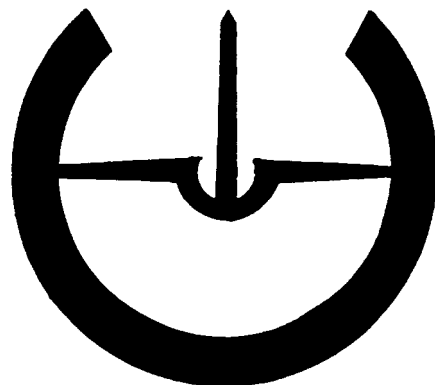# The British Sundial Society

BULLETIN

VOLUME 16 (iii)   SEPTEMBER 2004

Front cover: Vertical slate sundial in church of St. Buryan, Cornwall [photo, the Thornes].

Back cover: Multiple dial on bridge at Wilton, near Ross on Wye.

VOLUME 16 (iii) - SEPTEMBER 2004

CONTENTS

BULLETIN

OF THE BRITISH SUNDIAL SOCIETY

EDITORIAL

Sundials Old & New, for all of us to contemplate. I enjoy reading about the restoration and renovation of old dials, just as much as about new designs. I hope (I feel sure) the those such as Harriet James at Market Lavington, and John Davis at Houghton Hall, gain as much satisfaction and sense of creative achievement as the inventors and innovators: Thiessen and Hofbauer, in this issue. Sometimes I find that we seem to have too many 'one-dial-articles'. But I do not like to reject any written efforts; when people have taken the trouble of writing-up something for the Bulletin they should see the result of their effort in print. I am glad to think that it is only rarely that anything has been rejected on the grounds that it is poor stuff or inaccurate. Keep writing!

VIAL DIAL

HEINER THIESSEN

This equatorial ring dial has been inspired by a 17th century planispherical hour index, featured in the BSS Bulletin March 2004. The old hour index from 1680 enabled the observer to work out solar time around the 'entire round Earth globe', all logically deduced from current local sundial readings at a reference meridian. A scientifically minded world had finally created the theoretical framework, that would enable people to read solar time, not only for their home location but also for all other longitudes around the globe at the same instant, even for the remotest and most recently discovered continents of this planet. An impressive victory for rational thought.

More food for thought for this new dial came from Chuck Nafziger (NASS) who has used ruler and spirit level to estimate the times for sunrise and sunset on his equatorial globe dial. It was the aim of this new design exercise to create a device that is a planisphere and a sundial at the same time.

WHAT CAN THIS DIAL DO?

Not unlike the old hour index from Hamburg, this new vial dial reads local solar time, not only for the ob-
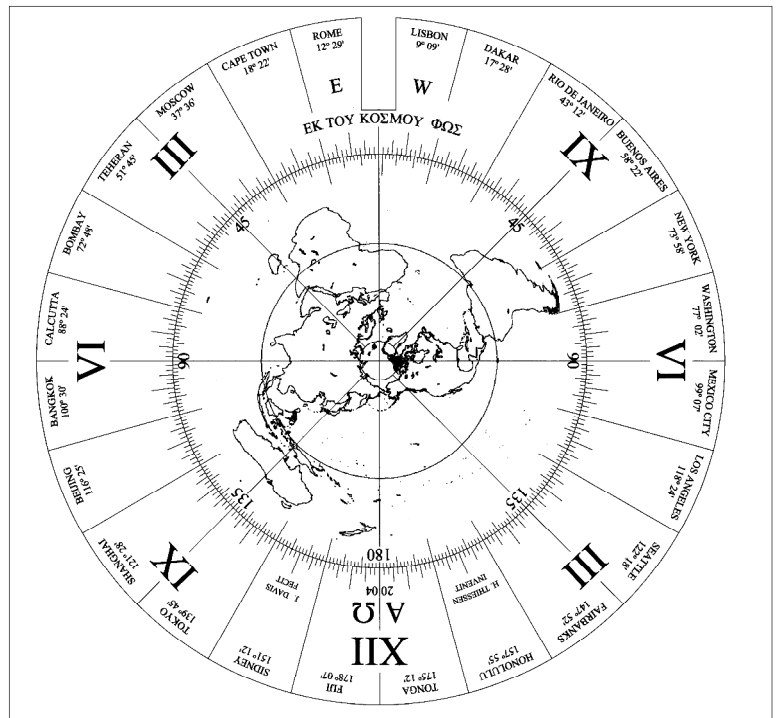

Fig. 1b. Engravings on Vial Dial. Graphics: J. Davis

server's local longitude but also for all other global longitudes simultaneously. It also shows for which longitudes and geographical regions solar midnight currently chimes in the new solar day. Finally it tells the times for sunrise and sunset on the day of observation. The instrument can be used anywhere on this planet, as long as it is tilted and aligned correctly.

WHAT ARE THE COMPONENTS OF THIS DIAL?

The instrument consists of the following:

1. a fixed equatorial dial face (diameter 180mm) showing a two dimensional representation of the entire globe, with the North Pole in its very centre. The image is a Polar Azimuthal Equidistant Projection with shorelines and longitude lines at 45° interval. Around its rim the dial face features the 360 degree marks for all longitudes around the globe. The observer's longitude mark (here 1° W) is highlighted in red, lengthened to 10mm and aligned to the local meridian.

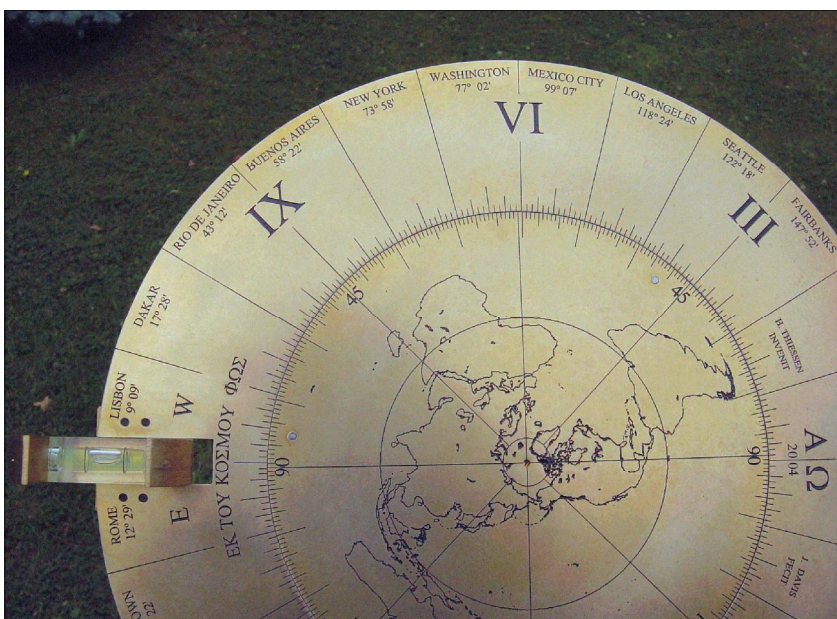2. the outer dial ring (diameter 295mm) fea-

Fig. 1a. The Vial Dial. The inner disk shows continental outlines and longitude lines at 45° intervals. The outer disk ring shows anti-clockwise hour numerals and carries the spirit level alidade to be aligned and tilted to gauge the hour angle and solar altitude.
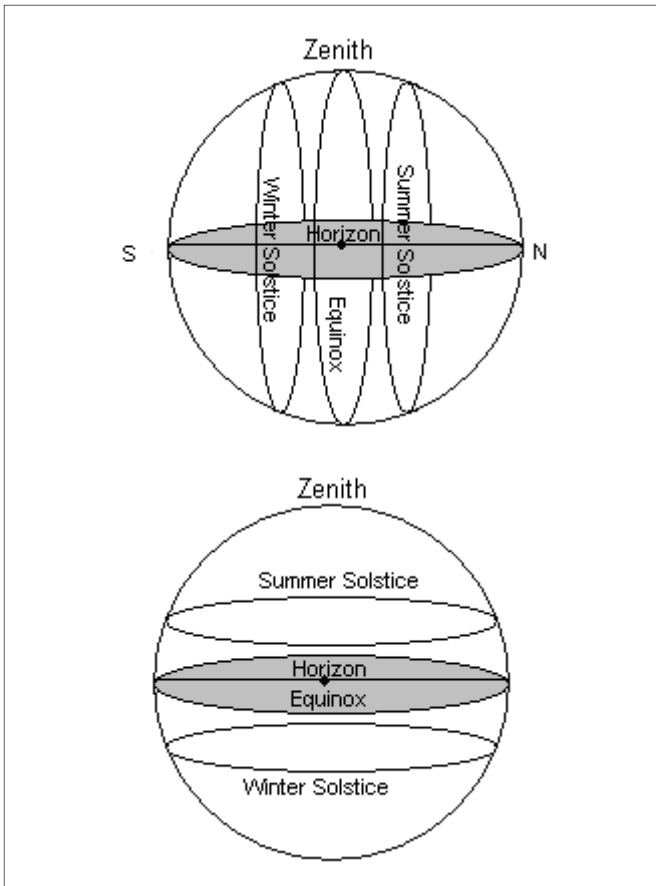
Fig. 2a. (top) The apparent movement of the Sun at the Equator. Fig. 2b (bottom) The apparent movement of the Sun at the North Pole.

tures the 24 hour marks plus the 5 minute interval markings for the entire solar day in an anti-clockwise direction and shows a gap of 15mm width centring on the midday mark. This gap has been cut to accommodate

3. a spirit level alidade, consisting of a brass disk of 15mm thickness and a 60mm diameter with a rectangular cut-out, to accommodate a spirit level block vial of 36mm length and to allow for a bore-hole through the sun-facing side of the disk. It also features on the opposite 'inside' arm, a 1mm conical depression , to indicate the correct place for the travelling spot of light, when the alidade is properly aligned and tilted. The alidade is fixed into the gap of the outer dial ring and can be pivoted towards the sun. (see Fig. 4)

4. The equatorial dial rests on a plinth with a surface that is slanted to the horizontal at the observer's co-latitude angle. This plinth is made of hardwood and should be aligned to the local meridian on a perfectly horizontal surface.

The mobile dial ring, mounted around the fixed dial face in the centre, represents the celestial sphere seemingly turning around planet Earth in real time. In reality it is of course the 'fixed' dial face itself that rotates eastward in real time with

its supporting mother ship and around its own axis, in parallel to the Earth's axis itself, while the outer dial ring needs to be re-aligned in a westward direction to continually 'follow' our Day Star. The instrument is made of brass of 3mm thickness. (see Fig. 1a)
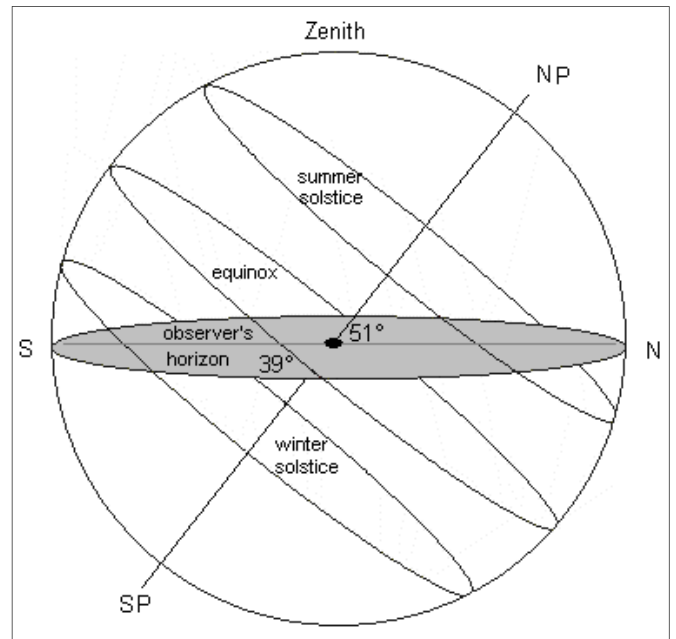

Fig. 3. The apparent movement of the Sun at 51° N.

WHAT IS THE RATIONALE OF IT ALL?

The sun's apparent orbit around planet Earth represents a celestial circle, slanted to the horizontal at the observer's co-latitude angle. On the equator with a latitude of zero, the sun rises vertically, i.e. at 90° to the horizontal on equinox day , describing a semi-circle in the sky and setting at exactly the same right angle in the west. As it 'plunges' fast below the horizon, the tropical night arrives with great speed. (see Fig. 2a)

At the North Pole on the other hand, the rising sun winds itself around the horizon at the spring equinox and during one long 'day' lasting until the autumn equinox, it gently spirals its way up to the Summer Solstice, where it reaches a solar altitude of 23.45° and then winds itself down again, until it finally disappears below the horizon for half a year. With a polar co-latitude of zero, there is no slant to the horizontal when the sun rises once a year (see Fig. 2b).

And at my own intermediate latitude of 51°North the sun rises and sets at the co-latitude angle of 39°to the horizontal at the equinoxes. So even after sunset there is plenty of time to get ready for dark. As the solar year progresses the solar altitude changes, due to a rising or falling declination of the sun, but all apparent solar orbits seem in fact like parallel circles, although it might perhaps be more accurate to describe them as loops of a spiral that threads its way up to the summer solstice and then down again past the autumn

equinox to the winter solstice. All these daily solar 'loops' lie in the same co-latitudinal plane of the observer, which is of course the equatorial plane.

Sunrises and sunsets can therefore be interpreted as points of intersection between the observer's horizontal plane and the heavenly circle described by the sun. At my own latitude the apparent movement of the sun throughout the solar year would look like that in Fig. 3.

Throughout the day the observer can measure the current solar altitude with the astrolabe-type alidade of this dial. This is done by moving the alidade on the outer disk ring to the current hour angle of the sun and by then tilting the alidade in such a way that it aligns directly to the altitude of the sun. When correctly aligned, a ray of sunlight will travel through the 1mm bore-hole in the alidade and hit the 1mm conical depression on its opposite projection surface (see Fig. 4).

As the day progresses, the observer can move the outer dial ring and with it the now properly aligned and tilted alidade
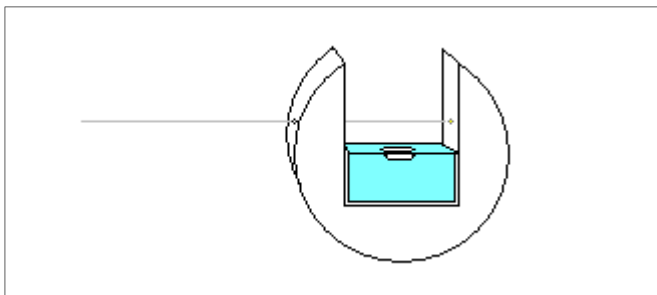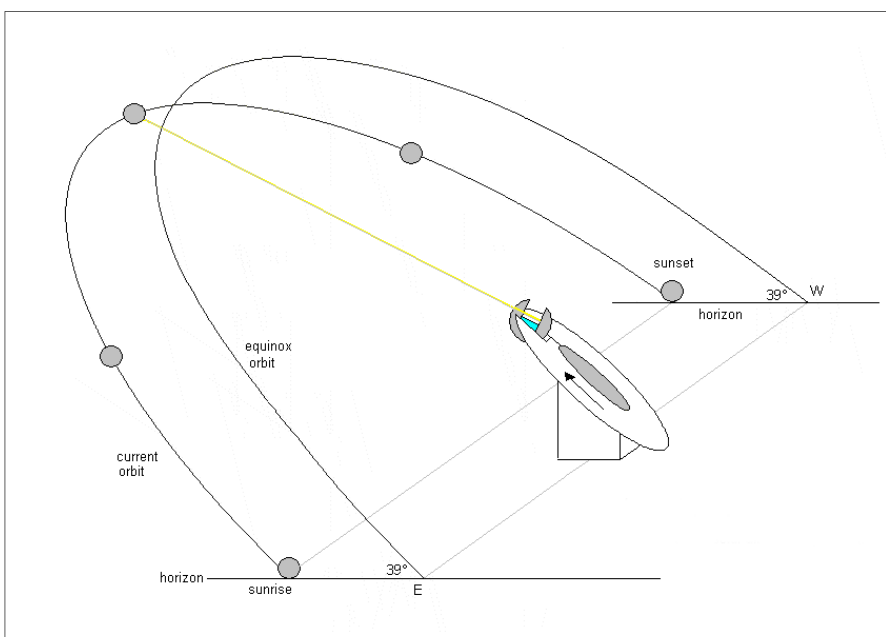

Fig. 4. The spirit level alidade.

Fig. 5. Alidade tracking the sun's orbit with sun's declination below zero and a solar altitude below 39° at noon.

through the equatorial plane in a clockwise direction. Without changing the tilt of the alidade, the sighting arm will now correctly point out the sun's apparent movement through the 360° of the equatorial ring , both above and below the observer's horizon, at least in the very short term, i.e. for one day of observation (see Fig.5).

The daily adjusted alidade on its circular journey through the equatorial plane would thus continue to correctly describe the changing solar altitude from sunrise to sunset for one single day of observation. The solar altitude angle would obviously be highest at local solar noon. At 51° latitude, it would range from 62.45° at the Summer Solstice to a mere 15.55° at the Winter Solstice, (see Fig. 3) but the moments of sunrise and sunset would always be defined by a solar altitude of zero, and thus by a perfectly horizontal position of the spirit level vial in the alidade.

Once the solar altitude angle of the alidade has been correctly established at some time during the day of observation, its clockwise progress on the equatorial disk ring would track the sun in its altitude accurately and would eventually lead to a horizontal sunset position, which could be confirmed with the help of the spirit level, built into the alidade.

HOW DO YOU READ LOCAL APPARENT TIME?
The observer moves the outer dial ring, so that the alidade points towards the hour angle of the sun. The proper tilt of the alidade will then enable a ray of sunlight to travel through the 1mm bore-hole in its outer arm and cast its own image in form of a spot of light onto the 1mm conical depression on the opposite 'projection arm' of the alidade.

At the equinoxes the tilt of the alidade will be parallel to the co-latitudinal plane of the equatorial disk of the dial itself, thus confirming a solar altitude of 39° at solar noon. During the weeks towards the summer solstice the tilt of the alidade will be rising towards the 23.45° above the equatorial plane, thus eventually confirming a solar altitude of 62.45° at solar noon for the summer solstice itself. During the weeks from the autumn equinox towards the winter solstice, the tilt of the alidade will be declining towards 23.45° below the equatorial plane, thus eventually confirming a solar altitude of a mere 15.5° at solar noon for the winter solstice itself.

The Solar altitude angle is of course directly dependent on the current declination of the sun, the latitude of the observer (here 51°) and the current hour angle of the sun. For the hour of solar noon and thus an hour angle of zero, the following simplified function applies:

Solar Altitude Angle = 90 - [Local Latitude - Solar Declination]

At solar noon, and at my own local latitude of 51° N, the solar altitude angle at the equinoxes would thus be:
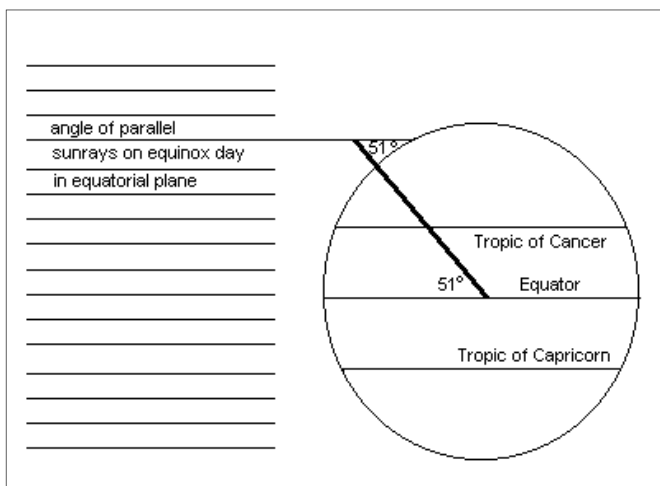
90- (51-0) = 39° (see Fig. 6).

Fig. 6. Solar altitude at the equinox. As 'parallel' sunrays hit the planet at the equinoxes, a vertical pole at 51° latitude will cast a shadow indicating 39° solar altitude at the end of the shadow on the ground.

In very much the same manner the observer can deduce the solar altitude angles at noon for the following solar declinations. For a latitude of 51° the following results would apply:

At +23.45° solar declination:
   90-(51-23.45) = 62.45° (approx. 21.6.)
At +20.00° solar declination:
   90- (51-20) = 59 ° (approx. 21.5./ 24.7.)
At +10.00° solar declination:
   90- (51-10) = 49° (approx. 16.4./ 28.8.)
At -10.00° solar declination:
   90- (51-[-10] = 29° (approx. 20.10/23.2.)
At -20.00° solar declination:
   90- (51-[-20] = 19° (approx. 22.11./21.1.)
At -23.45° solar declination:
   90-(51-[-23.45]= 15.55° (approx. 21.12.)

