who was grumbling away about the Serpent-Bearer, muttering that he would sting the so-and-so, and that he didn't want no snakes about neither. *He* should be the only one to have poison, and what did They think he was. The Ram didn't say anything, but thought to himself that if they *must* have a Serpent-Bearer the Scorpion's part would be the best place for him. He certainly wanted no one on *his* patch.

Having commiserated with the Scorpion for a time, the Ram went on to watch the Archer who was galloping about shooting arrows at a target as he thundered past. He was rather a vain person and was getting annoyed by the Goat who had been making rude remarks about him, but at the same time keeping a safe distance from the hooves. The Ram made some tactful remarks about how clever the Archer was, and what a good shot. However as it is rather difficult to chat to someone who is rushing about all the time, he went on to bandy words with the Goat. If you hadn't seen the Goat you would know he was there by the extremely strong smell. The Ram always enjoyed the Goat's company as he was amusingly catty about other people. The Goat took the Ram to a specially good piece of grazing which he had kept secret, and they had an enjoyable half-hour together. The Ram was careful to keep the Goat in front of him because the Goat always thought it was funny to come up behind people and give them a good butt. In his turn the Goat was wary of the Ram's huge bulk and enormous horns.

By now the Ram was getting rather thirsty, so he sauntered on the the Water-Carrier who looked after the beautiful fresh water stream which watered the island. He was rather idle and was always ready for a chat. They discussed the weather and other matters, and how things would never be the same again now they had the Serpent-Bearer foisted on them. The Ram now thought it was time he was getting home, so he set off on the last part of his journey, which was past the beach belonging to the Fishes. They were disporting themselves in the sea, and called to the Ram to join them. He thanked them but decided he did not want to get his fleece soaked with salt water. So he



shouted good-bye, and they shouted back Cetus the Whale had been asking after him.

Then thankfully he came to his own meadow again, and sank down on the luscious grass. His round of the island had taken longer than he thought, a total of eleven months, so he decided to spend the next month at home.

Editorial note: The boundaries of the constellations as drawn by the International Astronomical Union in 1928 brought the constellation Ophiuchus the 'Serpent Bearer' onto the ecliptic, thus bringing in a thirteenth 'Zodiac' constellation. In this re-drawing the sun's period in Scorpio was lessened. (Hence the Scorpion's anger about the Serpent Bearer in the story). In many Zodiac pictures the Archer is a man kneeling and taking aim with his bow. In other pictures, and in this story, he is a centaur, Chiron, who taught the ancient Greeks to navigate by the stars.

SUNDIALS IN ISRAEL

SHAUL ADAM

Sundials have been produced and used in the land of Israel since olden times. It is interesting to consider the various types in use in different eras, and to survey the dials old and new, still in use around the country.

EVIDENCE OF ANTIQUITY

Evidence for the ancient use of sundials comes from written sources and also from archeological artifacts.

Written Sources: The accounts in the Bible (II Kings 20 and Isaiah 38) of the 'steps of Ahaz' clearly refer to a shadow in use as a time marker. Ahaz was king of Judah 742-727 B.C. and the sundial was still in use during the era of his son King Hezekiah. A book of religious rules, the Mishna, of the 2nd century A.D. mentions 'a nail in an hour stone.' An interpretation of this work by a learned rabbi, Ramba'm, in Spain in the late 12th century A.D. describes the 'hour-stone' as follows: "A stone will be built in the land, and on it will be drawn straight lines, the names of the hours written on them, and it is round, and in the centre of this round, a perpendicular nail, on a perpendicular angle; all that will stick-in [place] equal shadow of this nail to one line from these lines will know how many hours passed of the day…"

According to tradition the hour-stone was round and may have been a horizontal sundial, but it could also have been a spherical or hemicyclium type that was in use in Israel at that era.

Archeological artifacts: A number of archeological expeditions during this century have found objects identifiable as sundials. Indeed finds have also been make by chance in fields near kibbutzim, not as part of a formal archeological dig. Most of these dials have been of the hemicyclium type (Berosus dials) belonging to the Byzantine era, 3rd to 4th centuries A.D.. The oldest sundial artifacts were found in excavations at the Kotel (Wailing Wall) in Jerusalem; and on Mount Hebron, the palace of Khilkia. These belong to the 1st century A.D..

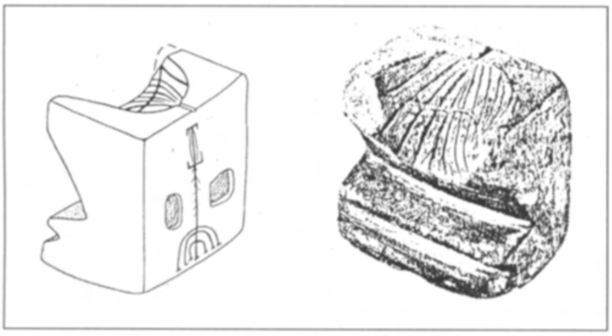


Fig. 1 Sundial found in excavation of the 'Herodian House'

Fig. 1 shows a drawing of a sundial unearthed from the 'Herodian House' in the Old City of Jerusalem. It is a small portable stone sundial. On its back is a carving (upside-down) of the Seven-branched Candlestick, a typical Jewish symbol, showing that the dial was made or owned by a Jew. The sockets each side of the candlestick probably held jewels.

A particularly significant find was make by Dr. A. Negev, at Curnub in the desert SE of Be'er-Sheva. The dial was found next to the Byzantine church tower. It is of the hemicyclium type, unearthed complete and unblemished, with only the gnomon missing. At the centre is a carved cross, its head marking noon; on each side are carved palm leaves, their axes marking the hours of 9a.m. and 3p.m.. The importance of this find is that the dial's clear precise shape makes its use unambiguous. This reinforces the identification of the use and date of similar but more fragmentary artifacts found elsewhere.

The archeological evidence shows that sundials of the hemicyclium type have been used in the land of Israel for the 500-year period 1st century B.C. to 4th century A.D..

PRESENT DAY SUNDIALS

Eighteenth and Nineteenth Centuries: The oldest sundial of Israel probably standing on it original site, and one of the most beautiful artistically, is a polar dial standing in the yard of the large mosque of Acre. Its dial plate is made of white-grey marble carved with symmetrical decorations. In front there is a sentence carved in Arabic: 'This sundial and the mosque were built by Ahmed Busha el Gazal in the year 1201 of the Hegira, the year 1789 of the Christian calendar.' Ahmed Busha was the Turkish governor of Acre from 1775-1824. The dial plate is 70 x 50cm, standing on a 2m plinth, and in order to reach it one must climb a few steps. Today it is locked behind bars and hard to reach; it requires the permission of the manager to open the locks. (Fig. 2).

Fig. 2 Polar Sundial, Acre, Ahmed Busha Mosque

A horizontal dial dated 1884 is placed on the roof of a Franciscan monastery beside St. Peter's Church, Jaffa. It is marked for hours and half-hours, with initials for the months and zodiac symbols. It has been described in a review published in 1961 but I have not seen it.

Early Twentieth Century: In the first part of this century two sundial makers were working in Israel. One was Rabbi Moshe Shapira, born in Jerusalem in 1889. The other was Father Ivan Frankovitz born in Jugoslavia in 1882, who came to Israel in 1938 and served in many different monasteries.

Fig. 3 Vertical Dial, Jaffa Street, Jerusalem

Moshe Shapira followed his hobby of sundials from the age of 17, and derived much of his knowledge of the movement of the sun in the heavens from the books of Jewish rabbis and scientists. He built 7 dials, mainly in Jerusalem, and concentrated on the traditional Jewish time table: prayer times and so on. The first dial he built, in 1908, is the largest sundial in Israel today, and may well be the most accurate one. It is made of painted wood, shaped as a halfcircle 5m in diameter, and is placed on the south wall of the third floor of a seminary in Jaffa Street, Jerusalem. It carries a mark for every 5 minutes (Fig. 3).

In the large synagogue of Petach Tikva (east of Tel Aviv) Shapira built a sundial, actually 3 interlaced dials, engraved on grey marble, on the synagogue's western wall. For these dials he invented a new reading method, which he called the 'spot method' or 'pinhole method.' Instead of the regular gnomon, there is a flat horizontal metal strip at the top of the dial, its end bent slightly downward; and a small hole is drilled in the bent section. This hole allows sunlight through it and creates a small light-spot in the shadow of the strip; the light spot's position on the dial face reads the time. (Fig. 4). Sadly the dials are in poor condition and badly maintained; the dial faces are faded and hard to read, and permanently stained. A smaller dial of the same kind was built by Shapira on the eastern wall of Hagra synagogue in Jerusalem. It is shaped like a trapeze with double markings for European and Jerusalem hours.

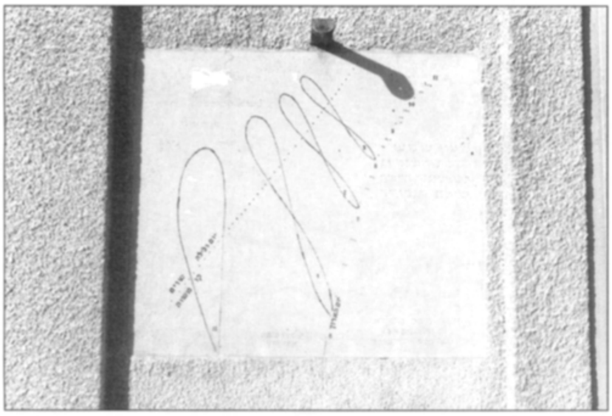


Fig. 4 'Pinhole gnomon' dial at Petach Tikva

The second famous dial-maker, Father Ivan Frankovitz, came to Israel in 1938, served in a number of monasteries, and died in Nazareth in 1967. He might be considered as the champion of sundial builders of Israel. In every monastery in which he stayed, even for the shortest time, he made a sundial: horizontal, vertical or a combination of the two. He may have used the 1884 sundial of St. Peter's in Jaffa as a model for his horizontal dials. On many of his dials he used a chronogram, with bold letters giving the numerical value of Roman numerals the addition of which gives the date (year) in which the dial was made. Thirteen sundials in Israel are known to have been made by Frankovitz. Fig. 5 shows one of the two dials he made in 1942 in the yard of a church on Mount Tavor (SE of Nazareth). The dial consists of two marble faces, vertical and horizontal, with a joint gnomon. Fig. 6 shows a vertical dial in the entrance yard of the church of the monastery in Tabcha on the coast of the Lake of Galilee. It is placed on the south wall of a new building and is 90 x 60cm. In its centre is inscribed the 6-pointed Star of David, and the hour lines radiate from the star. According to the chronogram it was built in 1955. The Latin inscription reads:

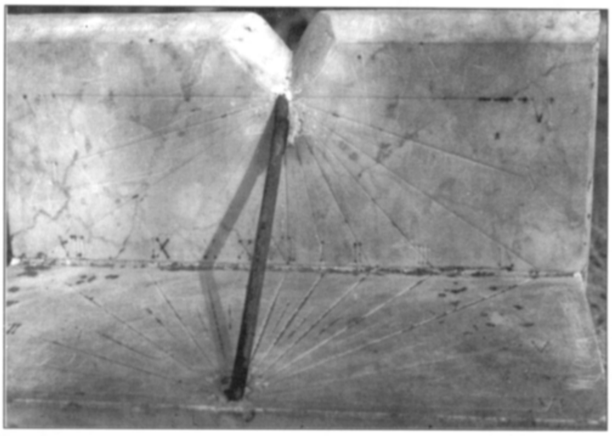


Fig. 5 Vertical/horizontal dial, Chuch on Mount Tavor

o stella **M**aris
virgo p**V**ra gen**I**trix
nostras rege **V**ias horas
pa**C** **I**n ara p**I**e nos orare
o re**X** a**V**e et reg**I**na
bene**DIC**tos **I**n ae**V**o **C**antare

I = 1, V = 5, X = 10, C = 100, D = 500, M = 1000.

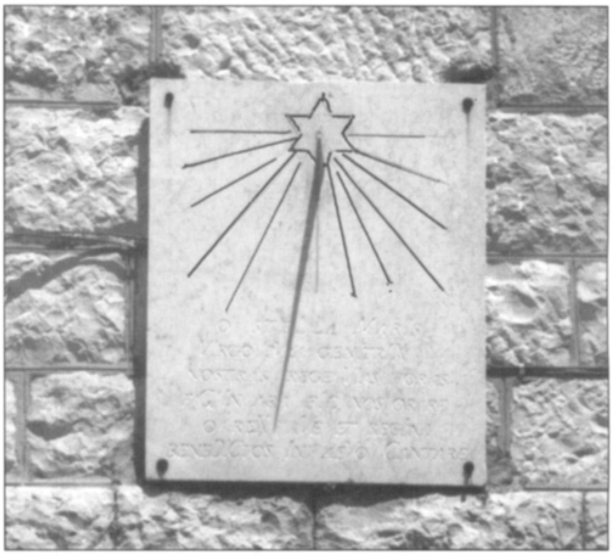


Fig. 6 Vertical dial, Tabcha Monastry. 'Star of David'

Another vertical Frankovits sundial is to be seen on the Freier School in Nazareth; the chronogram indicates the date 1950. There is also a motto carved in both Arabic and Hebrew: 'In the sun I will work, but in the shade I will rest.' A number of other Frankovitz sundials are known to have been made but are in poor condition or damaged.

Other modern sundials:

(a) On the arched gate beside the Omar Mosque and the Rock Dome on the Temple Mount in Jerusalem there is a simple but pleasing vertical sundial of grey marble. The digits for the hours are engraved arabic numerals, and there are 5-minute markings. The gnomon is a simple copper rod.

(b) In the park around the tomb of Baron E. de Rothschild in Zichen Ya'akar there is a lovely statue of a sleeping boy holding a sundial; it is pleasing but not accurate. (Fig. 7).

Fig. 7 'Sleeping boy' statue and sundial, Zichen Ya'akar

(c) In Dagania kibbutz near the Lake of Galilee in the garden of the local museum there is a very good horizontal sundial: a round copper plate inserted in a square block of polished basalt. (Fig. 8, a & b). The gnomon is a copper triangle. The hour markings are made by soldering, thus protruding from the plate. There is a table for the equation of time. On one side of the basalt block is the motto: 'In the shade of our days on earth.' On the south face is the proverb: 'The day is short, the labour is long.' The sundial was designed in 1948, and was made in the 1960's by students of Bezalel College of Arts.

Fig. 8a Dagania Kibbutz: horizontal dial

Fig. 8b Dagania Kibbutz: dial and plinth

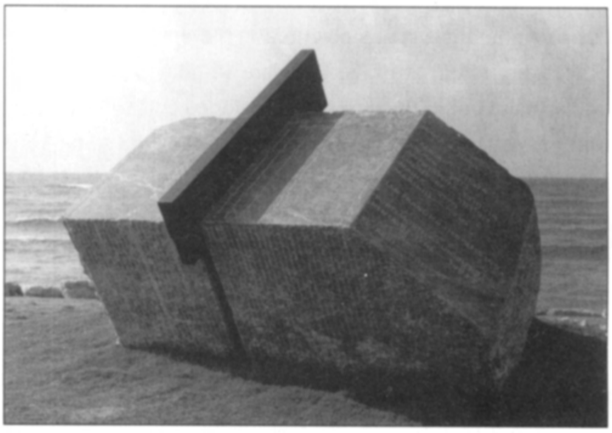


Fig. 9 Polar dial, Bat Galim, "...simple but very good..."

(d) On the sea shore of the Bat Galim district of Haifa there is a good polar sundial make of polished basalt, including the gnomon 4 or 5cm thick. The dial carries information about the time in other parts of the world. The design is simple but very good, and the execution is of high quality. (Fig. 9).

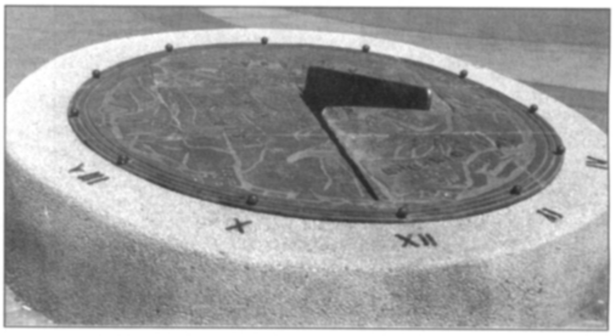


Fig. 10 Eilat, "...built just for art, with no care for scientificc rules

(e) Fig. 10 shows a sundial near the maritime observatory on Eilat on the Dead Sea coast at the southern tip of Israel. I could not decide what type it is, since the dial plate declines from the horizontal, and the gnomon is perpendicular neither to the plate nor to the horizon, nor parallel with the earth's axis. The dial is neither horizontal nor polar, and is not accurate at all. Perhaps it was designed for another place and relocated at Eilat. It seems to me that the dial was built just for art, with no care for scientific rules.

This concludes my description of the most interesting dials of Israel. However I have made several sundials myself, one of which is shown in Fig. 11, a & b. It is a large analemmatic dial in which the public may participate. It is the first (so far the only) one in Israel of this type. It is located in the 'Land of Israel' Museum in Tel Aviv, next to the planetarium. I designed and planned it, and the paving was laid down by the Museum staff. The main paving is of white limestone and the month scale and hour marks are of terra cotta. The sundial forms an interesting attraction for the Museum visitors.

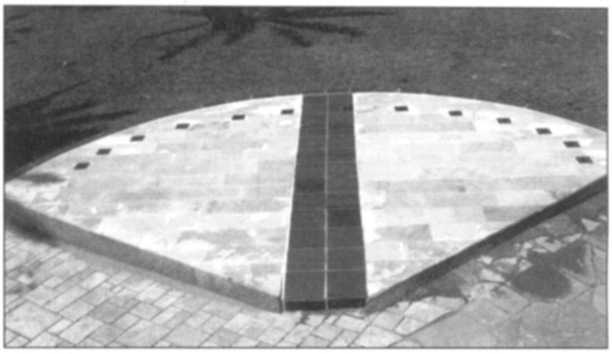


Fig. 11a Analemmatic Sundial - The Land of Israel Museum

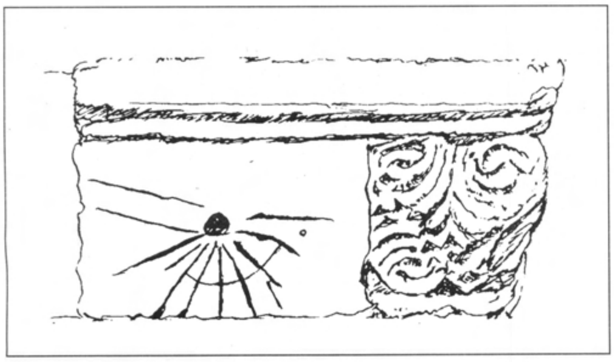
Fig. 11b Analemmatic dial, 'for public participation'

MASS DIAL

FRANK POLLER

For half as long as the church has stood
The gnomon's shadow finger fell
Across the mass dial's stony face,
Telling as nearly as it could
What times the ringer should toll the bell
To summon all to God's holy place.

Mechanical clocks have come and gone
- As their winders and watchers every one -
But this antique dial still looks at the sun
And, given a gnomon, could call forth again
The faithful few who may remain.



BEHOLD THE GLORIOUS SEA!

HARRIET WYNTER

Behold the glorious sea!
Blues, grey greens and flecks of white
Mirror the tones of the sky's blue light
Robbed from the sun's intensity
By preferential scattering.
High frequencies are the first to go
So donor sun is left on low
And colour gold then down to red
Falling to horizon, bled
By greater depth of air
To longer wavelengths and despair.
But no! the sun lives on in white light glory
Reflected on the moon's night journey.

THE STEPHENSON SUNDIAL AT KILLINGWORTH

FRANK EVANS

The sundial on Dial Cottage, the home of George and Robert Stephenson at Killingworth, Northumberland, was, according to John Rowland[1], one of the achievements that both engineers were most proud of in after-life. Indeed on one occasion, George Stevenson told members of the British Associatio that this was one of the finest things that he and Robert had ever done, in view of their sad lack of knowledge at the time.

The dial is dated 1816, the year in which George was thirty five and Robert thirteen. J.C. Jeaffreson, Robert Stephenson's biographer, described its genesis: "The earliest drawing by Robert Stephenson's hand of which there is any record, was that of a sun-dial, copied from Ferguson's "Astronomy" and presented by the lad to Mr. Losh, in the year 1816, in token for his gratitude to him as his father's benefactor. This drawing set the father and son on another work - the construction of a real sundial, which, on its completion, was fixed over George's cottage door, where it still remains, bearing the date: August 11th, MDCCCXVI"[2].

Robert's own account, quoted by Rowland, reads: "We got a Ferguson's "Astronomy" and studied the subject together. Many a sore head I had while making the necessary calculations to adapt the dial to the latitude of Killingworth. But at length it was fairly drawn out on paper, and then my father got a stone, and he hewed and carved, and polished it, until we made a very respectable dial of it."

It would seem that the calculations for the dial, made, in the practice of the time, without trigonometric tables and relying on a system of chords, were principally those of Robert while the execution of the work was George's. Indeed it has been suggested that in truth George had little head for figures and that, in sending his son to school at Dr. Bruce's academy in Percy Street in Newcastle he aimed to use his son's brain to supplement his own deficiencies. (John Bruce, LLD., DCL., FSA., whose highly respected school was founded in 1806, was remarkably well qualified for a schoolmaster).

The dial is, of course, still to be seen, although there is not, and perhaps never was, any trace of "August 11th" in its inscription, only the year of its making. Like all dials of the time it is set to local time, not Greenwich; and L.T.C. Rolt in his biography of the Stephensons[3] was mistaken in suggesting that the two took account of longitude as well as the latitude of Killingworth in its construction. The carving of the dial plate is pleasing but not artistic and the heavy iron gnomon might equally have been made by a jobbing blacksmith. The dial is designed for a south wall with hour lines drawn symmetrically from six a.m. to six p.m., which raises a point of interest. Symmetrically placed hour lines and a vertical gnomon are, of course, indicators of south-facing dials, such as are commonly found on, for instance, the south walls of churches.

But the cottage at Killingworth is not quite south-facing. It faces about fifteen degrees west of south. There are two ways of overcoming this difficulty. The first is the mathematical way of the skilled dialist, when the gnomon is angled away from the vertical so that it may truly lie in the plane of the earth's axis, the hour lines being adjusted accordingly. This method requires more mathematical power than that need for laying out a south-facing dial. The second way may be thought of as the engineer's way. Here a simple solution is found by wedging the dial plate out from the wall until it *does* face south. Then, a south-facing dial will serve.

And that is what the Stephensons did at Killingworth. For a visitor, it is worth examining the Killingworth dial to observe this point. Doubtless the calculations for a south-facing dial were at the extreme of the thirteen year old Robert's capacity, which in no way belittles his immense achievement in designing the dial at all. He could indeed be proud of it.

Dial Cottage and its dial are in the care of North Tyneside Metropolitan Council. The dial was refurbished a few years ago but now again needs attention. The gnomon is bent out of true, the dial plate needs repainting and if the dial is to be of use the trees surrounding it need pruning. But it is a robust construction and will last many years yet, a monument and credit to two of the country's greatest engineers.

ACKNOWLEDGEMENT

I am especially grateful to BSS member John Ingram for drawing my attention to relevant quotations from Jeaffreson and Rowland.

REFERENCES

1. Rowland, John: *"George Stephenson, Creator of British Railways."* Odhams, London, 1954, p. 99.
2. Jeaffreson, J.C.: *"The Life of Robert Stephenson, FRS."* (2 vols.) Longman, London, 1864. Vol 1, p. 44.
3. Rolt, L.T.C.: *"George and Robert Stephenson: The Railway Revolution."* Longmans, London, 1960, p. 17.

QBASIC SUNDIAL PROGRAMS SUNDL1,2 & 3

P.A. LAMONT

The Computer Programs described are:-

SUNDL1	Horizontal Garden Dial and South Facing Vertical Wall Dial.
SUNDL2	Vertical Wall Dial, East or West Declining.
SUNDL3	Wall Dial, East or West Declining with Dial Proclining or Reclining.

All three Programs have been designed from first principles to produce initial solutions in terms of Shadow Angles. The solution for SUNDL3 involved the adjustment of the primary variables (Latitude, Declination and Proclination) to take account of the non-rectangular intersection of the Gnomon and the proclining/reclining Dial. It was then treated as SUNDL2 and finally subjected to an angular transformation of co-ordinates to produce a rectangular Dial with a horizontal baseline.

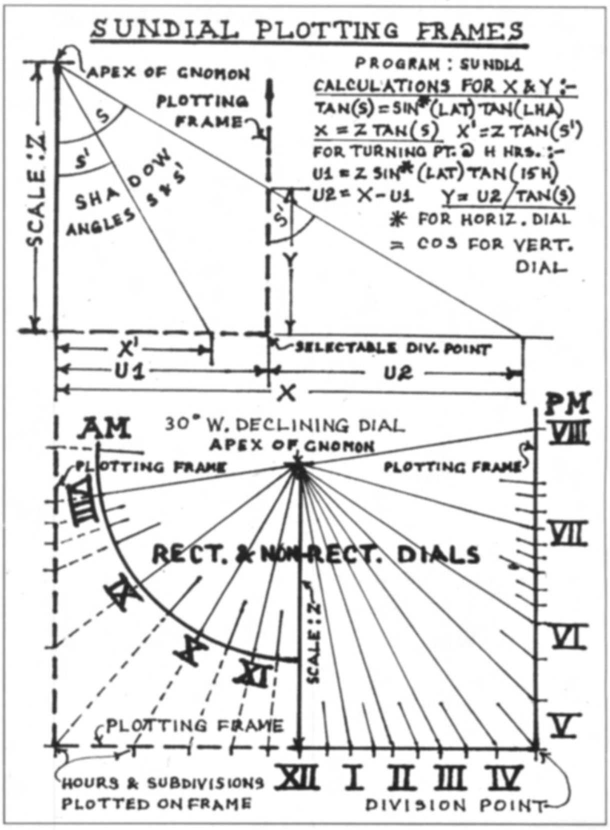
Whilst Shadow Angles inevitably constitute an essential element of the solutions and should be included in the printouts, Angles are not easy or convenient to plot when setting out the actual Dials, particularly when small time intervals (say 5 or 10 minutes) are included in the design. Linear equivalents of the angles provide a more convenient addition to the printouts as these can then be plotted accurately on straight lines with the aid of scales. This feature had been included in all three Programs.

