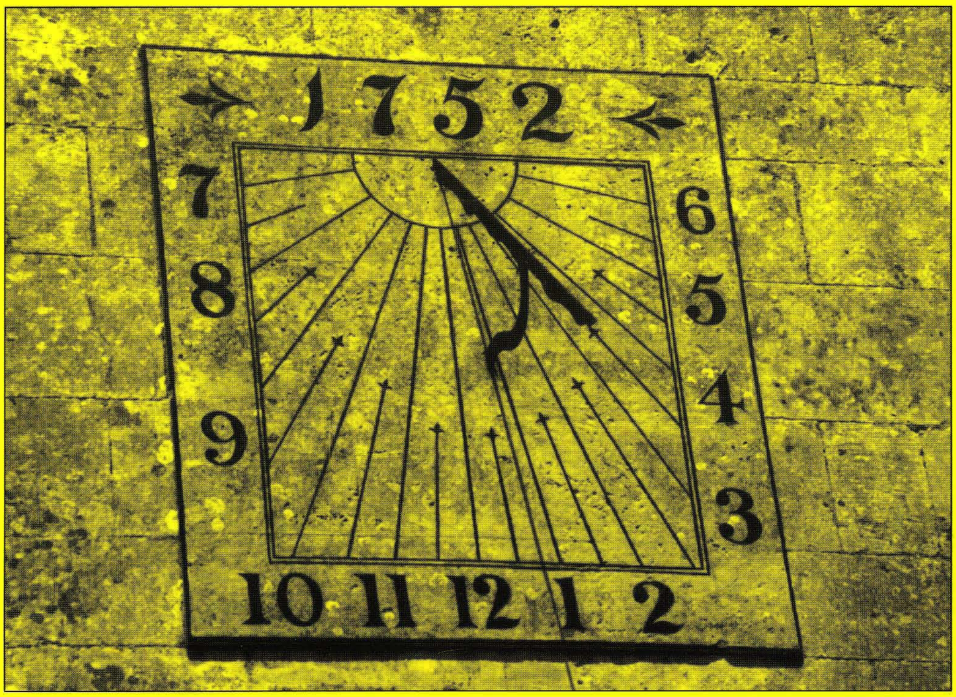
The British Sundial Society



BULLETIN

VOLUME 13 (i) MARCH 2001

Front Cover: Vertical Dial, St. Mary's Church, Great Witcombe, Gloucestershire (Photo: A.O. Wood)

Back Cover: Mass Dial, St Mary's Church, Harmondsworth, Middlesex (Photo: the late C.K. Aked)

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VOLUME 13 (i) - MARCH 2001

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BULLETIN

OF THE BRITISH SUNDIAL SOCIETY

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EDITORIAL

The Bulletin is to become, from this year, a quarterly journal, appearing in March, June, September and December. We hope therefore that contributors will see their material in print somewhat sooner, after submission. Each issue will contain 44 pages, so the annual total of pages will be 176, some 20 pages more than were published under the previous system, which was 52 pages 3 times a year. We are pleased with this increase in page numbers: Heretofore the editor and printer have had to worry, before the appearance of issue, about how best to squeeze quarts into a pint pot. Happily our contributors are so numerous, prolific and enthusiastic that there is always a wealth of material awaiting publication

Among other items this issue includes as expected another sprinkling of Millennium Sundials. There is a detailed account of the making of one of the 'Awards 2000' Sundials, a considerable engineering feat as the heavy stainless steel gnomon of the huge wall-dial has no external supports. There is also Part 1 of a 2-part article on the History of Time Measurement. Enjoy your reading, and keep on writing: we have 20 more pages to fill. But we hope you resist the temptation to write anything more, for at least a year, about the Venerable Bede: we are weary of this topic!

Note from Editor

We have received, as a mark of friendship for the BSS, a copy of the second issue (December 2000) of the Journal of the Japanese Sundial Society. It will be on display at our next Annual Conference. Although few of us read Japanese, we may all enjoy the photographs, several of which show large monumental public sundials. This is our first contact with a Sundial Society in Asia. The art and science of dialling is truly cosmopolitan.

A BRIEF HISTORY OF THE MEASUREMENT OF TIME

HARRIET WYNTER

'Old Time, the clocksetter, that bald Sexton, Time'- Shakespeare: King John. Act 3

PART 1: THE CALENDAR

Introduction

As we settle into the 21st century, it is hard to imagine that during the 1930s, the only time information on the 'wireless' was the Greenwich Time signal which the BBC broadcast twice a day. Announcers were reprimanded for giving listeners additional time checks from the studio clock. Our attitudes towards time have since changed as technology fills our lives. The years have never rolled by so fast, as instant communication crowds one global event onto another. Advances in science and technology have made enormous differences to the way we deal with the rush of time and some of us fantasise about the slower world of childhood. But the clocks are ticking; we cannot go back. Why ever did we need clocks at all? To some the clock is a tyrant, but time measurement was necessary for the development of civilisation and for our comprehension of the universe. The 'Clock of the Universe' is the only true time, but it is irregular and does not synchronise with our clock time. We are now going to examine some of the methods of measurement that were invented to harmonise civil timekeeping with astronomy.

The Beginnings of the Calendar

Many of us do not understand astronomy because we do not need it to tell the time, cushioned as we are by technology. But we all have an intuition of time in relation to events in our own lives, the repeating cycles of nature and civic responsibilities. For thousands of years, this was the only way in which time could be measured. As *homo sapiens* counted on his fingers, so he counted the stars in the heavens and noted their repeating patterns. In about 4,000 BC, the peoples in the ancient fertile lands between the Tigris and the Euphrates, once called Mesopotamia, invented numbers, writing and reckoning. It was the beginning of Western civilisation. Pre-dating all other cultures, the Sumerian system of positional notation, like their writing, was recorded in cunieform on clay tablets; and with these numerals, they conceived the basic ideas of mathematics. Calendars were produced by an educated elite which endeavoured to put some order onto the untidy universe. Because of the mystery and superstition surrounding the return of the seasons, the calendars became instruments of power and persecution, secret information which was denied to ordinary folk, too occupied with survival and slavery.

How, Why and Who devised the Calendar

Astronomy is the most venerable of the sciences. It developed out of the needs of farmers to forecast when to sow and harvest in order to survive the winter. The only indicators available were the apparent gyrations of stars, sun, moon and planets, so observations over long periods produced a data base of temporal information. As civic groups proliferated, information was needed for festivals, shipping, contracts and so on; and many attempts were made to construct a calendar which would coincide with the seasons. Whenever the calendar became out of step with observed phenomena, anyone in authority could add an additional day to adjust it. This system was open to abuse. The person in charge sometimes forgot or intentionally did not adjust the calendar for his own political or economic ends.. The Sumerians developed a slightly different system, based on a calendar year of 360 days, rounding off the lunar month to 30 days. The solution slotted nicely into their mathematical system based on the numbers 6 and 60, which, when multiplied, made 360. It is not clear why this numerical system was selected, but it still serves us very well as the mathematical basis for the division of the circle and its implications in compass bearings and altitude instruments and any others which measure degrees, minutes and seconds of arc. Bright stars seen with the naked eye began to be identified by name. Thus, a system of grouping twelve sets of neighbouring stars into signs of the zodiac was invented. As each group of zodiacal stars was visible at mid-heaven for a twelfth part of the year, the notions of seasonal rotation and the 12 month year became established. Perhaps the Sumerians selected twelve signs of the zodiac because the number 12 divides into 60 and 360. Whatever their rationale, the Babylonians later adopted the Sumerian system. Despite being obsessed with astrology, the Babylonians were nevertheless amazing astronomers, and they went on to introduce the 24 hour day, which divides nicely by 6 and also multiplies into 360.