But all of this is purely theoretical information for the seeker of abstract knowledge and not necessarily of concern to the hands-on diallist, who merely aligns and tilts the alidade towards the Day Star. Once the alidade is correctly aligned and tilted to the sun, the observer can read L.A.T. at

the point, where his highlighted local longitude mark on the inner dial face coincides with the appropriate time marking on the outer dial ring. While it may be local noon for the observer, the anti-clockwise arrangement of the hour numerals on the dial ring will assist him to read L.A.T. for Moscow, Bombay, Beijing, Seattle, New York and all other locations on the planet at the same time. Engravings around the rim of the mobile disk ring detail the longitudes of 24 major locations on Earth, so that the observer can align the longitude mark for, say Seattle, of 122° 18' on the map disk with the appropriate time marking on the outer disk ring (see Fig. 1b).

As the sun progresses, the observer merely moves the outer dial ring in a clockwise direction to the new correct point of alignment. The tilt of the alidade itself will not have to be changed and should remain correct for the rest of the day of observation, as any changes in solar declination should be negligible within an observation period of 12 hours. New days of observation however will require re-alignments of the tilt of the alidade, as changes in solar declination will become tangible, especially around the equinoxes with fast changing declinations of the sun from one day to the next.

HOW DOES THE DIAL READ THE ARRIVAL OF A NEW SOLAR DAY?

Apart from its midday line the disk ring also features a midnight line 180 degrees away from noon. To the left and right of this midnight line are engravings of the Greek letters Alpha (A) and Omega (Ω), symbolising the beginning and the ending of the solar day. With the help of this midnight line the observer can identify the current longitude and thus the geographical regions associated with same longitude, where a new solar day is beginning at the time of observation.

The mobile disk ring thus demonstrates that at 11.00 a.m. Greenwich L.A.T., today's solar day only just kicks in at 165° West of Greenwich on the west coast of Alaska. And then of course, only one single hour later, at solar midday at Greenwich, tomorrow's solar day begins (at 00.00 L.A.T.) at 180° West with the midnight line directly over the international dateline, while at the very same time it is only 1.00 o'clock L.A.T. of today's early morning on the west coast of Alaska. Mind boggling stuff this, but the dial has at least helped me to see a tiny bit of light.

HOW DO YOU READ THE HOURS OF SUNRISE AND SUNSET FOR THE DAY OF OBSERVATION?

With the alidade correctly aligned and tilted towards the sun at any time during the day, the observer can now 'anticipate' the hour of today's sunset by 'fast forwarding'

the rest of the day of observation. This is done by moving the outer dial ring and with it the correctly tilted alidade in a clockwise direction to a position of solar altitude of zero. This is achieved when the block vial inside the alidade shows a perfectly horizontal level. The time of sunset is now read off, where the highlighted local longitude mark on the inner dial face coincides with a time marking on the outer dial ring. On equinox days with the vial tilt being exactly in the equatorial plane, the time for sunrise and sunset would of course be 6.00 a.m. & 6.00 p.m. L.A.T. anywhere on the planet and regardless of local latitude. (see Fig.1a showing the sunrise position on equinox day with the alidade at 90 degrees east of the observer's local longitude and an L.A.T. reading against the local longitude mark of 6.00 a.m.).

The time for sunrise can be similarly established by moving the alidade with its built-in vial to a horizontal morning position, where it simultaneously indicates solar noon somewhere over Asia. It goes without saying that the local apparent time difference between sunrise and midday should always be equal to the time difference between midday and sunset on the same day of observation. This rule does not apply to standard mean times.

MOTTO

Figs. 1a and 1b shows the dial carrying my favourite motto

ΕΚ ΤΟΥ ΚΟΣΜΟΥ ΦΩΣ

which is placed around the midday line on the outer ring. It means 'The Universe Brings Light' or literally 'Out of Cosmos Light'.

PRODUCTION

The Vial Dial has been cut, photo-etched and assembled by Dr. John Davis of Flowton Dials, Ipswich who has also provided the computer generated art work.   Design and copyright Heiner Thiessen.

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NOTES FROM THE EDITOR

A Treat

On *Saturday 18th September*, at 2 p.m., Dr Jim Bennett, of the Oxford Museum of the History of Science, will be giving a 'gallery talk' about the world's largest collection of Sundials. No need to book: just turn up on the day (Broad Street, Oxford, close to the Bodleian Library).

A Correction

(*Sent in by A.O.Wood*) Despite the efforts of both the Author and Editor, Tony Belk's Wulff Net, in the report of the Oxford conference 2004, appeared as 'Wolff Net'.

RESTORATION OF THE HOUGHTON HALL SUNDIALS
a study in patience

JOHN DAVIS

Houghton Hall in Norfolk[1] (Fig. 1) was built by Sir Robert Walpole, Britain's first Prime Minister, in the 1720s. The house, sitting in grounds of 4000 acres, has a central block in the Palladian style with north and south service wings connected by curved colonnades. The north service block was severely damaged by a fire sometime in the Victorian period. When the Marquess of Cholmondeley, the current owner and Walpole's descendent, decided that the time had come to restore the block, four large iron rods were discovered projecting from the stonework high up on the octagonal cupola. The architect (Michael Morrison of the Norwich firm of Purcell Miller Tritton) thought they might be the remains of some sundials as the matching cupola on the

Fig 1. *Houghton Hall, as viewed from the top of the tower on the North Service Block. The main house is on the left and the mirror-image South Service Block is on the right. The inset shows the octagonal tower and cupola of the South Service Block with the clock faces which match the restored dials.*

south service block houses a tower clock with four faces. He contacted the Bulletin Editor and, as I was the nearest BSS member, I was invited to give an opinion.

When I first visited Houghton Hall in April 2001, the country was in the grip of the foot-and-mouth epidemic so the Hall, with its pedigree herd of white hinds, was closed to the public and the entrance was guarded by a man spraying

antiseptic. The restoration was already in full swing. Large blocks of damaged stone were being removed from the tower and it was clear from the fact that the builders' vans

Fig 2. *The top support of the "north" dial gnomon poking through the middle layer of scaffolding. Note that it meets the wall well away from the raised circular stone of the dial face.*

had "By Appointment" signs on them that this was going to be a high quality job. After climbing up the multi-stage scaffolding, I found that the iron rods were indeed the gnomons of four vertical sundials on the (approximately) north, south, east and west faces of the octagonal tower (Fig. 2). The stonework formed raised circular surfaces nearly 1.5 metres (4½') in diameter on each of these faces and the 38mm (1.5") diameter iron bars spanned the circles, being supported from the tower by substantial but elegantly S-shaped struts. The stone circles had been accurately set to the vertical, in contrast to the surrounding areas of the

Fig 3. *One of several large weathervanes on the towers showing the probable original date of the dials.*

tower. The stonework was completely bare with no incised or painted lines and no sign that a wooden face had ever been attached.

I was able to measure the positions of the gnomons before they were removed from the damaged stonework: they were sunk deeply into the stone which they had damaged as they rusted. The measurements were difficult because they had

Fig 4. Drilling the large holes in the replacement stones for the "west" dial gnomon.

to be made from two levels of the scaffolding and because the gnomons were generally not supported from the actual dialplanes but from the curved cornices of the tower. Only the gnomon on the "north" face actually met the dialplane within the circular dial face. It was not until I was processing my measurements at home that I realised that the original designer had positioned the gnomons so that, on the "east" and "south" faces, they passed in front of the centre of the circles. This convenient positioning had not been possible for the "west" face but it was as close as could be achieved with the available mounting points. The designer obviously knew his gnomonics. I was able to measure the declination of three of the faces (no usable sun fell on the "north" face in April) and found that the faces were actually about 14.5° from the cardinal directions, with the tower being around 1° out of square.

No archive pictures of the original dials could be found. It seems likely that they were painted, either directly on the stonework or on wooden panels, and had been destroyed in the fire. The replacement dials were thus designed from scratch and it was decided to make them match the clock

Fig 5. How many men does it take to install a sundial? Drilling the fixing holes for the plywood template of the west dial.

faces (Fig. 1) on the south service block as far as possible. Two other modern multiple dials were used for inspiration: those on the Gate of Honour at Gonville and Caius College[2], Cambridge, and C. Daniel's dials on St. Margaret's church, Westminster[3]. The Houghton dials are viewed from a considerable distance so a very simple design was adopted, showing the hours and with the half-hours indicated by lozenges. Large numerals are used and not all of the hourlines are numbered. The four alternate faces of the octagonal tower without dials have circular apertures in the stone and these were matched with gold sun motifs on the dial faces. An early design showed a two-tone blue face using a light blue ring to maximise the contrast of the gnomon shadow, and a dark blue centre. This was complemented with Arabic numerals modelled on those used for the year 1727 on the weathervane (Fig. 3). The final choice, though, was for a simpler dark blue face with Roman numerals as this produces a closer match to the clock faces. The east dial, which is the one most clearly seen by visitors, has the motto "VITA IN MOTU" on it and also, in small letters around the periphery, the names of the designer and makers. The west dial shows the expected year of installation, MMII.

Several different construction methods for the dials were considered. These included incising and painting the stonework of the tower and producing thin dial faces in stone, GRP, or vitreous enamelled steel. The prime consideration was the longevity of the dials as it would be very difficult to reach them for maintenance without a complicated scaffolding structure. Eventually, the choice fell on vitreous enamelled steel disks as these should have excellent life, take vivid colouring, were quite thin and were surprisingly

reasonable in price. The steel was to have blue enamelling on both sides (to prevent ingress of water and to equalise stresses) and the gilded lines and numerals formed with an enamel containing finely-ground gold particles. The thickness of the two-layer disks was set at 25mm and this was

allowed for in the delineation of the hourlines as it affects the effective height of the gnomon. Three of the faces are complete disks but the north face has a narrow removable

Fig. 7a. The north dial in position, but without the narrow gnomon access strip. Photo: M. Hollingsworth.

section to allow it to fitted around the gnomon.

During the summer of 2001, while the designs were being finalised, the gnomons were removed and repaired. This consisted of cutting off the sections which were embedded in the stonework and welding on fresh sections of stainless steel, being careful that the new stubs were parallel to allow them to be reinserted into the stone. The nearly three hundred year old ironwork was then simply bead-blasted and given a black powder-coat. Re-installation (Fig. 4) required 2" diameter holes to be drilled 9" deep into the new stonework of the cornices and epoxy-bonding the stainless steel in. A surface grout of lime mortar was used around the holes. The marking and positioning required some care as there were no convenient reference origins and few flat surfaces. With the main restoration of the tower completed in the Autumn of 2001, the scaffolding was taken down with the intention of re-erecting it in the Spring to install the dials.

Only one company in Britain had an oven with the capacity

Fig 6. Craning a dial, in a protective box, onto the tower. The lower picture shows the galvanised brackets screwed to the stone to receive the dial. Photos: M. Hollingsworth.

Fig 7b. The completed dials.

to produce such large enamelled items but they were keen to undertake such a prestigious job. Full-size masks (transparent negative films of the dial artwork) were produced for them and they started work on the steelwork. Then everything went quiet for a long time – phone calls were evasive, letters went unanswered and progress slowed dramatically. Eventually it transpired that the parent company had gone into liquidation and the factory locked up – it took the architects some effort to extract their quite expensive masks from the Receivers. For a while it looked as though the large-capacity enamelling oven would be purchased by a competing British firm, allowing them to take over the contract, but this failed to materialise. So we entered a second round of tendering and evaluation, including reconsidering the options for stone dials. The final choice, partly on grounds of cost, was to remain with the vitreous enamel option using the international firm of Vitramet Europe Ltd. They undertook to do the structural design work at their offices in Kettering but the actual enamelling would be done in their nearest oven with the required capacity – in Mexico! This took some time and it was mid-2003 when the dials arrived in Norfolk. On inspection, it was found that the angled gnomon cut-out on the north dial sloped the wrong way, presumably because the disk had had the gilding applied to the back instead of the front. Back to Mexico!

Thus it was within a week of the 3-year anniversary of the

start of my involvement that that the dials were finally installed in March 2004. I had a slight panic when I realized that I had not put alignment marks on the circular dials so it was not immediately clear where the exact top of each disk was. Only the south face had a vertical noon line but, luckily, the sun motifs could be used to establish the verticals on the others. Temporary plywood templates were used to mark out the positions of the large galvanised fixing brackets which held the dials to the stonework (Fig. 5). The dials were craned into position (Fig. 6) and, when the scaffolding was removed, a deceptively simple set of dials was on show (Fig. 7).

REFERENCES
1. www.houghtonhall.com
2. The Gonville and Caius dials are SRNO 1716 and can be

seen in "Cambridge Sundials", Stanier & Brookes, Pendragon Press, Cambridge (1991).

3. The St. Margaret's of Antioch, Westminster, dials are SRNOs 2160-3 and are shown in "Sundials", C. Daniel, Shire Publications, (1993).

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FROM THE REGISTER

This is the first of an intermittent series of features showing dials from the BSS Register, selected for their general interest. This issue has two dials – old and modern – from Suffolk. Readers are invited to submit their own suggestions for future issues, which will be included where space permits.
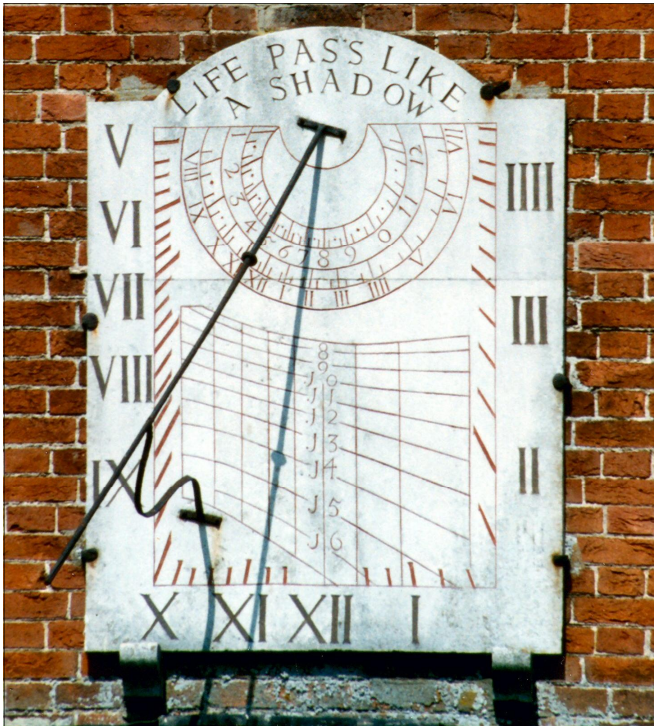
SrNo 1273 Grundisburgh, Suffolk
O.S. Ref. TM 223 511

This dial on St. Mary's church is thought to date from 1731, making it contemporary with the brick tower, although the church itself dates back to the 14th century and also has a (well hidden) mass dial. The dial sits immediately below a good tower clock and the church is in a very pleasant environment beside the village green, complete with a stream flowing through the middle of it. The dial, an east decliner with a nodus on the gnomon, has two interesting items of furniture in addition to the motto of "Life Pas's Like a Shadow". The first is the set of declination lines which are calculated for the hours of daylight (8 to 16) rather than the more common zodiac sigils. These are crossed by vertical straight lines which are presumed to be for the sun's azimuth, although they are unlabelled.

The second feature is the pair of extra chapter rings around the foot of the gnomon. The inner one, with Arabic numer-

als, is 4 hours behind local time and so represents a longitude of about 60° W. This could be the West Indies, probably Barbados, or Newfoundland. Several merchants from nearby port of Ipswich traded with the sugar plantations in the West Indies but it is thought that the local squire at Grunsborough Hall had connections to Newfoundland. The outer ring with Roman numerals is 2½ hours ahead of local time and is thus for a longitude which would fit with Jerusalem.

SrNo 0917   Woodbridge, Suffolk
O.S. Ref. TM 277 492

This excellent modern equatorial dial in Elmshurst Park, Woodbridge, was given to the community in 1988 by its maker, Robert Scott Simon. He was a member of the BSS until recently and made a number of large sculptural dials, mainly as private commissions in East Anglia. This stainless steel structure has a mechanism built into its polar axis which produces a rotation of the hour arc to compensate for the Equation of Time. The observer merely turns a knob to align the current date with an index mark.

THE VERTICAL SUNDIAL OF SAINT LAVRENTIOS CONVENT
E.TH. THEODOSSIOU, Y. KOURIS & V.N. MANIMANIS

ABSTRACT

One of the important monuments of the middle Byzantine period in Thessaly is the Convent of St. Lavrentios, built in the middle of 14th century AD on the eastern slopes of Mount Pelion. Its construction began during the reign of the Byzantine emperor of Trapezous Alexios III Comnenos (1349-1390) by the monk Lanrentios from Athos. The Catholikon of the Convent is adorned with an excellent piece of a white marble vertical sundial showing eleven hours. It is one of the very few - possibly less than ten - existing sundials on Byzantine churches in Greece.

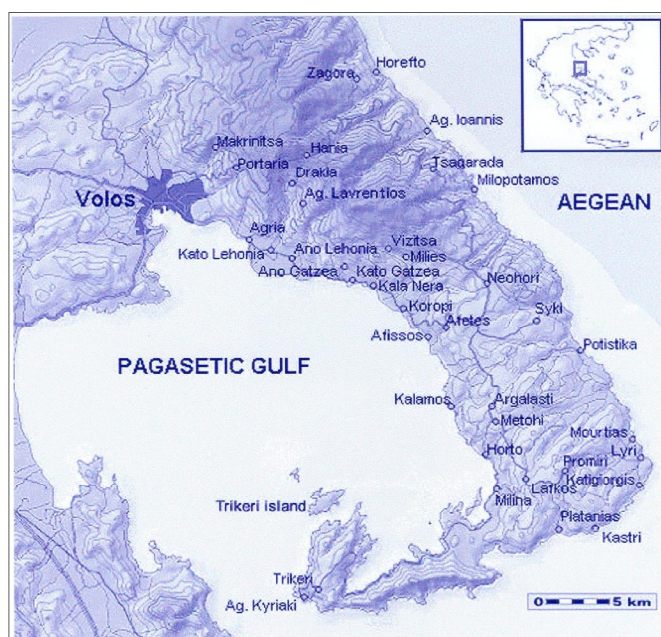*Key words: Convent of Saint Lavrentios, Pelion, sundial*

Fig. 1 A map of Mt. Pelion's peninsular, showing the village Agios Lavrentios (Saint Lavrentis) due east of the city of Volos at a distance of 10km as the bird flies (22km by car.

INTRODUCTION

Monastic life was at its highest point in Mount Pelion, in the Thessaly region of Magnesia, during the 14th century AD, a period during which we observe a massive immigration of monks from Mount Athos to Pelion, because of the heretic followers of the Greek philosopher and monk Barlaam (1290-1348) from South Italy. Near the middle of 14th century, the monk Lavrentios from Athos settled on the eastern slopes of Mount Pelion and along with other monks established a monastic community in 1378. The main church of the monastery was built, according to the inscription on the south side of the Catholikon, in 1378 (ATOH in Greek numerals), upon the ruins of an older Latin monastery dedicated to San Andrea. Catholic monks, belonging to the Order of Saint Benedict

(Benedictines), built the old Latin monastery in an unknown year of the 10th century. The name of Apostle San Andrea (Saint Andrews) was honored, as patron saint of the town of Amalfi in South Italy, as a Latin inscription at present reads.

The modern Convent is consecrated to both archdeacon martyr Agios (Saint) Laurentios (258 AD) and its founder monk Lavrentios, who was declared *Hossios* (Blessed) by the Orthodox Church after his death and is commemorated on the 1st of June. The church of St. Lavrentios constitutes the Catholikon (the main church of a monastery), and it must have been built during the second half of the 14th century AD. The donor is said to have been the Byzantine emperor of Trapezous Alexios III Comnenos (1349-1390). The Catholikon of the Convent is a domed cross-in-square church of the composite four-column type, having a two-level inner narthex, which is the main characteristic of the medieval Byzantine churches of Pelion and Central Greece (Thessaly). The wall masonry is pseudo-isodomic with sculptured porous stones at the lower section and "cloisonné" masonry at the upper part.

Lavrentios is the Greek form of the Roman cognomen Laurentius (Laurence / Lawrence in English), which meant "of Laurentum". Laurentum was a town in ancient Italy, its name probably from the Latin laurus (laurel). Laurentius the martyr was Archdeacon of the Athenian Pope of Rome Sixtus II or Xystus II (257-258 AD). So, St. Laurentius was a 3rd century deacon and martyr from Rome. According to tradition, he was roasted alive on a gridiron because, when ordered to hand over the Church's treasures, he presented them to the sick and poor. The Saint Lavrentios Convent gave its name to the nearby village, a community of about 500 people at a median altitude 550 m above sea level, and played an important role in the uprisings of Thessaly and Pelion against the Turks in the 19th century (1821, 1854, 1878). The village is a short road trip of 22km from the city of Volos (capital of Magnesia prefecture).