On rectangular Dials, the west, central and right borderlines of the Dial can immediately be used to plot the horizontal X Offsets and vertical Y Offsets. The points on the borders, representing the hours and their subdivsions, then constitute the starting points of the normal sundial pattern of radial lines converging inwardly towards the apex of the Gnomon. The proportions of the Dial can be varied as required by the appropriate selection of the point of division between the X and the Y scales, which usually occurs with shadow angles between 40 and 50 degrees. With circular and other non-rectangular Dials, an initial rectangular plotting frame can be established just outside the limits of the required Dial and a similar procedure followed for the radial lines.

On the computer, the Table of Times, Shadow Angles and X Offsets appears first after the selection of a Division Point and, if necessary, its re-selection until a satisfactory layout is obtained. The Table with the Y Offsets and the continuation of the Times and Shadow Angles then appears thus completing one half of the Dial. With horizontal and south facing vertical dials, the other side of the Dial is of course its mirror image, but with E. or W. Declining Dials, the two sides are different as the sign of the E/W Decline Angle has to be reversed. This is achieved in the Programs by dealing with the "Acute" side of the Dial first and following automatically with the "Oblique" side.

The accompanying Diagram illustrates the principles and calculations involved in establishing the X and Y Offsets and incorporates a composite W. Declining Dial showing the application of the method to rectangular and non-rectangular Dials.

The three programs were originally written in BBC Basic during the 1980's and updated from time to time for "User Friendliness" before being rewritten in Microsoft QBasic in 1984 after the acquisition of a "486" Computer. They have been a very useful starting point in the design and construction of numerous Dials during recent years, including a number of experimental Declining, Proclining, Reclining Dials constructed to verify (with some relief it is confessed!) the results produced in the rays of the Sun by the somewhat convoluted mathematics underlying Program SUNDL3.



WHEN THE SUN SHINES

JOHN DAVIS

Sundials only work when the sun shines, and many articles have been written on the variation of the length of the day throughout the year. But an equally large effect on the occasions when a sundial is usable, especially in Britain, is due to the fact that the sun is often obscured by clouds. This article sets out to see just what percentage of the time a sundial is really capable of giving a reading.

The commercially-available instrument which I use to record the hours of sunshine employs the same shadow casting principles as a sundial. It comprises eight light-sensitive electronic sensors set on a plate around a 5 cm circle, with a 0.5 cm diameter black plastic post set vertically in the centre.

When the sun is shining, at least one of the sensors is in the shadow cast by the post, and the difference in signal is detected by the instrument's electronics, used to control the elapsed time counter. The whole arrangement is covered by a small hemispherical glass dome to keep it weatherproof.

The sensitivity of the instrument is set by a small preset control. The question is, how hazy should the sun be and still be recorded as "sunny time"? As far as I have been able to discover, there is no formal definition of this, which leads me to wonder how sea-side holiday resorts manage to compete with each other for the "sunniest beaches" on a fair and equal footing. I have adopted a rather empirical setting corresponding to having a clear shadow which allows a dial to be read accurately. In practice, this means that a very thin, high cloud cover does not stop the recorder.

The other requirement for the sensor is that it needs to see the sun from sunrise to sunset without any interruptions. Most practical, residential sites cannot meet this criterion. In my own case, despite the lack of hills in Suffolk and the fact that the sensor is mounted on a pole attached to the chimney, the sensor only works from dawn to about 6:30 pm in the summer, when it becomes shadowed by a large poplar tree. In autumn, the lack of leaves on the trees improves things slightly, and in winter the sun sets well before it reaches the offending tree. Thus, on the graphs which follow, the lines show the maximum observable daily hours of sunlight, as well as the theoretical and actually observed values.

All the results are calculated for Ipswich, with a latitude of 52 5' North.

Figure 1 shows the actual results for 1996, which will be remembered as being a very average one for English weather. It can be seen that there is a very wide variation in the daily sunshine, from zero to nearly the maximum, for every month. Only when many years of records are available and averaged out will it be possible to get a clear indication of the real trends. The most striking facts seen in Fig.1 are how far short of the maximum sunshine there actually is, and the relative invariance of the sunshine from month to month. This latter point is seen more clearly in Figure 2, which shows the daily sunshine as a percentage of the maximum observable: there is no discernible trend.

The total sunshine for each month is shown in Figure 3, which confirms that the hours of sunshine for each month are very approximately a quarter of the maximum observable. Overall for 1996, 1180 hours were recorded, as opposed to 4117 which could have been observed (4417 theoretically observable from sunrise to sunset).

One other important feature to dialists is the maximum number of consecutive "no sun" days. This would have been particularly important in the times when sundials were used to regulate mechanical clocks, as it determines the maximum error which could build up in the clock. As can be seen in Figure 4, there are appreciably fewer sunless days in the summer months, and the maximum number of consecutive sunless days also unsurprisingly occur in the winter. For 1996, the longest period without sun was nine days in March. It is worth noting that the minimum time registered by the recorder is 0.01 hours (36 seconds), so a dialist would have to be fairly fast on some days!

Overall, it can be seen that sundials do have some disadvantages when compared to clocks when used in England, and the results also help to explain why solar heating has failed to catch on here. It does mean, though, that British dialists are always pleased to be able to exercise their instruments!

The sunshine recorder (and other meteorological instruments) in position.

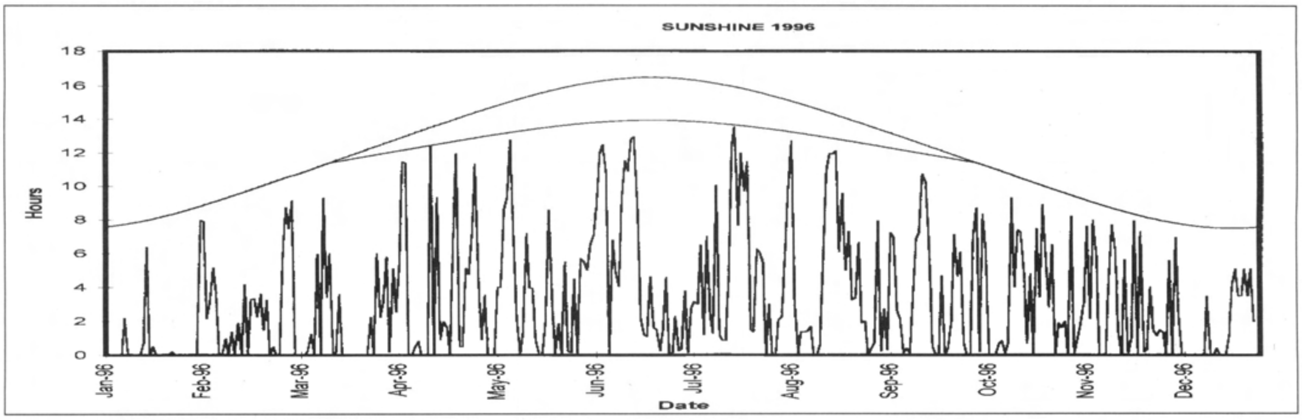


Fig 1: Daily observed sunshine in hours compared to theoretical (top curve) and maximum observable (lower curve) values.

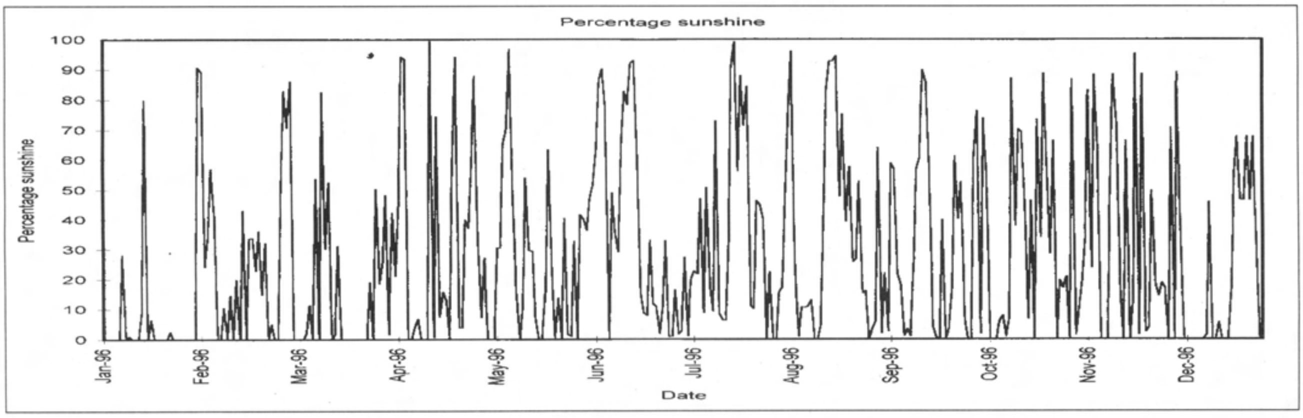


Fig 2: Daily observed sunshine as a percentage of the maximum observable.

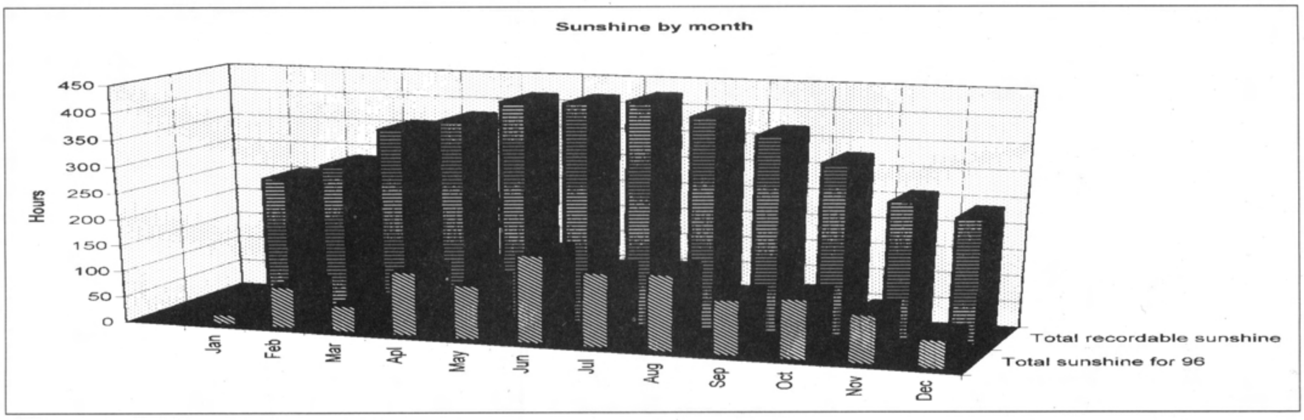


Fig 3: Monthly sunshine values (actual and maximum observable).

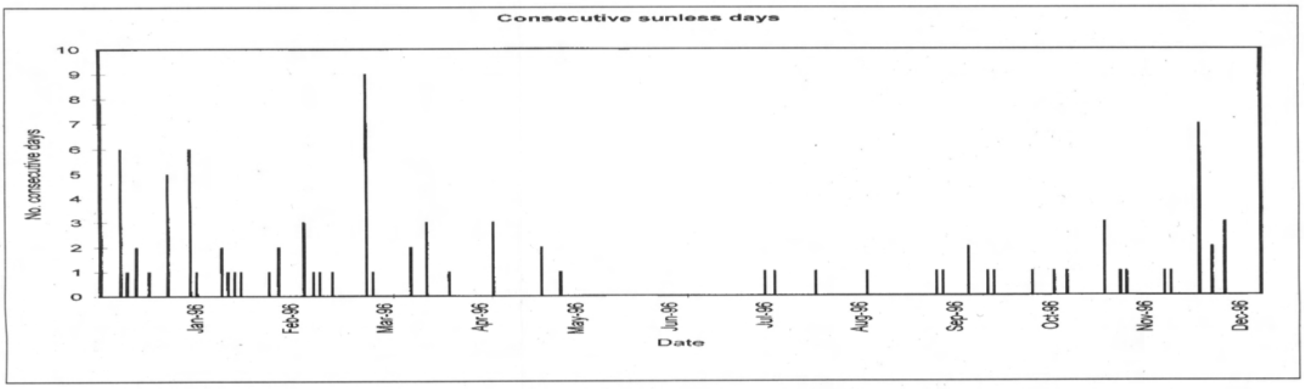


Fig 4: Variation of the number of consecutive sunless days throughout the year.

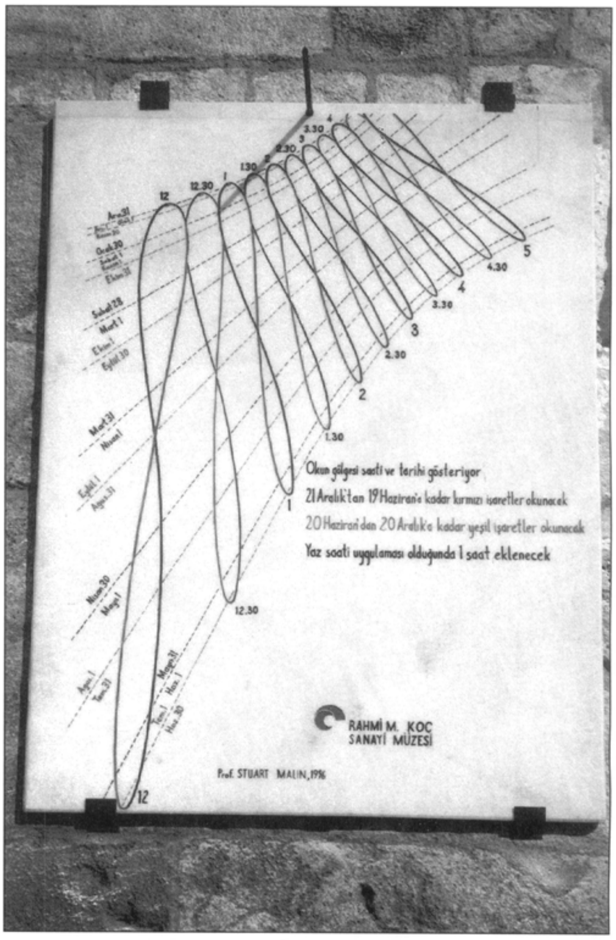
A NEW ANALEMMIC SUNDIAL IN ISTANBUL

STUART R.C. MALIN

The Rahmi M. Koç Industrial Museum is housed in an old Ottoman foundry on the bank of the Golden Horn in Istanbul. As well as a large collection of industrial artefacts (traction engines, locomotives, cars, ships, marine engines, etc.) it displays a small but fine collection of early astronomical instruments, many on loan from the Kandilli Observatory. This includes, amongst the astrolabes and quadrants, a few dials: Butterfield, garden (by Cary) and turret. So what could be more appropriate for the outside wall than a sundial? Answer: two sundials! This came about because the building faces south-west, so the front is in shadow early morning and the SE wall misses the evening sunlight. The solution is to have an A.M. sundial on the SE wall and a p.m. one on the SW. They are close to the corner, so the midday transition causes no inconvenience.

The dials are of marble, about one metre wide by 1.5m high. They are analemmic, with the shadow of the point of a 30cm, arrow-shaped, brass prong indicating Turkish mean time and approximate date. Hour lines and half-hour lines are inscribed, accurate to within a minute, but intermediate times must be interpolated. Broken lines indicate the start of each month, with an uncertainty of one day because of the leap-year cycle. The shadow of the arrowhead traverses the dial twice in the course of a year, scanning from top to bottom from the December solstice to the June solstice, and from bottom to top from June to December. Different hour and date lines are required for the two intervals. To distinguish between them, those for the December to June interval are red and the others are green. As Gordon Taylor has pointed out, this is an unfortunate choice for the colour-blind! However, they are popular colours in Turkey (red for the Turkish flag and green for Islam) and I was, perhaps, influenced by childhood memories of 3-D pictures viewed through gelatine spectacles. The provision of a chained, coloured viewing-glass (changed from red to green at the December solstice and from green to red at the June solstice) is an option, if the present system proves too confusing.

The azimuths of the walls were determined by measuring the angle between the wall and the horizontal shadow of a plumb-line at a known time. Using these azimuths and the latitude and longitude of the Museum, the lines were calculated and plotted by means of the computer program described in the June 1995 Bulletin (Plain Sundials, S.R.C. Malin, pp 45 - 48). Full-size versions were made by sticking together a mosaic of A4 computer-plots, and the lines were transferred to the marble slabs with the aid of carbon paper. The lines were inscribed and painted by a monumental mason. Marble tombstones and their makers are common in Turkey, and materials and labour for both sundials came to less than 300 pounds. The main problem was to persuade the mason (not entirely successfully) that the lines should be inscribed accurately, without artistic licence. Also, the distinction between the hour lines and the thinner half-hour lines is less obvious than I would have liked. However he undertook this rather unusual commission enthusiastically and made a good job of it. The erection of the sundials was no mean feat, accomplished with the aid of a trestle, spirit-level and four strong men. I had nightmares about a slippage, resulting in one of the men being impaled by the brass arrow, driven home by several hundredweight of marble, but all went smoothly on the day.



The instructions on the sundials are in Turkish (as are the months). They translate as:

"The shadow of the arrow points to the time and date."
(Black).
"Read red markings from December 21 to June 19."
(Red).
"Read green markings from June 20 to December 20."
(Green).
"Add one hour for summer time."
(Black).

Further and yet larger vertical analemmic sundials are planned for the Kandilli Observatory, on the Asian shore of the Bosphorus. Watch this space!

THE FLOATING GNOMON

EDMUNDO G.A. MARIANESHI & NICOLA SEVERINO

(TERNI, ITALY & ROCCASECCA, FR, ITALY)

The Floating Gnomon (Gnomon Flotteur) is an unusual and strange little instrument operated by the sun to check and/or reset mechanical watches. It was invented by Prof. Hoarau-Desruisseaux, a Belgian, and was presented at a seminar in Brussels in 1895.

The instrument is not easy to classify but it certainly belongs to the sphere of Gnomonics. It was invented at that particular time in the history of time measurement characterised by the progress of mechanical watches, both large and pocket size, which had reached a fair degree of accuracy; but they did not escape the serious inconvenience of accumulation of errors. A valuable mechanical watch that is slow by only two seconds in a day reaches an error of one minute after a month. At the end of the nineteenth century there was no widespread system of distance communication of time signals, so people were compelled to have recourse to the old sundials, which though not perfectly accurate, were at least free from the accumulation of errors. Only several years later were telephone and radio fully available to every village, house and family. Hence came the effort in this period to improve old and invent new gnomonic devices.

The device to be described consists of a cylindrical metal container 29cm in diameter, 30litres capacity, 4/5 full of water. Another smaller metal container 17cm in diameter, 5.5litres capacity with sealed lid, is free floating in the water. Below this smaller container is a weight of 4kg to stabilise floating through lowering the centre of gravity of the system. On top of the floating can there is a sighting diopter, pivoted to allow a change of angular height with reference to the horizontal plane, i.e. the surface of the water. The diopter has a lens focussing the sun's image on the screen fitted with a cross-wire for exact centering. See Fig. 1 & Fig. 2.

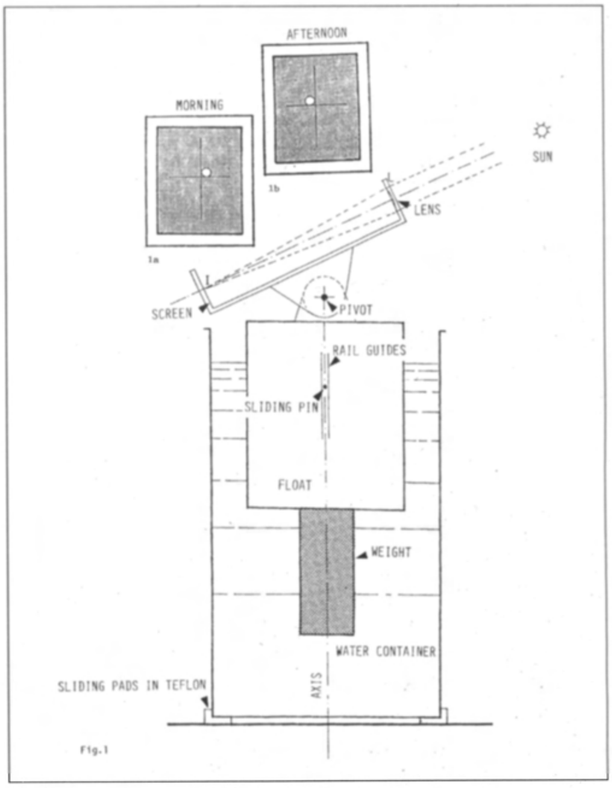


Fig. 1

Fig. 2

The float is free to move vertically but a couple of opposite radial pins sliding in two vertical U-rails soldered to the inside of the large container restrain its turning in the azimuth sense with reference to the large container. When the water container is made to turn on its axis, the float and its aiming device are dragged along. Owing mainly to the water, the instrument is heavy and it is not easy to turn it gently as required. So it is necessary to provide some low-friction sliding blocks as supporting pads, resting on a flat smooth horizontal surface. The material suggested for these blocks is Teflon.

The Floating Gnomon described above is one that we built a couple of years ago, following exactly the description of the inventor, but variations have been introduced by us with the purpose of improvements, and also to allow use of cheap and readily available materials and components. Fig. 3 shows the original picture as reported in the paper of 1895. It is not difficult to compare this drawing with that of Fig. 1 and find the differences. One of these differences in in the aiming diopter; that in the original apparatus is not supplied with a focussing lens but has a little gnomonic hole through which the sunbeam passes to give a tiny light spot on the screen. In our apparatus the focal length of the lens is 16cm; the very sharp image of the sun is 1.4mm diameter.

The operating principle of the Floating Gnomon is very simple. Using the watch to be checked, the moments at which the sun reaches the same height before and after culmination (true noon) are read and noted. The difference of these two readings divided by two gives the time elapsed from true noon; that is to say, this elapsed time is the true time at the moment of the second reading. Indeed for reasons of symmetry with reference to the meridian place, equal hour angles (in absolute value) correspond with equal heights above the horizon. The true local time found must be corrected for the locality longitude referred to the standard time meridian, and for the Equation of Time. Practically the operation is as follows:

1. Turn the diopter around the pivot so as to aim in the sky a little higher than the sun.
2. Without changing diopter position turn around the large container on its axis in the azimuth sense until the sun reaches the diopter height and so appears on the screen. The situation appears as in Fig. 1a. Immediately take the first reading of the watch to be checked (R1).
3. Turning the large container, always without changing the diopter position, wait for the moment in which the sun is again at the height of the diopter and the situation on the screen is as in Fig. 1b. Immediately take the second reading of the watch (R2).
4. Calculations (two examples)

   Example 1

   Afternoon: Second reading (R2) 15h 53m
   Morning: First reading (R1) 08h 41m
   (R2 - R1)/2 = 03h 36m = 15h 36m (o'clock)

   Longitude from standard time meridian - (00h 02m)
   Equation of time + (00h 14m)

   15h 53m - 15h 36m - 00h 02m + 00h 14m = 00h 05m
   The watch is fast by 5 minutes

   Example 2

   Afternoon: Second reading (R2) 19h 33m
   Morning: First reading (R1) 10h 41m
   (R2 - R1)/2 = 4h 26m = 16h 26 m (o'clock)

   Longitude from standard time meridian + (00h 09m)
   Equation of time - (00h 07m)

   19h 33m - (16h 26m + 00h 09m - 00h 07m) = 03h 05m
   The watch is fast by 3 hours 5 minutes.

The merit of the Floating Gnomon was to allow the checking and resetting of watches without performing angular measurements or defining geographical bearing or needing particular places, walls or dials for specific locations. Furthermore, any craftsman or amateur could build it inexpensively and easily. The Gnomon Flotteur today has only historical interest. Acquaintance with such an instrument enables us to enter into the spirit of the age and to understand how imagination and ingenuity can help to overcome practical problems.

FIGURES

Fig. 1. Sketch (not to scale) of the Floating Gnomon made by the authors. Above: 1a, the sun's image as it appears on the screen at the moment of the first reading; 1b, the same image as it appears at the moment of the second reading.

Fig. 2. Photograph of the Floating Gnomon made by the authors out of cheap and readily available components. The metal containers are empty paint tins; the lens is a +6 diopter from cast-off glasses.

Fig. 3. Original sketch of the Gnomon Flotteur from the paper of 1894. V = container; F = Float; CC'tt = Restraint system between the water container and the float; E = Plate fitted with gnomonic hole O; S = sunlight beam; CR = plate with cross hair; g = cotarpin locking angular height of aiming device.