Astronomical Problems & Solutions No:1 Sidereal or Astronomical Time

We should now leave history for a moment in order to examine the scientific evidence, as it will highlight the difficulties early astronomers encountered as they strove to comprehend the universe. If scientific facts leave you cold, skip this section and refer to it as and when you need it in the text. Sidereal Time, the standard used by Astronomers, is determined by the diurnal rotation of the earth which turns on its axis in 23 hours 56 minutes and 4.1 seconds. Because of its annual rotation around the sun, the earth revolves once more than is apparent so the sidereal day is 3 minutes 56 seconds shorter than the mean solar day. The motion of the earth in relation to the stars is uniform and astronomers can expect the passage of a star to cross the meridian exactly 3 minutes and 56 seconds earlier than the previous night. However, the sidereal year cannot be used for civil purposes because of a phenomenon called *precession of the equinoxes*, first discovered by Hipparchus (fl.146-127 BC).

The north/south axis of the earth at present tilts 23° 27' to the plane of its orbit round the sun. This angle is called the sun's Ecliptic, (the sun's apparent orbit of the Earth.) As the earth performs its annual rotation around the sun, the twelve groups of zodiacal stars which lie astride the Ecliptic become visible from Earth in different positions in the sky. As each group of zodiacal stars gets closest to the sun, an observer on earth can see them at his mid-heaven, from which he can assess the date on his calendar. The equinoxes are the two occasions in the year times when the sun's apparent orbit (ecliptic) crosses the equator and day and night are of equal length all over the world, before the sun apparently moves from one hemisphere to the other. However, in every successive sidereal year, the equinoxes retrograde along the sun's ecliptic. This *precession of the equinoxes* explains why the calendar dates of the Vernal (spring) and Autumnal Equinoxes slip backwards and cause the calendar to be out-of-step with reality. So the sidereal year cannot be used for a civil calendar, although this precession does not affect astronomers. Precession was not fully explained until Newton described the gravitational pulls of the sun against the imperfect sphere of the Earth. Newton concluded that the Earth is actually an oblate spheroid, a sphere bulging at the equator and flattened out at the Poles. (Astronomers during the 17th /18th centuries, checking transits of Venus near the equator, learned from Newton to shorten the pendulum of clocks to adjust for the difference in gravity caused by this bulge)

Astronomical Problems & Solutions No: 2 The Solar Year

The solar day is based on the period between two successive returns of the sun on the meridian. The movement of the Earth around the Sun takes 365 days 5 hours, 48 minutes and 46 seconds. This is the measure of a mean (average) year. However, the mean and the solar day-lengths actually coincide only on four days in the year; the sun lags about 14 minutes 28 seconds behind mean time on February 11th, and 15 minutes 18 seconds ahead on November 3rd.

Astronomical Problems & Solutions No: 3. Dividing the days into hours - the unequal and the equal hours

Division of the days into hours was difficult, because except at the equinoxes the lengths of daylight and night-time periods are not equal to each other and neither are the hours into which they are divided. Such unequal (planetary) hours change in length throughout the year. However, if the length of the whole solar day/night period were to be divided into 24 equal parts these equal hours would be invariable. This was the system used by astronomers before the advent of the clock, when the system became universal.

The Solar, Lunar and the Combination Calendar

The solar year, the solar day and the lunar month are the only natural divisions of time. All the rest are arbitrary. Calendars can be solar, lunar or a combination. The movements of the sun and moon are different, so it was difficult for their calendars to keep in step. Because of the apparent regularity of the phases of the moon, some societies used a system based on the lunar month. Observation of the phases of the moon led to the natural division of the year into thirteen lunar months, which began at dusk when the new lunar crescent was observed at sunset. The year began with the vernal equinox (now March 20th) when the sun's ecliptic crosses the equator into the northern hemisphere. Though used by peoples of antiquity, the lunar year needed too much adjustment for civil purposes. Thus, with some exceptions, it was abandoned in favour of the solar year. In ancient Egypt the lunar calendar was adopted for religious purposes and the solar calendar for civil life. They ran concurrently and did not always coincide. In about 2500 BC., an intercalation rule was adopted to insert extra days as required to make the lunar calendar dependent upon the civil. This international, invariable Egyptian calendar that integrated the lunar with the solar year had a far reaching effect throughout Persia, Armenia, Greece and Rome to Revolutionary France. Of these, the major centre of influence on the measurement of time in the modern world was Rome.

The Roman Calendar

In 304 BC, Cnaeus Flavius, a Roman plebian, angered by the secrecy surrounding the publication of the annual calendar, stole the astronomical codes and posted them in the Forum for all to see. Thus becoming universally known throughout the Roman world, the calendar was at last denied to no one as an independent objective secular factor. In ancient times, the calendar had been reckoned at random, usually by the number of years in the reign of a sovereign in the community, or after some great victory. In Rome, they used AUC *(Ab Urbe Condita)* 'from the foundation of the city'. The old Roman lunar calendar, said to have been invented by Romulus, founder of Rome, was full of inaccuracies and was originally based on the numeral 10 (X). According to Ovid, this was because they only had ten fingers on which to count. Although there had been murmurings to start the year after the winter solstice, the Roman year began in March, (Martis). Then came Aprilis, possibly referring to the raising of pigs, then Maias, after a local Italian goddess and Junius after the queen of the Roman gods, Juno. After that, the months bore numbers, fifth - quintilis, sixth - sextiles, seventh - September, eighth - October, ninth - November and tenth - December. A successor to Romulus added two more months, Januarius and Februarius, making a total of twelve months, containing 355 days.

The Julian Calendar

The Roman calendar had become totally unsatisfactory by the reign of Julius Caesar. Returning from Egypt, where he had witnessed the successful reforms to the Egyptian calendar made by Sosigenes of Alexandria, Julius Caesar invited Sosigenes to reform the Roman calendar. In order to avoid future discrepancies with the seasons, Sosigenes proposed an elegant solution. Using a solar calendar, beginning soon after the winter solstice on January 1, he constructed a year of twelve months divided into 365.25 days. The months alternated between 30 and 31 days with the exception of February which had 29 days, plus an extra day every fourth year, for leap year. After the Senate had proposed that the name of month quintilis should be changed to July in honour of Julius Caesar, they also proposed that the month sextiles (August) should be named after his successor, Augustus. However, in the Sosigines system, July had 31 days and sextiles only had 30, so the Senate decided that it would be disrespectful to give the new Caesar fewer days than his predecessor. Their solution was to raid February for a day and add it to August and change the lengths of September, October, November and December, thereby ruining the simple method of reckoning, and necessitating the jingle we learned as children. Caesar's Julian calendar was introduced in the year 46 BC. To make up for the difference in days between the old Roman calendar and the new, the year 46 BC was 445 days in length. In spite of Caesar's announcing that his calendar would be the end of confusion, everyone called it the year of confusion because of the disruptions it caused all over the Roman world.