THE VERTICAL SUNDIAL OF SAINT LAVRENTIOS CONVENT

On the exterior of the main church of Saint Lavrentios (Catholikon) there is an excellent sundial made of marble. This vertical sundial has probab1y never been listed anywhere nor has it been sufficiently studied, like the other nine (?) "Byzantine" sundials in Greece; it should be stressed that the number of the vertical sundials on church

Fig. 2 The St. Lavrentios vertical sundial has been incorporated in the south wall of the main church (Catholikon) of the Monatery, symmetrically over the window's lintel.

walls is very small compared to the large number of Byzantine churches in Greece. This particular sundial is located on the exterior south wall of the church, above the right window (Fig. 2) and it is an excellent decorated plaque of white marble. This semicircular plaque has been placed above the overwindow column of cement (lintel) of the right window, but it is placed upside-down! The horizontal line -of the upper side of such a dial represents the horizon, and at local noon the shadow will fall on the vertical line which should be perpendicular to that "horizon", and this line is usually carved at the end of the sixth hour, as on the sundial at Hossios Loukas in Boeotia1. However, this is not the case with St. Lavrentios' sundial. Here there are ten hour-lines, dividing the semicircle into 11 equal hour sectors. The hour numerals, shown in Fig. 3, are ancient Greek numbers from A to IA, namely: Α, Β, Γ, Δ, Ε, ΣΤ, Ζ, Θ, Ι, IA, scratched on the small blocks at the end of each hour sector. Both the hour-lines and the Greek numbers are very well preserved and clearly visible, testifying to the upside-down orientation of the plate. So, we do not know if it is a real Byzantine sundial, or an ancient piece incorporated in that wall just as a decorative element, like the ancient lion head above the red ceramics and characteristic of the Byzantine architecture. The metallic gnomon of the dial has been stolen or lost. Every metallic piece was valuable at that period.

The Saint Lavrentios Convent's sundial uses ancient Greek numerals, so this sundial is much earlier than the late 13th century, when Fibonacci (Leonardo da Pisa, 1170-1250)

introduced the indo-arabic numbers in Europe. This is certainly not a sundial of the 14th century, when the church was erected.

Two are the most probable answers to this puzzle:

1. This sundial belongs to the Greek Antiquity, being an operational or decorative element of the pre-existing at the site ancient temple of Artemis (Diana). However, the vast majority of the ancient Greek sundials are either horizontal semicircular or cone-shaped, built to stand by themselves in their place.

2. Even most probably, this vertical sundial is a construction of the 10th Century AD, made by the Benedictine monks and used by the older Western monastery of San Andrea.

Fig. 3 A close-up of the sundial. Note the upside-down Greek numerals (letters), which contrast with the typical Byzantine decoration of red ceramics, and the ancient lion head above the dial plate.

After the second Schism, the San Andrea monastery and its sundial were abandoned. The gnomon of the dial disappeared, while its plate was left among the ruins of the ancient Artemis temple. In late 14th century, the Orthodox monks who, under Lavrentios, were building the Catholikon of the new monastery, incorporated many ancient pieces of the Artemis temple in the walls of their church, as is evident by an ancient plaque above the central entrance, by the marble lion head, and other elements. They even incorporated the Latin inscriptions of the San Andrea church:

PECUNIA AMALFI TAM

ƎNQHDV +.

However, not knowing the use of the sundial, they placed it upside-down, not as an operational element but in a way that fitted best with the arcs of the Byzantine architecture. In any case, we are pleased from the discovery of this mediaeval sundial in St. Lavrentios. It is one of the few sundials of that period that we have already located in Greece, and we will hopefully describe and present each one of these.

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4. N. Yiannopoulos: 'The Monastery of Agios Lavrentios on Pelio', Scientific Yearbook of the Society of Byzantine Studies, Athens, vol. 11, 1935, pp. 385-407 (in Greek).

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A SUN AND MOON DIAL WITH BABYLONIC AND ITALIAN HOURS

KARL G. HOFBAUER

Fig. 1 The dial and its surroundings.

This sundial is the latest addition to a small collection of four other dials that were designed and built during the past eight years in the grounds of an old country inn and farm house in the Black Forest. The purpose of its construction was to provide indications not yet given by the already existing, more conventional dials on site. In particular, it should show Babylonic and Italian hours during the day and serve as a moon dial during the night.

The dial is made of red sandstone and is inlaid with white sandstone and dark grey volcanic stone. The decorations show the earth's orbit around the sun and the moon's orbit around the earth. A small symbol of a church indicates a plane which is parallel to the length axis of the Basel cathedral, which is directed towards the point of sunrise at the summer solstice. The corresponding other plane is directed towards sunset at that time of the year. The two further planes of the dial are parallel to the walls of the old farm house next to it, which are facing, with remarkable precision, southeast and southwest, respectively.

The two latter planes carry dials which indicate Babylo-

nic and Italian hours. Moreover, engraved lines show the solstices and equinoxes. The border between the red and the white sandstone gives the corresponding indications for the moon. The upper, slightly inclined, plane of the dial carries a circle made of white sandstone. Its lower half is a conventional horizontal dial, while its upper half is a correction device for reading time at night from the shadow of the moon.

In summary, this sun and moon dial is an instrument for measuring time during day and night and gives additional indications such as the direction of sunrise and sunset at the summer and winter solstices. Its planes and angles are designed in a way to relate the dial to the house next to it and to the city of Basel, where its owner lives and works.

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Bürchau   *Leimenstrasse 66*
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Germany   *Switzerland*
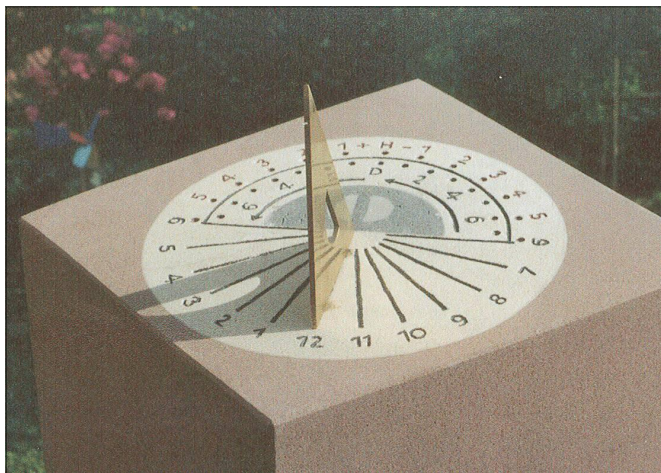
Fig. 2 The horizontal dial and moon table.
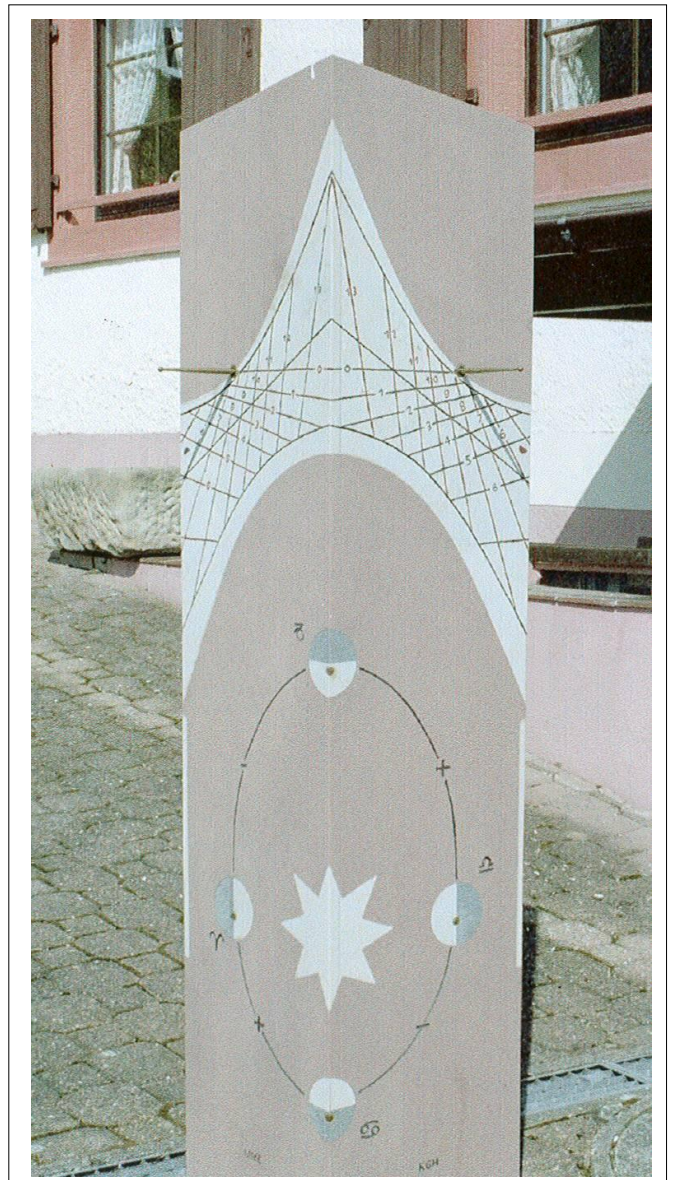
Fig. 3 The southeast and southwest faces of the dial showing Babylonic and Italian hours, as well as the Earth's and moon's orbits.

HOUR LADY

No, it is NOT a Mass Dial. It is the work of a modern artist/dialmaker, Ian Hamilton Finlay. The dial is situated at Dunsyre, Lanarkshire, Scotland. The photo has been received by the kindness of Nicole Marquet and Tony Wood. Tony hopes to follow up this photo and to find and photograph other works by this maker.

John Davis comments: *The artistic layout of this dial looks very similar to the "NASS Angel" described by Fred Sawyer in NASS Compendium 6(4), pp.27-30, (1999). In fact, the Sawyer design is a new form of vertical diametral dial and has little gnomonic connection to the present dial sculpture. See also the picture in Michael Cowham's article in this issue.*

RESTORATION OF THE SUNDIAL ON MARKET LAVINGTON CHURCH

HARRIET JAMES
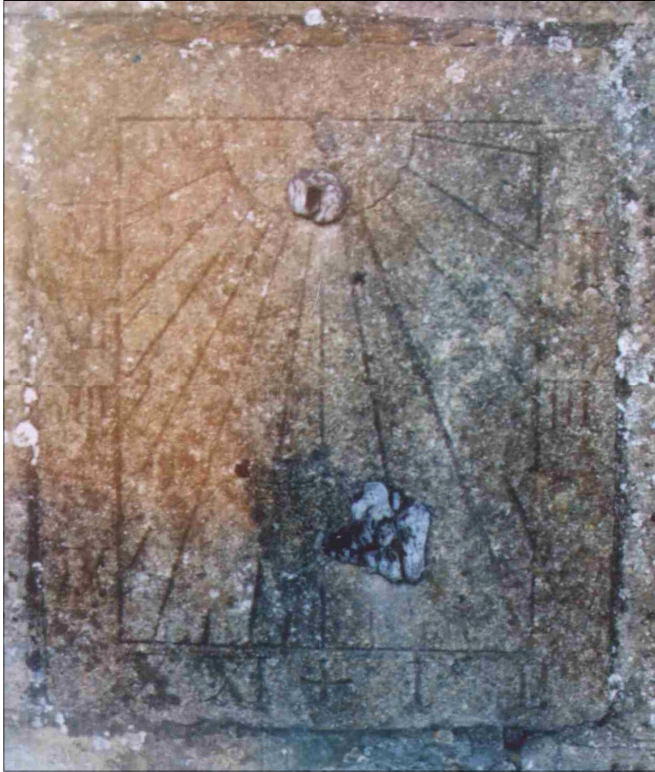
Fig. 1 Before restoration.

The sundial at the church of St. Mary of the Assumption, Market Lavington in Wiltshire, is set into the wall about 20 feet from the ground over the door of the south porch. It is carved into a piece of shelly sandstone different from the local stone of which the church is built. The stone measures approximately 490 (w) x 590 (h) x 50 (d) mm, perhaps 20" x 24" x 2" originally. The date of the sundial is unknown, but its layout and the shape of the numerals suggest that it may be late 16th century, or 17th century.

The sundial is a simple east-decliner reading local solar time. There are hour lines from 6am to 5pm and shorter intermediate half–hour lines, all in an inner rectangle 359 (w) x 457 (h) mm (perhaps originally 14" x 18") with Roman numerals 1¾" tall in an outer border. The numerals and lines are carved in v-section and some of them are badly weathered. The numerals are quite well designed and carved with thin and thick strokes ⅛" wide and ¼"–⅜" wide respectively. Four is delineated as IIII not IV. Noon is indicated by a cross. There was no trace of paint in any of the carved detail, but I painted the detail black to make the dial readable from the ground.

The dial's old gnomon is missing although there was one in existence within living memory. This was probably not the original gnomon as there were several lead and mortar-filled holes in the stone in which there might have been a

Fig. 2 Several different attempts at fixing the gnomon correctly.

Fig. 3 Mortar-filled hole at the origin and loosened lead plug with rectangular hole at its centre.

foot to a gnomon. Various attempts at fixing the gnomon in the correct position had been made, including one attempt to make the sundial a west-decliner! It is not surprising that complaints about the accuracy of the sundial were made by J. L. Maddox, a patient at Market Lavington mental asylum in the 1930s. He had constructed his own noon-line sundial (see BSS Bulletin 16(i), p.33, 2004).

Embedded in one mortar-filled hole was the foot of an old iron gnomon of ¼" – ⅜" irregular circular diameter. This foot was in the correct position for an accurate fixing of the gnomon. It was not uncovered until the restoration was underway, by which time the replacement gnomon had been made in 3/8" square (not round) section bar. There

Fig. 4 The cleaned dial stone with wet mortar filling the holes.

Time	Measured on dial (degrees)	Theoretical (degrees)
6:00 am	64.52	70.1
6:30 am	61.87	60.6
7:00 am	47.62	52.3
7:30 am	43.7	45.1
8:00 am	36.8	38.8
8:30 am	32.99	33.1
9:00 am	26.50	27.9
9:30 am	23.54	23.0
10:00 am	18.16	18.4
10:30 am	12.69	13.9
11:00 am	7.84	9.4
11:30 am	4.12	4.8
12:00 pm	0	0
12:30 pm	5.37	5.1
1:00 pm	9.92	10.6
1:30 pm	15.52	16.7
2:00 pm	21.49	23.6
2:30 pm	28.82	31.5
3:00 pm	39.12	40.6
3:30 pm	47.4	50.9
4:00 pm	59.32	62.5
4:30 pm	71.39	74.8
5:00 pm	82.40	87.2

Table 1. Hour angles from noon.

was a further lead-plug in the stone with a rectangular hole at its centre positioned within the semi-circle centred about the dial's origin. This must have been for another foot. A hole at the origin itself was filled with mortar. It was hard to tell which of the holes were the original fixing holes for the gnomon but the neatest and smallest holes filled with similar mortar were the hole at the origin and the hole around the old iron foot. I designed the new gnomon to reuse the hole at the origin and a new hole for a foot in sound stone just above the site of the old iron foot.
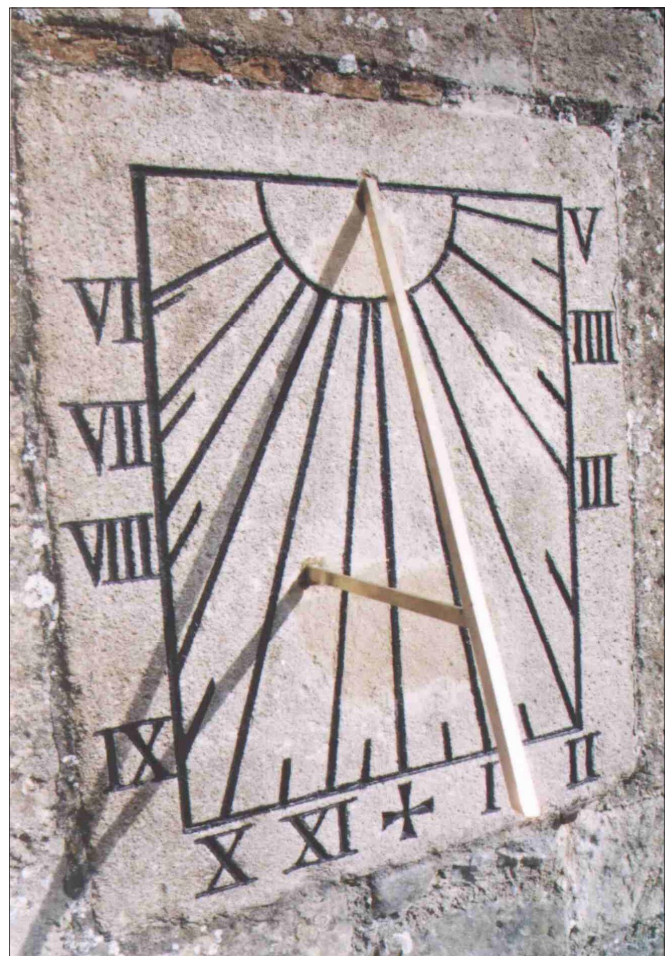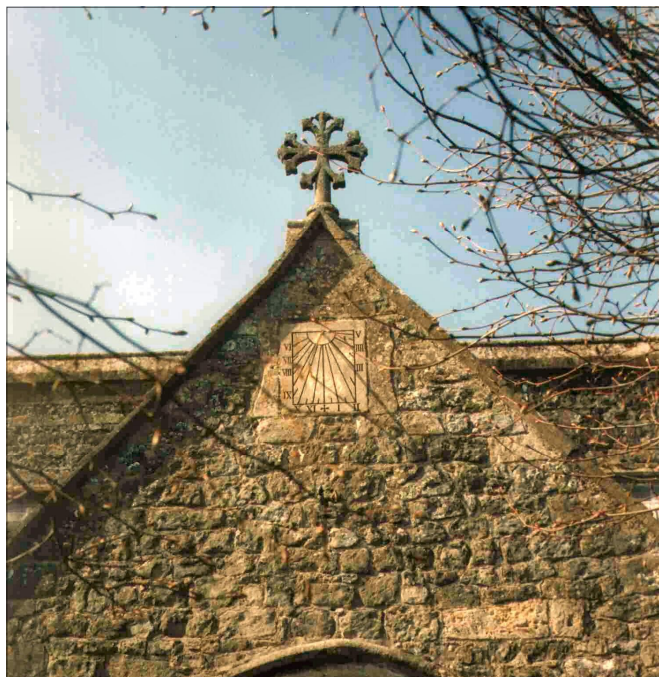

Fig. 5 The restoration completed.

Fig. 6 The restored dial on the porch.

The declination of the sundial is 16° 52' east of south. The latitude of the church is 51° 17' N and longitude 1° 58' W. There appear to be some errors in the original layout of the hour lines, though they were quite difficult to measure on rough and weathered stone. Some are at the wrong angle and not drawn accurately from the dial's origin.

CARRYING OUT THE RESTORATION

The dial stone was cleaned with water to remove lichen. The lead plugs were then removed. This was a difficult task as there is a hollow behind the stone and the end of the lead had plugs had dripped into it. When the plugs had been extracted the resulting holes were filled with a mortar to match the original stone. The missing segments of hour lines were scribed into the mortar while still wet. When the mortar was dry the carved detail was tidied and painted with black signwriter's enamel. A small iron clamp exposed near the bottom right corner of the dial stone was cleaned and filled round with new mortar as water dripping from it had made a hole in the surrounding mortar. Otherwise the mortar was in very good condition as were segments of a rusty-orange stone (Guiting stone?) which had been used to wedge the dial into its niche.

The replacement gnomon was made of brass to avoid rust and it was set into the stone with an epoxy stone glue. It was positioned so that the centre of its shadow lies along a line when it is the hour or half-hour local solar time.

The church was provided with the text for a leaflet describing the restoration and explaining how to read the sundial.

The restoration was funded by Mr and Mrs T. Gye of Market Lavington.

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READERS LETTERS

Sotheby's

I always enjoy the articles about recent auctions since they show portable dials which we might not otherwise have the chance to see. However, I was concerned to see the Sotheby's advertisement in a recent Bulletin which (since it quotes an estimated price range) appears to offer a fixed dial for sale. If it is now in its original location and is then sold and moved, this might be construed by readers as an act of vandalism.

An important vertical dial on a listed building would be protected by the listing, so should a horizontal not be similarly protected? I do feel we should discourage the view that fixed horizontal dials are tradeable artifacts.

Frank Coe
7 St Andrew's Close
Stapleford, Cambs CB2 5DX

Mike Cowham comments: horizontal sundials appear for sale at auction quite frequently, as do other artistic products such as sculpture and paintings. (The only consideration which might place a sundial in a slightly different category from any other tradeable artistic artefact is that many sundials are made for a particular latitude and longitude.) The particular dial of which the sale was advertised in the Bulletin was sold for about £180,000, to an owner who is aware of its value and who will conserve it for the foreseeable future.