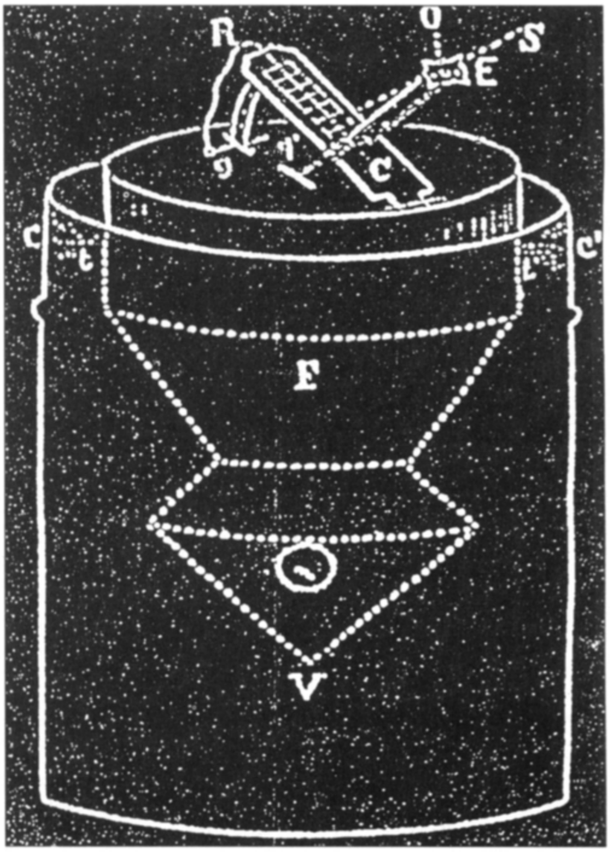


Fig. 3

WINDOW DIAL AT APULDRAM, WEST SUSSEX

R.A. NICHOLLS & C.M. LOWNE

INTRODUCTION

Fate having been tempted by the use of the word "unique" in our article on the dials at Thornford, Dorset[1] , we have now learnt of a dial at Apuldram, West Sussex where once again the vertical window jamb is used as the style of a horizontal dial. We can console ourselves with the fact that the shadow is used on the interior cill facing east and not on the exterior south-facing cill as at Thornford. Such interior use has been discussed elsewhere, e.g. Fantoni[2], but not exterior use.

GENERAL

Apuldram (sometimes spelt Appledram) is a small and very old settlement on the shores of Chichester harbour. The name has probably been derived from the Saxon "Apulder Ham"or apple-tree village. The church itself (Fig. 1) dates from about 1100 AD and in its present form from about 1260 AD. The south porch (Fig. 2) contains the dial and was built in the 15th century. The church is dedicated to St. Mary the Virgin. (Steer[3]).

Fig. 1 The church of St. Mary the Virgin at Apuldram.

Fig. 2 The south porch.

THE PORCH AND THE DIAL

The porch is of flint, with stone quoins and door and window surrounds. The porch windows are small and rectangular and almost merit a description as slits (Fig. 3).

Fig. 3 Close-up of the east window of the porch.

The east window has lines cut into the horizontal surface of the cill to form the sundial with the south window jamb acting as the style. The porch interior is lime-washed and besides the dial lines there are other designs, symbols and letters cut into the wall of the window. There are four lines cut for the sundial, all radiating from the south-east corner of the cill. The lines are thin and regular and appear to have been cut with the aid of a straight-edge. Fig. 4 shows the lines which in the picture have been enhanced for clarity.

Fig. 4 The dial, with lines enhanced.

MEASUREMENT OF THE DIAL

Fig. 5 shows the plan of the cill and lines, together with the bearing of the east wall of the porch. All angular measurements are not more accurate than ±1°. The scale is full-size. Also shown is the latitude and longitude of the church.

ANALYSIS OF THE LINE ANGLES

A dial of this nature with a plain vertical gnomon, working from the azimuth of the sun rather than its hour-angle, cannot of course show the same times consistently throughout the year. It can indicate certain times on specific dates depending on the declination of the sun. Restricting attention to integral hours and half-hours of local apparent time, examination of the Apuldram dial line azimuths shows that the best approximation to a consistent indication of hours and half-hours occurs when the sun has a declination of +4. In the 15th century this would have occurred on or about March 22 and September 4, allowing nine days for the difference between the Julian and Gregorian calendars. On those dates the gnomon shadow would have reached the dial lines at times near 8, 9, 9.30 and 10.30a.m. local apparent time, with a root-mean-square error of ±4minutes. The dates are close to those of festivals associated with St. Mary the Virgin, the feast of the Annunciation on March 25 (Lady Day) and the saint's day on September 8. On those dates the sun's declination was +5 and +3 respectively and the dial errors are not significantly greater with reference to the same times. Table I shows the line angles, the derived azimuths corrected to true north, the times of the gnomon shadow reaching the lines and their differences from the nominal times.

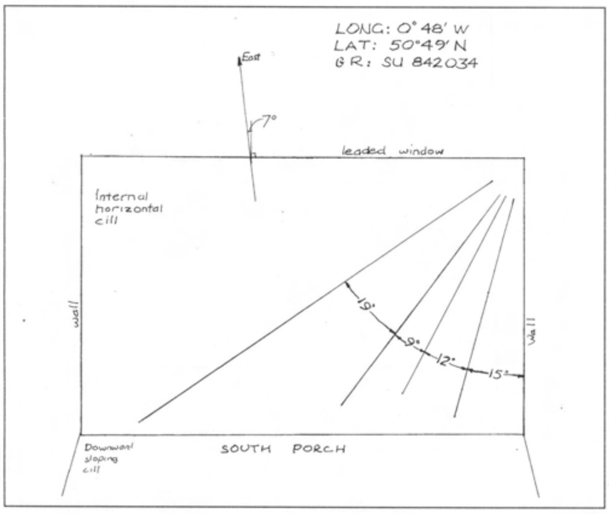


Fig. 5 The dial angles and other data.

Table I

Line no from south jamb	1	2	3	4
Meas'd angle from church west	15	27	36	55
north	75	63	54	35
True angle from north	68	56	47	28
Azimuth of sun to shadow the line	112	124	133	152
Nominal local apparent time	0800	0900	0930	1030
Times for declination +5 (Mar 25)	0805	0856	0932	1037
Difference	+5	-4	+2	+7
Root-mean-square difference ±5 minutes				
Times for declination +3 (Sept 8)	0759	0852	0927	1034
Difference	-1	-8	-3	+4
Root-mean-square difference ±5 minutes				

The dial may therefore have been intended to show the nominal times on either of the two days, or perhaps both. If the latter, it was a convenient coincidence for the priests that the same dial would serve for both! We can obtain no information as to the possible canonical importance of the particular times shown by the dial.

In the earlier article[1] we found that the better of the two dials at Thornford could be intended to indicate integral hours from 6a.m. to 11a.m. and also 12.30p.m.on the day of the patronal festival (St. Mary Magdalene) of the church, with a similar root-mean-square error to those found in Table I. The arguments advanced for the possible method of construction of the Thornford dial apply here also. It is most unlikely that the dial was laid out by calculation, the only reasonable supposition is that it was delineated by reference to some independent time standard, perhaps a portable sundial.

THE EXTERNAL STONEWORK OF THE WINDOW

At the present time the dial cannot work in the way described above. The external window reveal makes an angle of about 30° with the perpendicular to the wall, or 127° with respect to true north. It is therefore impossible for sunlight to fall on the dial from any azimuth greater than 127°, and lines 3 and 4 in Table I are now inoperative. The effect can be seen in Fig.4, where the shadow of the reveal enters the window rather less than half-way along the lower right-hand pane Line 4 is in shadow, but the shadow edge is not yet parallel to the line, showing that the sun's azimuth required for the style to shadow the line has not been reached.

We may assume that when the dial was made all the lines did receive sunlight: there seems little point to a dial in which only half the lines are of any use. Possibly the reveal has been altered from one which had a greater angle (about 60°) to the wall. Alternatively, the angle forming the style may originally have been an external corner with the window unglazed. The outer flintwork and the stone window surround would in that case have been added later, possibly when the window was glazed.

CONCLUSION

The discovery of two dials which can be interpreted as showing hour or half-hour times on dates associated with the patron saints of their respective churches suggests the possibility that there may be other examples as yet unrecognised. We would urge dial recorders on visiting a church to examine the window cills (both inside and outside) to locate any horizontal dials of this nature. There is however no reason why a calendar date and time dial should be horizontal; it could equally well be vertical with a horizontal gnomon. Some of the apparently anomalous mass dials found throughout the country are perhaps of this type and might repay closer investigation.

REFERENCES

1. Nicholls, R.A. and Lowne, C.M., Two Unusual Mass Dials in Dorset, Bulletin of the British Sundial Society, 96.1,12, (1996).
2. Fantoni, G, Windows and Balconies as Simple Sundials, Bulletin of the British Sundial Society, 94.3, 32, (1994).
3. Steer, F.W., Guide to the Church of St. Mary the Virgin, Apuldram, Apuldram PCC, (1994).

D.I.Y. DIALLING SCALES

G.N. THORNE

After reading the very interesting article by F.W. Sawyer in the January bulletin, I decided to investigate the possibility of producing the dialling scales mentioned.

First of all, the necessary calculations needed to be carried out. A program such as Excel would do that. For those not familiar with spreadsheets, the equation needs re-writing. That for latitude then becomes:-

```
=  (Sin(A2*PI()/180)/SQRT(1+(Sin(A2*PI()/180))
   *Sin(A2*PI()/180)))
```

and that for the scale of time becomes:-

```
=  (Sin(E2*PI()/180)/(Cos(E2*PI()/180)
   +Sin(E2*PI()/180))
```

The = is necessary to define a function, i.e. to do a calculation, rather than access data. The extra complication comes from the fact that all angles require to be converted to radians, hence the (A2*PI()/180) expressions. The A2 & E2 refer to cells where the data may be found, and the calculations are carried out for all the data cells.

The results showed, as expected, that the value for 90 degrees on the time scale was unity. I decided that the length for the time scale should be 255mm, and a similar scale factor applied to the latitude scale gave a length of 159.1mm.

As to producing the scales, DTP programs such as PagePlus by Serif allow positioning of objects e.g. boxes, lines etc.to the nearest 0.1mm. Using this program the outline boxes were drawn, and the sizes of the various calibration lines decided. It was a simple matter to copy the number of lines required somewhere on the page, and then move them individually to near where required. The data given as to the position of the line on the page can then be edited to move it to the exact position required. This sounds terribly tedious, but with a little practice you can place it very close with the mouse, requiring very little editing. The production of both scales took less than two hours (Fig. 1). The scales can be cut out and stuck onto cardboard or plastic and could even be laminated to make them more durable. I enclose copies of the calculations and the finished scales.

Use of the scales was checked against the use of the unit square method, and fortunately both gave the same result!

If anyone is interested, I can provide a printout of the calculations &/or scales via a stamped addressed A4 envelope, or a copy of the files if provided with a formatted disk with envelope and return postage.

My address is:
Flagstaff House, Welwick, E. Yorks, HU12 0RY.

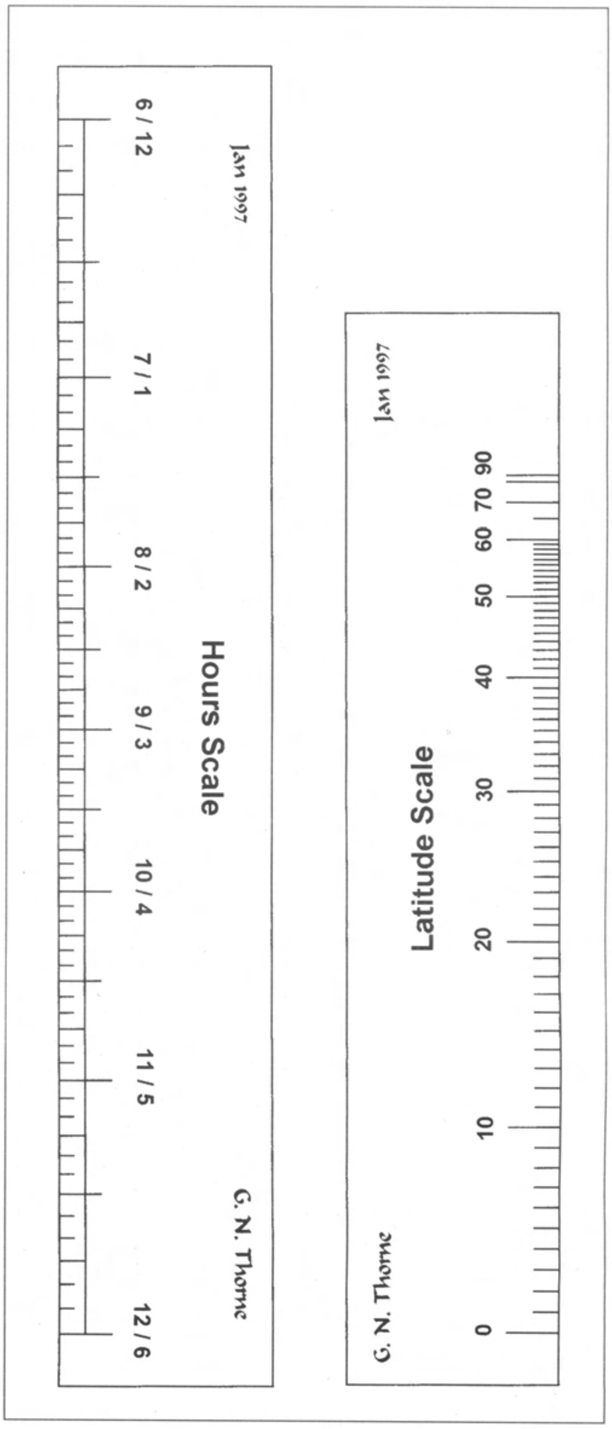


Fig.1

LAT	CALCN	*225
1	0.01745	3.9
2	0.034878	7.8
3	0.052264	11.8
4	0.069587	15.7
5	0.086827	19.5
6	0.103962	23.4
7	0.120974	27.2
8	0.137845	31.0
9	0.154555	34.8
10	0.171088	38.5
11	0.187428	42.2
12	0.203559	45.8
13	0.219467	49.4
14	0.235139	52.9
15	0.250563	56.4
16	0.265728	59.8
17	0.280624	63.1
18	0.295242	66.4
19	0.309575	69.7
20	0.323616	72.8
21	0.337359	75.9
22	0.3508	78.9
23	0.363936	81.9
24	0.376764	84.8
25	0.389282	87.6
26	0.401488	90.3
27	0.413384	93.0
28	0.424969	95.6
29	0.436245	98.2
30	0.447214	100.6
31	0.457877	103.0
32	0.468238	105.4
33	0.4783	107.6
34	0.488067	109.8
35	0.497543	111.9
36	0.506732	114.0
37	0.515639	116.0
38	0.524268	118.0
39	0.532626	119.8
40	0.540716	121.7
41	0.548545	123.4
42	0.556117	125.1
43	0.563438	126.8
44	0.570514	128.4
45	0.57735	129.9
46	0.583952	131.4
47	0.590324	132.8
48	0.596473	134.2
49	0.602403	135.5
50	0.60812	136.8
51	0.61363	138.1
52	0.618936	139.3
53	0.624045	140.4
54	0.62896	141.5
55	0.633687	142.6
56	0.638231	143.6
57	0.642595	144.6
58	0.646784	145.5
59	0.650802	146.4
60	0.654654	147.3
61	0.658342	148.1
62	0.661872	148.9
63	0.665247	149.7
64	0.668469	150.4
65	0.671543	151.1
70	0.684791	154.1
80	0.701674	157.9
90	0.707107	159.1

TIME	CALCN	*225
1.25	0.02135	4.8
2.5	0.04183	9.4
3.75	0.06151	13.8
5	0.08045	18.1
6.25	0.09871	22.2
7.5	0.11634	26.2
8.75	0.13338	30.0
10	0.14990	33.7
11.25	0.16591	37.3
12.5	0.18146	40.8
13.75	0.19659	44.2
15	0.21132	47.5
16.25	0.22569	50.8
17.5	0.23972	53.9
18.75	0.25343	57.0
20	0.26685	60.0
21.25	0.27999	63.0
22.5	0.29289	65.9
23.75	0.30556	68.8
25	0.31801	71.6
26.25	0.33027	74.3
27.5	0.34235	77.0
28.75	0.35426	79.7
30	0.36603	82.4
31.25	0.37765	85.0
32.5	0.38915	87.6
33.75	0.40054	90.1
35	0.41184	92.7
36.25	0.42304	95.2
37.5	0.43417	97.7
38.75	0.44524	100.2
40	0.45626	102.7
41.25	0.46723	105.1
42.5	0.47817	107.6
43.75	0.48909	110.0
45	0.50000	112.5
46.25	0.51091	115.0
47.5	0.52183	117.4
48.75	0.53277	119.9
50	0.54374	122.3
51.25	0.55476	124.8
52.5	0.56583	127.3
53.75	0.57696	129.8
55	0.58816	132.3
56.25	0.59946	134.9
57.5	0.61085	137.4
58.75	0.62235	140.0
60	0.63397	142.6
61.25	0.64574	145.3
62.5	0.65765	148.0
63.75	0.66973	150.7
65	0.68199	153.4
66.25	0.69444	156.2
67.5	0.70711	159.1
68.75	0.72001	162.0
70	0.73315	165.0
71.25	0.74657	168.0
72.5	0.76028	171.1
73.75	0.77431	174.2
75	0.78868	177.5
76.25	0.80341	180.8
77.5	0.81854	184.2
78.75	0.83409	187.7
80	0.85010	191.3
81.25	0.86662	195.0
82.5	0.88366	198.8
83.75	0.90129	202.8
85	0.91955	206.9
86.25	0.93849	211.2
87.5	0.95817	215.6
88.75	0.97865	220.2
90	1.00000	225.0

THE ANGEL OF CHARTRES

CHARLES K. AKED

THE CITY OF CHARTRES

Chartres is a city in north central France, capital of the Eure-et-Loire Department. It consists of two main parts, the upper and lower towns, connected by steep streets, and is a mainly agricultural centre with some manufacturing. The highest point of the city is crowned by the world famous Cathedral of Nôtre Dame built in the twelfth and thirteenth centuries. It is one of the most famous Gothic structures in the world.

There is a long history at Chartres Cathedral of the attempts over the centuries to determine time accurately, mainly for the purpose of conducting religious services and ceremonies at the appointed times, with the subsidiary purposes of timing the day-to-day activities of the religious community serving the cathedral, and those of the surrounding town.

The imposing west facade of the cathedral was rebuilt in the 12th century and is substantially the same today, (see Fig. 1) although the south tower (on the right) is late Romanesque of the 13th century, and the north spire is late Gothic, of the early 16th century.

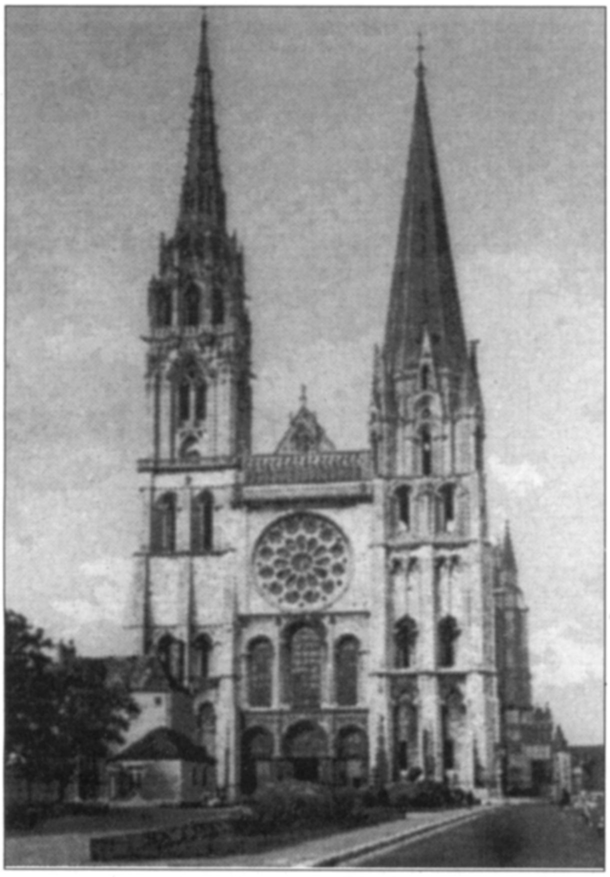


Fig. 1

TIMEKEEPING IN THE CATHEDRAL

The Cathedral archives show that in 1258, the King of France (Louis IX) decreed that the Chapter of Chartres Cathedral would be:

"...held responsible for the making, installing and maintaining in one of the belfries of their church or other suitable place, a clock which can serve the whole town with a drum or bell at the *equipolent*, which will serve also as the bell of the Watch..."

The equipollent (modern spelling) implies equal division of the daylight hours, i.e. at noon precisely; so the whole community was to be given an aural signal at noon precisely. The reference to the bell of the Watch is in regard to giving the community warning in case of trouble by those appointed to oversee the safely of the town (the Watch)

THE FIRST CHARTRES MECHANICAL CLOCK

The earliest solar indicator may have been no more than a simple noon line; however by 1359 one of the Cathedral documents mentions the existence of two clocks, an interior one for the morning awakening of the monks, and one in the cloister whose dial was to be observed for the manual striking of a bell to indicate the hours. The details given are insufficient to determine what these clocks may have been. An interior one cannot be a sundial; it was probably a manually struck bell, whereas the "clock" in the cloister could be a sundial. A mechanical clock at this time would have been merely a striking one.

However, it was not until 1392 that the Cathedral authorities decided to enter into a covenant with Ph. Mauvoisin, Locksmith to the Cathedral, to make a clock to strike the hours mechanically in the same way as the clock installed in the Palais de Paris.

This clock had a very simple mechanism, for it consisted merely of a great wheel driving the pinion of a crown wheel which impulsed a foliot through a verge escapement. The dial was one metre in diameter and driven from the great wheel to turn once each twenty-four hours. The clock was driven by a heavy weight, the only means of doing so in the early days of horology. (The time measuring part of the Salisbury Cathedral Clock, the oldest working example in the world, was made in 1386, about the same time as the Chartres Cathedral clock). Although so simple a mechanism, the design of these machines exercised the greatest minds of the period. They represented the most advanced machines ever made up to then.

From here onwards the records are confused because there were many changes in the timekeeping systems in use in the Cathedral and references are made without giving the exact details of the clocks concerned. One could interpret the records such that the first early clock survived for centuries but we know from many records that the early clocks often gave great trouble to those caring for them and rarely lasted more than a few decades, not so much from wear and tear, but from deficiencies in the design.

Fig. 2

THE ANGEL OF CHARTRES

Whatever the system of timekeeping in the Cathedral in the early part of this millenium, the authorities in the 1500's erected a sundial on the South Tower of the Cathedral, (Fig. 2). It is mounted about ten feet off the ground. To give such a mundane instrument a measure of sanctity, a tall Gothic figure of an angel was utilised, possible taken out of one of the niches in the facade for these are all empty today. Some writers remark that the figure is enigmatic; to the present author it shows the face of the figure as a simpering youth, in spite of his angelic wings.

The sundial is a rectangular block of stone on which considerable effort has been expended to make the hour annulus stand proud of the dial surface, and, unusually, the hour lines too, instead of the customary grooves cut into the panel. The hour lines seem to have been cut according to the required pattern for the latitude, and the hours are indicated by Gothic numerals, which was the fashion at the time. On the back of the postcard which the writer obtained at the cathedral in the 1970's, the date is given as 1528 although the third figure from the left definitely looks like a 7. At one time a new piece of stone has been let into the panel at this point and this numeral re-cut. Most authors take the date to be 1578.

Although the angel appears to be occupied in holding this panel out at arms' length, which would have been very tiring over the centuries, the dial panel is actually supported on two massive wrought iron brackets, so in effect the angel is merely standing behind the panel, and not looking too pleased about it. Around the angel's head is a nimbus or halo: no doubt at one time it would be resplendently gilt when angels were more deferentially treated than in our present agnostic age.

To give the poor chap some protection from the weather, there is a stone canopied hood over his head, (see Fig. 3). Whilst this photograph does not show the sundial in great detail, it at least shows the gnomon rather better, a somewhat crude iron rod bent near its centre to provide a gnomon and support simultaneously. If the dial was scientifically delineated, it is wasted now since the operating part of the gnomon is almost horizontal. At the time of the writer's visit, it was a cold gloomy day and it was difficult to take photographs because of the very poor light.

Some past writers have averred that the original gnomon was merely a horizontal rod sticking out at right angles to the sundial plane. In such a case the "hour lines" of the dial would have been at equal angles, for the early dials were not so much for indicating hours as for division of the day, or as event markers. The modern idea of time is not that which the people of medieval times subscribed to, and indeed around the 13th to the 15th centuries, changes were taking place in timekeeping methods because of the gradual introduction of the mechanical clock. To the majority of the population then, dawn, noon and the onset of darkness were the regulators of everyday life. Daylight meant work, darkness brought about the possibility of relief from toil: just as today, most people were more interested in knowing how much time was left before work could be vacated, rather than the actual time of day.

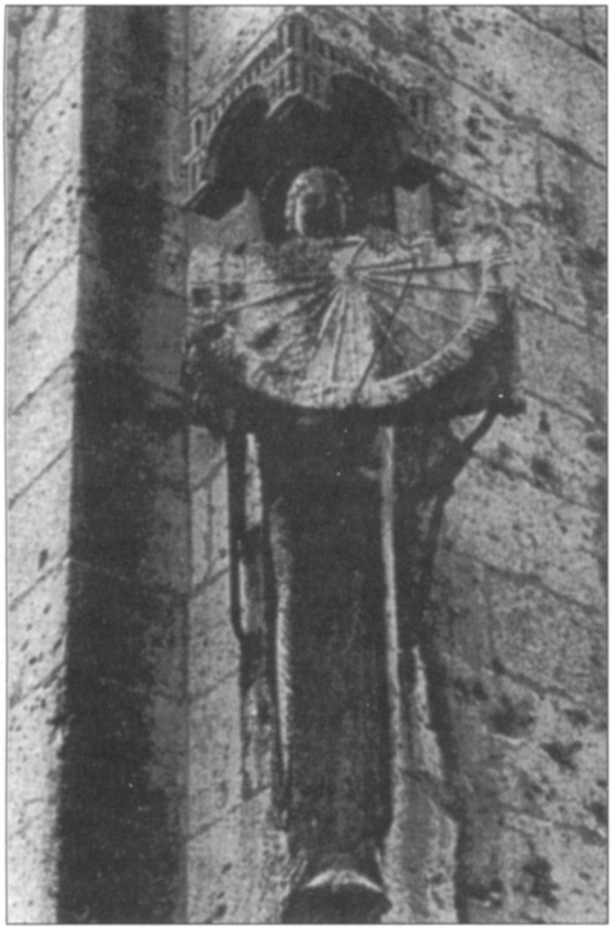


Fig. 3

This explains too why the sundial continued to exist by side with the mechanical clock for at least five hundred years, although the sundial was modified by scientific design and the use of a polar gnomon to give a clock-like indication of actual equal hours, something which the ancient diallists never aspired to achieve since equal hours had no meaning for ordinary people in those days.