The Romans did not divide the months into weeks as we do, although every eighth day was a market day. Instead of named days, they were numbered and counted from signal days of the month. The first of the month was entitled a *kalend* from which our word Calendar derives. The fifth or seventh was called *nones* and the middle of the month was entitled *ides*. For example, while the first of the month was a *kalend* (of the month), the following days were counted as so many before the nones which fell on either the fifth or seventh. After the nones, days were counted before the *ides* which fell on the middle of the month. The 'Ides of March' in Shakespeare's *Julius Caesar* were the days between the 7th and 15th March. It may seem complicated to us, but the Roman world had got used to it and the practice continued well into the Middle Ages as an adjunct to other systems such as the annual commemoration of the martyrdom of Christian saints which filled the gaps in the almanac.

The Catholic (Universal) Christian Church and the fixing of Easter

While entertaining the bishops of all the various Christian sects then in existence at his expense at the Council of Nicaea, AD 325, the Emperor Constantine persuaded them to combine forces in a universal (catholic) Church, and in return for a docile population with their eyes set on heaven, he placed the clergy outside the taxation system. According to Gibbon, his aim was to muster a powerful Christian religion as the spiritual arm of his empire and to this end, Constantine endeavoured to prise Christianity away from its dependence on its Jewish roots.

He announced that in future, the Christian day of rest would be on Sunday, not Saturday, which was both the ancient Hebrew seventh day derived from Genesis, and the pagan Roman Saturn-related day of rest. Sunday would also be the first day of a seven-day week-a move which would placate the sun-worshipping Mithraic peoples in his empire. Christ rose on a Sunday- this was the explanation given - and Christian prelates grudgingly accepted Sunday, the Sun's day, because Christ was the light of the world. Each day of the seven-day week was named after the seven heavenly bodies known in antiquity-Sun, Moon, Mars, Mercury, Jupiter, Venus, and Saturn, in that order. The correct order of the planets was not followed because astrology dictated which planet influenced the first hour of each day, thus giving its name to the day. (Latin names of the week live on in the Romance languages. However, in Britain, which had also been invaded by Saxons and Vikings, the names of some of our days of the week reflect their influence - Twi's day, Woden's day, Thor's day, Freya's day; Saturday may have survived the Roman occupation).

Constantine also declared that Easter (a derivative of Eostre - one of the goddesses of Spring) had to be celebrated universally on the same day. Originally tied to the Jewish festival of Passover in the Hebrew lunar month of Nissan, the actual date wandered through March and April. So the 'movable feast' of Easter was settled as taking place during the week following the first full moon after the vernal equinox unless it coincided with Passover, when it had to be delayed until the following week. The idea that a sacred Christian festival, the keystone of the faith, should depend on adjustments to the Hebrew calendar made by Jewish priests, was unthinkable for Christian communities. Having fixed the date of the vernal equinox at March 21, Constantine did not realise that the Julian Calendar onto which he had tacked the wobbly date of Easter was already faulty in AD 325 and would lead to untold problems later on.

THE CHRISTIAN CALENDAR: CE - CHRISTIAN ERA - NOW CALLED COMMON ERA

The Julian calendar was in force all over the Roman world when Emperor Constantine founded the Catholic Church at the Council of Nicaea in AD 325, although at that time, AD 325 had not been invented. AD *anno domini* 'the year of our Lord', was the logical reckoning for the Christian world, but this did not catch on immediately. Struggling to make some sense of the erratic calendar for their calculations for Easter, Christian scholars took their Day 1 from the accession of the Emperor Diocletian (our AD 284) for Year 1, using the abbreviation AD for *anno dioclitiani.* It became a matter for debate as to whether Diocletian who had been one of the worst oppressors of the early Christians should be so honoured; but the church response had been that it was not Diocletian but the early Christian martyrs themselves who were being remembered.

An abbot working in Rome, Dionysius Exiguus, (500 - 560) producing canonical law and calculations for Easter, dated his letter to his bishop Petronius in what he called *anno domini* 531, but which at that time was referred to by others as anno dioclitiani 247. This suggested that he preferred to count the years from the birth of Christ. How Dionysius calculated the date of birth of Christ is unknown, for no-one had made a record at the time, and the gospel writers were not unanimous. Dionysius counted his date of Christ's birthday as Year 1 because zero had not yet been invented. Christ would have celebrated his first birthday in AD 2, his 29th birthday in AD 30 and so on. This is why the year 2000 is not the beginning of the 3rd Millennium but the end of the 2nd Millennium. Our Hindu/Arab notational system of 0-9 was introduced into Europe in about the 12th century. Before this, all numbers were portrayed in Roman numerals in which there is no zero. Dionysius made history when he entered a short postscript to his manuscript of calculation tables for Easter for the following 95 years with anni Domini nostri Jesu Christi (the years of our Lord Jesus Christ) 532-627). *Avant* J C. or BC (before Christ), the inverse term of AD, did not come in until 1627; when it was used by an astronomer Denis Petau while teaching at the Paris College de Clermont.

Dionysius's innovation did not change dating conventions immediately, but his logical association of the Christian calendar with the birth of Jesus Christ influenced subsequent scholars and his dating went unchallenged until modern times. His friend Cassiodorus first used the AD system in a published work in 562, *Computis Pascalis*, a textbook on how to calculate Easter, a much used *vade mecum* for uneducated monks during the dark ages that followed in Northern Europe. Use of the term AD did not become widespread until the 10th century. However, a notable exception was the Venerable Bede (672-735), whom erudite diallists will remember for his sundial with which he calculated the calendrical error in the date of the equinoxes. Bede, an isolated but brilliant scholarly monk in Northumbria, used the term *Anno Domini* in his *Ecclesiastical History of the English People* (731). Taking the work of Dionysius, he abandoned the arbitrary use of 95 year periods and was the first to use systematically a 532 year cycle and to account for leap year. He included four epacts (Metonic cycles of 19 years which adjusted lunar to solar calendars), multiplied by seven for the days of the week.

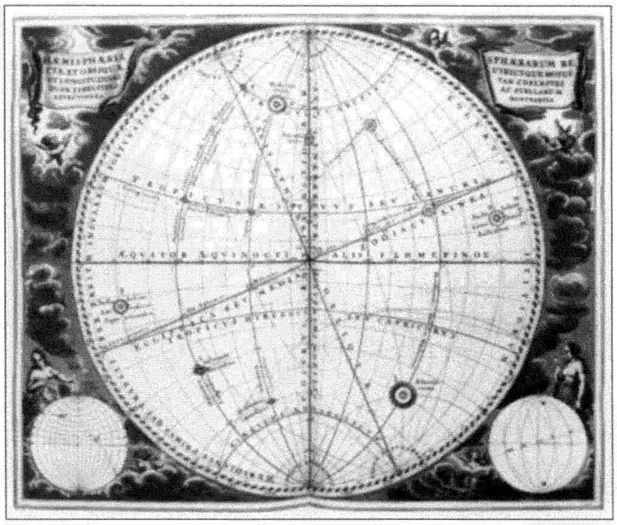

Fig.1. Celestial Map with stars (from Andrea Cellarii's 'Atlas Coelestis')

Problems with the Christian Calendar

The Emperor Constantine did not realise that the Julian Calendar on which he hung the new Christian Calendar was already inaccurate, so successive computations for the date of Easter became more and more out of step with reality. By the fifteenth century, the actual date of Easter became a pressing problem for the Catholic Church, which had become the accepted guardian and authority for the accuracy of the calendar. By the beginning of the sixteenth century, the calendar had drifted over twelve days since

Julius Caesar's time, and over nine days since the Council at Nicaea. It had become more and more divorced from reality because of faulty astronomy. The future of Catholicism itself was in doubt as Lutheran teaching spread from its centre in the University of Wittenberg in Germany. There was much anxiety over the inaccuracies in celebrating Easter, and other faiths ridiculed the Catholic Church which was unable to date properly the most holy moment of the Christian year.