BSS ANNUAL ACCOUNTS YEAR ENDING 31 DEC 2003

[These accounts should have appeared in the June Bulletin in the report of the AGM of the Society. There were to have been placed immediately after the Treasurer's report on Page 75, but were omitted by an oversight. Apologies are due to the membership and especially to the Treasurer whose hard work ensured that the accounts were ready on time—Ed]

INCOME AND EXPENDITURE

INCOME	2002	2003	EXPENSES	2002	2003
Subscriptions (1)	£12,198.32	£12,588.09	Bulletin (5)	£11,500.47	£8,056.62
Gift Aid (2)	£1,702.15	£4,094.82	Publications (6)	£872.97	£4,732.00
			Officers (7)	£2,683.70	£3,611.55
Events			**Events**		
Yarnfield 2003 (3)		£9,447.41	Yarnfield 2003		£13,244.72
Cornwall 2003		£15,330.00	Cornwall 2003		£14,967.86
Oxford 2004		£5,815.19	Oxford 2004		£42.10
Combined 2002 events	£14,384.90		Holloway 2005 (8)		£989.34
			Combined 2002 events	£15,696.25	
Sales (9)	£1,263.50	£1,689.77	Sales (9)	£0.00	£400.12
Auction (13)		£801.00	Auction (13)		£348.00
Advertising	£210.00	£106.00	Advertising	£47.00	£24.87
Donations (Somerville) (14)	£39.00	£328.00	Library (10)	£155.05	£136.00
			Internet (11)	£532.13	£146.88
			Somerville Lecture	£45.50	£130.00
Interest	£1,027.86	£1,025.98	Banks/Insurance (12)	£231.00	£649.84
Awards 05	£0.00	£30.00	Awards 05		£33.30
Offprints	£0.00	£89.00	Offprints		£89.00
Misc	£0.00	£38.40	Misc	£90.00	£0.00
TOTALS	**£30,825.73**	**£51,383.66**		**£31,854.07**	**£47,602.20**
St. Katherine Cree Fund (4)		£1,080.00			
Net income	**-£1,028.34**	**£3,781.46**			

Notes

1. Amounts paid in US dollars have been converted to sterling at the exchange rate in force when balances have been repatriated, or at the rate on 4/1/2004 for the balance held in the USA.
2. The amount for 2002 is for the 2001 subscriptions and the amount for 2003 is for the 2002 and 2003 subscriptions.
3. Some income for the Yarnfield Conference appeared in the 2002 accounts
4. These donations, held on behalf of the St. Katherine Cree Sundial Restoration Fund, are **not** part of the BSS assets.
5. Three editions paid for in the year.
6. Printing of the three publications"Biographical Index", "Make a Sundial" and "Oxford Sundials".
7. Includes postage, leaflets, travel, computing sundries, meeting room costs etc.
8. Advance deposit for the 2005 Conference.
9. Sales of booklets, sweatshirts, slides, ties etc by Margery Lovatt, Jane Walker & David Young
10. Subscription to the Bromley House Library (Nottingham) and purchase of books.
11. Hosting of the BSS website and SOTI costs.
12. Bank costs (inc international), credit card start-up costs, Society liability insurance.
13. Includes books sold after the Conference. Costs include a donation to the British Heart Foundation for W. Rodber items.
14. The Andrew Somerville Memorial Fund now contains all donations to the BSS and its reserves are part of the general BSS Assets.

General Notes.

A. The accounts are prepared on a payments and receipts basis. That is, money is booked when it is received or spent (i.e. when cheques are written, not presented). This is in line with the Charity Commission's guidance.
B. The year-end funds are held in approved investment accounts and in current accounts.
C. Events are priced not to make a loss, with a nominal contingency of 5%.
D. Stocks are valued at nil as they are unlikely to have any value if the Society were to be wound up. This does not impact our cash flow.

Statement of Funds

Year ending 31 December	2002	2003	
Current account balance	£5,742.86	£3,333.34	
Deposit account balance	£16.27	£16.35	
BSS USA current account	£0.00	£610.37	converted at 1.794 $/£
Charities Office Investment Fund	£24,572.56	£30,218.46	excludes St. Kath Cree Fund
TOTALS	**£30,331.69**	**£34,178.52**	
Change in funds during the year	-£1,028.34	£3,781.46	
Income received during the year	£30,825.73	£51,383.66	
Expenses incurred during the year	£31,854.07	£47,602.20	
Excess of income over expenditure	**-£1,028.34**	**£3,781.46**	
Andrew Somerville Memorial Fund	£871.14	£1,069.14	(included in the above balances)
St Katherine Cree Restoration Fund		£1,080.00	(excluded from the above balances)

BSS Stock on 31 Dec 2003

No.	Item
2530	Bulletins
5	CD-Rom out-of-print Bulletins
23	Bulletin binders
10	Glossary
454	Make a Sundial
502	Oxford Sundials
168	Cambridge Sundials
4	The Ancient Sundials of Ireland
9	Cornish Sundials
2530	Postcards
83	Lapel pins
51	Biographical Index of Sundial Makers
2	Sundials Australia
8	Clocks IV
2	Lincolnshire mass dials (CD-Rom)
0	Fixed Dial Register 2000
0	Tie

The above items have zero nominal value because, if the Society were to be wound up,
they are unlikely to be saleable. This does not impact our cash flow.

BSS Library Valuation
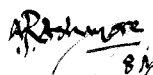
The valuation of the contents of the BSS library (housed at the Bromley House Library, Nottingham) is based on
the valuation made by Mr P. Rogers of Rogers Turner Books in October 2003.

Books with a replacement value of £50 or greater were individually valued. A total of 51 books fell into this category.
The remaining 335 books were divided into two classes, with nominal replacement costs of £10 or £20.
BSS publications such as Bulletins are not included in the valuation.

Number of books	Representative value per book	Value
27	£50 to £100	
17	£101 to £300	
7	£301 to £1000	
Subtotal for individually valued books		£10,800
175	£10	£1,750
160	£20	£3,200
	TOTAL	**£15,750**

The value of other BSS assets (computer, office equipment etc) is currently being assessed and will be presented
as part of an Asset Register in the 2004 Accounts.

Treasurer: 8/3/04   J R Davis

Checked by: A R Ashmore
8 March '04.

Chairman   C Daniel 8/04/04.

JOSEPH McNALLY'S SLATE SUNDIALS

JOHN DAVIS, MICHAEL J. HARLEY and HARRIET JAMES

There is a long history of dial making in Ireland[1]. The earliest dials, made of stone and over a thousand years old, are to be found in the ruins of the monastic settlements that dot the country[2]. Much later, the scientific instrument making trade flourished in the 18th and 19th centuries with notable Dublin makers such as Mason, Yeates and Lynch[3] producing beautifully crafted bronze and brass sundials. Slate was also used for dials at this time all over the country because it was readily available and could be worked by local artisans with varying degrees of skill ranging from the naïve to the sophisticated. One such slate dial dated 1796 in the Down County Museum[1] shows that the maker, William Straney, had a very sophisticated style indeed as well as an appreciation of the underlying geography, astronomy and mathematics. The best known Irish slate, known as Killaloe slate, came from Portroe, near Nenagh Co. Tipperary. Slate was quarried in this area since the middle ages with peak production reached in the 1840s when 800 people were employed in the quarry. Because of its superior quality, imported slate mainly from North Wales became increasingly common in the 19th century, especially for the houses and gravestones of the wealthy. It is most likely that quality Welsh slate was sought after by the Irish dial makers of that time in preference to the local product.

Most of the early Irish slate dial makers seem to have produced only one or two dials each, possibly for their own use. Then in the early 1800s two County Down makers established themselves with distinctive styles and went on to sell their dials in Scotland and England as well as in Ireland. One of these, Richard Melville[4-6], is well known and was particularly prolific, producing horizontal dials with multiple gnomons. His little known contemporary Joseph McNally has only nine dials recorded, mainly with multiple gnomons, but his is an equally important story. McNally records his profession on one of his dials as "Ship's Broker and Commissioner" and, as all but two of his dials were made for Portaferry in Co. Down or its surroundings, it seems reasonable to assume that this is where he lived and worked. In the 1830s Portaferry was a thriving seaport and market town on the east coast of Ireland about 25 miles south east of Belfast. It had a considerable trade in agricultural produce, coal, timber and fishing with a population of around 2000 people. It had a parish church, a Presbyterian church, Wesleyan, Methodist and Roman Catholic chapels and two schools. To date, it

Fig. 1. One of the best preserved McNally slate dials, in a private collection. The engraving is coloured white, yellow and orange. Below: McNally's signature and '510' in Greek numerals.

has not been possible to trace McNally's background, as the census records for the first half of the 19th century were destroyed when the Public Record Office in Dublin burned in 1922 during the Civil War. The records for the second half had been pulped by order of the Government during the First World War. Other genealogical sources such as the Tithe Books, Wills, Probate records and Piggot's Almanac have been searched but to no avail. The slate dial making tradition continued in Co. Down with makers such as Patrick Doyle in the 1850s[7], a Portaferry schoolteacher with a strong interest in navigation – a good way for local boys to escape the agricultural poverty of the time.

All but one of McNally's extant dials feature multiple gnomons with five circular dials on a rectangular plate, usually with the larger central dial serving for two geographical locations, one being the design location for the dial. See Fig. 1 for an example. The design locations for the nine dials are shown in Table 1. The latitudes and longitudes of the subsidiary dials locations are usually listed elsewhere on the dials and are shown in Tables 2 and 3. Other features which are common to several of McNally's dials are various astronomical diagrams and the use of Greek acrophonic symbols to give the date. These sometimes have the initials E.K. above them, standing for Etos Kyriou[8], Greek for "the year of the Lord". Not all of the dials are dated but those which are cover the very short span of 1832 to 1835. The dials all carry multiple mottoes in both English and Latin and these are listed in Table 1. On two of the dials the engraving still shows evidence of being filled, with the major lines being in white and some of the other decorations in orange and yellow. If these are the original colours they must have been very striking when they were new.

Design Location	I shew....	Qualis vita....	Life in its...	Quasi umbra...	Veni Vedi...	Claritutem spend	Vigor aetatis	Sol gloria...	Brevis...	Lux...	Dum...	A virtuous ...	Hora pars...	Mors omnia..	I Live..	Appollo	Ars longa..	Luceo...	Vale non...
Irvine						√	√												
Maryport	illegible																		
Lat 54° 3' N Lon 6° 0' W					√			√	√				√	√	√	√			
54° 20' N	√				√				√								√	√	√
Ballyphillip	illegible																		
Portaferry	illegible																		
Corbally	√							√	√										
Lat 54°20' N Lon 6°16' W	√	√	√	√	√														
Portaferry Lat 54° 20`N 6° 16` W	√							√	√	√	√	√							

"I shew by the kindnefs & splendour of the sun"
"Qualis vita, finis, ita" (What a man's life is, so will be his end)

"Life in its greatest vigour is altogether vanity"
"Quasi umbra, transit vita" (As a shadow, passes life).
"Claritutem et splendorem solis indico" (I announce the brightness and radiance of the sun)
"Vigor ætatis fluit ut flos veris" (Life at its best is but vanity
"Veni, Vedi, Legi, Vale" (I came, I saw, I read, Farewell)

"Sol gloria spheræ" (Sun, glory of the earth)

"Brevis hominum vita" (Human life is short)

"Lux venit ab alto" (Light cometh from on high)

"Dum spectas fugio" (While you watch, I fly away)

"A virtuous life, a happy eternity"

"Hora pars vitae" (Time is part of life)

"Mors omnia vincit" (Death conquers all)

I live and die daily

Appollo is my teacher

"Ars longa vita" (a shortened version of 'Ars longa ut vita' – Art is as long as life)

"Luceo & Lateo" (I shine and I set)
"Vale non morator hora" (Farewell, time does not wait)

Table 1. The nine known McNally slate dials and their mottos.

IRVINE DIAL

The "Irvine" dial (Fig. 2) came to light in 1959 when its owner's parents moved into a house in Paisley, Renfrewshire, and found it in an outhouse. It is 540 by 370mm and about 20mm thick and is unsigned, leading initially to the idea that its maker was "E.K."! The central, larger, dial has twin chapter rings and is labelled "Irvine & Smyrna" so, as Irvine on the west coast of Scotland is only about 20 miles from Paisley, it seems highly likely that this is its original design location. At that period, Irvine was the third largest seaport in Scotland[9].
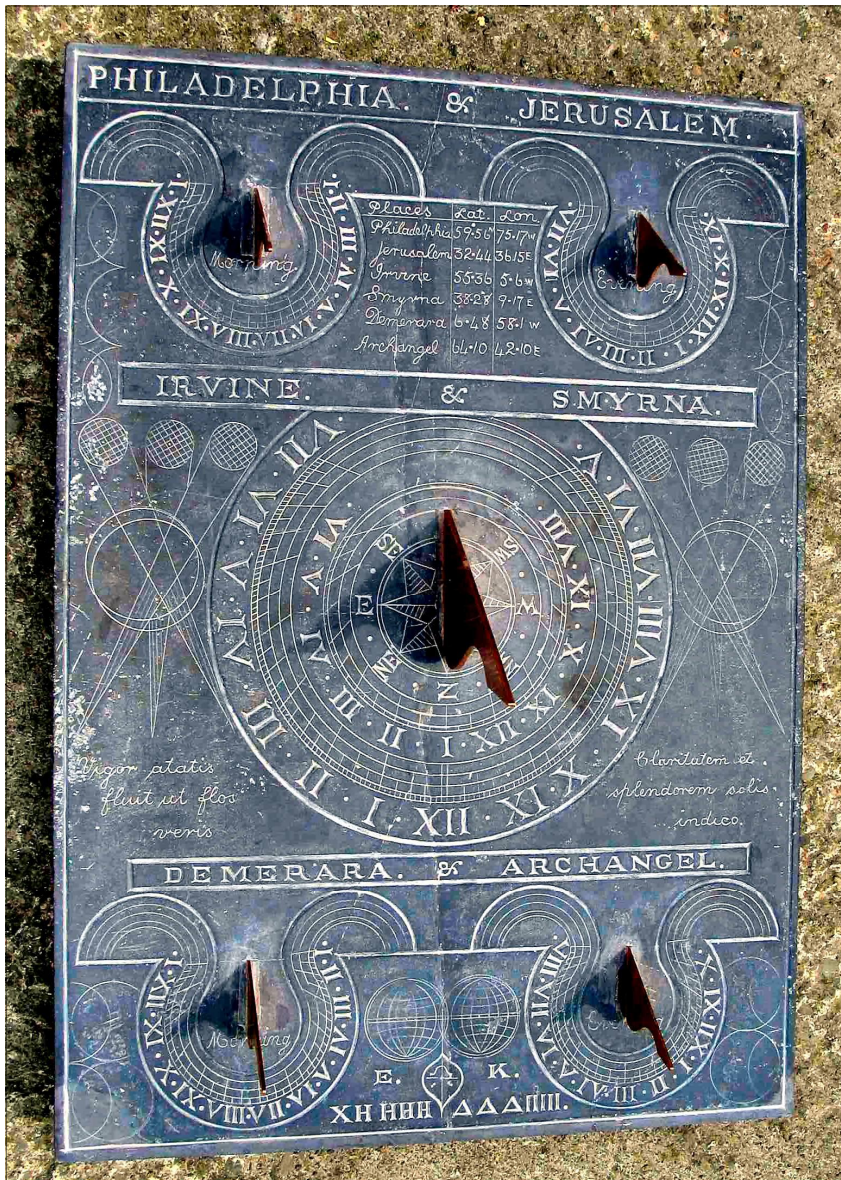

Fig. 2. General view of the Irvine dial after its recent restoration.

Place	Lat on dial (N)	Actual Lat (N)	Lon on dial	Actual Lon
Philadelphia[1]	59º 56' [2]	44º 9'	75º 17' W	75º 40' W
Jerusalem	32º 44'	31º 47'	36º 15' E	35º 10' E
Irvine	55º 36'	55º 37'	5º 6' W	4º 40' W
Smyrna	38º 28'	38º 30'	9º 17' E [2]	26º 30' E
Demerara	6º 48'	7º 0'	58º 1' W	58º 0' W
Archangel	64º 10'	64º 40'	42º 10' E	41º 0' E

1. Assumed to be Philadelphia, USA.   2. Gross error.

Table 2. Table of the latitudes and longitudes engraved on the Irvine dial compared with their modern values.

The latitudes and longitudes of the six locations for which the dial indicates the time are given on the dial and are shown in Table 2. The names are explicitly paired ("Philadelphia & Jerusalem", Irvine & Smyrna" and "Demerara & Archangel") in a way not seen on McNally's other dials. This set of place names is unique in the authors' combined experience and hence it was a challenge to discover why they had been chosen. The strongest clue is that Smyrna (now Izmir in western Turkey) and Philadelphia (now Alasehir, and only about 130 km from Smyrna) were two of the locations of the Seven Churches of Asia, thought to have been founded by St. Paul. Smyrna and Philadelphia are mentioned in chapters 2 and 3 of the Book of Revelation and are the two churches of which Christ made no criticism. Today, Smyrna remains a place of importance to the Orthodox (Coptic) church. Jerusalem, of course, has strong Christian connections and although Archangel in Russia does not immediately seem to be a place of religious significance the word "archangel" features heavily in all Christian literature. Archangel was also the first Russian port to be opened and Britain was one of the first countries to import goods from there. An internet search has revealed that the sailing ship *Friendship*, built in Massacusetts in 1796, visited Smyrna and Archangel several times over the period 1807-1810, but this is probably a coincidence. The six place names have significance to various Christian denominations, particularly the Moravians. They founded a community at Gracehill in Northern Ireland in the 18th century and sent out individuals and missionary groups to numerous locations. One John Montgomery was sent to Irvine in Scotland in the mid-1770s. Others went to Philadelphia in the USA (a group which eventually went on to found the steelworks at Bethlehem).

Fig. 3. The Greek date on the Irvine dial and its preferred form.

From 1735 they undertook missionary work in Demerara in the West Indies. Thus it seems likely that the owner was trying to show his religious beliefs and he may also have been a seaman or ship owner from Irvine.

The latitudes and longitudes quoted on the Irvine dial are generally quite close to the accepted modern values. One exception is for Philadelphia, where McNally seems to have chosen Philadelphia on the river Delaware in the USA instead of the old Asian town and then engraved the correct longitude but a latitude of 59º N instead of 39º. (It is notoriously difficult to distinguish 3 and 5 in many old typescripts and McNally may have misread his source.) There was another, smaller, Philadelphia of similar longitude and a latitude of around 44º N[6] but this seems a less likely match. Another exception is Smyrna, where the correct latitude is given but the longitude is stated as 9º 17' E instead of 26º 30' E. This incorrect longitude has also been used in drawing the timescale on the inner chapter ring of the central dial.

The form of the Greek acrophonic numerals giving the date (1835) is unusual. The layout (Fig 3) is non-standard in that the numeral for five is usually[11] Γ rather than IIIII and 500 (a component of the century 1800) is generally written by putting a small H (for 100) inside a Γ. On the Irvine dial, an H is followed merely by a space. On other McNally dials the H for 500 is surrounded by fine lines above and to both sides (see Fig 1).

The Irvine dial has two Latin mottoes, (see Table 1) written in script. The first, *Claritutem et spendorem solis indico* can be translated[12] as "I announce the brightness and radiance of the sun", although *claritutem* should probably be *claritatem*. The second is *Vigor ætatis fluit ut flos veris* which appears in "The Book of Old Sundials"[13] where it is translated very freely as "Life at its best is but vanity" although a more literal translation is "*The strength of age/life flows away like the flower of Spring*".

When the Irvine dial was found in 1959 it had a major crack in the slate and gnomons for just two of the small subsidiary dials. These were in the form of thin brass triangles leaded into the slate. They had then been bent over for reasons of safety. They seem to have angles rather greater than 56º although they are difficult to measure accurately. The hourlines of the central dial, which incorporates a noon gap, are all accurately directed to the correct origin of delineation. Their angles have been analysed by least-squares fitting and indicate an optimum latitude of 56.5º±1º, in acceptable agreement with the figure of 55º 36' given on the dial for Irvine. Comparison with other McNally dials suggests that the gnomons were originally of a simple pierced design and that the surviving gnomons were replacements. When they were removed during the recent restoration it appeared that the slots in the slate had been previously disturbed. A complete set of replacement gnomons was made with an angle for the latitude of Irvine. At the request of the dial's present owner, their shape imitates those on a dial by Melville in the National Museum of Scotland, with the central gnomon being larger than the four subsidiary ones. The gnomons were set into the original slots with epoxy resin. The crack and chips in the slate were glued and filled and some missing detail recut.