Looking at the Chartres sundial, made less than a hundred years before the first accurate mechanical clocks (achieved by English clockmakers when the anchor escapement was invented) it is evident that its designer knew exactly what was required. The apparently incorrect angular division between I and II in Fig. 2 is because the gnomon is shown as a bright line. If the view in Fig. 3 is examined, the angular division of the hour lines can be seen to mirror those on the other side of the dial exactly.

The Angel of Chartres is seen by thousands of footweary tourists each and every year, and no doubt this will continue for another few centuries to come unless some dire disaster strikes. Obviously the Angel will have to exercise his patience for a very long time to come, for the first reaction of an elderly observer standing below the Angel of Chartres is to take out a pocket watch, whereas the younger ones glance at their wrist watches! They are no wiser after this, since the sundial, even if its gnomon were correctly set, would inform the viewer only of local solar time, and not the artificial regularity of Paris time.

TELLING THE TIME BY CARDBOARD

DAVID J. BOULLIN

INTRODUCTION

My own interest in sundials is confined to study of the various examples that I come across during the course of daily life, work or play. Dialling is left to the expert.

The attitude to sundial construction was slightly modified as a result of a book I received on the subject at Christmas 1988. The book is entitled: *Sundials and Timedials*, by Gerald Jenkins and Magdalen Baer, published by Tarquin Publications, Stradbroke, Diss, Norfolk IP21 5JP, price £3.95. I have not seen this book in any of the major bookshops: but I expect it can be obtained through booksellers. It is listed in the 1988/9 'Tridas' catalogue published by 'Tridas,' 124 Walcot Street, Bath BA1 5BG. Tridas have shops in Richmond, Surrey; Bath; and Dartington, Devon.

Sundials and Timedials is a 15 sheet A4 format booklet printed on moderately thick card. It is basically a cut-out book of a variety of sundials and time dials. The production is to a high standard and it is moderately easy to cut out and make the various timetellers. The instructions are not comprehensive, although most horologists with some knowledge of dialling will be able to construct the models without too much difficulty.

There are nine models to be made:

1. Traditional horizontal sundial.
2. Two-sided equatorial sundial.

3. Three-in-one sundial [horizontal, vertical and equatorial dials].
4. Sunbeam equatorial sundial.
5. Solar compass.
6. Polar sundial.
7. Time cylinder to find the time around the world.
8. Suntracker to find the elevation and bearing of the sun.
9. Nocturnal.

The centre of the publication comprises four pages printed on thinner paper; these are to be detached from the staples and make into a 16 page booklet. There is basic information given of time and brief accounts of the nine models.

The text in the minibook gives a most easily understood introduction to the topics of solar time, sidereal time, clock time, and much else. It should be read before starting out on construction of the models.

CONSTRUCTION

The only items required to make the nine models apart from the book itself are a very sharp scalpel blade or craft knife, passe-partout, a high quality, preferably steel, rule and adhesive. I used UHU, but BOSTICK CLEAR will do as well.

The lines on the diagrams have either to be cut through or lightly scored where they are to be folded. On one or two occasions I cut through where I should have scored only, and had to remedy the damage with passe-partout.

Most of the models are very easily made. I commenced with no.1, the horizontal dial as it was a familiar type to me. This was probably a mistake as this dial requires considerable finesse to finish properly as eight pieces have to be glued together simultaneously in the last step. Also this dial would benefit by having something weighty in the base. As the authors say, these various dials are not for permanent siting outdoors, but the horizontal dial would easily blow away in even a moderate wind.

I then moved on to the equatorial sundial, which is very easy to make; followed by the combined three-in-one sundials [horizontal, vertical and equatorial dials combined]. This was undoubtably the most interesting since one can see how the sunlight falls on each dial and visualise the equatorial dial parallel to the equatorial plane.

The most difficult construction was the so-called sunbeam equatorial dial which is an equatorial dial with a slit gnomon casting a beam of light onto a concave dial. Here the instructions are minimal and I made the silly error of attempting to construct the dial convex instead of concave in spite of knowing the dial should be concave. Fortunately I spotted the error fairly quickly and was able to slit the stuck portions of the dial and reverse the contours to the correct shape; the damage was repaired with passe-partout, and then every part fitted nicely.

The construction of all nine models would probably take about 6 hours. It is worthwhile making very accurate incisions along the lines to be cut and similar but shallower marks along the lines to be folded. What is encouraging is to see that the model illustrated in the book have actually been made from one of the books. They are shown warts and all, and are not professionally produced for the purpose of illustrating the book.

Once the dials are finished they can be set up alongside each other and set to time, either using sunlight or simulated sunlight with an electric spot lamp.

For me the next step will be to use the dials for a complete year. With the suntracker, for example, the path of the sun in the heavens throughout the year may be plotted by making a few observations each day when the sun shines.

My view of Sundials and Timedials is in fact summarised in the introductory paragraph to the minibook, which reads as follows:

The principles which underline all sundials are much less complicated than many people realise and the aim of this minibook is to explain them and introduce some useful formulae. Hopefully the combination of the models in this collection and the explanations in this minibook will tempt you to to make some experimental dials of your own. There is no need for such sundials to be complicated or permanent. They can be temporary and makeshift. It is interesting to experiment with simple designs and it is most satisfying to see crudely constructed devices telling the time with precision. Perhaps this might lead on to making others in more permanent materials. There is something highly attractive in using natural means to show something as fundamental as time. And don't forget the motto: 'CARPE DIEM' meaning 'Make good use of the day.'

The amateur may find that this unusual booklet is a good introduction to sundial construction.

MERIDIAN LINES
THE 1997 ANDREW SOMERVILLE MEMORIAL LECTURE

CHARLES K. AKED

Although present at the time of decision when the suggestion of an Andrew Somerville lecture was first mooted at Jodrell Bank in 1991, I cannot now remember whose proposal it was. However this annual event has produced an outstanding series of lectures, and an awe-inspiring standard of erudition which I find myself having to follow. Furthermore, at the time of the invitation to give the lecture, I had already fired all my big guns in the field of gnomonics by publishing my major theses in the BSS Bulletin, and I can assure my listeners that editing the Bulletin for the last eight years has left me little time for any personal research into dialling topics.

Today I want to deal with an aspect of gnomonics which arose out of the requirements of the Roman Catholic Church to deal with the vexed problem of ascertaining the correct date for observing Easter, the cardinal rules for which were laid down by the Council of Nicea in AD 325 and which still apply today. The main rule was that Easter Day would fall on the Sunday after the Full Moon upon, or the next after, the Spring Equinox. It seems simple enough, but as this involves three unrelated periods, the week, the lunar month, and the solar year, it becomes a most complicated affair to calculate. The Nicean Council was totally unaware of the potential effects of the Julian Calendar upon its decision, for the rationalisation of the Roman calendar by Sosigenes in BC 46 had built-in defects, mainly due to the adoption of a 365 day year. By the sixteenth century the difficulty of dating Easter correctly for ecclesiastical purposes forced Pope Gregory XIII to arrange the reform of the Julian calendar and restore the Spring Equinox to the correct date of 21st March, from which the calendar had strayed by plus 10 days, making the Spring Equinox ten days too early. How this was accomplished, so that the calendar has not required a major revision since, is too long to recount here.

I am not going to speak about sundials as such today, for the majority of these are really sun-shadow dials. I intend to speak about an analogue of these whose origins go back many thousands of years. The Egyptians often incorporated apertures in temples or pyramids so that on a particular day, at a particular moment in time, a ray of sunshine penetrated to illuminate some object to indicate the memory of a past event, person of note, or some important date. It is a feature of monumental sundials to this day.

The great monument of Stonehenge, in a similar manner, is arranged so that at the moment of the Summer Solstice, the Heel Stone is illuminated at dawn, and likewise there are barrows as in Ireland where the sun shines briefly into an inner chamber each year to indicate some event such as the Winter Solstice. These all make use of large man-made structures

MERIDIAN LINES

My topic for today is that of the complex meridian lines placed inside buildings, mainly to be found in Italy and France. These require a large building of great stability, suitably orientated and of sufficient length to accommodate a line placed on the local meridian upon which an image of the sun can be projected around noon on every day of the year. Instead of a shadow on a dial plane which is surrounded by sunlight, the meridian line has a spot of light projected into a dimly lit area, on the lines of a camera obscura, the inverse of the normal sundial. Every BSS member knows that the scaling up of an ordinary sundial does not necessarily lead to a greater accuracy of indication; or they should do, if they have read Dr. Mills' excellent article on the subject. The problem is the size of the sun, which actually occupies about two minutes (in time) of the visual orbit at the equinoxes, making sharp-edged shadows impossible. Larger dimensions of the dial are necessary for an increased accuracy of time determination. These can be achieved with the internal meridian line. The bright image is less hazy than a shadow, the contrast ratio much greater than with an ordinary sundial, and the projected image moves with a far greater velocity. In some respects the meridian line can be thought of as the noon portion of a sundial.

The main requirement is for the gnomon aperture to be placed at the greatest height possible to give a large radius of action for the sun's rays below it. Vertically below this is the origin of the meridian line although this will never be required for use at latitudes above 23.5 degrees north. The meridian line must be truly directed north/south, i.e. pointing towards the north Celestial Pole although it is absolutely horizontal. In other words it is a small length of the local meridian. With this arrangement, it is possible to determine local solar noon. The use of any watch, as long as it has a second hand, is quite good enough for this purpose.

Even this improvement of accuracy over the ordinary sundial is not good enough to check the rate of an accurate mechanical clock, whose daily error of indication is less than the uncertainty of this daily time observation. For greater resolution we must chose a star which is as far from the celestial pole as possible but remaining above the visible horizon for the whole year. Using a telescope fitted with internal cross wires, and knowing that a star behaves as a point source of light, it is possible to ascertain the correct sidereal time to within a fraction of a second, good enough for all mechanical clocks ever made; although there are small latent errors remaining in this method of obtaining sidereal time.

So although the meridian line can give fairly accurate local solar time at noon for the purpose of allowing a time signal to the locality, it is obvious that this would not be enough to justify their construction. We have to look further for the reasons for their invention and realisation, for they were costly instruments, and intrusive in religious buildings.

In the 16th and 17th centuries it was desired to know the exact value of the ecliptic, (i.e. the sun's maximum and minimum declinations), the exact moment of the Spring equinox, also that of the Autumnal equinox and the Summer and Winter solstices, the accurate local latitude, and the value of the precession of the equinoxes. Above all, the Catholic Church's obsession with the precise determination of the date of Easter opened the coffers to allow suitable instruments to be built, so that the date of the Spring equinox could be fixed with absolute certainty. Although the Catholic church had long known of the great difficulties caused by the Julian calendar's deficiencies, centuries were allowed to slip by before the first reformations were undertaken simply because of the strong opposition to interfering with what was thought of as "God's Time." The Julian calendar had been in use for such a long time that it was thought of as a natural law. In fact, following the Gregorian calendar reforms, there was a radical change in the purpose of meridian lines since they were employed to prove that the reforms introduced were indeed correct. The doubts about the Gregorian calendar did not subside, even within the Church itself, for many decades, until the overwhelming evidence of meridian lines gave convincing proof.

DESCRIPTION OF MERIDIAN LINE

A brief outline of a basic meridian line will be helpful before we go on to discuss the actual examples. The designer of such lines first searches for a building which has been in existence for a long time, so that he knows he has a stable structure which is not going to change dimensions with the passing of time. He does not want the height of the gnomon aperture to vary! This is essential to the basic accuracy of the instrument; nor does he want the floor, on which the meridian line is placed, to subside. The building must be long enough to accommodate the meridian line, about 40 metres at the latitude of Rome for a gnomon height of 20 metres, and proportionately larger for greater gnomon heights, plus increasing length with latitude. The building must also have the correct orientation and be free from surrounding obstructions. The meridian line must interfere as little as possible with the purpose for which the building was erected, and so all in all there are but few places where these unwieldy instruments can be easily accommodated. The ingenuity with which the designers overcame these restrictions will become clearer later on.

The gnomon height is divided into one hundred parts using a chain with one hundred identical links. A plumb bob dropped from the gnomon aperture is used to mark the start of the meridian line. The meridian line is laid out perfectly horizontally by the use of a water channel running the whole length of the line for reference purposes, removed after the line had been completed. When Cassini laid out the San Petronio meridian line, he actually calculated the height difference between the horizontal line he desired and the arc of the earth it actually spanned and decided that it was so small that it could safely be ignored. The daily changes in floor level were probably far greater.

The meridian line laid out on the floor is usually provided with two scales. One is marked out in one hundredth divisions of the height of the gnomon above the meridian line and is linear; the other is in degrees and is non-uniform since the spacing varies according to the angle of the rays of the sun striking the floor. The divisions are close together at the Summer Solstice and furthest apart at the Winter Solstice. Thus it is difficult to judge the exact reading between divisions with the degree scale.

It will be seen that the length of meridian line over the gnomon height is the tangent of the angle of the declination of the sun, so the meridian scale is actually one hundred times the tangent of that angle. As the scale is linear, the reading between divisions can be subdivided into ten or even a hundred parts by a vernier rule. The obtained values can be looked up in a prepared table of values and the angle of declination obtained to a far greater accuracy than with the degree scale. In practice the degree scale was rarely employed and usually became redundant. With the meridian line at San Petronio, for example, the degree scale was later replaced with one for conversion of local solar time to Italian hours.

For use with stars, a telescope was employed, placed on a small carriage which could run along the meridian lines, with corrections for the height of the telescope above the meridian line.

To embellish the meridian line, it was usual to place the twelve signs of the Zodiac at the points where the sun entered these signs, plus an engraving of the sun's image at the Summer and Winter Solstices, and the Equinoxes. These can be absolutely correct only for a particular year, since there are small changes from year to year because the earth does not encircle the sun in a whole number of days.

ACTUAL MERIDIAN LINES

I have listed below the main outstanding meridian lines and where they are, or were, installed.

Date	*City*	*Site*	*Gnomon*	*Designer*
1437	Constantinople	S. Sophia	50m	Ulugh Bey
1468	Florence	S. Maria	90m	P. Toscanelli
1576	Bologna	S. Petronio	25m	E. Danti
1636	Marsiglia	College	17m	P. Cassendi
1653	Bologna	S. Petonio	27m	G.D. Cassini
1702	Rome	S. Maria	20m	F. Bianchini
1743	Paris	S. Sulpice	26m	Le Monnier
1756	Florence	S. Maria	90m	L. Ximenes
1786	Milan	Duomo	24m	A. De Cesaris
1791	Naples	Museum	14m	G. Cassella
1802	Messina	Duomo	14m	A.M. Jaci
1830	Catania	Monastery	22m	N. Cacciatore

There are, of course, many more meridian lines existing today, but these are, in general, much smaller in scale and less decorative.

It will be noted that England does not have a single example. In England they are represented by the most primitive types of all, for example the noon line at Salisbury cathedral placed on the north enclosing wall, which is touched by the shadow of the tip of the great spire at midday, and virtually useless as a time indicator. There is a meridian line, or rather noon line at Ramsgate which was intended to obtain local solar time at noon for the setting of marine chronometers of vessels in the harbour, rather better in design but quite useless for the purpose; and there is the neglected meridian line at Durham Cathedral, again a noon line, now almost destroyed by decay. We have to rest on our laurels by having the Prime Meridian at Greenwich, resting on the longitude zero, but it is a rather tatty brass strip. I always have the feeling, when astride this, (as most of the visitors do for a souvenir photograph) that if I am not careful , the whole world will split into two halves and me with it. I would feel much safer if this area was reinforced at this cleavage point.

The first great meridian was constructed at Constantinople by Ulugh Bey, nephew of the great Tamerlane, in the huge cathedral of St. Sophia. The gnomon height was 180 Roman feet, about 50 metres. It is no longer in existence and little is known of its actual construction or for what purpose it was built.

Next in appearance, and the first in the Catholic Church, was the meridian line installed in the cupola of the church of Santa Maria del Fiore in Florence by Paolo de Pozzo Toscanelli in 1468. The gnomon aperture height was 90 metres. It proved unsatisfactory for various reasons but nevertheless remained until 1756 when the Jesuit Priest Leonardo Ximenes restored it to working order. It did not play any significant part in the reform of the Julian calendar or in the verification of the truth of these changes.

Egnazio Danti, in 1576, installed the first meridian line in the Basilica of San Petronio, Bologna, with a gnomon aperture height of 25 metres. Again this was not entirely satisfactory: the results obtained were not accurate enough. However this meridian line was put out of action when the enlargement of the church resulted in the removal of the wall containing the gnomon aperture. In 1653, the growing anxieties of the Catholic Church caused the Pope to commission Gian Domenico Cassini to restore Danti's meridian line. Cassini soon came to the conclusion that it was impractical to do so and instead determined on an entirely new instrument. He found the plan of the enlarged cathedral an almost insurmountable barrier to a meridian line because of the great pillars separating the main nave from the side naves containing chapels. The majority of the scientists of the day declared it to be impossible; Cassini carried out his calculations and decreed otherwise. Just to demonstrate how close to impossible it was, his meridian line passes within less than a centimetre of two adjacent pillars in its passage through the space between them. Cassini raised the height of the gnomon aperture to 27 metres. That of Danti's had not been stable, perhaps through the instability of the wall containing it, and the effects of an earthquake on the building.

Even the Pope had doubts about the new calendar reforms and requested Danti to design a meridian line to be installed in the Vatican in the Tower of the Winds for purposes of verification. This was not really a suitable place because ideally a meridian line should be located on solid ground. It was found later that the tower was not suitable as an astronomical observatory because of the movement. This shows it was rather a bad choice for a meridian line. Furthermore the dimensions allowed only a rather modest meridian line, and the gnomon aperture was only just over 5 metres above the line. However it was mainly intended as a show piece, with the most wonderful paintings to adorn the room where the line was installed. As the Gregorian calendar reforms had been completed before this meridian line was constructed, it played no part in these reforms, and with its modest size, was not a serious instrument for verification. In fact it was not perfectly laid out and hence never gave perfect indications.

THE MERIDIAN LINE AT SANTA MARIA, ROME

I propose now to describe the most beautiful of the meridian lines existing today, that installed in the Church of St. Maria degli Angeli in Rome. The building did not start out as a Christian church but was built for public baths by the Emperor Diocletian in the third century AD, and in view of its later use as a Christian church, it is rather ironic that

Diocletian launched a fierce persecution of Christians throughout the Roman Empire before he abdicated in AD 305. It was chosen by Francesco Bianchini as the most suitable building in Rome to install a meridian line, when Pope Clement XI commissioned him to do the work. Bianchini must have looked at St. Peter's, but because this immense basilica is oriented truly with the altar on the East, there is insufficient room to lay out a meridian line across the width of the nave. There appears sufficient space under the transept: perhaps there were religious objections to it being placed there. The height of a gnomon aperture in the roof here may have been too great for the corresponding length of line below. If the pressure of the calendar reforms could not overcome these objections when Gregory XIII was in power, then obviously there must have been strong reasons against a meridian line in St. Peter's basilica.

The basilica of St. Maria degli Angeli was then in the form that it had been given by Michael Angelo, who placed the principal nave in the position where the transept is today. Bianchini did not work from scratch but used the meridian line installed in Bologna as his model, for Cassini was a friend of Bianchini. Work proceeded very quickly, and by 6th October 1702 it was sufficiently finished for Pope Clement XI to pay a visit (he only had to travel a couple of miles from St. Peter's). The Pope had a medal struck to commemorate his visit, showing the basilica nave crossed by a ray of sunlight similar to the medal struck in Bologna in 1695.

Ostensibly this meridian was built to check the conclusions of the Gregorian reform of the calendar but it was started too late to check the results of leaving out the leap year in 1700.

OTHER MERIDIAN LINES

Amongst all these wonderful examples of meridian lines, it would seem that only that of San Petronio made any significant contribution to astronomical knowledge in determining the value of the obliquity of the earth's axis. Compared with properly equipped astronomical observatories, the means of determining the celestial coordinates of heavenly bodies was crude.

The first installation of the meridian line by Danti at San Petronio in 1582 gave quite ambiguous results over the decades of observation to determine the movement of the earth's axis, as did the meridian line installed by Le Monnier in St. Sulpice, Paris. A slight movement in the building is quite sufficient to swamp any small changes in the observations.

The primary purpose of determining the spring equinox was also quite crude, for the moment when the sun's declination is exactly zero and occurring at noon is rare. If the weather is inclement, the whole purpose of the installation is lost. Of course, the sun's daily declination is changing very slowly as it reaches minimum value and then reverses sign.

The accuracy of the determination of the moment of midday by a meridian line was nothing like good enough to check the better mechanical clocks after about 1715 with the invention of the dead-beat escapement and mercury temperature compensation for pendulums by George Graham, the notable English clockmaker and instrument maker. These could perform to a weekly accuracy of a second or better and needed the observation of the transit of a star to provide the required time standard for checking.

All in all, it seems to me, that although the great meridian lines of Europe were greatly discussed in their day, they were really created to impress those who came to see them. The visitor today stands in awe of their great size and obvious artistic merit. To examine one tablet in the church of Santa Maria degli Angeli and look at the Zodiac sign created from coloured marbles alone, gives a sense of wonder that anyone could create such beautiful pictures from small coloured pieces of marble. But it must be said that the contribution to astronomy by meridian lines was of very limited value even in their heyday. But they salved the conscience of the Roman Church in its commitment to the correct observance of Easter.

The last great meridian line was installed at Catania in the Benedictine Monastery. The gnomon aperture height was 22 metres, and its designer was N. Cacciatore. There was a meridian line installed in the dome of Messina Cathedral in 1802, but this was destroyed in the earthquake of 1908 and never reinstalled. Most of the meridian lines have been put out of action by the closing of gnomon apertures, but all suffer from the wear and tear of people constantly walking on them. Even with the most beautiful of all the meridian lines, that of the Santa Maria degli Angeli, one finds pews and other church furniture placed on the line itself, with no attention paid to taking care of the delicate marbles. Generally speaking the work of those supposed to be restoring the meridian lines has resulted in the loss of features through the lack of understanding of the principles behind the creation of these magnificent instruments..

There are, of course, many smaller meridian lines to be found in places other than churches, but in general these are glorified noon lines placed indoors, usually not more than a metal strip running north-south and a few identification points, or even a row of brass studs in a wooden floor. They may even be hidden under carpets as at St. Andrew's University in Scotland, and its southern point some hundreds of yards away, used as a washing line post.

One of the improvements possible with a meridian line was used only at the meridian line of St. Sulpice in Paris,

Fig. 1 The Meridian Line of San Petronia Basilica, Bologna

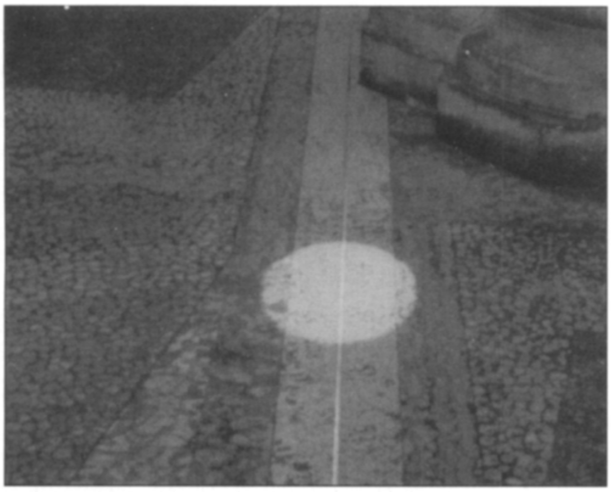


Fig. 2 The sun's image at noon, San Petronio, Bologna

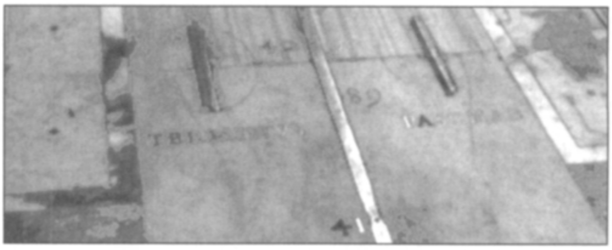


Fig. 3 Brass strips showing the limits of Easter, Santa Maria degli Angeli, Rome

Fig. 4 Zodiac sign, Cancer, Santa Maria degli Angeli, Rome

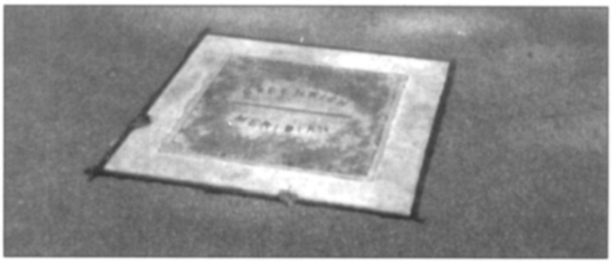


Fig. 5 World's shortest meridian line, Chingford, Essex (home of David Young, BSS Secretary)

namely the fitting of a lens at the gnomon aperture to give a focussed image of the sun on the meridian line. This gives an infinitely sharper image of greatly increased luminosity. Because of the great change in distance along the meridian line from summer to winter solstice, this really requires more than one lens to cover the range, and the lens needs to be adjusted at intervals to be at right angles to the sun's rays at noon, so it must be mounted so that it can be partially rotated as required. One could, in theory, produce a very tiny spot of light on the meridian line, but the heat produced would be excessive in intensity. The accuracy of observation of the moment of noon would be increased although hardly likely to be of use to check any accurate mechanical clock other than over a long period of time. But it would have helped in the determination of the equinoxes and solstices, for the normal indication is a large ellipse of light. As at Durham Cathedral, where there was far too little space for a full horizontal meridian line, the meridian line can be traced upwards on the vertical wall. This gives a better indication at the winter solstice, for the image ellipse is not stretched out as much as in the normal meridian line, when it becomes much fainter, important when the image is in the partial obscurity of the shade of a cloister wall.