Internal and External Time

How could this have happened? The answer lay in the perception of time itself. Internal time forms part of ultimate reality, whether it is philosophical, poetical, spiritual, ecclesiastical or even what St. Augustine called 'sacred' time. It is completely different from external time which is constantly reviewed and updated, based on mathematical principles. External time is the experience of duration, and the regular succession of repeating phenomena measures duration. But the Church would not accept the necessity for scientific evidence as it could prove dangerous to an institution based on revelation. The theory that 'knowledge is power' was a threat. Instead of free thought and scientific enquiry, the Church urged the laity to concentrate on eternity and obey the teachings of the Christian fathers. Although the Church in Rome had absolute power over souls, it nevertheless suffered from both internal strife and attacks from barbarians without. Fearing for its future, the Catholic Church insisted that canon law was unassailable and any deviation would imply heresy with painful consequences.

Against this background, few scholars dared to suggest that the Christian calendar, with its formula for the celebration of Easter, could be wrong for astronomical reasons. To criticise the Calendar was to attack the Church, but for the Church to accept astronomical evidence that there was no foundation for a calendar which did not reflect the natural world was unthinkable. And yet the Church was desperate to regularise the date of Easter, which could be achieved only by good astronomy. There seemed to be no solution and yet, while insisting that their computations for the correct date for Easter were divinely inspired, some scholars within the Catholic Church were using astronomy to achieve better results.

By the twelfth century, this difference of perspective became critical as Logic was invoked in the new universities to show that what was perceived in the natural world and what was expressed in ecclesiastical canon based on faith, were not compatible. A breathing space was achieved with a compromise by St.Thomas Aquinas (c.1227-74) in his *Summa Theologica*, when he integrated the two opposing concepts of the sacred and the secular into one doctrine. He combined Aristotelian theory of knowledge based on reason with his own ideas of higher knowledge derived from revelation by a bold assertion that Platonic imperishable ideals could be proven by Aristotelian logic. After his death, *Summa Theologica* became the basis of Catholic theology, its precepts became canon law and it underlay all subsequent political and social enquiry into the position of man in the state or in the universe. Thomas was canonised in 1323. His compromise allowed the acceptance of uncomfortable truths which seemed to contradict the church. It also allowed science to seek its own truths within strict limits. In the meantime, Aristotelian science was taught at universities and it was expected that it should be learned parrot fashion, without argument or deviation.

Aristotle, Ptolemy and the Geocentric Universe

Before its final destruction by the Arabs, the great Library of Alexandria contained hundreds of thousands of manuscript books collected from all over the Mediterranean and was the epitome of knowledge from the ancient world. Aristotle's own publications and his collection of books are said to have been donated to the Library. Among the many scholars attracted to its archives was Claudius Ptolemy (c.AD.150) who, quoting Hipparchus, assembled the geocentric system of astronomy contained in his *Almagest*. A consummation of Greek astronomy, founded on Aristotle with modifications, the *Almagest* remained the basis of all European astronomy until Copernicus. It was copied endlessly by scribes throughout the centuries before it took its first printed form in Latin, translated by Regiomontanus (1496). It was a masterpiece which described the construction of the earth and heavens. From an observer's point of view, it seemed that all the luminous heavenly bodies in the sky rotated around the earth; a concept that suited the popular idea of a homocentric universe.

Impossible to prove or disprove at that time, the idea could not be refuted scientifically as the technology was not yet available. But anyway, why should it not be true when observers had the evidence of their own eyes? A puzzling feature of the night sky was the mysterious appearance and disappearance of the planets, the so-called 'wandering stars'. Ptolemy drew on the astronomical works of Aristotle (384-322 BC), a prolific writer on all aspects of science. The planetary explanation described a series of concentric circles in which the planets rotated in crystalline spheres during their annual circuit around the central earth, thus causing them to be periodically invisible from earth. This belief survived until it was discredited by Copernicus, Brahe and Kepler.

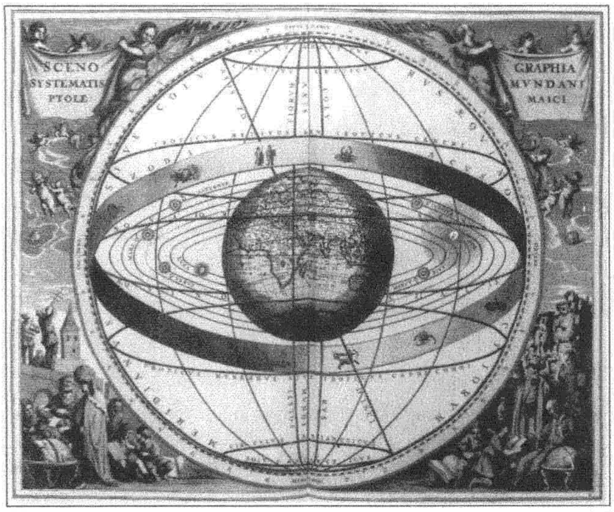

Fig.2. Ptolemy's System
(from Andrea Celarii's 'Atlas Coelestis'

The Heliocentric (Sun-centred) Universe
While the Vatican was trying to decide what to do about Lutherism, there was an ambivalence about new ideas and a sort of ecumenical liberalism prevailed. This uneasy peace could end at any time, as it ultimately did with the Counter Reformation when Pope Paul III instigated another Inquisition in 1542 led by the Jesuits. The Church dealt with subversive material by burning it, while the author shared the same fate if he refused to recant. Titles were placed on an Index of Forbidden Books so that to be caught owning one would bear the same penalty as actually writing it.

Nicholas Kopernik (Copernicus) (1473-1543) an obscure Polish cleric, became involved in the reform to the calendar after receipt of a letter in 1514. This was a copy of a letter from Pope Leo X to heads of state requesting opinions from their astronomers about the reform of the calendar. The main problem was the matter of the dates of the equinoxes. Copernicus nightly observed the heavens from his tower and came to the realisation that the Earth could not be at the centre of the universe and that this belief was the cause of much faulty astronomy. With mathematical proof, he was convinced that he was not mistaken; but he was torn between his scientific experience and his devout catholicism and, undecided, he delayed publication. He allowed his Lutheran disciple, Georg Joachim Rheticus (1514-1576) to publish a treatise in which the idea of a heliocentric universe was floated, without an adverse Church reaction. Copernicus finally went to press with *De Revolutionibus orbium coelestium* (1543). Copernicus had written a dedication to Pope Paul III referring to the letter of 1514 from his predecessor, Leo X, which had inspired his life's work, and begging his indulgence for this new science. Unknown to him, his friend the Lutheran Bishop Osiander added an unrequested preface to the work, assuring readers that the Copernican system of the universe was just another conjecture. The motivation for Osiander's preface is unknown and the source of much speculation; but seeing the proofs on his deathbed, Copernicus was enraged by this apparent betrayal.