Fig. 4. McNally's Maryport dial before its theft. Photo: R Sylvester.

Place	Lat on dial	Lon on dial	No. of dials
Corbally	54° 20' N	6° 16' W	1
Savanna	31° 57' N	81° 19' W	3
Calcutta	22° 36' N	88° 33' W	2
Botany	34° 8' S	151° 18' E	1
New York	40° 41' N	74° 8' W	3
Van Diemens	41° 30' S	131° 10' E	2
Baltimore		76° 55' W	1
Madras		80° 35' E	1
Natchez		92° 10' W	1

Table 3. The locations for the subsidiary dials on McNally's Portaferry dials.

MARYPORT DIAL

Another McNally dial was on an elaborate memorial in the churchyard at Maryport, Cumbria[14,15], (Fig 4) although it has recently been stolen. Maryport is on the southern shore of the Solway Firth, almost opposite the Scottish port of Kirkcudbright which is well known to diallists for its abun-
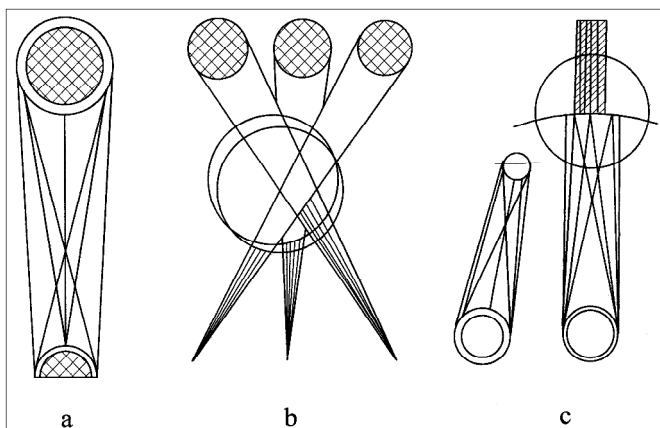

Fig. 5. Drawing of the astronomical diagrams found on several of McNally's dials. The centre figure (b) is the most common.

dance of dials. This dial was made for Richard A Turnby, a Maryport master mariner and whose name is on the dial. The central dial appears to be for Jerusalem and Maryport and the subsidiary dials are for New York, Sierra Leone, Bengal and a location which is virtually illegible but may be Papua (New Guinea). It seems likely that these were ports which Turnby had visited. Underneath the signature of "Joseph M'Nally" are the words "Shipbroker, Commissioner".

Many of McNally's dials, including the Maryport and Irvine ones, feature a pair of globes as part of the decoration. Globes were a key part of the design of William Straney's earlier 1796 slate dial[1] referred to earlier, although in that case it was clear that they represented a stereographic pro-

jection of the celestial sphere complete with ecliptic and constellation sigils whereas McNally's are much simpler. It may be that McNally was preserving a local style by including them.

PORTAFERRY DIALS

A total of seven McNally dials are now in or around Portaferry, Co. Down, either in the Down County Museum or in private collections: some of them were seen during the 1996 BSS tour of Northern Ireland[16]. Some of the details of the dials are given in Tables 1 and 3. There is a tendency for the subsidiary dials to be positioned on the dialplate in the same order that they would be found on a map, i.e. with locations west of Greenwich on the left and the more southerly locations at the bottom. One of the dials in the Down County Museum has its main dial calibrated for Jerusalem and Corbally, was made for a "JAˢ Murry" and is signed "J·MᶜNally fecit". Corbally House is a rural location about 25 km west of Downpatrick so it is probable that it was made for a local dignitary. Another has had McNally's name crudely removed and that of a William Ardissil inserted in its place. Two of the dials in private hands have the remains of a colourful infill to the engraving and, whilst it is not certain that this was actually done by McNally, it was done a considerable time ago and would be a natural way of making the details stand out on the dark slate. One of these private dials has additional Greek numerals for 510 underneath McNally's signature (Fig. 1). We are unable to explain this: the number seems too large to be a serial number for the dial. It might possibly stand for 5 October in a rather idiosyncratic format.

ASTRONOMICAL DESIGNS

All of McNally's dials have much decorative engraving on them in a similar style. Either side of the central dial on the Irvine dial are mirror-image diagrams (Fig. 5b) which have an astronomical feel about them. Very similar diagrams appear on the Maryport dial. At first sight these appear to show the position of the sun at the solstices and equinoxes, although the left and right (in Fig 5b) suns make angles of ±26° with the vertical rather than the astronomical values of ±23.5°. An alternative explanation is that they represent a prediction of an eclipse. There was an annular eclipse[17] of the sun visible from northern Ireland and England and southern Scotland on May 15 1836, just one year after the dial was made. Certainly, eclipses were in the public imagination at that time, following William Wordsworth's 1820 poem "The Eclipse of the Sun"[18]. The sun's rays in the diagram do not cross the centre of the "Earth" but it has not proved possible to extract a significant location on the

globe from the diagram. It seems at present that the diagram is a highly schematic view rather than a geometrically accurate one.

Other astronomical diagrams (Figs. 5a and 5c) are found on one or more of the dials. As they always take the same form, it is probable that McNally had a pattern which he referred to, possibly from a book on astronomy although the exact source has not been identified.

THE MELVILLE CONNECTION

The facts that the two most prolific makers of multiple slate sundials came from the same region of Ireland, sold dials in Scotland and had overlapping dates seem unlikely to be pure coincidence. The earliest[6] known dial by Richard Melville is dated 1832. Made for a John Sandwich of Downpatrick, it is now in the Down Co. Museum and is a very simple single dial with the hourlines incorrectly laid out at equal angles. The next earliest known Melville dials are from the late 1830s and early 1840s and show the fully-developed five-dial layout which later became his trademark, although at this stage they were without the Equation of Time tables which were found on his later dials. Melville's early (Irish) dials usually have the names of their owners on them, as do some of the McNally dials, though the later Melville Scottish ones usually did not. Melville moved to Scotland sometime around or before 1843 and it is perhaps significant that Clarke et al[6] say "Melville may have made the short crossing from Ireland to Irvine". In the meantime, McNally had made several high quality multiple dials with dates of 1834 and 1835. As a ship's chandler, McNally could have accepted commissions from mariners visiting Ireland or he may have travelled to the west coast Scottish and English ports with his vessels. It is tempting to suggest that Melville learned the five-dial design from McNally, either directly or indirectly. Their early designs are quite similar but Melville later went on to develop the style further, with as many as nine subsidiary dials, more place names and the addition of Equation of Time tables. Many of these later dials are signed Melvin rather than Melville. With the depressed economy of the time in Ireland, it would have been natural for Melville to follow in McNally's commercial footsteps to Scotland.

The letter-cutting on McNally's 1835 Irvine dial is of inferior quality compared with that of Melville's, as evidenced by an 1845 dial which has recently been restored[19]. Both makers used letters cut in v-profile with a chisel or scribed with a point. Melville's copperplate is more elegant than McNally's. He uses thick and thin strokes in calligraphic style whereas McNally uses only one thin stroke. As the maker of many more dials, Melville would clearly have had

the opportunity to refine his technique and style after McNally apparently ceased production.

CONCLUSIONS

Joseph McNally's slate dials are highly decorative and form an important link in the long tradition of slate dial making in Ireland. It is hoped that further examples will be uncovered in the future, and that more details of his life, and his connections with other dialmakers, can be found.

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17. NASA eclipse website: http://sunearth.gsfc.nasa.gov/eclipse

18. *High on her speculative tower*

Stood Science waiting for the hour
When Sol was destined to endure
That darkening of his radiant face
Which Superstition strove to chase
Erewhile, with rites impure......

   W. Wordsworth, The Eclipse of the Sun, 1820.

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ACKNOWLEDGEMENTS

We are very grateful to a number of people for allowing us to photograph their dials and for help in tracing and analysing them. They include: Richard Caldow, Mrs. E. Cooper,

David Dunlop, David Gooding, George Huxley, Michael Lowne, Betty Lyttle, Patrick Powers, Anne Somerville, Robert Storey, Robert Sylvester, Jill Wilson, David Young.

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BOOK REVIEW

C.St.J.H. Daniel: Sundials, Shire Publications, 2nd edition. Revised and illustrated in colour, pp.56 (2004). Price £5.99.

Shire Publications have just published a second edition of 'Sundials' by Christopher St.J.H. Daniel. The first edition in 1986 was reprinted four times, and the latest reprint in the year 2000 has been out-of print for some time. This revised and expanded second edition contains over 100 colour photographs; and its accessible style will make it absorbing reading for anybody who has an interest in sundials. Christopher Daniel's deep knowledge of the subject shines through in his lucid writing, and in his careful selection of the dials used for illustration. This small 56 page book is a potted history of dials and explains the relevant basic information about every type of dial. His economy of style tells you just enough, but leaves you wishing that he would go on and tell you more. He never loses sight of the human element, reminding the reader how dials have touched our lives in one way or another. A nice illustration of this is the dial in Petts Wood, Kent, commemorating the institution of British Summer Time. My personal favourite from the book is a seventeenth century 'horizontal' ceiling dial used to calculate the date and time from inside the building. The black-and-white photograph of the 'upper' equinoctial dial looks curiously dated but the rest of the book is a delight. I am sure that this a publication all BSS members will want to own; it is tremendous good value at £5.99 and will run and run.

Margery Lovatt
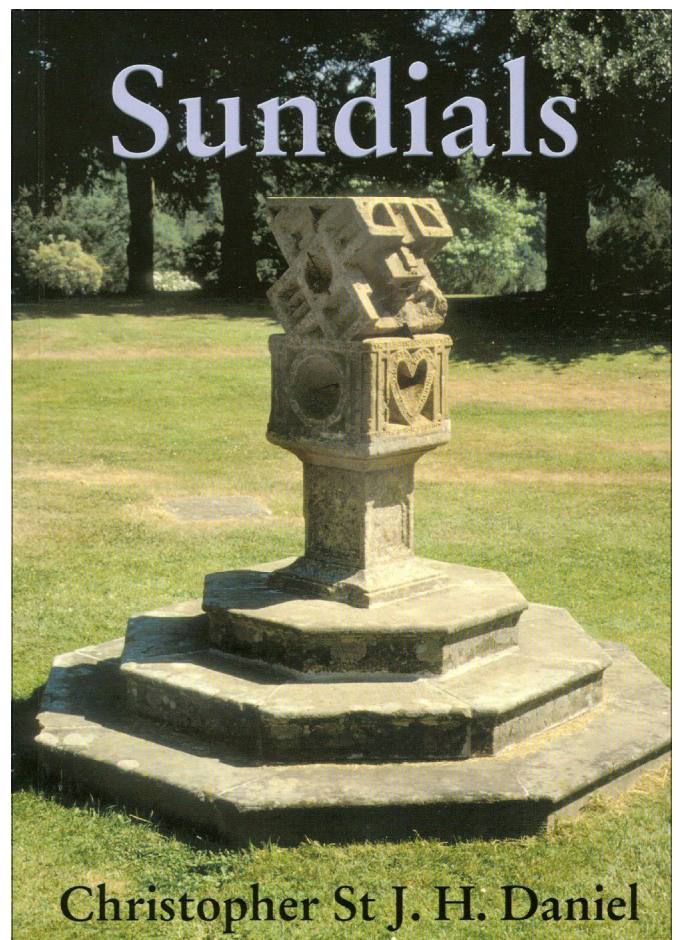
READERS' LETTERS

'Variety in Uniformity'… Comments

[At the end of his article 'Variety in Uniformity' in the June issue of the Bulletin, A. Capon requests information and asks a number of questions about the dials he has described. Two readers whose comments are printed below can supply Mr Capon with some of the information required - Ed.]

A Comment:

In his article 'Variety in Uniformity' in the June 2004 Bulletin, Tony Capon asked about the source of the vertical south dials cast in metal and showing a row of medieval figures. They were in fact made by the Midlands firm of Pearson Page and were illustrated in their 1931/3 catalogue as item No. 4212. They cost 90/- each (£4.50!). The catalogue contains numerous other designs, both cast and hand engraved. A line at the top of the page requests purchasers to state the intended latitude but it seems unlikely that the company had multiple patterns for the cast dialplates although they may have tried to adjust the gnomon angle appropriately. The catalogue was shown and described by Denys Vaughan in the *Bulletin of the Scientific Instrument Society*, 3, pp.10-11 (1984) and in a follow-on article in issue 5.

John Davis
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No. 4212 Wall Dial Cast Plate
14in x 12½in, 90/-

Another Comment:

I refer to A. Capon's short article in the last Bulletin 'Variety in Uniformity: an oxymoron'. Mr Capon has come across several cast dials of an attractive appearance. He will also find several dials of this model in the Sundial Register. These dials were all made by Pearson-Page and later Pearson-Page-Jewsbury in Birmingham in the mid 20th Century. I am sure that these were made in quite large quantities. The attached, rather poor picture of this dial, is from one of their catalogues. It shows it as model 4212, a Wall Dial, Cast Plate, 14in x 12½in in size, at a price of 90/- (or £4.50).

Pearson-Page have been responsible for making vast quantities of reproduction brass items throughout the middle of the last century. We are only interested in their sundials of which they have listed around 600 different models in their various catalogues. Assuming that hundreds were made of each model it is likely that they made over 100,000 dials and probably nearer to 250,000 of them. Many are turning up and are being recorded in the Sundial Register. They are not necessarily bad dials, and most are worthy of our attention. Some were even hand engraved and properly delineated for a specific latitude. Many more were exported, especially to the USA, Canada and other regions. Where Pearson-Page were rather naughty is that they frequently signed and dated their dials to make them seem old. Many are dated around 1640 and I have even seen makers names such as 'Tompion, London' on them.

I am currently researching Pearson-Page and hope to be able to publish an article on the company and their sundial products. I may even be able to publish facsimile copies of one of their catalogues and list of dials so that they may be more easily identified.

Mike Cowham
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Haslingfield
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Waugh's Equations:

In looking through my article as printed in the June Bulletin ('Reflexions on True North…', *BSS Bull.* 16(ii), pp.69-72), I see that I clearly must have forwarded at least one diagram with my MS that does not accord with the data. As a result the accuracy of Waugh's equations is unreasonably maligned in that article.

My profuse apologies for this confusion. I am now looking through my files to see whether I can find out exactly what has happened but in the meantime if you do get any letters of query perhaps you could either pass them on to me to answer, or get the writer to drop me a line?

Patrick Powers
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Harpenden AL5 2ET

EQUATORIAL SUNDIAL UNVEILED BY THE QUEEN

D A BATEMAN

Horsham, in West Sussex, hosted Her Majesty the Queen and HRH the Duke of Edinburgh on 24 October, 2003, to visit Christ's Hospital School and open The Capitol, the new centre for the arts. As a central part of the ceremonies, the Royal Party unveiled a large bronze sculptural sundial (Fig. 1).

Fig. 1. The Queen and Duke of Edinburgh after the unveiling of the dial.

The initial idea for the project came from the sculptor Edwin Russell and his wife Lorne McKean. Both have been involved with Horsham District Council over a number of years - Edwin by virtue of bronze roundels for a memorial and other works, and Lorne with her graceful recreations of swans alighting on water for the Swan Walk shopping centre. The town was seeking a millennium project, and a large sundial would fit with the planned development of a central area called Blackhorse Way Forum. The location, on a raised pedestrian area, offered reasonably unobstructed morning and mid-day views of the southern sky. However, a very large beech tree does give some shading of the afternoon sunshine.

Fig. 2. The underside of the dial with the dinosaurs at the start of the time line.

The dial is relatively straightforward, with the equatorial ring being 2.74 metres in diameter and gnomon ring 2.22 metres in diameter. The gnomon ring is plain with a rectangular cross section and, in keeping with this, the gnomon is also rectangular. The shape of the latter does not interfere with the timekeeping as the eye estimates the centre of the shadow on the equatorial face, which is the same for a circular, square or rectangular 'rod'.

What distinguishes this dial from others of this type is the wealth of historical detail that is sculpted into it. The source of information came about through collective endeavours and research to portray the history of Horsham in an informative and most attractive manner. The staff at the Horsham Museum prepared a series of historical facts and events relating to Horsham and the immediate area, and

Fig. 3. The sculpted cameo of the Roman and Saxon periods.

Fig. 4. The Royal Observer Corps depicting Horsham's involvement in the second World War.

Fig. 5. The motto on the dial is from Shelley, who was born in Horsham.

these were interpreted into a series of sculpted cameos set in the main ring of the dial. Fig. 2 shows the underside of the dial with the dinosaurs at the top with the 'time line' (going anti-clockwise from below) linking to the Romans and Saxon eras. Fig. 3 shows a beautifully modelled marching Legion and a Saxon ploughman. A more recent scene is depicted in Fig. 4, where the Royal Observer Corps represents the fact that one of the plotting rooms for the Battle of Britain was in Horsham. The final sculpted cameo is a panel with words by the poet Shelley, who was born in Horsham. A 52 page booklet by Jeremy Knight, the curator of Horsham Museum, gives explanatory notes for all 30 of the cameos. The theme for the cameos range from the dinosaurs to the present day, covering the topics mentioned above, and such as the Crusader Knights, the local iron industry, the horses of Horsham, William Penn and the Quakers, and the author Hilaire Belloc.

In addition to the sculpted detail, there is a complete annular ring of bronze set into the polished limestone plinth with recessed flood lighting. This is divided into many sectors, each with engraved text about Horsham. Fig. 6 shows one entitled Flowers, Music and Cautionary Tales which gives a sentence or two about local features and events. One such sector gives the equation of time together with the engraved signatures of the sculptors.

A later addition to the plinth has been hour markers to make the dial work as a horizontal dial as well. It was felt that this would reinforce the point with the general public that this very sculptural structure is indeed a sundial, by seeing such markings before being aware of the numbers engraved on the relatively narrow inner face of the equatorial ring.

Whilst full credit is given to Edwin Russell and Lorne McKean for the overall design, others involved were Damien Fennell, professional sculptor, who did much of the detail on the cameos, and Joanna Migdal for dial orientation and hour markers, and Freda Fowler of Horsham District Council for the plinth design. Freda handled much of the liaison with the contractors, the structural engineers for the all-important fixings concealed within the plinth, and booking the largest long reach crane in the South of England to lift the 2.5t dial into place. Sponsors for the project were J Sainsbury Developments Ltd, Sainsbury's Supermarkets Ltd, and Allders Department Stores Ltd.

Author's address:
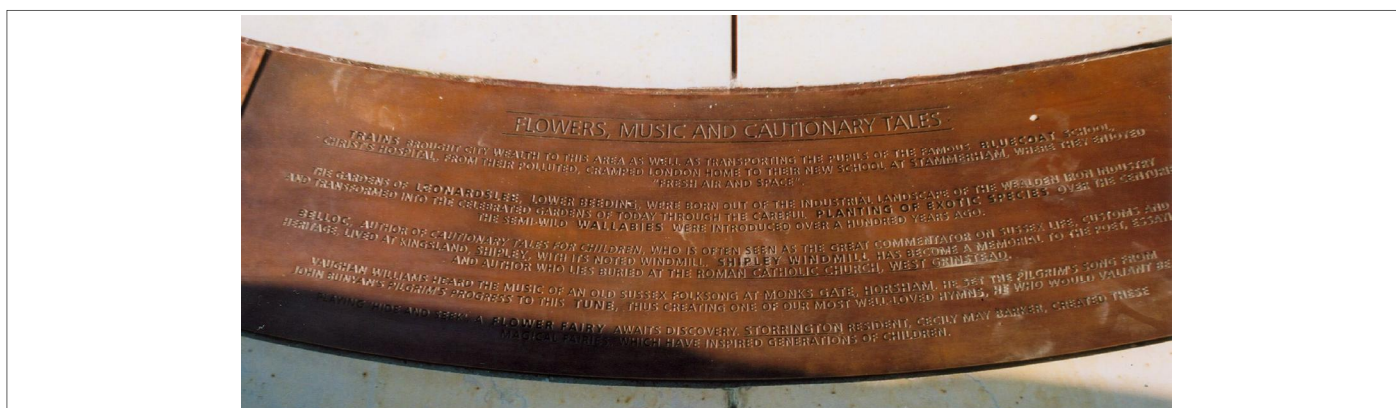*4, New Wokingham Rd*
Crowthorne, RG45 7NR

Fig. 6. One of the many bronze sectors, set in the plinth, gives even more information about Horsham and Sussex history.

# AN AUSTRIAN VISIT AND TWO RATHER DOUBTFUL DIALS

MIKE COWHAM

A spring visit to Austria was just what we needed with a camera at the ready. We journeyed across Germany and into the Czech Republic; one of our favourite haunts. In one small village in Southern Bohemia, Zlatá Koruna, we stopped to see their famous monastery. As we entered the village we saw the first dial high on a building. Our tour around the monastery showed us more dials in various

A dial in the centre of Zlatá Koruna.