But the main impression of these monumental meridian lines is that they are really show-pieces rather than serious astronomical instruments, and as a time standard for the correction of accurate clocks, cannot be taken seriously.

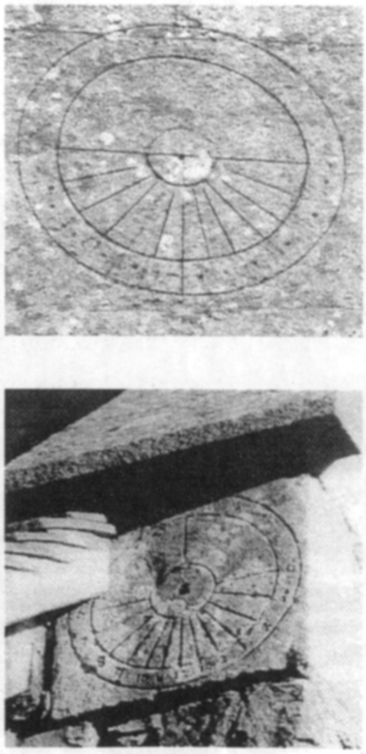
Probably the main reason for such magnificent combinations of science and art not being installed in Protestant churches is because, as with the modifications to the Julian Calendar, they were not acceptable to non-Catholics. Queen Elizabeth I would very much have like to have adopted the reformed calendar but unfortunately it would have smacked of papacy, hence anathema to the average Protestant. More than a century later, its delayed adoption still provoked great unrest in the country because the people thought their lives were being shortened by the eleven days removed from the calendar. No possibility existed therefore of the installation of Roman Catholic meridian lines in Protestant churches. This is a very great pity for these art the most impressive of all dialling works.

READERS' LETTERS

MASS DIALS

Karlheinz Schnaldach's article on Mass Dials in Bulletin 96.3 was interesting and informative; we are indeed blessed with Mass Dials in the United Kingdom. I gather the correct count is about 5,000, and certainly Gloucestershire has its fair share, all sizes and shapes.

I was none too happy with the paragraph commenting on the Gleahaussen dial (Fig. 16). The hour line spacing is non-uniform, more as per a sundial, and the strange ciphers are Roman numerals but using a U instead of V, VIIII for nine, and writing the I's above the U. + is used for X and again the I's are written (or carved) above.



Similar spacing occurs on mass dials at Coln St. Aldwyn and Sandhurst, Gloucestershire (see accompanying photographs), and presumable others. I wonder how far apart in time these dials are from the Gleahaussen dial?

After discussion with other members about this article, I should add the following further comments:

Figure 4, which shows a Byzantine dial with twelve equal divisions, is marked with the old Greek numerals for 1 to 12 and seems (7th century) a very late use of such numerals. The use of upper case may or may not be significant, but Ref. 1 indicates an original implication of ordinal numbering, i.e. first hour, second hour etc, rather than 1 o'clock and so on.

Figure 6 which gives 'shadow lengths' monthly also lists at the foot the equinox and solstice days. The days quoted are a month or so different from current thinking. This is a diversion from the subject of Mass Dials, I realise, but perhaps someone can explain. (The Julian/Gregorian calendar transition accounts for only a few days at most).

REFERENCES

1. Flegg, G. *Numbers, their History and Meaning*, Pelican 1984
2. Smith, D.E. *History of Mathematics*, Vol II, Dover 1958
3. Negebauer, O. *The Exact Sciences in Antiquity*, Dover 1969
4. Danzig, T. *Number: the Language of Science*, Allen & Unwin 1947
5. Cajori, C. *A History of Elementary Mathematics*, Macmillian 1959
6. Solomon, C. *Mathematics*, Hamlyn 1972

A.O. Wood

PROFILE - CORRECTION

I would urgently like to make a correction to my profile in the last Bulletin (97.2). To say that "I made a successful career starting from scratch and on an individual basis": is not what was said. I made it quite clear that without the training from a master teacher and without Brookbrae Ltd. which has provided regular commissions over the years there would certainly not be a career here. To Brookbrae in particular I wish to apologise sincerely for the totally incorrect view that has been put forward.

Also many of the list of Public Works are incorrectly attributed to myself alone. They were team projects in which I was a member, and certainly not wholly responsible.

This was also pointed out to the interviewer: particularly in respect of Qaboos University Oman, Armillary Sphere Kew Gardens, Sundial at Tower Hill Station, Knife Fork & Spoon Trust House Forte, 3 metre Sundial Balfour Beaty, Analemmatic Sundial Thorpe Park, 3 Metre Revolving Clock, Al-ain Dubai and others.

Apologies to all those into whose shadows I have stepped. And maybe in future those profiled could have a chance to see the copy first.

Joanna Migdal

DOUBLE (CLOCK-SUN) DIAL

Apropos the Double (Clock-Sun) Dial about which Margaret Whitaker wrote in the April Bulletin, I am well acquainted with this curiosity since I park my car alongside it whenever we take tea with my friend and colleague Rev. Frank Wilson and his wife, who live at Prospect House on the hillside above. The double-dial is on his property and he gave me the following account of its history some time ago, in return for my promise to give an illustrated talk on 'The Sundials of Ryedale' to his Ampleforth History Society.

At the foot of Frank's garden stood the premises of Richard Preston & Sons, Masons, fronting Ampleforth Main Street and built in 1837. To advertise their trade they placed in the window of their shop certain stone-carved curiosities, of which this double-dial was one. No one in Ampleforth remembers its ever containing a clock mechanism or exhibiting permanent sundial markings. It was a mason's conceit.

In 1987 the property was demolished when Frank took over Prospect House and bought the land on which the shop stood. The exhibits which had been indoors in the shop window were saved by being incorporated into the west-facing party-wall with the neighbouring property which had to be rebuilt after the demolition. For the first time in their lives, and for ten years now, clock and dial have been exposed to the weather.

I had been intending to write to the Bulletin about this very dial, and to enquire if any readers have knowledge of other combined clock-sundials elsewhere, and details of their construction. I am persuaded that the Ampleforth example, even if it had been completed, would have been a failure in its 'sundial' mode if not in its 'clock' mode.

Rev. John Wall

RESTORATION OF DIAL AT ST. HELEN'S

I was doubly delighted to read Alan Smith's article (Bulletin 97.2) on the restoration of the 18th century sundial at Hardshaw Friends Meeting House, St. Helen's, as I worshipped there regularly during the 1960's.

Vertical sundials are quite a common feature of 17th and 18th century Quaker meeting houses, where they obviously enabled and encouraged prompt attendance at meetings for worship. But the purpose of this letter is to draw attention to a related problem, perhaps peculiar to the Religious Society of Friends.

The unprogrammed, and mainly silent, meeting for worship ends when the elders shake hands. Today they do so with one eye on the clock, but it is unlikely that an early 18th century Quaker meeting could afford a clock. And the sundial, on the outside wall, could not be read from indoors. So how did the elders know when to conclude the meeting? I noticed in the meeting house at St. Helen's that one of the south-facing windows (off to the left of Figure 1 of Alan Smith's article) almost abuts the west wall of the interior. The sun therefore shone on the inside face of the west wall until roughly noon L.A.T., when the elders would have thought about shaking hands. This was true for every solar declination. Today daylight saving spoils the story, and anyhow the meeting house clock has usurped the meeting house sundial.

But I wonder how many of the early Quaker meeting houses still have some feature, a pillar for example, which the sun strikes at noon. Next time you stop to admire an old Quaker sundial, please nip inside and look for an elder's benchmark. And let me know! (4 Aigburth Avenue, St. George's Road, Hull HU3 3QA: 01482 216792).

Afterthought: St. Helen's is, of course, the "home" of Pilkington Glass who published, about 30 years ago, a full set of horizontal sundial plates, for every latitude from the equator to the poles, with instructions for transforming them into vertical dials for any orientation. This publication 'Windows and Environment Guide' is long out of print, but many architects still treasure it. For that reason alone, St. Helen's deserves its restored sundial. I am glad BSS had a hand it it.

Thank you, Alan Smith.

John Lynes

DIALS: WHERE TO SEARCH

I have abstracted information about the location of sundials and mass dials from a number of Arthur Mee's 'King's England' books. Some of this information has appeared in the Bulletin, No. 96.2. I have now compiled lists for the following counties: Devon, Herefordshire, Lancashire, Leicestershire, Norfolk, Rutland, Shropshire, Suffolk, Surrey, Sussex.

I have also abstracted information about the location of Mass-dials, compiled from A.R. Green's 'Sundials, incised dials and mass clocks.' Green's book lists many place names in the counties of Gloucestershire, Hampshire and the Isle of Wight, Herefordshire, Somerset, Wiltshire, Worcestershire and Yorkshire.

Mee's books were published in the 1930's and 1940's, and Green's book in the early 1920's. It will be interesting to discover how many of these dials are still visible after 60 or 70 years. This may be an instance in which negative evidence is useful, so it is worth making a note of any dial listed but no longer present. Such information gives an idea of sundial's life expectancy. Also if lists of 'no longer present' dials appear in the Bulletin occasionally, other diallists' fruitless searches may be prevented.

Copies of these county and place-name lists are available in exchange for an s.a.e and a small donation to the B.S.S.from: John Lester, 24 Belvidere Road, Walsall, West Midlands, WS1 3AU.

John Lester

UMKHONTO WE LANGA IN THE UK

On reading the fascinating article by Mr. Holliday in Bulletin 97.1, I set out to adapt his linear-law horizontal dial to UK latitudes (and beyond), and concluded as follows.

If the distance from the six o'clock mark to the gnomon is taken as ten units, then the distance between adjacent hour points on the spear curve varies thus:

Latitude	0	10	20	30	40	50	60	70	80	90
Hour dist.		15.1	7.66	5.24	4.07	3.41	3.02	2.78	2.69	2.62

The relevant hour distances can be set on a pair of dividers, and by walking these from one hour line to the next, starting at six o'clock, a linear-law contour can be added to any (symmetrical) dial. (If a dial for non-zero longitude is required, the hour points of a symmetrical dial can be shifted along the curve by four minutes per degree).

At UK latitudes the curve is not very spear-like, but in the case of a south-facing dial for 50° (based on data for a horizontal at 40°) the spear is transformed into a shield, being completed across the top by the 6am to 6pm line.

John Singleton

"ALMOST SUNDIALS"

As we approach the Millenium, scores of new public monuments are being planned. Happily, many will be in the form of sundials, but, less fortunately many will be "ones that got away" or "Almost" sundials. B.S.S. members with influence in the Municipal or Public Works sectors may be able to help in preventing such instances. Others like myself may wish to join fellow members in recording the missed opportunities in their district.

The East London Group (i.e. me) recently made a photographic survey of our area and discovered two examples. Fig. 1 shows an "Almost" analemmatic dial recently installed at Loughton Library. The mosaics in the centre panel and surrounding "Hour" plate illustrate various library topics, e.g. gardening, golf and the gospels, but predictably not gnomonics.

Fig. 1

A few miles away, an "Almost" helical dial has been erected at Stratford Bus Station (Fig. 2). A plaque grandly announces it as "The Time Spiral," which it could indeed become - a well-judged impact from a No. 257 double-decker (Northbound) is all that is required to produce the necessary 51.5° tilt.

Fig. 2

I wonder if the Editor would like to hear about other members' discoveries of "Almost" dials. Could such reports become a regular feature in these columns? Is there scope here for establishing a new society - The A.S.S.?

Well, Maybe not.

John Moir

‘I AM A SUNDIAL’

CHRISTOPHER ST. J. H. DANIEL

with no apologies to Hilaire Belloc

Last November, as a result of resolving some gnomonical problems for Dr. Derek McNally of the University of London Observatory, I was invited to be his guest at a dinner of the Royal Astronomical Society Club, on Friday, 14 February 1997. On accepting this kind invitation, I learned that I would be expected to ‘sing for my supper’, by giving a short, but witty speech, at some point after the loyal toast. I was free to choose my own topic.

I decided to relate some anecdotes and experiences that occurred during the years when I was a Research Assistant in the Department of Navigation and Astronomy at the National Maritime Museum, Greenwich. I followed this by referring to my host, whom I have known for over thirty years, and to the fact that I had noticed the name ‘McNally’ (his son) in the membership list of the *British Sundial Society.*

Thus, I introduced my captive audience to my most recent career in designing modern sundials, researching their history and writing about them. “Sundials hold the same fascination and have provided me with the same pleasure,” I explained, “as *R R Lyrae* cepheid variables and Johann Sebastian Bach did for Sir Richard Woolley” (a former distinguished Astronomer Royal).

I concluded my little speech by calling my Royal Astronomical Society audience’s attention to the 1920’s journalist, author and poet, Hilaire Belloc, who wrote several verses about sundials. His contemporary, H.G. Wells, declared that Belloc was “careless and ignorant as to his facts and slovenly and tricky in his logic.” Nevertheless, when it comes to sundials, this particular verse of his is invariably seized on to put the sundial in its place:

> *“I am a sundial, and I make a botch*
> *Of what is far better done by a watch.”*

My response to this, written especially, but somewhat hastily, for this occasion, was as follows:

> *I am a sundial: I determine time;*
> *I regulate the clocks that chime.*
> *When hours advance* (You wonder why?)
> *’Tis I alone expose the lie!*
> *But, lest you think I only run*
> *According to the Apparent Sun*
> *Know that I may oft be seen*
> *To indicate the Time that’s* Mean*;*
> *Allow for longitude at least,*
> *In hours or minutes, West or East,*
> *And pander to that crude* device,
> *If needs must pay for Summer’s price.*
> *Yet can I show, for your delight,*
> *The Solar* azimuth *and height;*
> *Tell how many hours each day must run*
> *And give the times of rise and setting Sun.*
> *Dabble I might in hours of the past*
> *Antique, seasonal, or planetary cast*
> *Babylonian and Italian hours project,*
> *Or simply ascertain that Noon’s correct.*
> *In every shape and size I may be found*
> *High on a wall or level with the ground.*
> *Mechanical parts and optics, if you please,*
> *Enable me to operate with ease;*
> *Small as a nut to nestle in the hand*
> *Or as a giant in structure I may stand.*
> *When clocks and watches fail to run,*
> *My course continues with the Sun;*
> *Science and Art I both combine,*
> *Forever as the Sun may shine!*

SEARCH FOR AUTHOR

An article entitled “The Turnbull Dial at Corpus Christi, Oxford” was submitted last year for consideration for publication in the Bulletin. When the typescript reached the present editor, there was no name or address attached to it. The editor would be glad to hear from the author, and hopes that he/she is a reader of the Bulletin.

If the material is still of unknown provenance at the end of the year, it will be discarded.

CHARLES K. AKED:
FOUNDING FATHER FIRST EDITOR AND VICE PRESIDENT
FROM THE CHAIRMAN'S PEN

It is now more than eight years since the British Sundial Society was formed in 1989. The idea of such a society had been in my own mind as far back as 1975. Specifically, I was concerned with recording sundials throughout the country, with the purpose of producing a national Sundial Register, which proposal I discussed at that time with Gordon Taylor, then on the staff of HM Nautical Almanac Office at Herstmonceux. I had some vague notion that, at some time in the dim and distant future, I would undertake this whole project single-handed!

I think that the first written mention of the proposed 'British Sundial Society' appears in a letter, by Robert Mills, dated 28 May 1976. At the time, however, I had enough on my hands, besides holding down a busy job at the National Maritime Museum. Since I knew of only two other people who appeared to be seriously interested in sundials, (one of whom was Dr. Andrew Somerville), there seemed to be no great urgency to form such a society. I had heard of Charles Aked, of course, as he had reviewed one of my earliest sundial works, but, so far as I knew, he was a 'clock' man with no particular interest in sundials.

In 1986, after I had left the Museum, I first heard of David Young. I had discussed the idea of a British Sundial Society sometime earlier with Andrew Somerville; but David offered the key to its foundation since he had said that he would be prepared to be the secretary of the contemplated organisation, the most vital administrative role of all. Nevertheless, it was not until 1989 that matters came to a head. Suddenly, so it seemed to me, Charles Aked emerged from the clouds of the 'clock' world and bluntly demanded to know what we were going to do about forming the proposed British Sundial Society. Thus it is to Charles that the *real* credit must go for 'kick-starting' the Society into life!

A meeting was held at David Young's house, when Andrew Somerville became the first Chairman, David Young became Secretary and Charles Aked became Editor of the proposed *Bulletin*. Whilst the secretary of a society is the foundation for its success, the editorship of a society's journal is no less vital to its progress, expansion and well-being. Charles immediately took the embryo *Bulletin* in his capable hands and with masterly skill very quickly made it into an outstanding publication. Not only has the *Bulletin* continued from the outset to be an attractive work, but invariably it has contained a good mix of well illustrated articles for all levels of interest. Its quality, in all respects, as the principal medium for communicating with members, has undoubtably earned the Society an enviable reputation. This, in turn, has not only been largely responsible for the vigorous early growth of the Society, but for maintaining the current high level of membership.

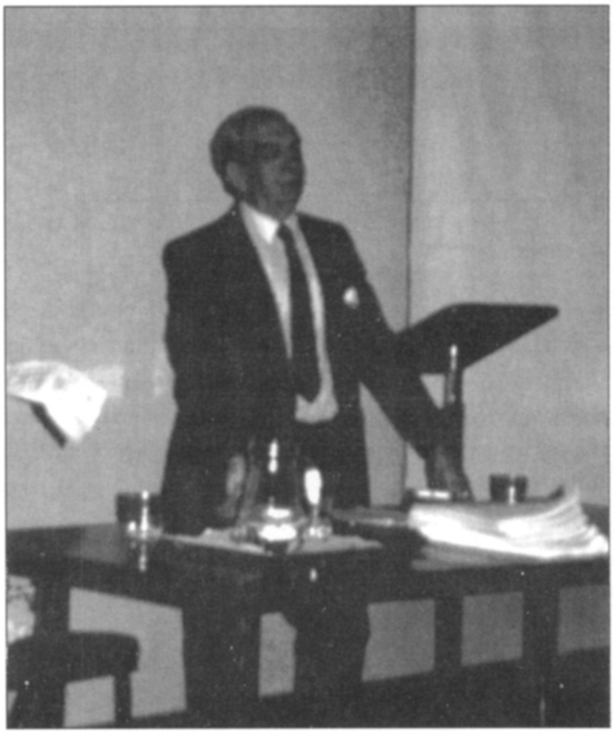
The Editor's task is not an easy one. Behind the scenes, Charles Aked put in an immense amount of time and effort into overcoming the innumerable problems that arose, not only with the printers, but with the contributors also. Whilst creating the impression that he was not altogether bothered by the failings of others, he would take great pains to check, double-check and put right the many errors that came to his notice. In doing so, he sought perfection, but was resigned to the fact that this was an impossible goal to achieve. As Editor, he frequently had to make unpopular decisions to produce the results in a suitable format on time and this he did, conscious that he could not please everyone, however much he tried.

During his editorship, Charles also contributed regularly to the *Bulletin* with editorials, photographs, articles, reviews and even poetry. An accomplished author and poet, he originally intended to pursue a career in chemistry and received training as an industrial chemist. The 1939-45 Second World War intervened and gave him a five year spell in the army, serving with the Royal Electrical and Mechanical Engineers (REME) in Radar Communications.

Following the end of the war, at the age of twenty-five, he briefly joined the family jewellery business in Rhyl, but left after a year to join a research team, working on naval communications, specialising in high-power transmitters and advanced radar techniques. During nearly forty years in the Royal Naval Scientific Service, until his retirement as Principal Scientific Officer in 1984, he contributed some thirty scientific papers to the Royal Naval Scientific Journal.

As if this were not enough, Charles Aked's life-long interest in horology led him to join the Antiquarian Horology Society in 1962 and take up various honorary posts, that involved him in writing, editing and publishing for the AHS. Gaining an international reputation in the field of horology, he has contributed over three hundred articles on the subject to many of the world's horological journals. Somewhere in the midst of this prodigious output, Charles also found time to take an interest in the history and development of dialling. Indeed he has produced a listing of over 3,000 dialling works and references, as well as writing many dialling articles that have appeared in a variety of publications. His remarkable knowledge, including foreign languages, his expertise, experience and skill provided the ideal qualifications for the man who took command of the Society's first and foremost publication. The Society was fortunate indeed that Charles was the right man, in the right place, at the right time. We owe him a tremendous debt of gratitude, not only as the founding member who was principally responsible for the Society's formation, but for his outstanding contribution to the Society's success.

Sadly, for health reasons, Charles Aked has now had to relinquish his editorial office, which has been taken on by Dr. Margaret Stanier. In recognition of his unstinting services to the Society, at last year's AGM he was elected a Vice President. He may no longer be 'at the helm' of the *Bulletin*; but the Society will still benefit from his sagacious influence. He has already embarked on a definitive bibliography of dialling references. We wish him a long, happy and rewarding 'retirement' from his remarkable term of office, as Editor of this *Bulletin*. I know that I speak for all of us when I say: *'Thank you, Charles.'*

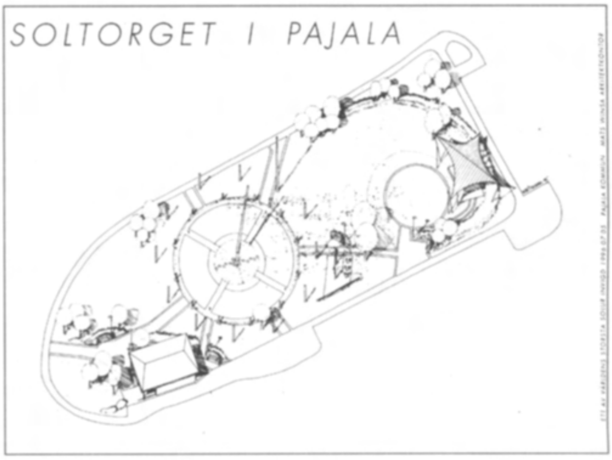


SUNDIAL IN PAJALA, SWEDEN

DR. G.B. TOWNSEND

The sundial shown in this photograph is situated in the Square of the Sun, Pajala, Sweden, some 70km north of the Arctic Circle: 67° 21'N, 23° 38'E. At the Summer Solstice the dial shows the time (potentially) for 24 hours a day. (Of course it is not very useful in mid-winter!) On the ground is a calendar made of 365 stones. The post to the north has signs of the changes of the sun's altitude during each month of the year. The inner diameter between the poles of the circular dial is 38.88m.

The builder is Mats Winsa, the town architect of Pajala. The sundial was officially opened on 5 July 1996. The author is in touch with the architect.



BOOK REVIEWS

CHARLES K. AKED

LA LEYENDAS LATINAS DE LOS RELOJES DE SOL

Jesus de la Calle

15 pages, one illustration on front cover. Paper covers, A4 format, 29.5 x 21cm. Published by the Associacón de Amigos de los Relojes de Sol, Madrid, 1997. Price not known. Foreword in Spanish.

This is a listing of 1022 sundial mottoes in Latin, with their translation in Castellano. It is therefore of interest to British diallists only for the Latin mottoes. They have, in the main, been taken from the 1900 edition of Gatty, the works of Boursier, Andrée Gotteland and Rafael Soler Gayá. A similar publication, with Latin/English translation, would be very useful for English readers, preferably in an A5 format to allow it to be carried in the pocket for reference purposes.

The author is to be congratulated for his work converting the Latin phrases into his native language.

OROLOGI SOLARI A TAGGIA

Mario Arnaldi

111 pages, 29 photographs, many in colour, 37 figures, plus five pages with details of making sundials in card, repeated on thin card, coloured illustration of sundial on cover. Card covers, 24 x 17.5cm. Published by the Commune di Taggia, 1996. Italian text, price not known.

The first part of this work commences with the history of the sundial, then the history of the measurement of time. It goes on to the beautiful Convent of St. Domenico, showing examples of the dials there; and this is followed by an account of the sundials of the small convent of the Cappuccini Priests.

This leads on to the sundial on the parochial church of Taggia, a small dial with an enormous tablet below extending the hour lines and an equinoctial line.

The second part deals with making gnomonics simple, going on to gnomonic curiosities such as finding the time from the length of a man's shadow or by use of the human hand. Notes are given on how to construct a vertical declining sundial, going on to details on the moon and how to make use of it for telling time. There are 4^1/2 pages on references in the text. Until the reviewer saw this section, he had not noticed a single reference, for the superscript reference number is printed so lightly that only the containing brackets indicate its presence.

There are several appendices, the first dealing with restoration, the second with finding the true time at Taggia, with an Equation of Time at 10-day intervals. Appendix C deals with the lunar table for adding or subtracting from a table to find the time from a sundial. Appendix D deals with the comparison of Italian and Oltramontne hours, with worked out examples for the meridian at Taggia and Rome.

A small glossary of dialling terms is given, pages 97-101. It is a simple outline. A short bibliography is offered; naturally many of the examples quoted are Italian works. The obligatory acknowledgement section is included, bringing the book itself to a conclusion, but there are further pages with cut-out models of sundials, first on paper, then repeated on thin card.

Mario Arnaldi is a prolific writer on dialling matters. This work is excellent in content and the way it is presented. Shame about the Italian text; ti is amenable to translation via an Italian/English dictionary, for this is how the reviewer disentangled the preceding details.

DUE FRAMMENTI DI OROLOGIO SOLARE ROMANO AL MUSEO NAZIONALE DE RAVENNA

Mario Arnaldi

16 pages, 9 figures, 4 or which are photographs. Thin card covers, 24.5 x 16.5cm. Extracted from Ravenna Studi e Richerche, III, 1996, of the Società di Studi Ravennati.

The extract is paginated 13-28, and the account deals with the two fragments of a Roman Sundial conserved in the National Museum of Ravenna. A reconstruction of the sundial is given, together with an illustration of a similar but almost complete example at the Archaeological Museum at Aquilea. The functioning of this type of dial is explained in some detail. Again the Italian text is a stumbling block to the English reader.