Although Copernicus is credited with the heliocentric theory, the idea originated from Aristarchus of Samos (310-230 BC), and the Pythagoreans (5th c. BC). With the exception of the planetised Earth, the remainder of his world system was barely changed from the traditional Greek hypothesis with its perfect concentric circles and crystalline spheres. Copernicus' greatest achievement was his discovery of the daily and annual motions of the earth, which explained planetary retrogression. His astronomical data, contained in Vols. II-VI of *De Revolutionibus*, were widely used in universities, while the heliocentric theory of Vol.I was largely ignored. Perhaps because of Osiander's apologia, or just because scholars were conservative, the idea that the earth moved remained a dangerous curiosity. Without scientific proof, neither the Copernican nor the Ptolemaic system could be a reality, but were simply philosophical explanations of what could be seen from Earth, termed 'saving the appearances'. However, some astronomers took Copernican theories very seriously indeed.

Tycho Brahe (1546-1601) designed and built his own observational instruments with which to re-determine the position of the fixed stars, as well as to observe the planets, the sun and the moon, and to record their motions. The Tychonic system placed the sun at the centre of the earth's orbit, but for religious reasons it did not totally accept the heliocentric system; it allowed the five visible planets to rotate around the earth. The system was welcomed because it allowed for observed phenomena, including the motion

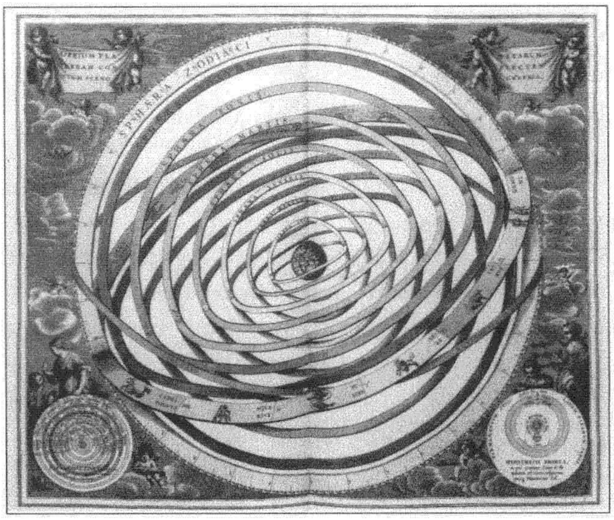

Fig.3. Tycho Brahe's hypothesis
(from Andrea Celarii's 'Atlas Coelestis')

of comets through space, which had caused Tycho to reject the Aristotelian notion of crystalline spheres. Tycho left his star maps to his successor, Johannes Kepler (1571-1630), a confirmed Copernican, who discovered the elliptical motion of the planets and demolished the theory of concentric circles. Galileo Galilei (1564-1642) observed the satellites of Jupiter through the lenses of his newly invented telescope, and he published his historic *Dialogo* (1632) that undermined Greek astronomy for ever. In addition, he wrote in Italian so that his work could be widely read. The Church had no quarrel with heliocentricity so long as it was just a conjecture, but when it seemed possible to prove its existence empirically, Galileo was summoned to appear before the Inquisition. Isaac Newton (1642-1727) in his *Principia* mathematically proved the existence of a concept, his law of universal gravitation, which explained the synthesis of the cosmos, and the underlying universal laws that proved its physical unity. Copernicus was finally vindicated.

The Gregorian Calendar

The ultimate papal volte face towards astronomy was inevitable when Leo X despatched his appeal in 1514. Many clerics were excellent astronomers and mathematicians, legitimately involved in the problem of the Calendar, carefully concealing or ignoring any controversial evidence that emerged. The drift of the calendar against the true astronomical year was finally resolved when, in a papal bull issued in 1582, Gregory XIII promulgated a reform of the calendar. This was based on the success of Christopher Clavius (1538-1612) and others in calculating the length of the Tropical year (between two vernal equinoxes,) to its nearest approximation so far. Ten extra days were removed from the year to make the adjustment. Whereas the Gregorian Calendar was almost immediately adopted by Catholic nations, it was not universally accepted for nearly 400 years elsewhere, sometimes because of its papist connections. Great Britain and her Colonies converted to the Gregorian calendar in 1752, by which time there was a difference of eleven days, because of a Julian leap year. There were riots in the streets. "Give us back our eleven days" cried the mob who, like us, relied on clocks and watches and evidently did not understand astronomy either.

With the establishment of the Gregorian Calendar, the main contribution of astronomy to the measurement of Time was complete. In the next few centuries, time-keeping for human convenience-for society, commerce, surveying and navigation-was mainly a matter of technology. There was a gradual increase in mechanical precision, from the astrolabe to the atomic clock. The history of the tools of the trade will be the subject of Part 2

ACKNOWLEDGEMENTS

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THE HORNIMAN MUSEUM REFLECTIVE CEILING DIAL

RAY ASHLEY & JOHN MOIR

RA:

On the 19th March 1994, Christopher Daniel gave a lecture at the Horniman Museum on dials and dialling, to inaugurate the sun-dial trail which the British Sundial Society had helped to establish. During his lecture he talked about reflective ceiling dials. My interest was immediately aroused as I had known nothing about them, and I set out to discover more about this rare type of sundial.

At about the same time. plans were well in advance for the construction of the CUE building as part of the museum's attractions. This is the Centre for Understanding the Environment, intended as a link between the museum's collection and the living world of the Horniman gardens. It is an ecological building, designed to house displays which highlight the relationship between the environment, people and science.

It seemed to me to be an ideal setting for a reflective ceiling dial as it would show visually the relationship between the position of the sun and the time of year as well as the time of day, and it would be an unusual addition to the sundial collection that was gradually being developed.

I approached Dr Elizabeth Goodhew who was responsible for CUE and who was also the driving force behind the sundial collection. She was very enthusiastic about the idea and was happy for me to go ahead. At this time John Moir was also interested in the Sundial trail, and was keen to join me in the project.

RA/JM:
We visited the museum and realised that the dial would work perfectly well in the main room in CUE, as it has a large ceiling area and high windows to the south. We used Ray's declination finder (Bulletin BSS 95 (i) p.51) to find that the building declined 7.2 degrees to the west of south, and measured the slope of the ceiling as 25 degrees. We also established the area that the dial would cover, and decided the appropriate point on the window-ledge on which to set the mirror.

It is worth mentioning that owing to the slope of the ceiling there would be a period of a few weeks around the winter solstice when the ceiling would be bathed in direct sunlight, thus reducing the contrast between the light spot and the background. We decided that this would be a small price to pay for the interest the dial would provide for the greater part of the year. We then went away, John to do the calculations and Ray to make the mirror, (Fig.1).