The pair of dials on the monastery gateway.
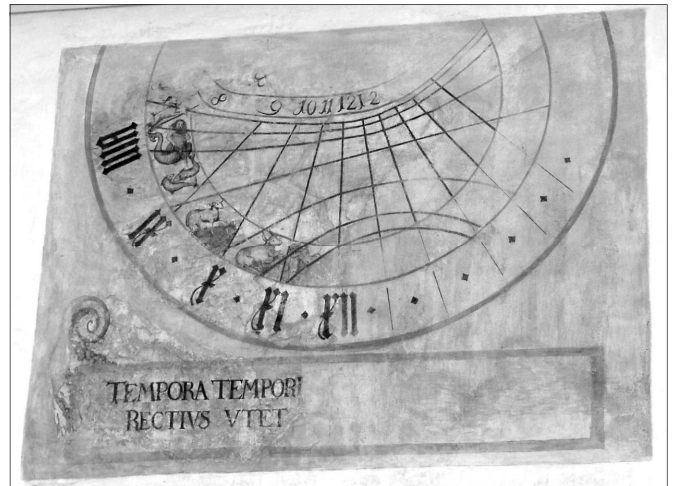
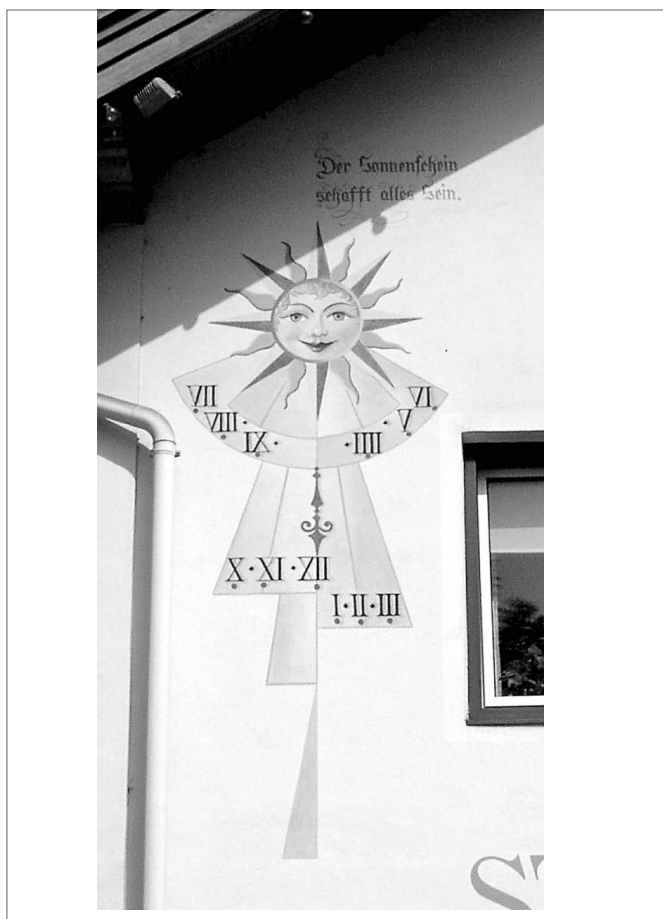*The sundials from the Monastery of Zlatá Koruna.*

places. I tried to ask our guide how many dials there were. She said 18, but I am not sure that she fully understood the question. 'Will we see them all on this visit ?' 'No', she said. Well, we certainly didn't see 18 dials but we did see six. Naturally, being interested in portable dials I asked about these too. Again, 'No'. Then on the far side of a cordoned-off room I saw the telltale signs of a disc tilted at

A pair of dials beneath windows in Weissbach, Austria.

A painted image of a dial in Hopfgatten, Austria.

about 45°. It had to be some kind of Equatorial dial. Eventually I persuaded our guide to let me get a closer look. It turned out to be an unsigned Equinoctial Mechanical dial, probably made around 1740, but many of its parts were missing. Perhaps it was made in nearby Linz, Austria by Franz Knittl who was well known for precision dials?

Once we arrived in Austria, there were dials almost every-

A rather 'non-dial' in Colmar, France.

where. It must have the highest number of dials per village of anywhere in the world. Some areas are much better than others - it is just a case of searching them out. I am sure that many of you are familiar with their beautifully painted dials of all sorts but I would just like to describe two of them.

The first, actually a pair of dials, were found on a house in Weissbach in Pinzgau. These dials were attractively placed on two sides of the house beneath windows. What a good idea! They are simple dials but I have never seen them beneath windows before. This may give BSS Members some ideas when they have not found the ideal space on their house for a dial.

The next dial is really not a dial. It is attractively painted on the side of a house in Hopfgatten. It has no gnomon and was probably never intended to have one. The house appears to be the home of an artist who specialises in house paintings. He has just painted on his house what he thinks a vertical dial should look like. It also has a motto, *'Der Sonnenfchein Schäftt alles Sein'*. (Sunshine Creates all Life).

My final dial was seen on the way home in the Alsace region of France, another of our favourite areas. The late

René Rohr lived here and has illustrated many of the fine dials of the Alsace in his books. This dial we found high up on a building in the centre of Colmar. At first glance it looks as if it could be interesting, but closer inspection shows that it consists of little more than radial lines - they could even be sunrays - with no numerals. Its gnomon too is at a strange angle, so it really is a doubtful dial.

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WHERE IS THE SUN?

GORDON E. TAYLOR

There must be a number of members like myself who have been consulted on the best way of orientating a sundial. A rough idea can be obtained from an ordinary magnetic compass providing that (a) there are no large metallic objects nearby and (b) that the deviation of the needle from true north has been determined for the date and the place in question. A thorough investigation of this problem has been made by D. Bateman[1]. In general, building plans cannot be relied on for the alignment of walls for the erection of vertical dials.

It is obviously much more accurate to use the position of the Sun. To facilitate the calculations I wrote a computer program in 1996 which gives the azimuth of the Sun for any place on the Earth's surface and for any date and time. Since then there have been other sources providing this data[2].

Delta T is defined as the difference between Terrestrial Time (TT) and Universal Time (UT). Thus

$$\text{Delta T} = \text{TT} - \text{UT}$$

Originally the second of Ephemeris Time (ET) was defined in terms of the annual motion of the Earth in its orbit around the Sun (1/31556925.9747 of the tropical year for 100 Jan 0d 12h E.T.). For all practical purposes we can say that TT = ET. An ephemeris of the Sun will originally be calculated using the time argument TT. Since 1925, Greenwich Mean Time (GMT) has been measured from midnight to midnight. Universal Time (UT) may be taken to be the same as GMT. UT is based on the period of rotation of the Earth, which we now realize is not constant, so that an accurate value of Delta T is only known in arrears.

The program I wrote in 1996 used an algorithm to determine an approximate value of Delta T in order to calculate the position of the Sun in right ascension and declination, and other quantities such as its altitude and azimuth. The revised program contains a similar algorithm but also allows the user to update the value of Delta T in the light of more recent information. The value of Delta T has changed during the previous century from -3 to +64 seconds and is currently about +65 seconds. It should be noted that ignoring the use of Delta T can currently give rise to a maximum error in the azimuth of the Sun of 0.5 degrees for latitude 53 degrees, rising to 1.0 degrees in latitude 37° and, in places where the Sun passes directly overhead, to 180 degrees. Thus it seems sensible to issue a revised version of the program in case the algorithm is unable to predict the value of Delta T to the requisite accuracy in future years. Although at this point in time the algorithm is adequate for the purposes of calculating the azimuth, users should note that up to date values of Delta T are given in a number of annual publications such as the Astronomical Almanac, the Handbook of the British Astronomical Association, and Whitaker's Almanac. I feel it is unlikely that users will need to apply a revised value of Delta T for at least the next ten years.

The output is on screen and also, on request, on line printer. It gives for any place, for any date-time or range of date-times, the azimuth and altitude of the Sun to a precision of 0.01 degrees. The altitude has been corrected for parallax and standard refraction. The time of transit is given, together with an indication of whether it occurs before or after the requested time. Also tabulated is the approximate Sun's local hour angle and declination (not corrected for parallax and refraction). Also given is the equation of time. The time (UT) may be input to the nearest minute, or even to the nearest second, if required, though the interval is always in integral minutes.

Press key to alter	Input data for SAZ	
Fl	Longitude (W. degrees)	2.5
F2	Latitude (N= + S= - degrees)	51.3
F3	Date (GREENWICH) (yyyymmdd)	20040925
F4	Time (U.T.) (hhmm)	930
F5	seconds (if required)	0
F6	How many date-times required	20
F7	Time interval (minutes)	1
F8	Output (Printer /Screen)	P
F9	Delta T (seconds) (or 9999 to Quit)	65.0
Fl0	ACCEPT VALUES (Run program)	

Check input data carefully before pressing F10 key

Position of SUN from						Long.	(W)		2.500	Lat 51. 300		
	U.T.					AZ.	ALT.		TRANSIT	L.H.A.	Dec	EoT
y	m	d	h	m	s	°	°	h	m	°	°	m s
2004	9	25	9	30	0	135.61	28.65	12	1. 54 a	-37.89	- 1. 05	+ 8 26
2004	9	25	9	31	0	135.87	28.76	12	1. 54 a	-37.64	- 1. 05	+ 8 26
2004	9	25	9	32	0	136.12	28.86	12	1. 54 a	-37.39	- 1. 06	+ 8 26
2004	9	25	9	33	0	136.38	28.97	12	1. 54 a	-37.14	- 1. 06	+ 8 26
2004	9	25	9	34	0	136.64	29.08	12	1. 54 a	-36.89	- 1. 06	+ 8 26
2004	9	25	9	35	0	136.90	29.19	12	1. 54 a	-36.64	- 1. 06	+ 8 26
2004	9	25	9	36	0	137.16	29.29	12	1. 54 a	-36.39	- 1. 06	+ 8 26
2004	9	25	9	37	0	137.42	29.40	12	1. 54 a	-36.14	- 1. 06	+ 8 26
2004	9	25	9	38	0	137.68	29.50	12	1. 54 a	-35.89	- 1. 06	+ 8 26
2004	9	25	9	39	0	137.94	29.61	12	1. 54 a	-35.64	- 1. 06	+ 8 26
2004	9	25	9	40	0	138.20	29.71	12	1. 54 a	-35.39	- 1. 06	+ 8 26
2004	9	25	9	41	0	138.46	29.81	12	1. 54 a	-35.14	- 1. 06	+ 8 26
2004	9	25	9	42	0	138.72	29.92	12	1. 54 a	-34.89	- 1. 06	+ 8 26
2004	9	25	9	43	0	138.99	30.02	12	1. 54 a	-34.64	- 1. 06	+ 8 26
2004	9	25	9	44	0	139.25	30.12	12	1. 54 a	-34.39	- 1. 06	+ 8 26
2004	9	25	9	45	0	139.51	30.22	12	1. 54 a	-34.14	- 1. 06	+ 8 26
2004	9	25	9	46	0	139.78	30.32	12	1. 54 a	-33.89	- 1. 06	+ 8 26
2004	9	25	9	47	0	140.04	30.42	12	1. 54 a	-33.64	- 1. 06	+ 8 26
2004	9	25	9	48	0	140.31	30.52	12	1. 54 a	-33.39	- 1. 06	+ 8 26
2004	9	25	9	49	0	140.58	30.62	12	1. 54 a	-33.14	- 1. 06	+ 8 26

Table 1. Input screen and resulting output from SUNAZALT.

An example of the display screen and the subsequent printed output is given below. For purposes of illustration it is assumed that the user needs to observe the Sun in a limited time slot on a mainly cloudy morning and therefore needs a very short time interval.

The program will run on any IBM compatible computer and is now available to any member of the BSS - just send me a 1.44Mb disk in a stamped addressed padded envelope, for the package, which is named SUNAZALT.

REFERENCES

1. D.A. Bateman: "Finding North with a magnetic compass - the accuracies achievable", Bull BSS, 16(i), pp.38-42, (2004).

2. P. Powers: "Reflexions on true north, large dials and the apparent sun", Bull BSS, 16(ii), pp.69-72, (2004).

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THE CYLINDRICAL BOX OF ANTONINUS PIUS - Part 1

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ABSTRACT

Vitruvius cites (De Architectura IX) "viatoria pensilia" as portable sundial. The "box" (Antoninus Pius) at KHM Vienna is studied applying the Padre Secchi calculation; although there is no evidence of equipment for suspending it; nor in any case for guaranteeing the required verticality. The possibility that the sundial could be a "rolling" one has been investigated.

Fig.1. The "Cylindrical Box of Antoninus Pius" at the Kunsthistorisches Museum, Vienna.

DESCRIPTION

The "Cylindrical box of Antoninus Pius" with its four thin disks is in the Kunsthistorisches Museum Vienna (KMV). The whole object consists of two halves of a bronze cylindrical box (diameter 40.5 mm; height 14 mm) with four thin (0.5 mm) bronze disks; the disks have been pierced and can thus be threaded onto a pivot fixed to the bottom of one half of the box. Astronomical lines are engraved on the bottom of the other half, which we can refer to as the "ceiling" of the box. Gnomonical lines are engraved on both sides of each disk with the exception of one side of one of them, where the lines seem to have been erased (this will be described more fully later). One of the external bases of the box carries the image, in relief, of the Roman Emperor, Antoninus Pius and the inscription: "ANTONINUS AUG PIUS PP TR P COS III IMP II" (De Solla Price[6]). On the other base there are images in relief of two horses and, rather damaged, the image of a horse driver. Figures 1-4 show the components of the dial.
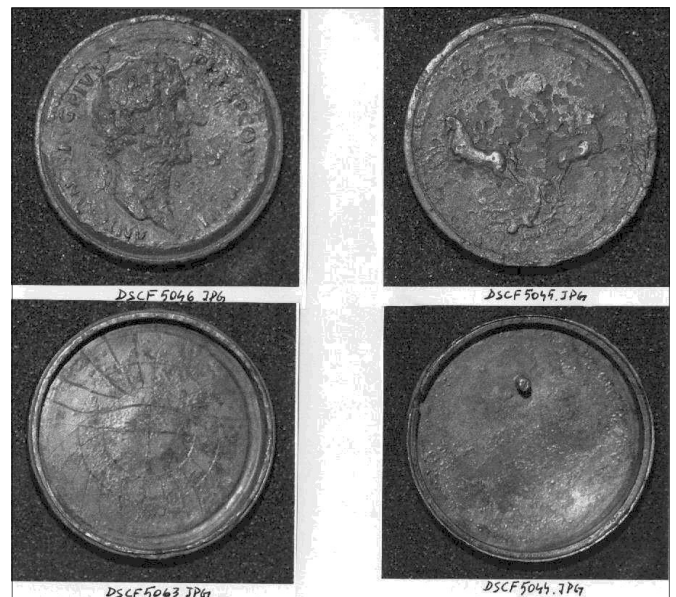

Fig. 2. The "box" cover (left side) and bottom (right).

The gnomonic lines of disk "D", on the "Rome?" side seem to have been completely and intentionally erased. On every disk there is a broken line which has an almost circular shape, confused by the names of the months, the centre is located in the middle of the circular hole (the pivot is fit to be threaded into it). Since the radius of the disk is shorter than that of said line, the two circular lines are clearly eccentric. It will be by us interpreted as the "Hora sexta" line (noon). Names of months are engraved on each disk but not all of them are easy to distinguish: comparing with the other disks and the "Rome–Ravenna Coin", the complete series of months (Julian calendar) can be described as follows:

JUN MAI APR MAR FEB JAN
JUL AUG SEP OCT NOV DEC

It is the general impression that the gnomonic lines are drawn on *all* disks, typically the transversal hour-lines commonly indicated by altitude sundials, are drawn almost randomly. The pivot exhibits an evident trace of truncation, which may not be intentional. If you observe the bottom part of the box (inside), you can see an incision on the circular box wall; the incision is triangular in shape ("V" shape). Evidently, to excavate the incision, the thickness of the box wall was reduced by a rasp in a rather rough, even
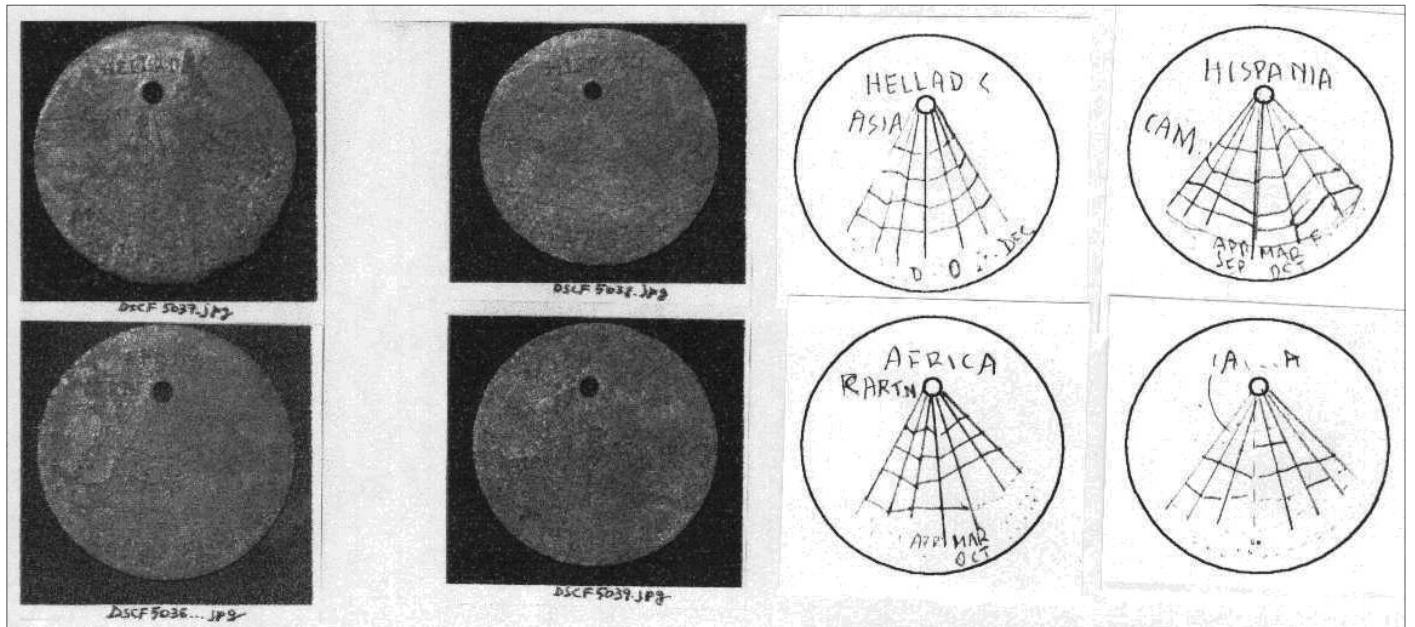
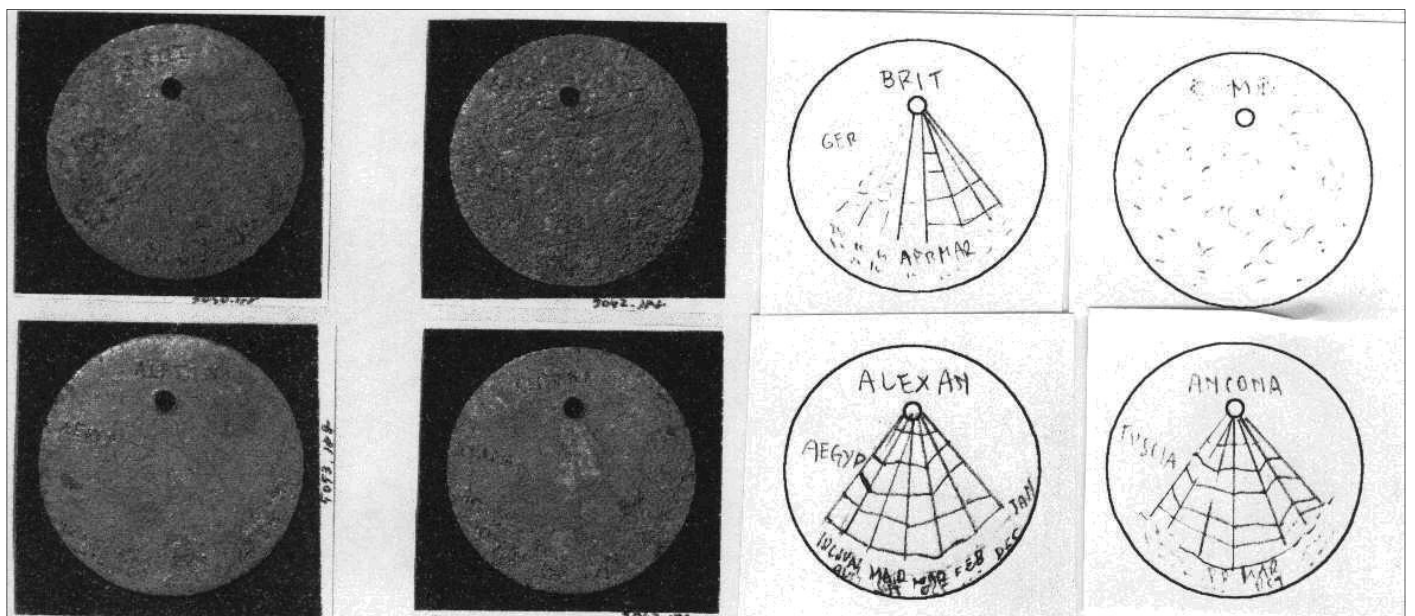*Fig.3. The "Hellad...Africa..." and "Hispania...A..A" disks.*

Fig. 4. The images of "Brit...Alexan..." and "Rome(?)- Ancona..." disks.

clumsy, manner that starkly contrasts with the highly re-
fined skill with which the whole object has been built.
Thanks to the cooperation of the KMV staff, I have been
able to make two thorough inspections of the object and I
have taken measurements and photographs, the best of
which are published herewith.