JOURNAL REVIEWS

CHARLES K. AKED

THE COMPENDIUM

The latest issue of the journal of the NASS, Volume 4 - Number 1 - March 1997

The 32 pages contain a wide range of dialling topics but show the dependence of the contents upon the President and Editor Frederick W. Sawyer III. It opens with an account of William Oughtred's Double Horizontal dial by Fred Sawyer.

The next article is concerned with The Description and Use of the Double Horizontal Dyall, which again seems from the pen of the Editor although originally written by the great English mathematician William Oughtred.

In "Some Secret Motion of the Earth", again by Fred Sawyer, he draws attention to the curious error of judgment made by Charles Leadbetter, where he thought that the delineation of a sundial was dependent upon the magnetic declination. It is followed by an apt quiz on finding the declination of a dial from its delineation.

It is interesting to see a contribution "Digital Bonus: Calculating the Hour Lines" by one of the oldest BSS members, Peter A. Lamont. It is remarkable that an 86 year old man can have such a profound grasp of the computer and dialling programmes.

The seventh part of "Error of Analysis of the Horizontal Sundial" by Lauroesch and Edinger covers the incorrect installation of a properly made and assembled sundial for the site. The errors are unlikely to worry the average diallist; they are for the purist with the finest quality sundials.

Part 2 of "The Eliptical, Circular and Linear Dials" by Réne Vinck of Belgium, deals with the linear dial and its mathematical proof.

There is a report by Woody Sullivan on a Sundial Meeting in Seattle at the University of Washington, finishing after a tour of ten sundials with a wine and cheese party at the Sullivan household. Appropriately enough the wine was Wehlener Sonnenuhr Auslese from the J J Prüm vineyard in Germany, recommended for any sundial gathering.

There is an interesting aside in the form of a letter from Robert Boyle defending the concept of a final cause, illustrating his argument with a sundial telling time from the shadow of the sun's passage. The next three pages detail the design and making of a stained glass window dial by Lee and Joanne Bowden.

In the Design and Construction Forum, Robert Terwilliger describes the marking out of an indoor analemma. An unusual project, that of a sundial to mark the hour to sunset, follows. It is presented by Mark Oglesby and is used at the Moore's Field for pilots of light aircraft that must land by sunset or shortly after. This requires no longitude correction, or Equation of Time.

In the Letters feature is one by Ross McCluney on mottoes and sayings in connection with sundials; and one by the reviewer on clock/sundial combinations.

Finally "From the Tove's Nest" by Fred Sawyer: an interesting expedition into the Republic of Northwest Queoldiaola, where the best sundials in the world are made. The Compendium ends with the Equation of Time and Solar Declination at Noon Eastern Time for April-June 1997.

A very pleasant and entertaining issue of a fine sundial Bulletin.

ZONNETIJDINGEN

The Bulletin of the Belgium Sundial Society, issue 1996-04 for December 1996.

This contains some interesting articles. It commences with a mathematical treatment of the Analemmatic Sundial by R.J. Vinck. It goes on to round examples exemplified by that designed by Gordon Taylor. An equatorial sundial with an analemma is illustrated; it is installed in Oslo on a massive granite base.

Next is an article on the Armillary Sphere, showing its features in detail, followed by an actual example on the following page. This leads on to an article on the varieties of equatorial sundials in Rupelmonde by J. Lyssens, and is illustrated by five actual examples.

Henny Vink-Quisenaerts gives an account of the well-known International Antique Scientific and Medical Instrument Fair held in the Portman Hotel in London on 27th October 1996 under the auspices of the Scientific Instrument Society. BSS members who have never visited this venue would find it quite an experience.

The final article is about a visit to the Kentucky Vietnam Veterans Memorial by Julie Lyssens and André Depuydt. This was fully outlined in BSS Bulletin 93.1 pages 9-16, erroneously quoted in Zonnetijdingen as Bulletin 96.3. The issue ends with a notice of an excursion on 21 June to Asten, Lierop and Weert.

DIALS OF BONAR

GORDON E. TAYLOR

An article on the Dials of Bonar by Gordon E. Taylor published in BSS Bull. 91.3 contains an incorrect Table. The correct version is printed below. Any BSS member who has a copy of Bull. 91.3 is invited to substitute this page for page 14 in his/her copy, and to ignore the list of errors given in BSS Bull. 95.2.51.

The author has made several previous attempts to have this correct list printed; he considers, rightly, that with the dispersal of Bonar Dials there should be a complete and correct list in print.

Ed.

Table 1. Names of ports on the Bonar sundials

Original Location	**Kinmure Castle**	**Bangor Abbey**	**Whithorn**	**Loudoun Castle**
Date of Dial	1623 December 11	1630 December	1632 September 22	1634 February 12
Compass Direction				
N	Sky	?	Galloway	Sky
NbE	Redbane	Aberdeen	Wigton	Bamfe
				Solway Sands
NNE	Leith	Wigton	Monros	Wigton
				Kirkubre
NEbN	Dundie	Dundie	Dundie	W. coast of Lorn
NE	Culros	London	Culros	Culros
				London
NEbE	Perth	Perth	Berwick	Perth
				Robin Hood's Bay
ENE	Stirline	…mal	Cork	Stirling
				Cork
EbN	Falmon	Torbay	Falmon	Falmon
E	Doward C		Humber	Douard Castle
EbS	Bristoll	Bristoll	Bristoll	Foulnes
ESE	Texel R	Brihar	Brihac R	Texell Road
SEbE	Kaskets	Dublin	Dublin	Dublin
				Mcnell's Castle
SE	Orknay	Orkny	Orknay	Wly Orknay
SEbS	Deep	Deep	Deep	Deep
				Needles of Wight
SSE	Yarmond	Yarmond	Yarmond	Dover fen
SbE	Callice	…nds	Calice	Calice
				W ilands
S	Galloway		Y	Dunkirk
SbW	Solway	Solway	Solway	Glasgow
				Aberdeen
SSW	Wigton	Leith	Horn	Gravesend
			Leith	Leeth
SWbS	Burdeaux	…lls	q Ferrie	Dundy
SW	Londn	…lere	London	Amsterdam
SWbW	RH Bay	Brouage	Perth	Berwick
WSW	Corke	Cork	EWC irland	EW coast Irland
WbS	Barnsey	…mon	Torbay	Caldy
				Lizard
W	Antwerp	Waterford	Douard C	Antwarp
WbN	Harpooll	Texell	Foulnes	Bristoll
WNW	Brih ick	Kyll	Texell R	Brihack
NWbW	Dublin	Jambay?	Portland	Uschant Ill
NW	Frizland	…ilor	Foyne	Pichtland Firth
NWbN	Lux	…w n	Kaskets	Kaskets
NNW	Dover	Bangar	Dover	Yarmond
NbW	Aire	Ayr	Ir	Ayr
				Cape Gallant

A SUNDIAL DEDICATED TO JAMES TAYLOR

E. VILAPLANA & P. GAGNAIRE
(Lyons, France)

HISTORICAL BACKGROUND

Mr. James Taylor, who played an important part in the early years of the British Sundial Society, was a talented gnomonist and the great-grandson of the famous George Boole, the creator of modern mathematical logic. When he visited Vénissieux near Lyons in 1990, he told us about his plan to create a horizontal sundial which would be installed in London and would have three distinctive features:

a) it would present hour lines in binary notation;
b) it would honour the memory of the three scientists whom James Taylor considered to be the real founders of computer science: Jean-Marie Jacquard, George Boole, Charles Babbage;
c) it would honour the cities where the three scientists lived and worked: Lyons, Cork and London.

James Taylor has passed away, but we have endeavoured to fulfil his plan, and the sundial we are describing combines the functions of an ordinary sundial with the three wishes he made. This sundial, constructed of enamelled lava stone, has now been erected in the garden of one of us (Emile Vilaplana) near Lyons.

THE TRIBUTE OF THE SUNDIAL

a) The hour lines are marked both by arabic numerals (24 hour clock time) and also by black and white discs symbolising 0 and 1 in binary notation.

4 = 100 = ●○○
5 = 101 = ●○●
6 = 110 = ●●○
7 = 111 = ●●●
8 = 1000 = ●○○○
9 = 1001 = ●○○●
10= 1010 = ●○●○
11= 1011 = ●○●●
12= 1100 = ●●○○
13 = 1101 = ●●○●
14 = 1110 = ●●●○
15 = 1111 = ●●●●
16 = 10000 = ●○○○○
17 = 10001 = ●○○○●
18 = 10010 = ●○○●○
19 = 10011 = ●○○●●
20 = 10100 = ●○●○○

b) An inscription gives the names and dates of the three scientists to whom the Sundial is dedicated:

J-M. Jacquard	1758 - 1834
C. Babbage	1792 - 1864
G. Boole	1815 - 1864

c) The cities where the three scientists were born or chose to live are represented by their armorial bearings. The arms of London are placed between those of Lyons and Cork as it is the capital of a state.

GNOMONIC FUNCTIONS OF THE SUNDIAL

We proposed to set up in the garden near Lyons a sundial in the same plane of space as that of a horizontal dial in Mr. Taylor's garden in London. A declining/inclining dial in Lyons would thus become parallel with a horizontal dial in London, and would give, in Lyons, a direct reading of London time. The declination is 152.66°, the inclination is 6.58°N.

a) *Hours:* Hour lines from 4 to 20 radiate from the gnomon and end in an intermediate circle beyond which they are figured in binary notation. The binary notation is contained in a wider circle which is subdivided into quarters of an hour by graduations and alternating colours. The shadow of the gnomon of the Taylor Sundial indicates apparent time in London, the latitude and longitude of which are noted on the circumference of the hour circle.

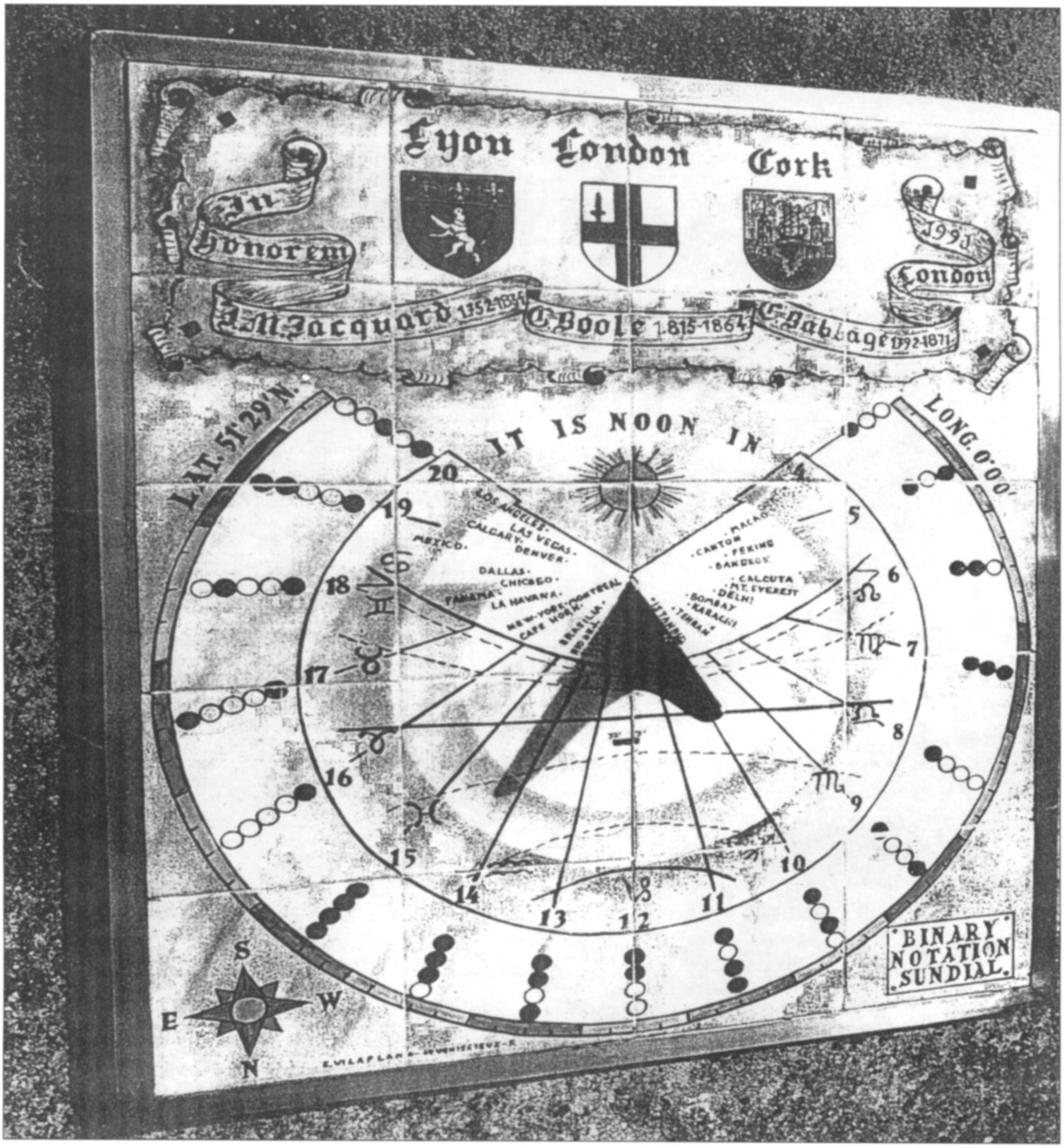
b) *Declination Arcs:* These arcs are represented by dotted lines for the 21st of each month, except the arcs of solstices and equinoxes, which are represented by red unbroken lines. The arcs are accompanied by the signs of the zodiac.

c) *Midday Around the World:* The names of 12 places east of London and 16 places west of London have been painted on either side of the triangular brass style. Accurately situated in accordance with their longitude, they indicate midday when the shadow touches them.

d) *Sunrise and Sunset:* Three concentric zones - red, orange and yellow - are limited by sunset and sunrise times at solstice and equinox, i.e.

summer solstice: sunrise 3.47am, sunset 8.13pm
equinoxes: sunrise 6.00am, sunset 6.00pm
winter solstice: sunrise 8.13am, sunset 3.47pm

e) *Sun Over Britain:* Overlapping the line 12, a small blue bar shows that the sun needs 39 minutes to cross all the meridians of the British territory: 7 minutes before noon and 32 minutes after noon.



The corners of the dial plate are filled with the title of the dial, and an 8-point compass rose.

So now in the gardens of E. Vilaplana, the 'Taylor Sundial' displays the time of London, and reminds us of very pleasant hours.

This short description scarcely does justice to our affectionate admiration for James Taylor, which must be shared by all who met him and have heard his enthusiastic talk of gnomonics. Our present membership of the British Sundial Society owes much to the man who in 1990 came on a pilgrimage to the city of J-M. Jacquard.

(M. Vilaplana has sent the following description of his calculation for the orientation of his sundial:

London:	latitude 51°29',	longitude 0°
Lyons:	latitude 45°46',	longitude -4°50E

The *declination* is the azimuth of the great circle (orthodromic sense) connecting London and Lyons, = 152.66° clockwise from north.

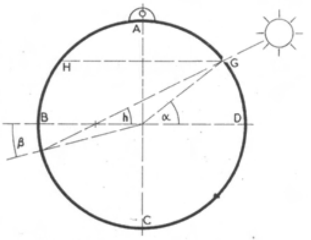
Distance in nautical miles from London to Lyons is 394.78.

So *inclination* in degrees is 394.78 / 21600 x 360 = 6.58°).

DE BOERENRING

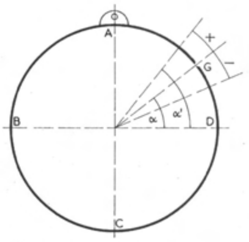
FER J. DE VRIES (NETHERLANDS)

The Farmer's Ring, by which name it is known in the Netherlands, is a simple ring dial, as detailed and discussed in recent issues of the BSS Bulletin. It is one of the class of sundials known as Altitude Dials, which give the time from the sun's height above the horizon, not its azimuth or hour angle.



$\beta = 2h - \alpha$

Figure 1a



$\alpha' = \alpha$ + degree of movement
$\beta = 2h - \alpha'$

Figure 1b

The scale on the inside of the ring consists of vertical date lines and diagonal hour lines. Sunlight passes through a small aperture, the gnomon hole or nodus, on the opposite side of the ring, traverses the inner space and casts a spot of light on the scale, from which the time may be read.

Figures 2-5 show four differing scales as they would be drawn on a flat plane (card or metal) before bending it into the shape of a ring. These are based on a ring with an inner diameter of 40mm and a width of 24mm, the hour lines being calculated for the latitude of 52° North, and the date lines are those of the first days of the Zodiac months, as is customary in dialling. The sun's declination(s) on these dates have been "rounded off" for convenience: -23.5: -20: 0: 11.5: 20: 23.5 degrees; this is quite accurate enough for a small dial such as this.

The date lines are 4mm apart across the width of the ring. Whilst parallel date lines are usual, they do not have to be, they can taper or even curve. The date scale only needs to cover six months, as the sun's altitudes are a mirror image of the first six months. Each date line can therefore serve for use on two complementary dates. The dimensions given here for this ring are for purposes of example only. The ring dial may be made of any size that is desired.

To read the time with a simple ring dial having a fixed nodus, it is suspended from its pendant with the nodus turned to face the sun so that a spot of light is cast upon the inner scale. The nodus being in the centre of the ring's width, the sunspot must be positioned on the centre date line, which is that of the equinoxes. An horizontal line is now imagined from that point to the date of observation, either on one of the other date lines or an estimated point between them. From this imagined point of intersection between the date and hour lines, the time is read off.

If the sunspot is placed other than on the centre date line, an error is introduced; this will be examined in detail later.

First a ring with a fixed gnomon will be outlined. With reference to Figure 1a, hole G is placed at an angle *a* from the horizontal. This angle is not critical as long as it casts a clear sunspot throughout the scale. In the example here, 38° is chosen (the co-latitude of 52°, but it does not have to be so).

When the sun's altitude is 0° (sunrise and sunset), the reading on the scale is the same for all dates. It falls on a straight horizontal line at a height equal to *a* from the centre of the ring. This is the horizon line H.

The sun's height (h) for the hours of the day can be calculated from the formula:

$$\text{Sin } h = \sin \sigma \sin L + \text{Cos } \sigma \cos L \cos A$$

where h = the sun's height (altitude)
σ = the sun's declination
A = the sun's hour angle
L = the latitude

From h and α the angle ß may be calculated:

$$ß = 2h - \alpha$$

Thus the complete scale can be drawn. The result will appear as in Figure 2.

Instead of the usual fixed nodus, consider the dial with a movable nodus. The angle of movement would be against a vertical scale of dates to correspond with the dates on the dial's hour scale. The amount of such movement can be chosen at random, see Figure 1b. Two such examples will be examined.

First assume that the movement will be $\overset{\sigma}{\cancel{2}}\alpha$, so for each date line we now have a new nodus angle: $s = \alpha + \sigma$. This gives rise to a new scale as shown in Figure 4 which, as one might expect, is about halfway between the examples in 2 and 3. It is not necessary that the movement be equal, or in any way related to σ. By doing more calculations, a scale with straight line for 9am - 3pm could be developed, for instance.

In all the examples given so far, the sunspot must be placed on the centre date line. Ideally, the sunspot would be placed on the date of observation, thus making the reading of the time much easier.

On the equinox dates, there is no error of reading, but when the sunspot is placed on any other date, offset from the centre of the dial, the effect is of the sunspot falling further down the scale, causing the dial to read fast in the morning and slow in the afternoon. The angle *a* must be corrected for this.

It is fortunate that Drecker[3] has calculated the necessary correction:

$$= d \cos (h - \overset{\alpha}{a} + p) \sin / (2h + P) \sin P \sin h$$

where P = angle of correction
= offset of date lines
d = internal diameter of ring
h = height (altitude) of sun
α = angle of gnomon hole (or α')

Therefore:

$$ß' = ß + 2P = 2(h + P) - \alpha \text{ (See figure 6)}$$

It is not easy to calculate P using this formula as written, but a computer or programmable calculator will make the calculations simple and repeatable for different offsets and solar altitudes.

A corrected drawing of the ring in Figure 2 is shown in Figure 5. It will be noticed that the required correction increases with the amount of offset and the height of the sun.

What do these calculations prove?

a) It is not possible to construct a ring dial in which all the hour lines are straight. Any line may be straight at will, but all the others will be curved.
b) A ring dial cannot be made with hour points only; there must be date lines also. The example in Figure 3 could possibly be used without the date lines but the error could be up to half an hour.
c) Unless the error is accepted, or the reading is adjusted, a simple ring dial cannot be used with accuracy without applying Drecker's formula for the offset date lines.

NOTES

1. When the sun's altitude reaches about 70° (not a problem in northern latitudes), the corrected error line starts to double back on itself within the width of the dial. Figure 7 from Drecker shows this phenomenon. On a dial for low latitudes this means that the date lines would have to be quite close together or taper or curve in towards the bottom of the scale. I think the scale would become a little difficult to delineate clearly (see Reference 3).

2. If on a dial with a movable gnomon hole, the nodus was made to move in a diagonal line across the dial face (although obviously calculated on the actual vertical movement), the date line positions for the nodus could be made to correspond exactly with those on the scale, therefore obviating the need for error correction.

3. Another method of removing the need for corrections on the conventional dial (Figure 2), would be to use an horizontal gnomon slot, as suggested by Thorne (Reference 2). This also solves the problem with low altitude ring dials.

REFERENCES

1. C.J. Thorne, "Portable Ring Dials", BSS Bulletin 96.1. 30-32, (1996)
2. C.J. Thorne, "Altitude Dials at Extreme Latitudes and Ring Dial Error". BSS Bulletin 97.2 24-28, (1997).
3. J. Drecker, "Theorie der Sonnenuhren", (1935), German text.

First published in the Bulletin of De Sonnewijzerkring, January 1983. English translation by author, edited by C.J. Thorne.

Fig. 2

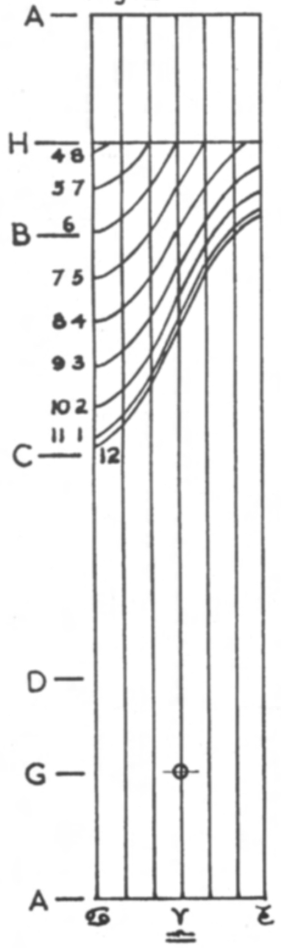


Fig. 3

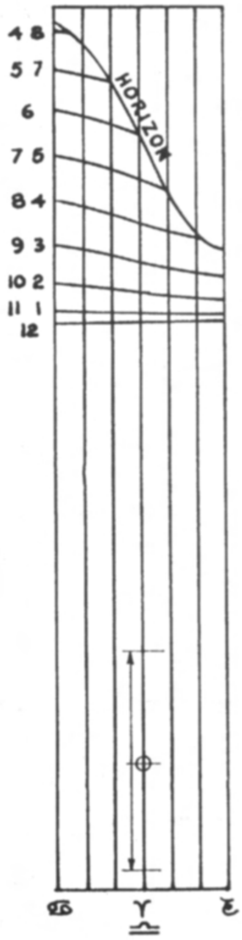


Fig. 4

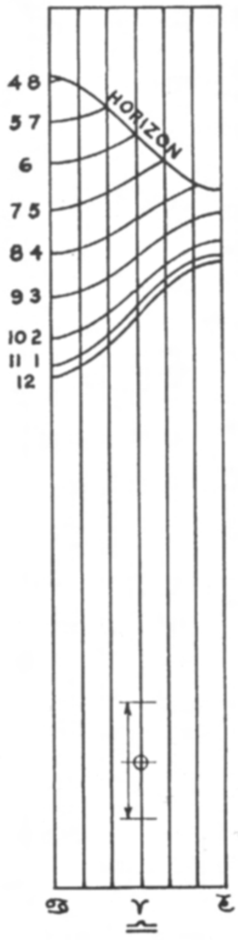
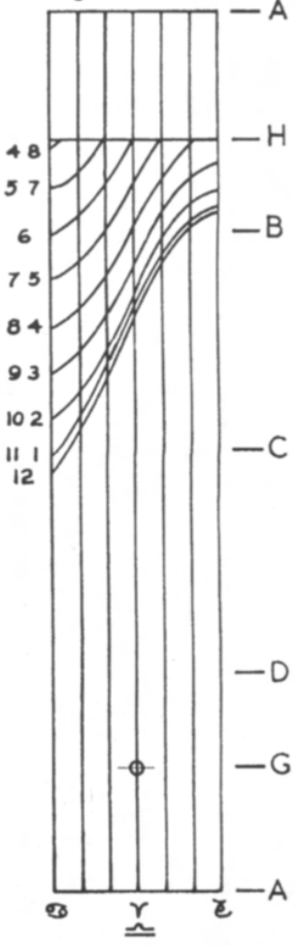


Fig. 5



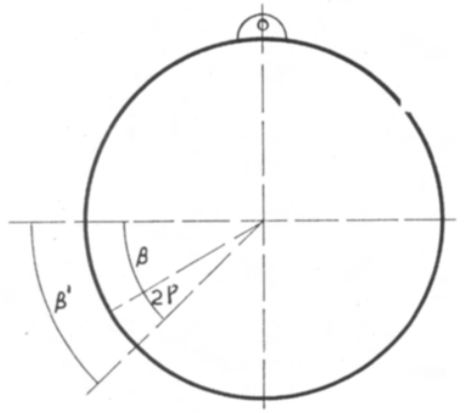


Figure 6

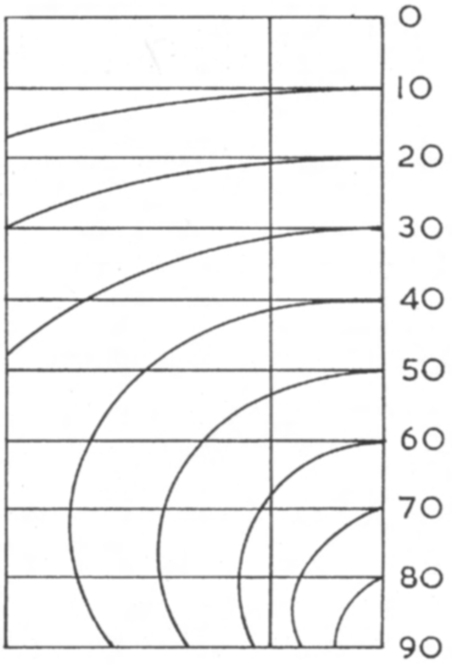


Figure 7

THE GUERNSEY LIBERATION MONUMENT

DAVID O. LE CONTE

THE CONCEPT

During World War II the Channel Island of Guernsey was occupied by German armed forces. Liberation came on the 9th May 1945 - one day after VE Day, and Liberation Day is now celebrated as a public holiday. The Island government, the States of Guernsey, decided that the 50th anniversary of the Liberation, 1995, should be marked by the erection of a monument of a distinctive and appropriate design.