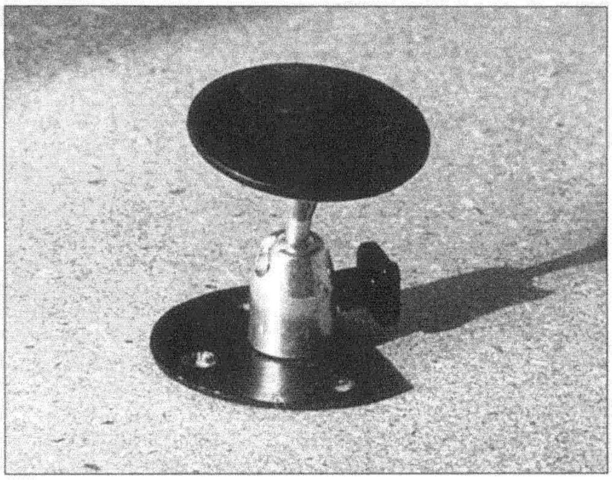

Fig.1. The adjustable Mirror

Having separately done our work, we contacted Dr Goodhew, who organised a movable tower to enable us to reach the dizzy height of the ceiling. We decided that initially we would construct the dial using coloured wool and drawing pins, to prove the calculations, before installing more permanent markings. We now had all the data needed to lay out the dial. Our chosen day for this task could not have been colder. Swaddled in duffel coats and scarves we climbed up to the window ledge and secured the mirror firmly in a horizontal plane, (Fig.2). The mirror had been made large, to facilitate the levelling process, and masked to give a small enough spot of light. We soon realised that we had a problem: the intersection of the vertical through the mirror and the ceiling plane was hidden behind a beam. (Fig.3)

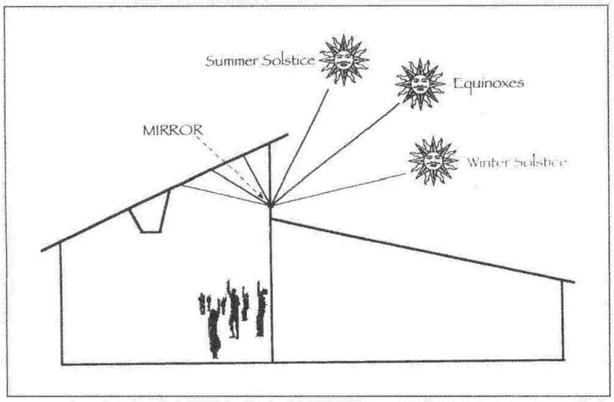

Fig.2. Position of mirror on window ledge

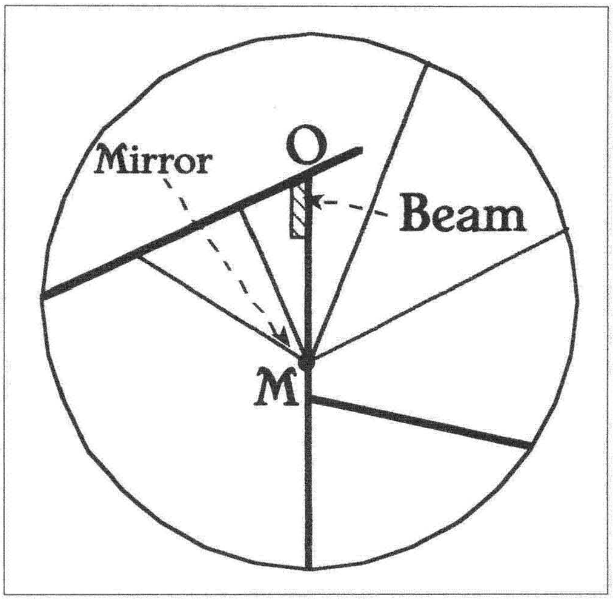

Fig.3. Detail showing troublesome beam

However with some "seat of the pants" trigonometry we calculated the height of the gnomon, OM in Fig.3, to be 1591 millimetres.

Our prepared table of x (horizontal) and y (down slope) co-ordinates were related to a gnomon, OM, of unit length. We therefore now had to multiply the co-ordinates (26 pairs in all) by a factor of 1591 to produce the actual x, y distances in millimetres. Finally we calculated that we had to subtract 127millimetres from each y measurement to allow for the interfering beam. When all this was completed we were able to measure and lay out the hour lines and equinox and solstice lines (Fig.4).We were particularly pleased when we

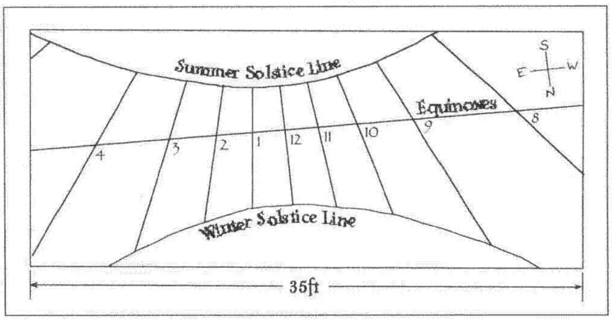

Fig.4. Layout of the dial

joined the three points used for the equinoctial and they formed a perfectly straight line. The job took all day, as we had to keep climbing up and down to re-position the tower.

To monitor the accuracy of the dial, we produced a record sheet and with the help of the CUE volunteers we were able to carry out a prolonged recording trial. Their observations, together with checks we made ourselves, indicate an accuracy to within a minute or so. Considering factors such as the rough nature of the building construction and our difficulties with measuring, we were satisfied with the results.

As mentioned earlier, the coloured wool used to delineate the dial was eventually replaced by more permanent and durable materials: plastic packing tape and dyed wooden strips, (Fig.5). In contrast to the freezing day that we selected for our first endeavours, we could not have chosen a hotter day for doing this. At least we were able to use the dial itself to let us know when further refreshment was due.

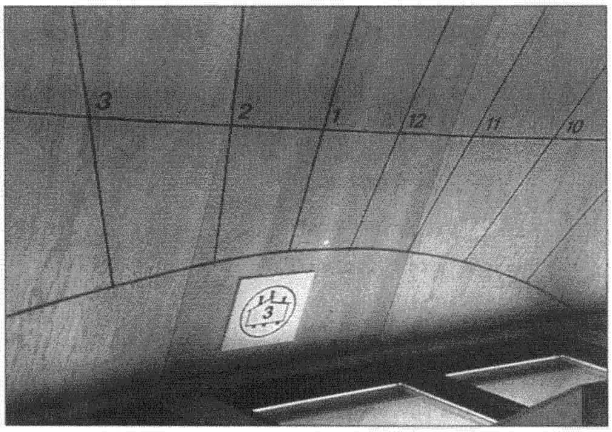

Fig.5. The dial 'doing its stuff'

The dial has been a source of keen interest and indeed some wonder for school parties and other visitors . It is therefore particularly regrettable that the sundial trail, including the ceiling dial, has had to be suspended pending the completion of an extensive improvement programme involving the buildings and grounds. Local BSS members are co-operating with Museum staff to establish a modified trail when work is completed in late 2001.

JM: DELINEATION:GETTING THE LINES RIGHT ON CUE

The CUE ceiling dial has a small mirror set on a horizontal window ledge in a wall which declines 7.2 degrees west of south. The sun's ray is reflected as a light spot onto the ceiling, which slopes at 25 degrees to the horizontal.

In Fig.6, M is the mirror, OM is the vertical and OY the line of maximum slope. P is the light spot. having co-ordinates (x,y) in relation to the axes OX and OY.