MISSING EVIDENCE

The above descriptions faithfully depict (at least I hope so)
the present aspect of the box and disks. Previously, how-
ever, this evidence was rather different, even in modern
times. On the basis of the evidence available at the time,
the object was in fact carefully described by Dr. Friedrich
Kenner[15] in a catalogue on a series of medallions belonging

to the Austrian Imperial family. There are, however, some
differences compared to current evidence.

The box was blocked by stain: Kenner reported that rust
had been removed and the box had been opened with diffi-
culty. The disks it contained were also blocked and only the
engravings of the "ROME" side of the "E" (or "F",
"G" ...?) disk could be read (see Fig. 5). A transversal hole
was cut across the pivot. A wedge passed through the hole
with the task of blocking not only an unknown number of
disks, but also a spear which was inserted into the pivot
rather like the hand of a clock. The drawing from Kenner[15]
(Fig. 5) provides a very clear illustration of this. The evi-
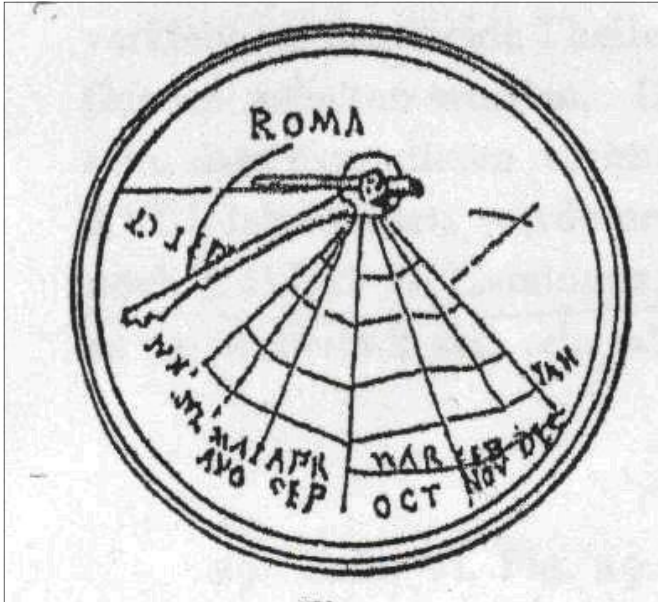dence suggests that, during various attempts to free the hid-
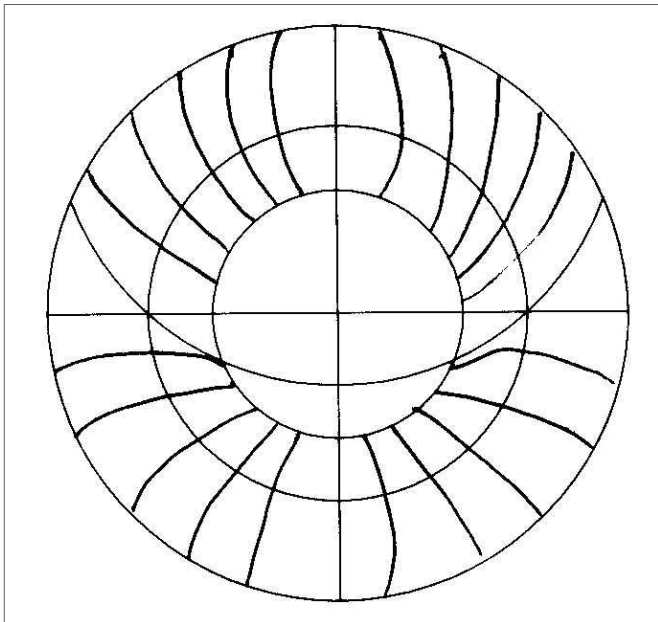
Fig .5. The missing evidence of the "box" (after Kenner[15]).
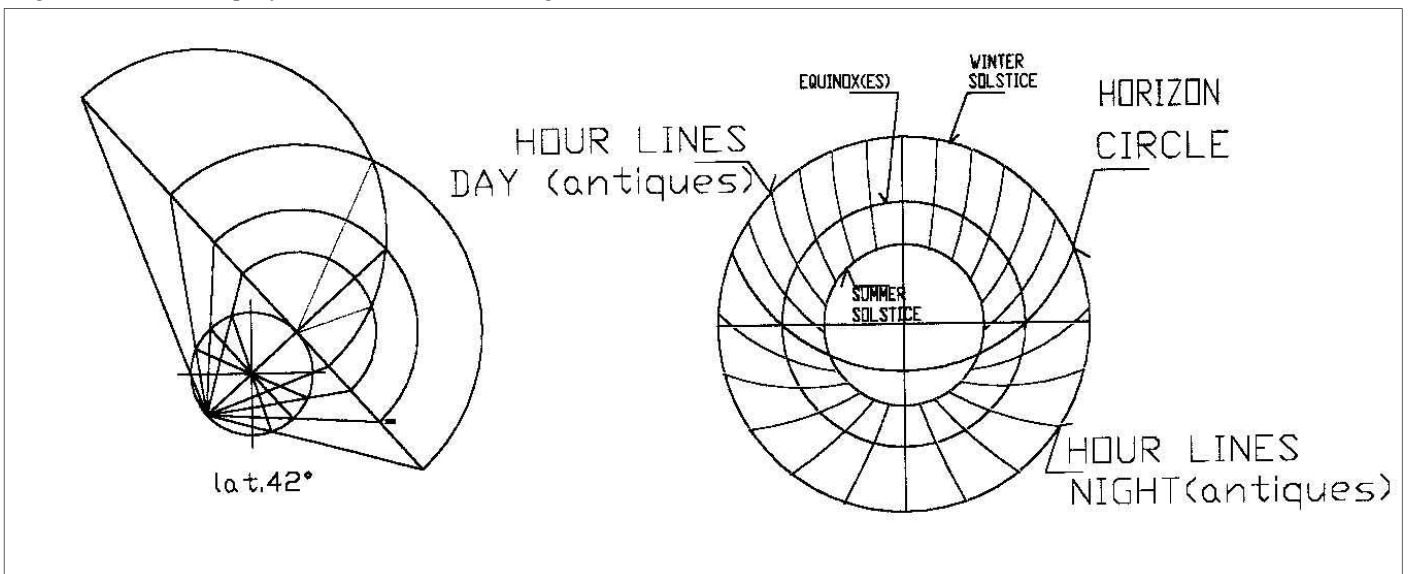

Fig.6. The astrolabe projection on the box "ceiling".

den disks, the pivot was truncated at the weakened part of the transversal hole. The original pivot was clearly much longer than the truncated part that can be seen today (7mm). It is important to note that the engravings on the "ROMA?" side of the "D" disk have now been completely erased. Since it is highly unlikely that such damage could have been caused in modern times, we can presume that the inscription on the upper side of the "ROMA" disk described by Kenner is not the same as the "D" disk. Here we read "DIEB.." on the left side (further than "ROMA" in the upper side). On the contrary, the left inscription on the existing disk has been interpreted by Price[6] as "EPIRUS". The position of the words engraved on the disk also seems to differ between the two.

The hypothesis that more than the four currently found disks were blocked and hidden in the original "medallion" is supported by another geometrical fact. Could the "spear", say the hand, be rather thicker than the disks? The answer is of course yes: for example 1mm. The thickness of the four retrieved disks (each approximately ½ mm thick) could be 2 or 3mm at maximum. Total thickness nowadays: maximum 4mm. So, since the purpose of the lost wedge was to restrain just the disks and the spear, we must infer that the length of the truncated pivot (6.5 mm) is not compatible with only 4 disks. Consequently, we can presume that there were more disks than the number found. The missing disks could have been lost in the same way as the "spear", the wedge and the (perforated) part removed from the original pivot did.

Another important piece of evidence is that the description by Kenner makes no mention of the action of the file (rasp) on the external cylinder (base) nor of the "V"-shaped incision. The drawing reproduced in the article shows no trace
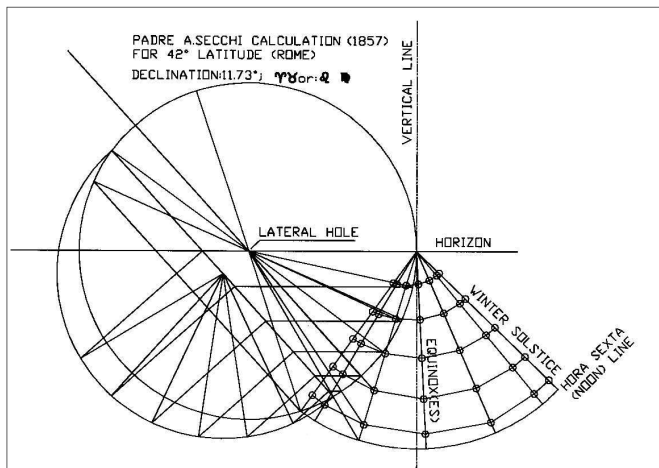

Fig. 7. An Autocad design of day and night angles at 42° latitude.

Fig. 8. The "Padre Secchi" calculation (Latitude = 42°) of the sundial with a lateral projecting point. In the sketch only the drawing for a sun-declination 11.73° (entering into the Taurus from the Aries) is reported.

of them, too. If any hole was on the cylinder originally it could be not drawn on Kenner's sketch since the drawing is a front-projection. Anyway Kenner's description is really very accurate and he doesn't mention any hole on the cylinder in the text. He doesn't name any "pinnule" too.

Finally, Kenner's assertion that the object was undoubtedly an heirloom of the Imperial family and probably came from the "Karthaeuser Sammlung"(Karthaeuser collection of 1755 or earlier) infers a lack of evidence to support an Aquileian origin. The analogy of the "box" with the "Roma Ravenna Coin", whose Aquileian origins are documented, was highlighted by Kenner, but no indication as to its provenance was provided.

PRICE'S DESCRIPTION

Prof. de Solla Price's 1969 paper[6] states that the sundial works by means of a "pinnule" which seems, in his sketch, to be applied in the correct position to be expected by the Padre Secchi calculation, in the same position where the hole is positioned by the "Commodus" (Museo Kircheriano) sundial. The same way the "V" shape incision could eliminate a possible "hole", by the same way there could be deleted the "pinnule". In any case a "pinnule", equipped by a hole or not, is rather unfeasible since, as it is drawn on the sketch, its protuberance would heavily prevent the closing of the box. In another part of the text it is mentioned a hole, instead of a pinnule, so we could infer that Price is describing the way this type of dial could generically work but not particularly <u>this</u> dial. The only certain determination is following: neither of two independent scholars[15,6] having the opportunity for doing it, describes the "V" shaped incision. Logically, it could be the remaining traces of <u>later</u> attempts to free the blocked, hidden disks. The evidence of a "pinnule" is rather doubtful for evident practical reasons.

THE ASTROLABE PROJECTION

The mistakes (Fig. 6) are not secondary and repeated: at summer solstice the division by six is made *not* on the seasonal day-arc but on the *equinoxial day-arc*[6]: hence the craftsman was not a skilled astronomer. Fig. 7 explains the way an astrolabe projection has to be designed today for the latitude of Rome (42°), with the aid of modern computerized drawing instruments. With some exceptions, already described, it seems to have the same look and proportions as the engraved circular lines on the "ceiling" of the box. Price[6] maintains: "This is by far the earliest existing exam-
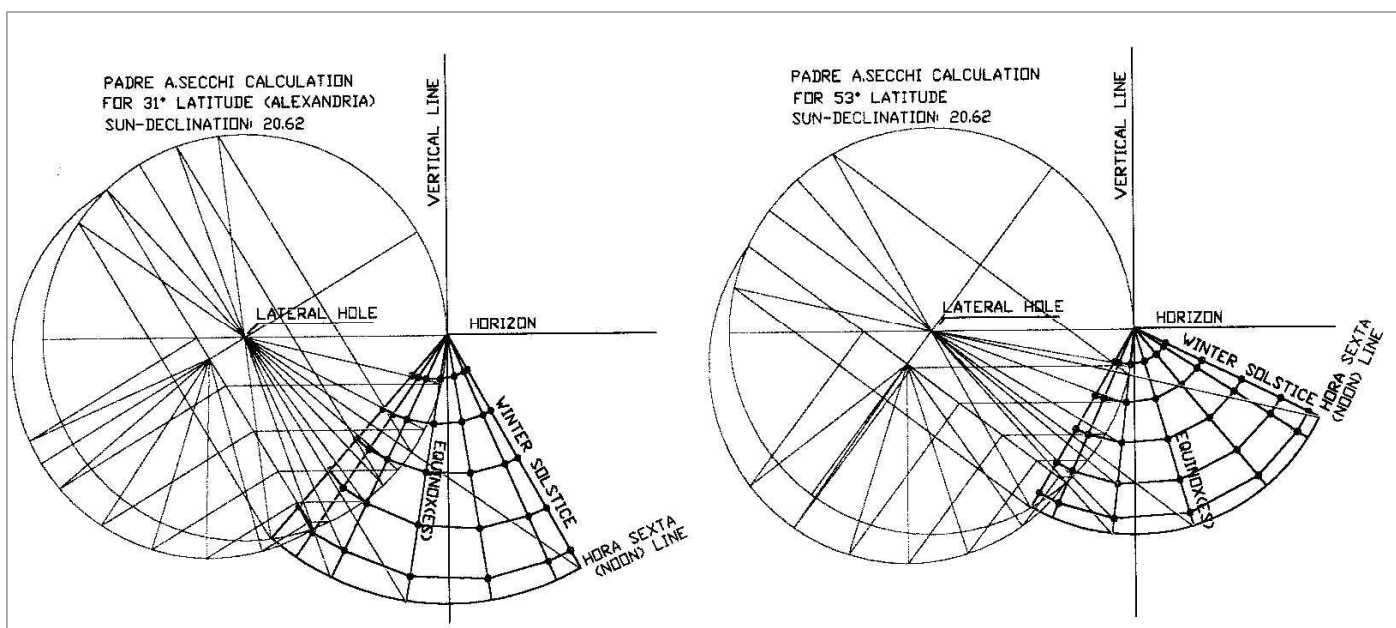

Fig. 9. The dial seems to "swing" as a bell by the range of variation of latitudes (31° to 53°); the scale would be rather different, too, say 35% by the same variation range. Only entering "twins" sun-declination (20.62°) has been reported.

ple of a stereographic projection on an instrument...".

In connection with a fitting *"anaphoric disk"* having the same diameter but rather transparent (*arachne*) and in any case equipped with a circular perforated split (*ekliptic*) it could simulate the position of the sun by every day of the year. By this hypothesis the projection could be drawn *only* on the box "ceiling" since, conversely, if drawn on the bottom, the rotation of the disk would be prevented by the pivot.

Another curious aspect that deserves attention is a famous plate (F.Villamena) illustrating the Renaissance astronomer, Christopher Clavius. It represents him seated in a room apparently holding many of his own personal astronomical and mathematical instruments. On the wall just behind him hang a "quadrant" and an astrolabe-"mater", on which the night arcs are traced.

A POSSIBLE DESIGN

The "box" has been cited many times but no attempt has thus far been made to describe in detail its gnomonic workings. Below I have endeavoured to do just that. Padre Secchi[22] studied the *"Commodus"* portable sundial of Museo Kircheriano in 1857; so he suggests a very interesting way to obtain, by means of the Ptolemy-Vitruvius Analemma, an altitude sundial which is illustrated in Fig. 8**.**

The calculations have been made for the 42° latitude (Rome) as follows:

1. Ecliptic longitude variations with a step of 30° each
2. Division of the day-arc into 12 equal parts (antique hours)
3. Ecliptic slope of 24°, as normally adopted by ancient peoples.
4. The *summer solstice* day-line is chosen to connect two points as follows: the first is on the horizon where it encounters the meridian circle, the second is determined by intersecting the m.circle by the projection of the sun at the *summer-solstice*. The Hora Sexta (noon)-line is chosen to be a circle whose radius be exactly the distance between said points (23mm on the dial).

In Fig. 9, the calculations which were at the time suggested by Secchi are represented, in particular for the latitudes of Alexandria (31°) and 53°: the tracings seem to "swing" the way a bell would perform as latitude varies from *"Alexan*dria (*Aegyp*t)" to "*Ger*many-*Brit*ain". The scale of the dial varies too, about 35% by the said range of latitudes: hence, being always the same the distance from the pivot to the (unfound) projecting hole, the disks should

perform, rather different engravings by different latitudes (clima).

Figure 10 illustrates the way the sundial could work; this sundial is enabled to work only if the line (we could refer to as the "two centres line") which contains the centre of the tracing and the projecting point (gnomon) are both on a horizontal line; it has to be underlined that, by the latitude of Rome, the angle between the horizon and the equinox line is about 92.8°.

In favour of this solution following arguments could be enumerated:

* the presence of the "spear" (similar to the hand of a clock) - it could be called a cursor
* a global appearance of the tracing being similar the Secchi tracing and in particular the angles among day-lines
* all the year seems to be covered by the sundial
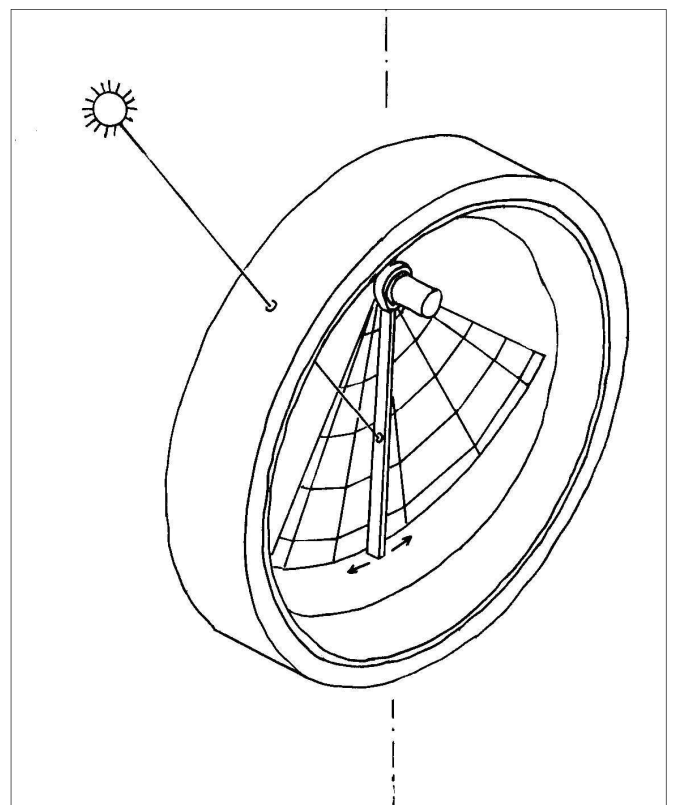
Against it, following arguments could be cited:

Fig. 10. The way the box could work in the "Padre Secchi" hypothesis; the user rotates the cursor in order to reach the current day-line. The equinox -line should be set, by every day and hour (Lat. 42°, Rome), about 3° rotated counter clockwise in respect of verticality but no evidence exists of any equipment feasible for said task. The existence of the hole is rather doubtful.
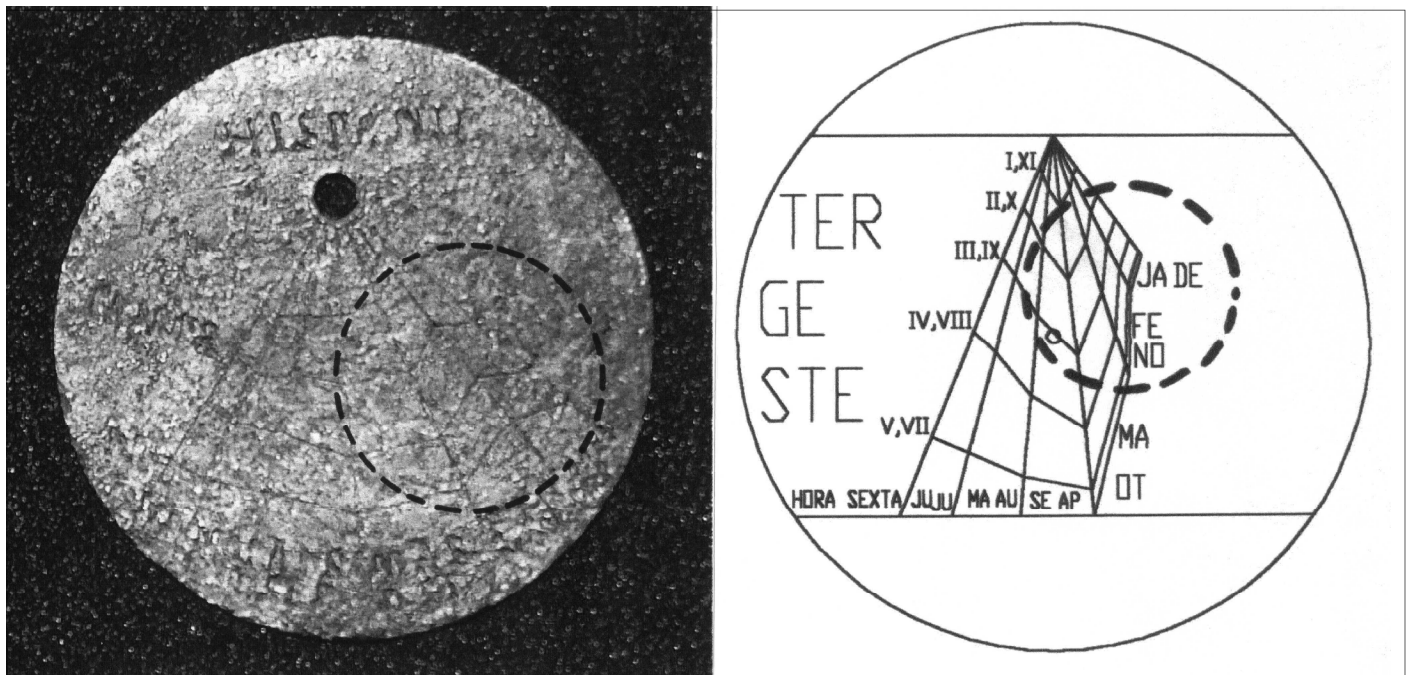
Fig. 11. The "Hispania..." disk (left) and the correct calculation (Lat. 45.65°) of the "Rome-Ravenna Coin".