The site chosen for the monument was at St Peter Port Harbour, the place where islanders met the liberating British forces in 1945 and rejoiced at their freedom. Today it is a popular spot where people can relax whilst waiting for a ferry to the outlying islands, or just sit and soak up the sun.

The Guernsey Liberation Monument provides a convenient place to sit and enjoy the sunshine [Photo: P. McMahon]

3,000 years ago, Neolithic man erected great stones on the Island, placing them as precisely as they could, using the best technology then available. The States of Guernsey resolved that the Liberation Monument should combine the idea of a standing stone with a pleasant place for people to sit.

The challenge facing Guernsey international artist Eric Snell, who was commissioned to create the Monument, was to relate such a simple concept with the one special day. His inspiration was to form 30 metres of stone seating into a curve defined by the path which the tip of the shadow of a 5-metre stone obelisk would follow on the 9th May.

Thus the Monument is a kind of giant sundial, designed for only one day each year - Liberation Day.

THE DESIGN

The obelisk is composed of 50 layers of polished Guernsey granite - one for each year of freedom. The top layers are sheared away to represent the years of occupation. The seating and platform are off-white French granite, which enhances the visibility of the shadow cast by the obelisk. Inscriptions carved on the seating record the major events of the 9th May 1945. The tip of the shadow falls a few centimetres up on the back of the seating, and points towards each inscription at the appropriate time: the signing of the surrender of the German forces at 7.15am, the landing of the British Liberating Force at 8.00am, and the unfurling of the Union Flag at 10.15am. Also recorded is the announcement by Winston Churchill: *Our dear Channel Islands are also to be freed today.*

The design of the Monument is not just specific to one day each year; it is also unique to Guernsey - in fact to this precise spot. Nowhere else would the Sun cast a shadow exactly on the curve of seating at the times marked by the inscriptions.

THE CALCULATION OF THE SHADOW PATH

As a member of the Astronomy Section of La Société Guernesiaise, the local studies society, and familiar with astronomical computation, I was asked to carry out the calculations required to determine the curve of the seating. Because of the Monument's large scale, and the fact that the shadow has to be significant for one day only, considerable precision is possible. I aimed for a maximum tolerance less than 30 seconds in time, and achieved an accuracy of about 5 seconds.

The problem was essentially that of a sundial calculation (horizontal dial with a vertical gnomon), with the difference that:-

- Only one day each year was being considered.
- The length of the shadow, as well as its direction was required.
- A high accuracy was needed.

I carried out an analysis of the prediction accuracy required, and found that a precision of $0^{\circ}.01$ in the position of the Sun would suffice. I then wrote a computer program called *SunShadow* to calculate the following:-

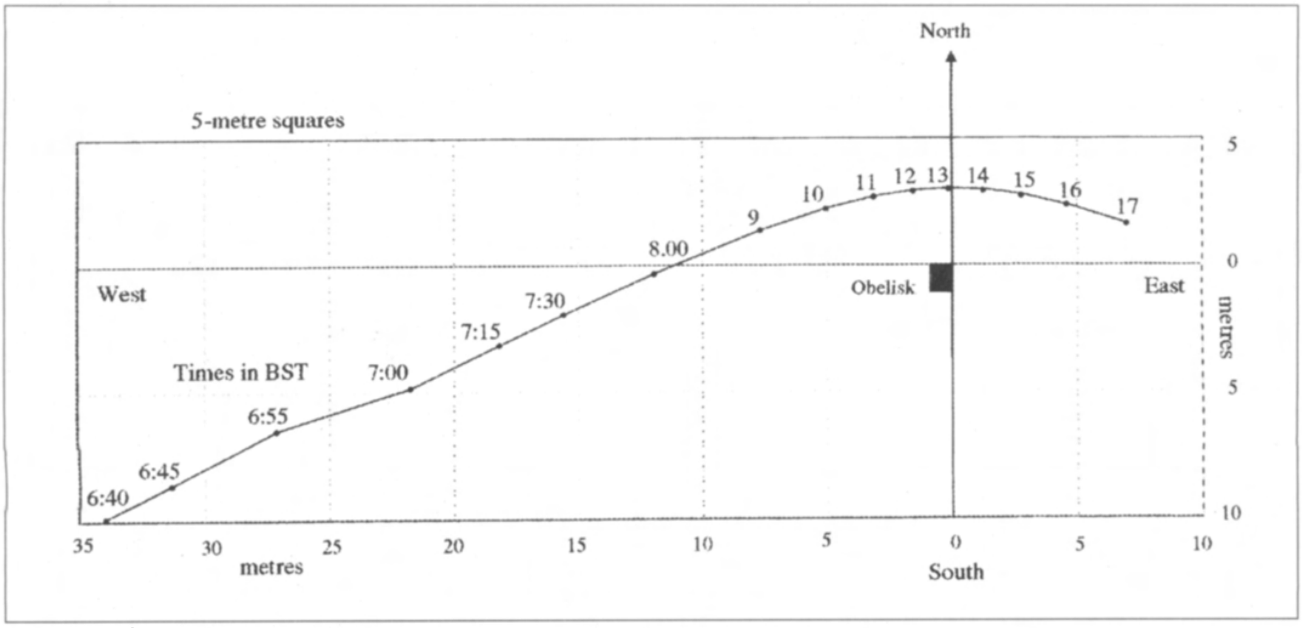


Fig. 1 The path of the tip of the shadow on the 9th May. The bend in the curve between 6.55am and 7.00am is where the shadow moves from the base to the seating

For the Sun:	Right Ascension (to 0°.01)
	Declination (to 0°.01)
	Altitude (to 0°.01)
	Azimuth (to 0°.01)
For the shadow:	Length (to 1 mm)
	Azimuth (to 0°.01)
	E-W distance of tip (to 1 mm)
	N-S distance of tip (to 1 mm)

All data refer to the centre of the Sun's disc. The E-W and N-S distances of the tip of the shadow from the base of the gnomon were required to lay out the path of the seating. The inputs are: latitude, longitude, date, time (UT), and gnomon height. The time output can be in UT or BST.

SunShadow uses Meeus's method[1] of calculating the solar coordinates, and includes a correction for atmospheric refraction by Bennett's formula[2]. Thorough checks were carried out into the accuracy of the program, including the use of the US Naval Observatory's *Floppy Almanac*[3] and *Mica*[4]. Reference was also made to Dr Peter J Andrews of the Royal Greenwich Observatory, who confirmed that the method and results appeared sound.

An initial experiment was then conducted, in order to identify any gross errors. I was assisted by Daniel Cave, a member of the Astronomy Section. The experiment was carried out in early August 1994, when the Sun's declination was similar to that in early May, using a one-metre vertical rod as a gnomon, It demonstrated the need for a high degree of accuracy in the construction of the Monument.

SunShadow was run for 1995 May 09 at 5-minute intervals for the required times, from 0640 BST to 0655 BST with a gnomon height of 5.55 metres (the height of the top of the obelisk above paving leading up to the seating), and from 0700 BST to 1700 BST with a gnomon height of 4.75 metres (the height of the top of the obelisk above the seating). Figure 1 shows a rectangular plot of the path of the tip of the shadow.

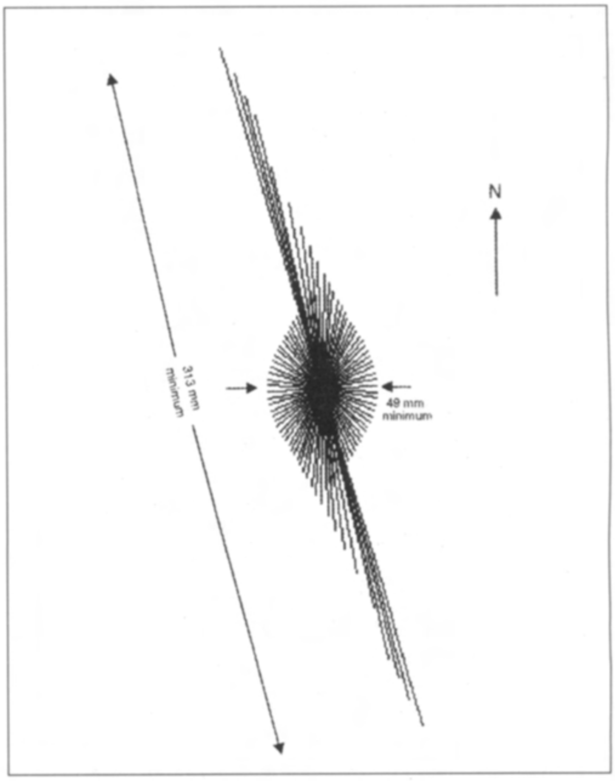


Fig. 2 Schema of top of obelisk

SHAPE OF THE TOP OF THE OBELISK

Dr Andrews pointed out that the shape of the top of the obelisk is important insofar as it affects the appearance of the shadow, and therefore the accuracy of the Monument[5]. The top of the obelisk as seen from the tip of the shadow must subtend an angle of at least the angular width of the Sun, ie $^1/_2{}^\circ$, so that the shadow tip has an umbral core. It cannot be a point.

The required dimension *d* is dependent upon the distance *L* from the top of the obelisk to the tip of the shadow. It is therefore dependent upon the altitude of the Sun, and varies during the day. It is given by the formula:-

$$d = 0.00873\,L$$

(since $^1/_2{}^\circ$ = 0.00873 radians).

d was calculated for 45 times during May 09. A schematic

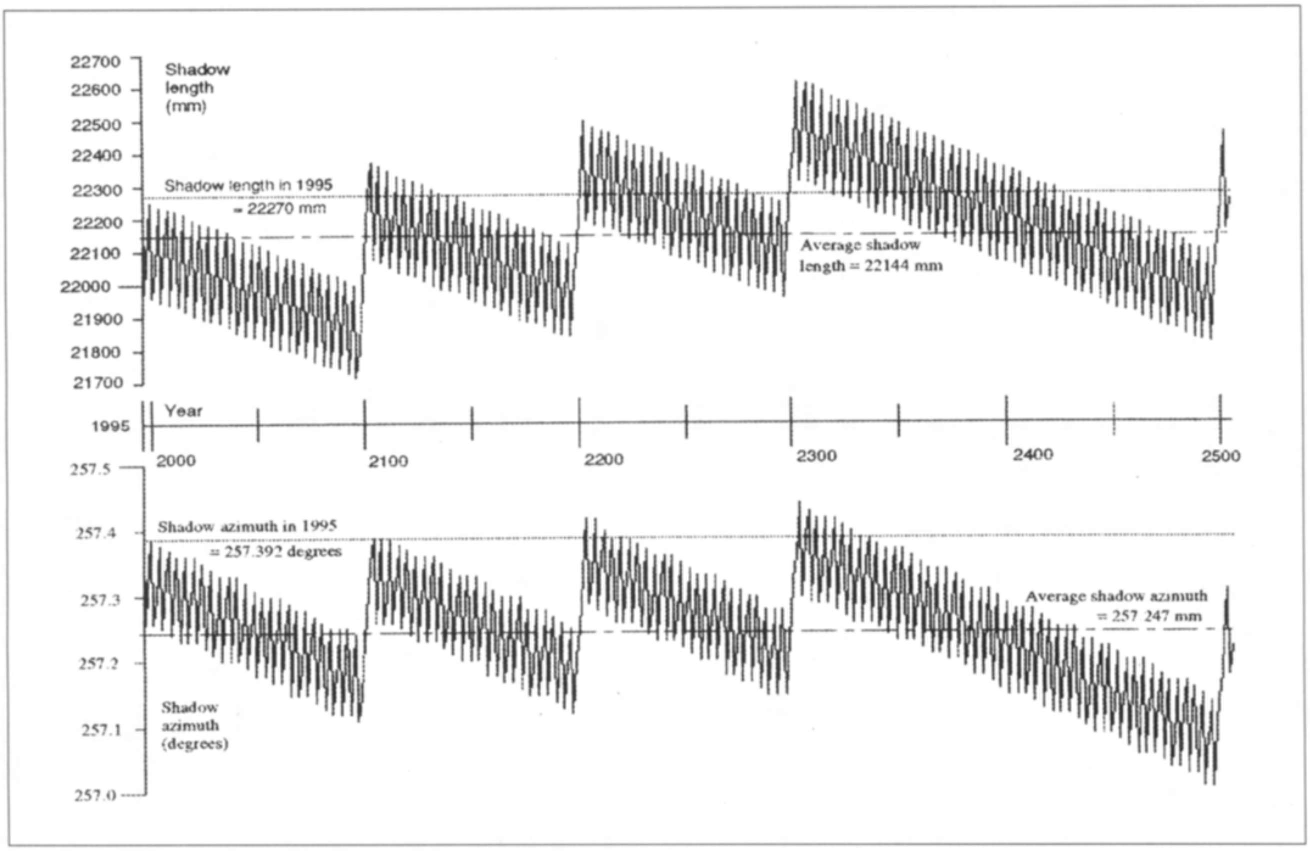


Fig. 3 Shadow length and azimuth for gnomon 4.75m high, 0600UT, May 09, 1995-2505

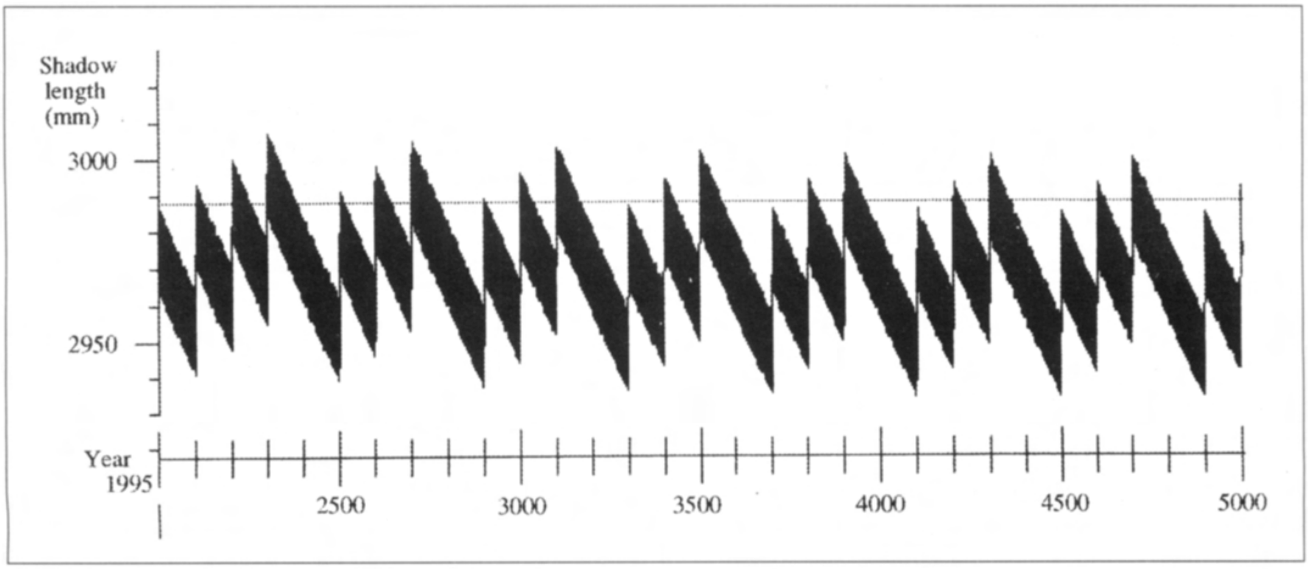
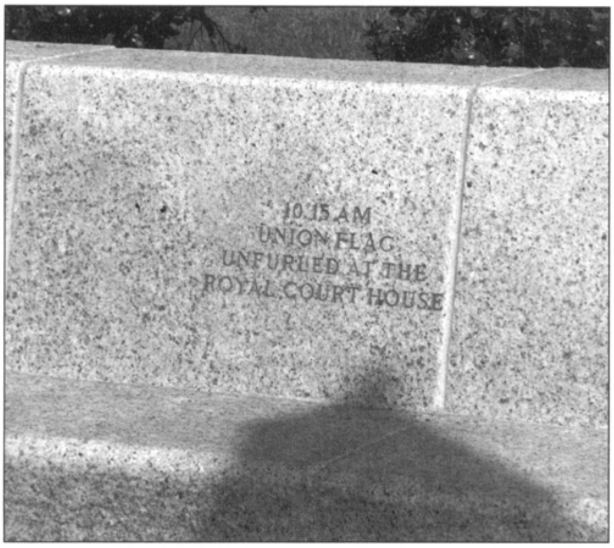


Fig. 4 Shadow lenth for gnomon 4.75m high, 1200UT, May 09, 1995-5005

representation of the top of the obelisk, based on the azimuths and minimum widths necessary to cast an umbra, is shown in Figure 2. It is not the shape of the top of the obelisk, but a mathematical plot from which a possible shape could be derived. It shows that the width of the top of the obelisk must be at least 313 mm at 0640 BST, 199 mm at 0700 BST, and 49 mm at 1300 BST.

The top of the obelisk therefore had to have a *bulk* in order to cast an umbral shadow at the required distance. It was also desirable to take into account the effect of this bulk on the apparent shadow length, as the shadow should properly be measured from the edge casting the shadow.



The tip of the shadow at the 10.15am inscription

It was concluded that the best shape for the top of the obelisk could only be determined by experimentation. The designer, Eric Snell, used my calculations to create a life-size model of the top metre of the obelisk, with the top few centimetres shaped in plaster. We carried out the experiments on a bowling green - the flattest area available - with the assistance of a States of Guernsey surveyor, Sean Harvey (also a member of the Astronomy Section). This exercise was necessarily done in the winter, and the low altitude of the Sun, compared to May 09, did not help. However, sufficient data was gathered to establish a probable best shape. In the event, two alternative tops were created, one higher than the other. The final shape chosen has a triangular cross-section (looking from above), and works well.

THE SHADOW IN FUTURE YEARS

In view of the fact that the Liberation Monument may well last several hundred years, I was interested in the behaviour of the shadow over that period of time. I therefore used SunShadow to calculate the shadow length and azimuth for a period of over 500 years. The results are shown in Figure 3. The 4-year, 100-year and 400-year cycles of the Gregorian calendar are apparent.

For academic, rather than practical interest, I also calculated the shadow length for a period of 3,000 years (Figure 4). The long-term trend of the calendar is shown. The Gregorian calendar gives an average year of 365.24250 days, compared with the tropical year of 365.24218 days, a difference of 0.00032 days, or one day in 3,125 years.

THE HEIGHT OF THE OBELISK

The long-term shadow length data shown in Figure 3 indicate that the length of the shadow on May 09 in 1995 was longer than the average shadow on that date over the next few hundred years. Indeed, the shadow will be shorter until the year 2103.Consideration was therefore given to increasing the height of the obelisk slightly, in order to allow for these long-term effects. In addition, it was recognised that the mathematical calculations of shadow length represent an ideal situation, which was unlikely to be attainable in practice. In particular two further effects could result in the shadow being shorter than the ideal.

The inherent diffuseness of the shadow because of atmospheric effects, creates a shortening effect. The main effect, however, is caused by the fact that the Sun is not a point source. The calculations were made using the centre of the Sun's disc, but light from the upper half must be taken into account.

One might, therefore, think that the reference point should be the top of the solar disc, rather than the centre. However, the shadow appears longer than that calculated using the top of the disc, because the additional disc area contributing light decreases with increasing radial distance from the centre.

Is there a point between the centre and the top of the disc which can be used as the light source?

Experiments to answer this question were carried out, first using a two-dimensional representation of the top of the obelisk, and then with the full-scale mock-up of the top metre, used on the bowling green.

However, it was not until the precisely level platform of the Monument itself was in place, that a one-third scale model of the obelisk gave a more definitive solution. The platform was used essentially as large-scale graph paper, with the north-south and east-west gaps between paving slabs being used as guides for those directions. Metal scale tapes were used to measure north, east and west distances, and shadow lengths.

These experiments gave an average light source just 0.093 degrees above the disc centre, with a range of 0.06 to 0.12 degrees, dependent upon the time of day. The wide range of the results demonstrated the subjectiveness of shadow observations, especially where the shadow was not very distinct.

As the Sun's azimuth moves towards the west, the edge of the top of the obelisk which "casts" the shadow is east of the reference point on the obelisk top. Thus, in theory, the shadow is lengthened by the amount of the displacement of the edge in the direction of the shadow, and a correction should be made for this effect. (On the one-third scale model this displacement, and therefore shadow lengthening, was about 12 mm for the late afternoon observations.)

However, in practice the requirement that the top of the gnomon must have a certain bulk to cast an umbral shadow means that the correction is largely nullified. Indeed, this was why the particular position of the reference point was selected.

It was also noted that, although the observed umbral shadow was shorter than the predicted shadow length, as expected, the penumbral shadow was clearly visible as an extension of the "true" umbral shadow for all but extreme shadow lengths. The eye, therefore, took into account this extension, and it could be easily seen that the shadow was really longer than just that indicated by the umbra.

A conflict occurred, however, because the above effect is less evident for long shadows, when the shortening effect of the light from the top half of the Sun is greatest. In selecting the obelisk height, therefore, there must be a compromise between having an umbral shadow which is long enough in the morning and late afternoon, and an umbral+penumbral shadow which is not too long at midday

I therefore calculated these effects for various obelisk heights for 1995 May 09 and for 1996 May 09, assuming the light source to be 0.093 degrees above the centre of the Sun's disc, and ignoring the dimensions of the top of the obelisk for the reasons described above.

The data are plotted in Figure 5. They appear to indicate that the best compromise for the umbral shadow would be a gnomon height of 4.77 m or 4.78 m. This would give an umbral shadow closest to the line of the seating.

However, three other factors had to be taken into account:-

1. It was desirable that the shadow tip was slightly (a few centimetres) above the seating line, so as to "point" to the inscriptions on the back of the seating.

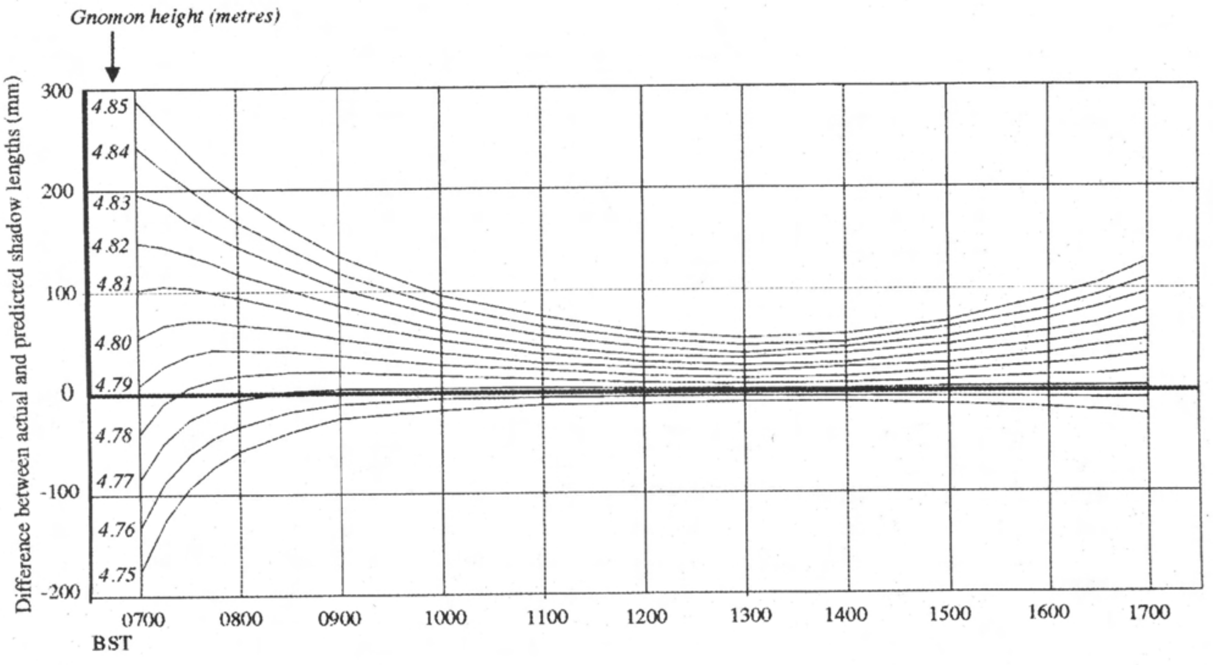


Fig. 5 Differences between actual and predicted shadow lengths for gnomons of different heights

2. The shadow in future years will be shorter, because of the higher altitude of the Sun[3]. The shadow before 0700 BST had not been taken into account.
4. The seating was built 5mm higher than planned.Further studies into these effects concluded that the gnomon height should be 4.825m, giving an obelisk height of 5.325m.