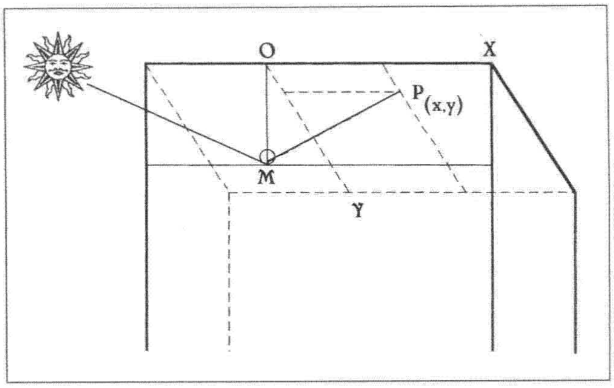

Fig.6. Geometry of reflective dial

To delineate the dial required the finding of the co-ordinates (x,y) of all the hour points on the equinox and solstice lines. First, the hour values for each of these declination lines were converted into values of the sun's altitude a and azimuth Z, using standard spherical trigonometry formulae. (See Note 1)

Before developing the equations to find x and y, we decided to simplify the geometry by considering instead a reclining dial with a vertical stick gnomon OM the tip of whose shadow lies at the point P. (Fig.7)

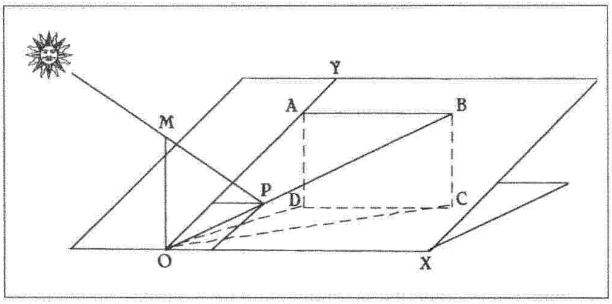

Fig.7. The equivalent reclining dial

Because the angle PMO is the co-altitude of the sun and lies in the sun's azimuth plane in both figures, *any solution for P(x,y) in Fig.7 will equally apply to P(x,y) in Fig.6 See Note 2)*

In Fig 7, AB is drawn horizontally through any point A in OY meeting OP, (extended) at B.

Perpendiculars AD and BC are dropped on the horizontal plane to form the triangle DCO.

The knowns in this figure are:

angle AOD = i (angle of slope) = 25°
OM = unit length
angle PMO = 90 – a (co-altitude)
angle COD = Zr = Z ± d (see Fig.8)

In Fig. 8

Z = Sun's bearing W of S
d = wall's declination W of S (= 7.2°)
Zr = Z-d

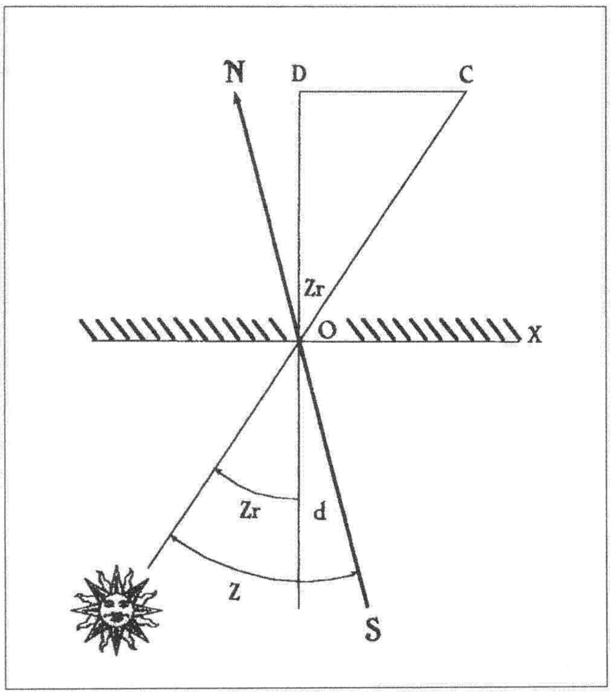

Fig.8.

(Note: when sun is E of S, Zr = Z+d)

We can now formulate equations for finding angle POA and length OP in Fig.7.

These are the *polar* co-ordinates of point P, which in turn will give us the x,y co-ordinates.

To find the angle POA (see Fig.7)

$$\text{Tan POA} = \tan \text{BOA} = \frac{AB}{AO} = \frac{DC}{AO} = \frac{OD \tan Zr}{OD \sec i} = \tan Zr \cos i$$

Therefore angle POA = arc tan (tan Zr cos i)

To find length OP:

First we must find the angle BOC (See Fig.7)

$$\text{Tan BOC} = \frac{BC}{OC} = \frac{AD}{OC} = \frac{OD \tan i}{OD \sec Zr} = \tan i \cos Zr$$

Therefore angle BOC = arc tan (tan i cos Zr)

Now referring to Fig. 9

$$OP = \frac{\sin PMO}{\sin MPO} = \frac{\sin (\text{co-alt})}{\sin MPO} = \cos a / \sin (a + BOC)$$

Therefore OP = cos a / sin(a + arc tan (tan i cos Zr))

Finally, P (x,y) is obtained from x = OP sin POA
y = OP cos POA

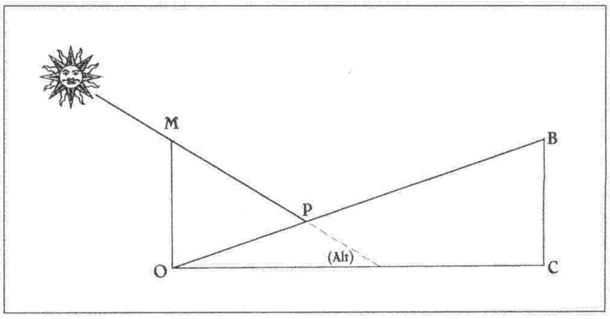

Fig.9.

The variables a and Zr were input into the above formulae to give x and y for each hour/declination, enabling us to produce a table of co-ordinates for each hour at both solstices and the equinox.

NOTES

1. For this and other methods, see Bull.BSS 12 13 (2000).
2. Thus, all we are doing is delineating a normal declining, reclining dial. This dispels the often-held belief that reflective dials are somehow more difficult to delineate than their equivalent planar sundials.

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KING'S COLLEGE CHAPEL SUNDIAL, ABERDEEN

JOHN S. REID

The records of the British Sundial Society suggest that the South facing wall dial on King's College Chapel, University of Aberdeen, may be the oldest in the country[1]. The chapel has just celebrated its 500th Anniversary with the publication of a historical volume[2] covering its architecture, fittings and role as a religious building both before and after the Reformation. The chapel is well known to have survived all the worst excesses of Reformation, of civil war and of Victorian restoration zeal. The imperial crown tower is one of only a few in Britain. Within, there is a fine example of medieval carved choir stalls, the most complete set in Scotland. On the South wall, high above the College quadrangle, the dial sits, set in the widest of the granite buttress that combine ornament with function. What could be more natural than the supposition that the dial has been there from the beginning? King's College was founded in 1495 and the building of the chapel begun in earnest in 1500. Lower down the buttress holding the dial is an armorial plaque to James IV, King of Scots, whose support at the foundation is recognised in the College's title.

Unfortunately, historical circumstances strongly suggest that the King's dial is not as old as the building itself. It would be quite extraordinary if it were. The description to be given shortly shows the dial as a plain South facing wall dial, with sloping gnomon. It is divided on the equal hour principle that was introduced in response to the mechanisation of public time brought in by the introduction of tower clocks in the thirteenth and fourteenth centuries. The earliest book in English describing such a dial[3] was published almost 100 years after the foundation of King's College. Later editions are in the College library[4]. This in itself does not preclude the dial dating to around 1500, plus a few years, because the College had strong European connections in its early years. However, the early College had no need of a functional wall dial because the mechanisation of time had reached King's from the very first. An early inventory describes the College clock as *horologium magnum ferreum, cum malleo ferreo ad horas signandas pondens,* a large ironwork clock that struck the hours. No sundial is mentioned in this apparently comprehensive inventory of fixtures and College property.