* the complete missing of any suspending equipment, which could assure horizontality to the "two centres" line;
* The doubtful evidence of a hole or any other projecting device in the correct position on the cylinder,
* Another similar object (Museo Kircheriano) was conversely in a correct way equipped both with suspending- projecting hole
* The disks are engraved ignoring the rather appreciable differences of the , correctly calculated, tracings by different latitudes (clima)
* the absence in the sundial calculated tracing of the reversed "V" shaped hour-lines which conversely is present almost in all the Antoninus Pius tracings, mainly by negative sun-declinations; such a particular figure resembles to hour-lines, by negative sun declinations too, of the "Rome Ravenna coin", as we shall later underline.

The evidence of a line (absent in all other disks) which could, theoretically, be interpreted as "horizontal" on Kenner's tracing cannot give support nor in favour nor against this solution since the angle it forms with the equinox line is much less than 90°, say 85° (it should be almost 93°); furthermore other casually engraved lines are evident on the drawing.

ANOTHER POSSIBLE DESIGN

The similarity of the gnomonic engravings of the "Rome-Ravenna coin" with one of our disks, selected randomly, might suggest the existence of a common gnomonic project or common "prototype" underlying both of these circular portable sundials. But as we will demonstrate, this cannot be the case. In any event, one important aspect in common with the "Rome-Ravenna coin" is the way in which the lines in both sundials lack a correct astronomic design. This indicates, in both cases, the existence of an unfound, previously existing model, which may have been correctly drawn. And as we shall try to demonstrate, the two "prototypes" were rather different. First, we must rule out the hypothesis that the sundial had "universal" use. Read superficially, the names of the regions of the Roman Empire engraved on the disks might incorrectly lead to the conclusion that the entire gnomonic design was intended to ensure that ancient hours could be reliably read at every latitude (clima) of the Empire. Indeed, if we combine the fact that the hour-lines were drawn randomly and that it would be nonsense to read a reliable time on the same side of a disk from the widest possible range of latitudes (as, for example, the "C" disk: 10° latitude from Northern Britain to Southern Germany), we can simply rule out this hypothesis and investigate another completely different use for said thin disks.

As will be demonstrated, the use of several very thin disks superimposed on each other in different numbers, was intended to almost continuously vary the distance of the gnomonic plane from the projecting point (the edge of the pivot); i.e. *to continuously vary the length of perpendicular* (and not lateral as in the previous case) *gnomon*. We must imagine that gnomons were "standardized" to obtain the *same* shadow-length at midday (hora sexta) in different
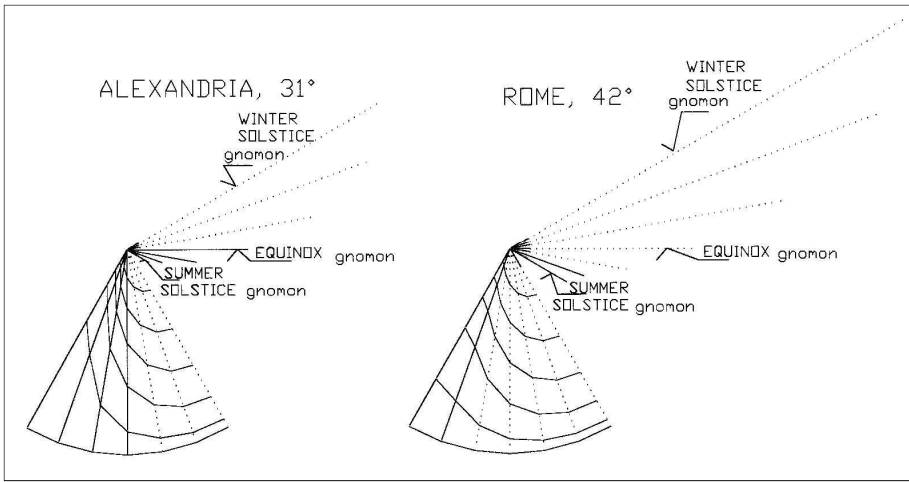
Fig. 12. The correct calculations for the latitudes 31°, 42°; seasonal noon shadow length is constant. Imagine the gnomons reversed on a perpendicular plane. Dotted lines refer to impossible gnomons and day-lines impossible to be used.

seasons of the year: a continuous variation in gnomon length which *might* (the conditional is necessary) ensure correct readings through a rather fine change in sun declination. In the case of the "Rome–Ravenna coin", this standardization of unequal noon shadow–lengths during the year, was lead by the holes on the ceiling of the "semi-camera obscura gnomon" trestle which, on using the sundial, had to be adjoined to the "coin" along the two "horizontal" lines. In the case of the "Rome-Ravenna Coin", the noon shadows were always unequal during the year, despite being standardized. Could our "*Antoninus Pius* cylindrical box" have a gnomon that, step by step, (almost continuously) changed during the year? The answer to this question has to be "yes", considering the very thinness of the disks (about ½ mm) that can be added (or taken away) to change the gnomon's length. Despite its obvious limits, correct use of the sundial could only be guaranteed in a limited part of the year (late spring and early summer). This was due to the obvious geometrical limits of the "box" and the disks contained in it. We are now going to demonstrate how the dimensions of the box limited seasonal use of the sundial.

We must first consider the hour-lines. If we imagine that a specific number of disks can be positioned so that the pivot is threaded into the circular hole, we can simply accept that, using the instrument as a sundial for any altitude - say by orienting the vertical disk towards the sun - the "Hora sexta" line can be represented by the (not always evident) circular broken-line with the centre in the pivot-gnomon (see Fig. 8). We can also readily accept that, as with the "Rome-Ravenna Coin", dawn and sunset have to be related to the pivot-gnomon itself. The principal reference points out for an ancient sundial, i.e. sunrise-sunset and noon are,

as we have seen, very well defined. Moving on to the other hour-point, the first obvious deduction is that they will all be positioned, for any sun-declination, between sunrise-sunset and noon! And this is the basic concept: a real oversimplification, which the craftsman probably applied by copying it or using his imagination!

One sign is the reversed "V" that can be observed in the hour-lines at vernal declinations: valid evidence is given in Fig. 11 which shows the "Hispania" side of the "B" disk, but similar evidence can be observed on almost every disk. Similar behaviour by the "Rome-Ravenna Coin" (Fig. 11 right) has been encountered on correct astronomic analysis. The similarity is very suggestive but let there be no illusion! In fact, the correct calculation for an altitude-sundial with a fixed shadow-length at noon exhibits completely different behaviour during the year.

Two calculations have been made (Fig. 12): on the left for the 31° latitude (Alexandria) and the right for the 42° latitude (Rome). Said calculation was performed as follows:
  1. Ecliptic longitude variations with a step of 30° each
  2. Division of the day-arc into 12 equal parts (antique hours)
  3. Ecliptic slope of 24°, as normally adopted by ancient peoples.
  4. A standardized shadow-length (umbra versa) of 23mm (the radius, measured on the disks, of the "hora-sexta" circle) at every sun-declination value.

Did the craftsman who engraved the lines refer to a "prototype" with standardized gnomons like the "Rome-Ravenna coin", without considering that the calculation could be done correctly? There is no answer to this. In any event, we shall continue to refer to the hour-lines calculated for the latitude of Rome (latitude 42°) for two main reasons*: first, the latitude of Rome is the same as the one observed by the astrolabe traces on the "box ceiling" and, secondly, the traces for the latitude of Rome are closer to a global view of hour-lines than those for the latitude of Alexandria; nonetheless, the lines on the Alexandrian side of disk (C) are far better traced than the others.

Fig. 13 illustrates the general workings of this particular type of altitude-sundial (axonometry):

1. the correct number of disks are threaded onto, or removed from, the pivot-gnomon to obtain the standardized shadow projecting at noon on the "hora-sexta" circle, ensuring that the last disk to be positioned, which will receive the shadow of the pivot-gnomon, is fitted with the current latitude (clima).

2. the "bottom" part of the box, with at least one disk, has to be vertically oriented towards the sun, like all altitude–sundials.

3. the half-cylinder with the disk(s) has to be rolled over a horizontal plane, maintaining sun-orientation, until verticality is obtained by the day-line in accordance with the actual day of the year.

4. The spear may have had a dual purpose: (a) it served as a reference for the current day (verticality); (b) the lack of a lateral shadow cast by the spear could ensure correct orientation.

5. The pivot-gnomon's shadow will exhibit the hour.

6. The "upper" part of the "box" with the astrolabe projection was not involved in the "gnomonic" use of the instrument, but served to read how many light-hours the traveller had at his disposal and similar tasks.

This is a rather complicated series of operations, which may never have been performed. The object could, instead, have been exhibited many times as a "status symbol". Furthermore, this theoretically very suggestive sequence of operations in this very ingenious ancient diallist design is, to some extent, incompatible with some limits of the "box".
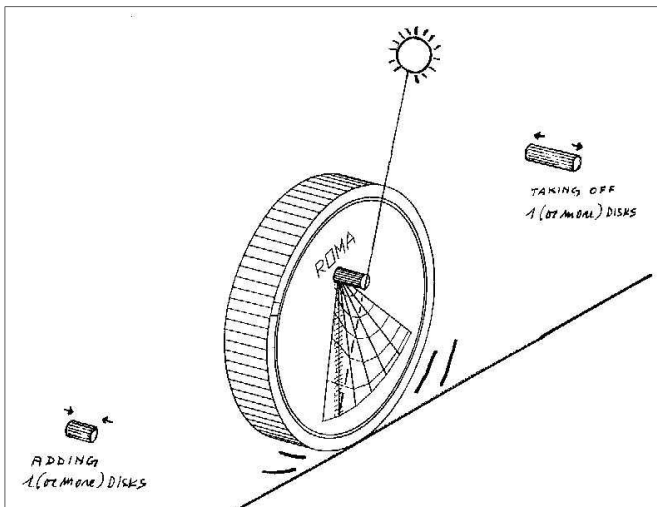

Fig. 13. *With a different number of disks (different declinations) the gnomon's length can be varied and, consequently, the noon-shadow length can be kept constant.*
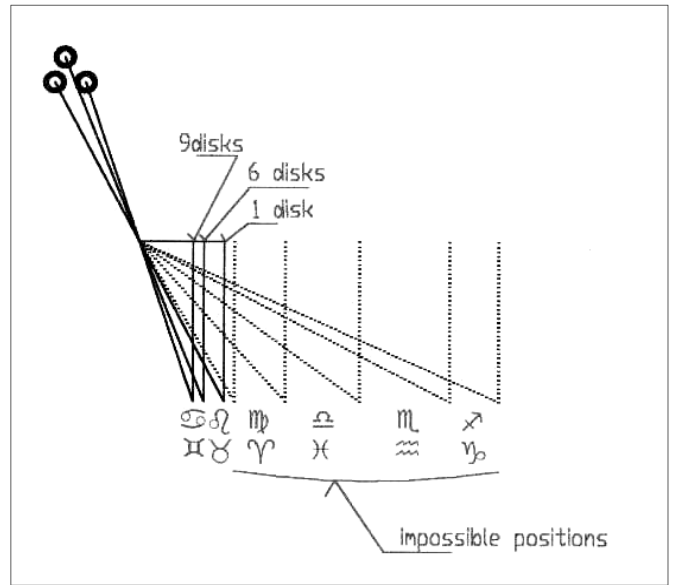

Fig. 14. *The altitudes of the Sun at the Latitude of Rome (42°). The dotted lines refer to impossible projections by the "box".*

The first stumbling block is the insufficient length of the retrieved pivot-gnomon. As initially indicated, the pivot seems to have been truncated, so we can imagine an original length of, say, the internal height of the "box". The pivot-gnomon could be no longer than 12mm. In any case, this length yields an interesting reconstruction.

Another difficulty stems from the limited number of disks (four): one can of course imagine, as demonstrated earlier, that the "box" originally contained more than four. For the reconstruction, we are going to demonstrate that it is convenient to imagine a "box" equipped with nine disks (four retrieved plus five "virtual" disks). Finally, as already explained, the lines traced by the gnomon for hours nos. I, II, III, IV, V, VII, VIII, X, X, XI are very inaccurate. Hour nos. 0, XII (sunrise - sunset) and VI (noon) are correct for intrinsic reasons.

Fig. 14 shows the altitudes of the sun at stepped values of ecliptic longitude. Permitted values are drawn in solid lines and "impossible" values of sun-altitude are in dotted lines. They stem from a 12mm virtual gnomon (since the one found was truncated by only 7mm), considering the "virtual" availability of nine disks of equal thickness to the four that have been found. Fig. 15 shows how the gnomonic instrument could work
The same way as by the previous case we enumerate the arguments in favour:

* the evidence of the reversed "V" shaped hour-lines by almost all disks, a figure which is typical of a tracing obtained by a frontal gnomon (Rome–Ravenna coin)
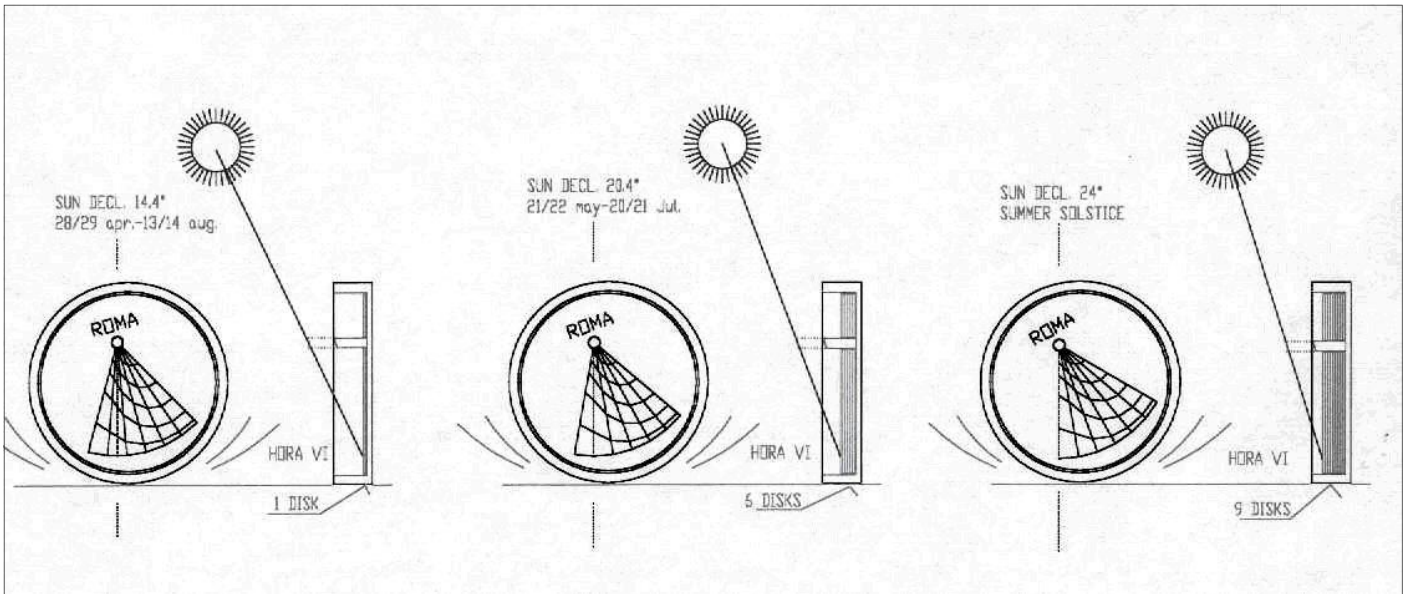
Fig. 15. A plausible reconstruction: the working of the "box" equipped with <u>9 disks</u> (instead of 4) and the <u>entire</u> gnomon. 100 days from late springtime till early summer are covered using 1 (end April), 2, 3...9 disks (Summer Solstice) and then again 9,8,7...1 (mid August).
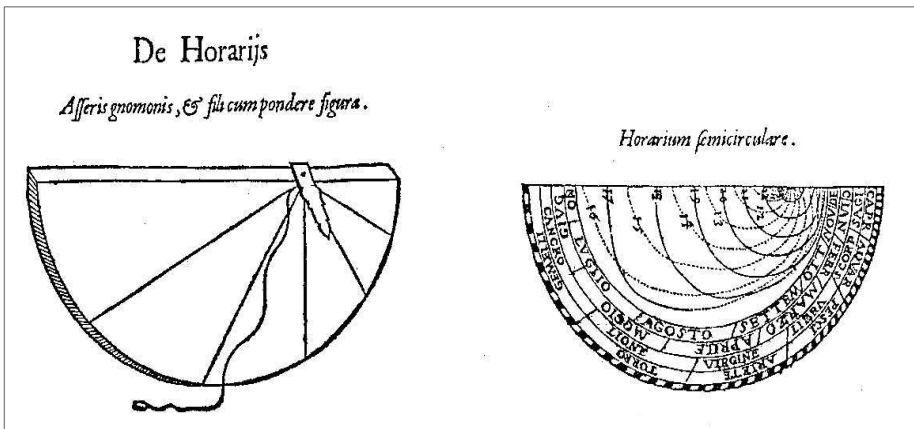

Fig. 16. A "rolling" altitude sundial – I.P. Galluci (1596) - The gnomon is constant and the hours are "Italian".

* the demonstrated evidence of a, sufficiently long, pivot which could plainly work as a "frontal" gnomon by an altitude dial
* the cylindrical shape of the box could assure its rolling in order to obtain verticality of current day-lines

And against:

* the circumstance that not all the year is covered by the sundial
* the missing of findings of other objects of this type
* the evidence, by Kenner's sketch, of the cursor whose usage would be, by this hypothesis, rather problematic

and historical period (albeit medieval), are unknown. This type of sundial was abandoned during the middle ages. Nevertheless, at the end of the 16th century, a similar "rolling" sundial, but with a constant gnomon and "Italian" hours, was described by I.P. Galluci; see Fig. 16. It was later mentioned by A. Kircher, too.

The cylindrical altitude sundial became commonly used as a portable sundial, better known as the "pillar sundial" or "shepherd's sundial". This type of sundial has also been found in an ancient Roman context: the cylindrical altitude sundial of Este (Padua), 1st century AD. The first description in the Middle Ages was made by the monk, Hermannus Contractus (11th century). In a chronicle of early 14th century the "pillar sundial" is said to have being built by a certain Paolo dell'Abbaco da Prato. A detailed description of the calculation of an altitude cylinder sundial was proposed by Johann v.Gmunden (first half of 15th century). After the common use of the compass, the "dypticus" became the most widely used portable sundial.

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To be concluded in the next issue.

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