CONSTRUCTION TOLERANCES

A detailed analysis was made into the tolerances allowable in the construction. The analysis concluded that the following tolerances should be adhered to:-

	Maximum tolerance	*Preferred tolerance*
Obelisk height	6 mm	1 mm
Obelisk tilt	4 arc-mins	1 arc-min
Platform and seating levels	6 mm	1mm
Direction of True North	7 arc-mins	1 arc-min
Laying out of shadow path and manufacture of Monument		1 mm

Checks made by the architect and builders during the construction of the Monument indicated that the preferred tolerances were, in fact, achieved.

However, there remained the possibility that differential subsidence (especially because the Monument is constructed on an old land reclamation site) might affect the accuracy, as the obelisk is not tied to the seating or platform. The architect resolved this potential problem by installing three jacking points in the base of the obelisk, so that, if necessary, its height and tilt can be adjusted.

DETERMINATION OF TRUE NORTH

It was necessary, of course, to determine the direction of True North to an accuracy of 0.01 degrees. Several methods were considered:-

1. An accurate compass bearing on magnetic north, with a correction for magnetic variation. Extrapolation from data given on Admiralty charts does not give sufficient accuracy. A more accurate extrapolation could perhaps have been made from the magnetic field model recalculated by the British Geological Survey every five years, with one due in 1995.
2. A bearing related to the Universal Transverse Mercator Grid, with a correction for the convergence of the meridians.
3. The stellar method used by astronomers for aligning telescopes with the North Celestial Pole, as described, for example, in Norton's 2000.0[6]. Some modern telescopes provide for accurate polar alignment through computer methods.
4. A bearing of the Sun, or the position of the shadow of a suitably sized, vertical gnomon, could be made at the accurately predicted time of local noon, when the Sun is due south.
5. O. Neugebauer has suggested a possible method by which the Great Pyramid of Giza may have been accurately orientated to the cardinal directions[7]. This involves observations of the shadow of a small pyramid, and its re-orientation on a trial and error basis until it is correctly aligned. It seems doubtful that this would give the accuracy required for the Liberation Monument, but the method could be analysed and a minimum pyramid size determined for the required accuracy to be established.

Attempts were first made with method 4, using a tall (15m) lamppost, with corrections for "lamppost lean". Unfortunately, the results were inconsistent, probably because the lamppost was telescopic, and its lean changed from day to day. Method 3 was tried with an 8-inch, computerised Meade telescope. This proved insufficiently accurate for the purpose.

Resounding success was scored, however, with a combination of method 2 and observation of Polaris, the Pole Star. Sean Harvey, the surveyor, laid out a north-south line across the Harbour of St Peter Port, based on the Universal Transverse Mercator Grid Zone 30 coordinates. This was then checked using a Topcon GTS-6B Total Station, with due offset from Polaris, as predicted by Mica, and confirmed with reference to other stars. The results were consistently within 5 to 10 arc-seconds of the surveyed direction.

THE CONSTRUCTION

Construction started in September 1994, and continued concurrent with the experiments and activities described above, until May 1995, under the supervision of the States Architect, Patrick Reade.

Local company LeRoy Limited were contracted to build the Monument, with the Managing Director, Phil Sebire, responsible for seeing it to a successful conclusion. Regular progress meetings were held with all persons involved. Because of poor weather conditions during the experiment phase, the final decisions as to the shape and height of the obelisk were not made until a few days before the unveiling. Two stones for the obelisk top were made, with different heights and shape. In early May 1995, Eric Snell and I decided to use the taller of the two, and this was duly installed.

The construction of the Monument. Designer Eric Snell and the author David Le Conte examine the foundations.
[Photo: Guernsey Press Co. Ltd.]

The cost of the project (not including the neighbouring pedestrian improvements) was £130,000. This was defrayed by public subscription, but the bulk of the cost was met by the States of Guernsey.

THE PERFORMANCE AND UNVEILING

HRH The Prince of Wales unveils the Monument on the 9th May 1995, the 50th Anniversary of the Liberation of the Island from Occupation by German armed forces.

In the early morning of the 50th Anniversary of the Liberation Day, the 9th May 1995, a small group, including all those involved in its design and construction, gathered to observe the shadow's progress. Final washing of the Monument made the early shadow difficult to discern, but when it did appear, shortly before 7.00 am, it was right on course, and progressed exactly as planned along the line of seating, pointing to each inscription in turn.

It was uncanny, seeing the tip of the shadow trace out the predicted path, almost as if the shadow itself was tied to the seating.

At 1.40 pm, in front of thousands of people, His Royal Highness, the Prince of Wales, unveiled the Monument, to the accompaniment of a fly-past of military helicopters. I was honoured to be asked, at the last moment, to describe sundial-like qualities of the Monument to the Prince.

Immediately after he left the site, and police allowed the public onto it, it was swamped by hundreds of people, the shadow totally lost amongst all the heads and bodies.
The Monument continues to serve both its commemorative function and its utilitarian one, being a popular spot for people to sit and enjoy the sunshine, and occasionally the shadow. Many may be indifferent to the fact that they are sitting on a piece of the Island's history, but the unique design of the Liberation Monument creates tremendous interest and acknowledgement of Guernsey's troubled past, and that wonderful moment of freedom celebrated at this very spot over 50 years ago.

On the 17th April 1997 the Civic Trust announced that the Guernsey Liberation Monument had won a coveted Civic Trust Award, recognising its outstanding contribution to the environment of the town and harbour, and stating: "This is a work of austere beauty that captures a moment in the island's history with power and precision". *The Liberation Monument has its own web page,*

at:http://www.guernsey.net/monument

REFERENCES

1. MEEUS, JEAN. *Astronomical Algorithms*, Wilmann-Bell, Inc., Virginia, 1991, page 153.
2. SEIDELMANN P. KENNETH (Ed.). *Explanatory Supplement to the Astronomical Almanac*, University Science Books, California, 1992, page 489.
3. The computer program *Floppy Almanac* is published annually by the U.S. Naval Observatory, and is available on-line through the Royal Greenwich Observatory.
4. *Mica* (the Multiyear Interactive Computer Almanac) is issued by the Astronomical Applications Department, U.S. Naval Observatory.
5. Dr Peter J Andrews, Royal Greenwich Observatory. Private communication, 1994.
6. RIDPATH, IAN (Ed.). *Norton's 2000.0. Star Atlas and Reference Handbook*, Longman Scientific and Technical, Harlow, Essex, 1989, page 74.
7. NEUGEBAUER, O. *On the Orientation of Pyramids, from Astronomy and History: Selected Essays*, Springer-Verlag, 1983, page 1.

DIALLISTS' CROSSWORD

JOHN SINGLETON

(Solution in next issue of the Bulletin)

1		2		3		4		■	5	6		7		8
	■		■		■		■	■	■		■		■	
9								■	10					
	■		■		■		■	11	■		■		■	
12					■	13								
	■		■	■	■		■		■		■	■	■	
■	14			15			■	16				17		
18	■		■		■	■	■	■	■		■		■	
19						20	■	21						■
	■	■	■		■		■		■	■	■		■	22
23		24							■	25				
	■		■		■		■		■		■		■	
26						■	27							
	■		■		■	■	■		■		■		■	
28						■	29							

ACROSS

1. Ices lost, melted at the height of summer (8)
5. Professional diallist from Leicester (1,5)
9. Angular elevation of the sun (8)
10. One supporting the BSS (6)
12. Frequently seen from any one of ten planets (5)
13. Instrument for finding 9 across (9)
14. Dial motto is melodious, but suffers from truncation! (6)
16. To fashion wood, for a gnomon perhaps (7)
19. Cooking device, or solar corona? (3,4)
21. Judge the entries (in sundial competition) (6)
23. Non-operational period for a sundial (9)
25. Least unnatural material for a flat dial (5)
26. Group of four (corners of the earth, perhaps) (6)
27. Planets of the solar system (8)
28. Retiring editor of the BSS Bulletin (1,1,4)
29. Worshipping the sun? Try a lido! (8)

DOWN

1. A grey area (Do wash!) (6)
2. Regions of certain distance from the equator (9)
3. The sun-god (5)
4. French dials (rumours dispelled) (7)
6. Star retrieval system for shuffling men in coms (9)
7. Blair's sun-sign blurred! (5)
8. Black magician, in touch with UFO's we hear (8)
11. Turn west, and make a mess of it (4)
15. Imply irate tone as set up sundial (9)
17. Source of dial mottoes, old or new (9)
18. Coasting? "We just don't know" - Patrick Moore (8)
20. Could be a dial, or a green fruit (4)
21. Related but changed (like BST v. GMT?) (7)
22. The heavens, as seen by the proverbial shepherd (3,3)
24. Time and the end of a match, or when BST ends (5)
25. Behaviour of the sun at 1 across (5)

INVITATION FROM FRANCE

Twenty-five years ago, on 13 December 1972, the Sundials Commission of the Société Astronomique de France was officially founded. The aim of the Commission was to bring together enthusiasts for Sundials, to exchange ideas and methods, and to record the gnomonic heritage of France.

Since then, many more Sundial Societies have been formed in Europe and all over the world. The Sundials Commission celebrates this year the quarter-century of its existence. For this occasion the Commission is organising in Paris an international meeting for the weekend of *18-19 October 1997*. The Commission invites all sundial enthusiasts, from France and elsewhere, to come and present their collections, designs, models and publications.

Saturday 18 October will be devoted to presentations and talks. On Sunday morning 19 October there will be a visit to sundials in Paris. We expect to arrange a 'bateau-mouche' trip for the Saturday evening. Participants are themselves responsible for their own arrangements as to accommodation and meals.

Communications will be in French. Subjects to be presented (title and summary) should be submitted as a diskette (PC or Mac) or as typescript, not later than 1st September, to the Commission for approval by the organising committee.

This committee consists of: Pierre Bacchus, Suzanne Debarbat, Andrée Gotteland, Serge Gregori, Nicole Marquet, Denis Savoie, Robert Sagot, Phillipe Sauvageot.

Presentations can be made in the form of photographs, video or slides.

Final letters of invitation will be sent out from the beginning of September, and will contain the detailed programme for the weekend. Please reserve the dates 18-19th October. We are hoping for many visitors so that all sundial enthusiasts will meet to celebrate this event.

Denis Savoie, Commission des Cadrans Solaire, Société Astronomique de France, 5 Rue Beethoven, 75016 PARIS, France.

ADVERTISING IN B.S.S. PUBLICATIONS

At the Annual General Meeting of the Society in April 1997, it was agreed that advertisements would be accepted for publication in the BSS Bulletin and in the Newsletter. Advertisements will appear therefore in the October 1997 issue and thereafter.

Advertisements must be for material directly related to sundials and gnomonics. They may include advertisements for books, computer programs, pictures, instruments, materials, processes.

Advertisers in the Bulletin must produce the copy of the text and graphics (black and white only) of the proposed material, and submit it, together with payment, to the Advertising Manager.

Typical prices are £80 per half-page, £45 per quarter-page. Small advertisements (text only) to appear in the Newsletter will cost 20p a word, minimum charge £5.

Further particulars may be obtained from the Advertising Manager, Mr. John Churchill, 55 Rushington Avenue, Maidenhead, Berkshire, SL6 1BY.

SUNDIALS AND SUN AT NEWBURY

MARGARET STANIER

On Saturday 31st May forty-six members of the British Sundial Society enjoyed a one-day meeting of talks, exhibits and discussion at Prior's Court School near Newbury, Berkshire. Many interesting exhibits, pictures and instruments, indoors and out on the lawn, lively discussion and some fascinating topics covered in 15-minute Talks, gave all participants a day full of information and pleasure.

When displays had been set up, coffee and biscuits served, and instruments adjusted, the greetings and technical chat started. Then about 11am David Pawley's whistle initiated the first of the morning's talks. Robert Mills spoke of Stonehenge and of its importance as an indicator of sun-rise-and-set and moon-rise-and-set on significant days of the year. He showed us his strip of twelve joined photographs giving the 360° open horizon view from the centre of the Stonehenge circle. Next came Colin Davis' set of delightful slides showing a sundial tour of Salzburg, where painted wall dials on courtyard houses are commonly adorned with pictures of saints as 'supporters'. Interspersed with Salzburg slides he showed wall dials of his own county, Northamptonshire, with hour-lines durably incised on limestone surfaces. Then there was a talk by Tony Belk, whose work in photographing buildings requires assessment of the moment when a wall of a particular orientation would catch the sun, tangentially or at right angles. He has invented a device for convenient prediction of the time when his camera must be set up, and he showed some slides giving examples of its use.

Picnic lunches on the lawn were accompanied by more demonstrations of instruments, apparatus and diagrams. Cardboard Dial cutouts were handed round by Peter Ransom of Southampton who had also brought a well-mounted set of photos of Hampshire Sundials.

Chris Daniel started the afternoon Talks session by describing the problem of setting and keeping a course at sea out of sight of landmarks: finding latitude by measurement of altitude of noon sun or pole star, by means of a quadrant, cross staff, back staff and finally sextant: all difficult to use on a rolling deck with wave-obscured horizon. Amazingly, back-staffs were still being made at the beginning of the nineteenth century. Chris Daniel gave us a glimpse of the errors which might creep in to even the best chart-making, and the disaster of running down one's latitude in the wrong direction. Captain Michael Maltin then spoke of the early stages of air navigation, in the 1920's and 1930's, and some of his wartime experiences. If alone in the sky in a Spitfire, fly downwards rapidly till the shadow of your plane becomes visible below you! A real drama, this.

After a short tea-break, Allan Mills gave us a lucid and mind-stretching talk about the possible use of the polarisation of sunlight for time-telling - a property usable even in conditions of thin cloud and overcast when sunlight is too hazy to cast a shadow.

Another half-hour of technical chat, photograph viewing and tea-drinking, and then we packed up exhibits, replaced furniture à la classroom, and dispersed. Once again the Society gives warm thanks to David Pawley for the unobtrusive competence with which he organised the meeting and kept us on time with his emergency whistle.

Prior's Court School, close to the M4 and the A34, has proved an excellent venue. Members came from Kent and Ipswich to the east, from South Wales, Devon and Bristol to the west, and from Northampton and Southampton on the Newbury longitude. We had the use of 2 classrooms and the staffroom coffee-making equipment; and on a day of bright sunshine it was easy to overflow through the glass doors onto the lawn. Altogether it was a thoroughly satisfying day of latitude and altitude, longitude and sunlight.

Sundials...

...and Sun

A NEW SUNDIAL FOR CHRIST CHURCH, OXFORD

MARGARET STANIER

When in about 1992 a new Fellows' Garden, the 'Pocock Garden', was planned for Christ Church, a sundial was suggested as a feature for inclusion. Apparently the idea originated from a magazine photograph of Christopher Daniel's Dolphin Dial; this caused the Christ Church dons to consider that a sundial of appropriate size for the setting might adorn their new garden and give a particular point of interest. The Christ Church authorities with the help of David Young and Ian Wootton of the B.S.S. set up a competition for the design of the new dial. Competitors were shown the site, and their brief included low maintenance cost, and as nearly vandal-proof as possible. The Competition attracted a number of skilful British entries as well as one from Spain.

The winning design is a multi-facet sundial by David Brown of Bath. It is inspired by the cube designs of Nicholas Kratzer, Henry VIII's diallist, who is known to have set up at least two dials in Oxford in the first half of the sixteenth century. David Brown's dial, besides using the vertical faces of the stone cube, uses the upper surface for a small hemispherical dial. It incorporates an equation-of-time analemma, and it is adorned by the armorial bearings of Christ Church, and of the University of Oxford. Placed in the context of Oxford, of dialling history, and of its garden site, it is an excellent choice. Its sturdy limestone construction will make it impervious to objects dropped from above. An added advantage, from the viewpoint of the Christ Church authorities, is the fact that the designer is also a maker; David Brown has already been comissioned to construct his dial, handsome and accurate and entirely in harmony with its setting.

The authorities at Christ Church were pleased with the interest shown in their design competition, and by the number and quality of the entries submitted. Accordingly a small display, on view for a couple of weeks in May, was arranged in the Art Gallery of the House, to show people a number of the best entries, including the winner's. The entries took the form of photographs, models, drawings and descriptions. Another Kratzer-inspired design was that of Harriet James; this, in addition to the basic stone cube, bore a vertically mounted brass disc with due east and west dials engraved on its two faces: quite pleasing but by no means vandal-proof. There were a couple of equatorial designs, one of which had a metal-wire-spider-web occupying its central space: a piece of ornamental fantasy without relevance to its context. A handsome hemicyclium by Allan Mills would have been this reviewer's choice as runner-up for the competition. In fact the runner-up was a highly original design by J.M. Bores of Madrid. It was a cone lying on its side, on the horizontal dial face which was inscribed with Bablyonian hours on one side and Italian hours on the other: very vandal-proof but too far removed from the realities of present-day timekeeping. The exhibition included an armillary sphere with revolving gnomon, and a couple of spiral dials. Visitors to the exhibition could well have been impressed by the variety of designs on view and by the ingenuity of modern diallists.

We hope that Mr. Brown will let us know when his Christ Church Sundial is completed. Bulletin readers would enjoy a photograph. The dial will of course be placed in a private garden, not visible to the public. However members of the Society, having a serious interest in dialling, will be able to obtain permission, by application to the Bursar's office at Christ Church, to view the dial.

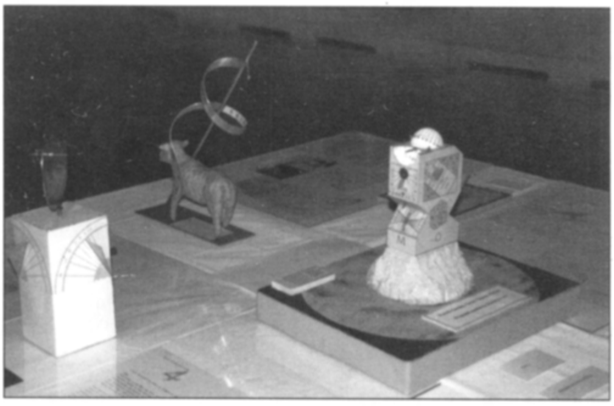


Fig. 1 Some models from the design competition: winning entry on right

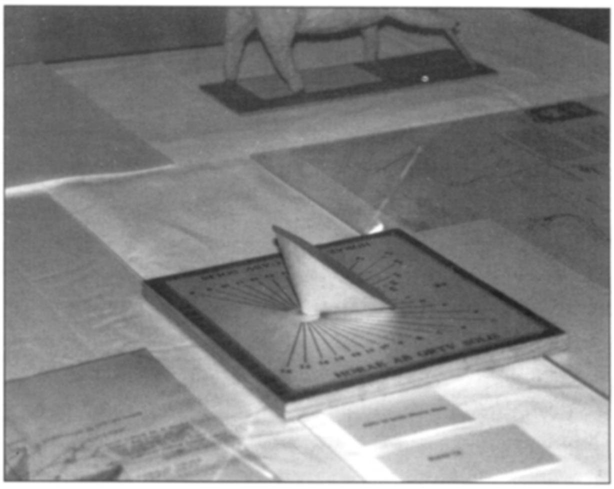


Fig. 2 Design by J.M. Bores, Madrid

B.S.S. CONFERENCE AT NEWTON RIGG, PENRITH - MAY 1997

ROBERT B. SYLVESTER

One may be forgiven for assuming that an agricultural college overshadowed by a bright comet (Hale Bopp) foretold ill-tidings, but nothing could have been further from the reality when it came to the B.S.S. Conference in Cumbria.

Delegates journeyed happily to this beautiful part of the 'far north' for a long weekend of intensive sundialling. Well attended as all our conferences are, Newton Rigg was no exception. Council got down to some serious business the day before, leaving until late Friday for the start of the conference.

Friday evening's lectures featured the work of Alan Smith in restoring the sundial above a doorway at the Friends' Meeting House in St. Helens. We have seen Alan's expertise in many guises but here he took us through he removal, inspection and cleaning of a once magnificent dial which had suffered over the years from bungled attempts by less able hands to restore it. Alan gave the dial new lease of life and earned the sincere gratitude of the owners who had sought his services.

Once again we were honoured by Fred Sawyer attending and bringing with him the good wishes of our sister group, the North American Sundial Society. Fred gave a thorough dissertation about the little known Asteroid Dial and card hand-outs after the talk enabled delegates to try it out for themselves.

It was pleasing to hear from our newer members and Gerald Stancey spoke from experience about 'The Dark Side of Computing.' There is a danger of regarding the computer with awe when it is merely our servant. Gerald illuminated his talk with outstanding errors made by computers, teaching us that we should use our intuition before putting our trust in one.

Saturday dawned bright and clear. The morning session featured lectures by Piers Nicholson, John Ingram and Doug Bateman. Piers has certainly aroused enthusiasm in the application of the Internet and, laced with amusing anecdotes, illustrated how powerful a tool it was in communication. As a result of his efforts, the Society is now being brought to a worldwide audience and new members are being acquired as a result. Piers hosted an early morning session before the main lectures and the growing importance and interest in using the Internet was amply attested to by the numbers in attendance.

John Ingram outlined his researches into Mass Dials at the church at Stockton in Wiltshire. Treating the subject comprehensively, we were able to see the setting of the church as a whole and the context in which the dials were set. It was mentioned that it was ironical that John's hobbies conflict so much: a passion for railways, which were one of the prime movers in the establishment of a Mean Time system which relegated the sundial to its now lesser role!

We have come to expect excellence of Doug Bateman and once again, we were not disappointed. Doug outlined his researches into noon sundials in Italy, and then he took us through the making of one which was set in a window gracing the entrance to DERA at Farnborough where he works. In the context of a research establishment, it is a functional scientific instrument and represents the principles of observation, analysis and application. It has proved to be a talking point among interested visitors, as sundials often are, and we look forward to a comprehensive article about it in the Bulletin before long.

By way of light relief, the afternoon tours explored some of the lesser known villages in the Vale of Eden in glorious weather. We were delighted to see a little-known Cross Sundial at a country estate, occupying pride of place in the centre of the garden. Close examination beneath the lichen which covered much of it revealed that it was the site of at least three more dials of different types. Nearby, the village church sported a variety of artifacts and markings, several with possible dial significance.

Off the beaten track is Long Meg and her Daughters, one of England's largest stone circles with an outlier which is said to mark the setting point of the mid-winter sun in Bronze age times. Though not a sundial, it is a sun related monument and therefore, particularly appropriate that it should receive our attentions.

An isolated farm showed us a sundial plate by the itinerant Ulster dialmaker Richard Melville. The slate plate bore five horizontal dials and much more elaborate engraving. It was recorded in 1990 and in vindication of the BSS National Survey, had recently been recovered after being missing for several years. It was with a sense of relief that it had now fallen into the hands of an appreciative new owner of the farm who wished to restore it.

One set of sundials which every sundialler associates with Cumbria is on the Countess' Pillar. By the side of the busy A66, we scrambled up a bank to see this splendid set of vertical dials, once neglected but now renovated by English Heritage with advice from our Chairman.

The Conference Dinner was addressed by the Chairman who expressed his pleasure at seeing the number of delegates who had attended. Afterwards, we were treated to a talk by Jane Walker about the Windsor dial which she had sought after finding references in the literature. This once fine horizontal dial was now in a sad condition, and it was illuminating to hear of the protection afforded to it in its early years, not even the king being allowed to touch it without a caution from an ever-present guard. A salutary lesson in these now vandal-ridden times as to how much importance was accorded to a sundial in times past!

The evening was wound up with the now traditional auction. With the Chairman wielding the gavel, the words 'unique, 'rare' and 'the chance of a lifetime' rolled too, too easily off his tongue. Those who did not bid could not help but revel in the general merriment.

On the Sunday morning we were treated to a talk by Peter Lamont, one of our senior members who specialises in open-book and hemispherical dials and who shows much skill in using computers to assist in delineating them. Still on the computing theme, Dr. John Davis followed with a demonstration of the versatility to diallists of a pocket-sized personal organiser in a way which surely its inventor never envisaged.

Between times, there was plenty to see and do. Rogers Turner was represented, with their welcome selection of books and the exhibition hall was frequently a hive of activity. Anton Schmitz once again showed us some heavyweight dialling with a stone globe dial while his friend Erich Pollaehne had a lovely display of photographs of his work. Particularly fascinating was a sundial memorial and also a multiple dial with around one hundred ways of reading the time. Erich also demonstrated a laser device to delineate a sundial which showed all the hallmarks of the precision engineering which we have come to expect from him.

Absent member Emile Vilaplana of France had on display, photographs of twenty years of his craftsmanship, including details of a binary notation dial to commemorate the pioneers of computing. The Mass dial section was represented with a display board of photographs and the practical side of our ever-versatile members was encapsulated in everything from specialist gnomons by Tony Moss, pipe sundials by Mike Shaw and orrerys by Dave Cook.

The high point of the conference was the Andrew Somerville Memorial Lecture presented by retiring editor Charles Aked. The subject of meridian lines took into account the thorny problem of the dating of Easter. Charles outlined the religious pressures regarding the installation of such lines in large monuments and listed examples, mainly in France and Italy. The lecture lived up to the excellence we have come to expect from him and fittingly fulfilled its role as the high point of the Conference.

It was with a sense of sadness that both Charles and Ian Wootton stood down from their places on Council at the AGM but credit was given for the valuable contributions they have made over the years.

The Conference continued the tradition of successful meetings of the Society, well attended and with many new members making an appearance. Considering that delegates travelled from beyond Europe to be with us, form Israel, the USA and Australia, what more fitting tribute is there to the vigour of the British Sundial Society?

Fig. 1 Cross Sundial at a country estate

Fig. 2 Members at the Long Meg stone circle

Fig. 3. Examining a Richard Melville sundial

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2


21 DEC
22 JAN
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21 DEC
22 NOV
24 OCT
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