It is true that absence of proof is not proof of absence but the College's archival records continue to be shed no light on the dial until the first glimmer in 1700 AD, when reference is made to *colouring the King's arms and dyall,* £12. It would be deeply satisfying if a clue here and another there could be put together so that by the end of the story we knew who had erected the dial, when and for what purpose. Unfortunately, although evidence has been sought for several years this is one real life piece of detection that has not worked out as well as any piece of fictional mystery. Let me cut to the facts that are known. The complete granite South wall with buttressing was erected in the 1770s following a fire in the adjacent library and sacristry, a building that 'lent-to' against the South chapel wall. This lean-to structure was cleared away in 1773 and the visible South wall erected as granite cladding over the existing sandstone chapel wall. Ornamental armorial plaques cut in sandstone that had adorned the previous lean-to structure and early buildings were re-erected on the new buttresses. No records describing this building work have been found but it is highly likely that the sundial was put in its present place at this time, when the buttressing was erected. 19th century drawings of the quadrangle show the dial.

The largest of these armorial plaques is the commemoration of James IV, mentioned above. The heraldic detail on this plaque is not particularly accurate, and circumstantial evidence suggests[5] that it was created about 200 years after the foundation, in the late 1600s. Such a date is also quite possible for the dial, which accompanies it on the same buttress, but their association may be a matter of chance. P.J.Anderson, a College historian of high repute and an indefatigable nineteenth-century College librarian, records that the plaque was originally erected above the West facing outer gate of the College. Although another maintenance record of 1748 refers to *mending and fixing the Dial plate*, no unambiguous record has been found that associates the sundial with the chapel prior its present 18th century location. Another apparently detailed survey describing the College architecture in 1725 by William Orem[6] fails to mention the dial. Does the object itself provide any clues?

DESCRIPTION

King's dial sits 9.5 metres above a low terrace on the North side of the College quadrangle. From the ground, the dial appears as dark as the metallic dial on Aberdeen townhouse, originally erected in 1730, with its fine gold-painted lines. However, a close examination (Fig. 1) shows that the King's dial is a square sandstone slab, 0.6 metres (2 feet) on each side, embedded into the buttress. The original lines on it are carved channels in the sandstone, now heavily weathered in places but made visible by gold lines overpainted on a dark background. The dark background

Fig.1. The King's College Chapel Dial

has been lightened by what is now a patchy coat of gunmetal grey, presumably added to give the shadow greater visibility but from the ground looking like metallic corrosion. Within the accuracy that they can be measured, the hour lines are correct for a South facing dial at the latitude of the College (just over 57° N). The pierced gnomon (Fig. 2), which is clearly a comparatively modern replacement of thin sheet metal, is corroded and cut at an angle of 29.5° instead of 33°. Given the distance that the observer is from the dial, this inaccuracy is not likely to be noticed. The line of buttresses is inclined 5° East of South, another minor departure from the ideal that will not make a significant difference to the observed shadow seen from the ground.

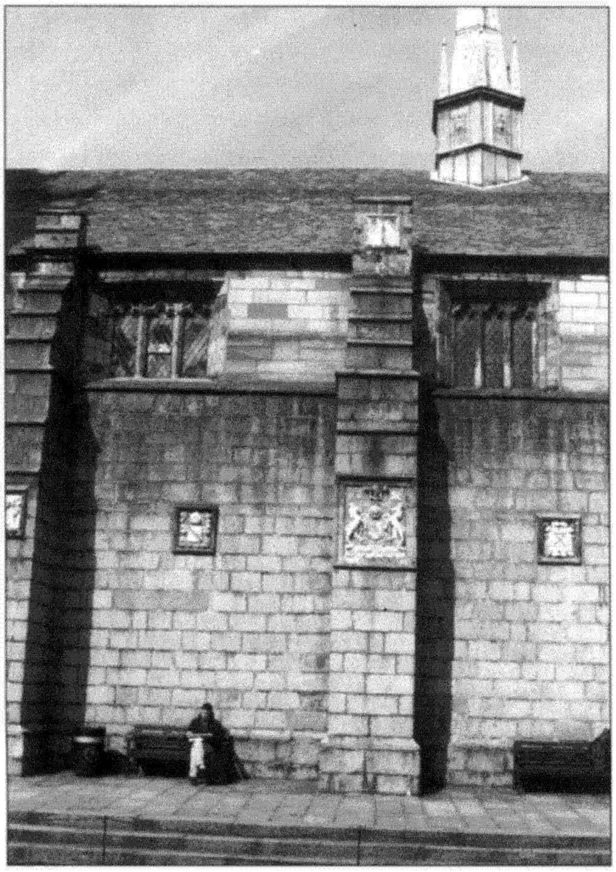

Fig.2. Part of the south wall of the chapel showing the dial at the top of the wide buttress

CONCLUSIONS

The simplicity of the dial is reminiscent of the earliest dated vertical dials in Aberdeen, a pair of small declining dials that are cut into the projecting sandstone gables of 22-24 Upper Kirkgate, inscribed 1694. The weathering on the King's dial is consistent with a late 17 century origin, as are the circumstantial archival records. However, the evidence is not strong enough to gain a conviction in a court of law. I believe it is almost certain the dial has been in its present location for the past 225 years. It is likely that it pre-existed the buttresses and, as with some of the other buttress ornamentation, may well have been carved in the second half of the 17th century. It is most unlikely that it dates from the foundation of the College, whose stone and mortar date from the very early 16th century.

The chapel dial has no motto and no religious significance in the context of the chapel. It should be enjoyed for what it is, an architectural ornament in a historic setting.

NOTES AND REFERENCES

1. The Society's record follows the description in D. MacGibbon and T. Ross *The Castellated and Domestic Architecture of Scotland from the Twelfth to Eighteenth Century* [Edinburgh, 1887 - 1892] vol V, p 358. This description includes major errors.
2. Jane Geddes: "*King's College Chapel, Aberdeen, 1500 - 2000*" [Northern University Press, Leeds, 2000].
3. Thomas Fale: *Horologiographia: the art of dialling* [Thomas Orwin, London, 1593].
4. King's College library have editions of 1626 and 1627.
5. Charles J. Burnett: "The Later Armorials", chapter 21 in Jane Geddes (op. cit.) .
6. William Orem: "*A description of the Chanonry of Old Aberdeen, in the years 1724 -1725, by William Orem, Town Clerk of Old Aberdeen*" [J. Chalmers, Aberdeen, 1791) and later re-publishers.

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WHAT'S THE ANGLE?

A. CAPON

As for many other BSS members, part of my interest in sundials involves searching out and photographing fixed dials. A mildly addictive but very satisfying activity, it often results in my standing beneath a vertical dial, camera in hand, casting about for the best place from which to take a picture. On many occasions of course there is little choice and one is forced to take a picture from a less than ideal angle due to restricted space or access. Even in locations where no such restrictions exist I am somewhat ashamed to admit that I have been unscientific enough simply to trust to instinct in identifying the spot from which to get the best angle. Imagine my delight therefore when I recently stumbled across a mathematical method of determining the optimum position from which to view a vertical dial.

In 1471 Regiomontanus posed the problem, 'At what point on the earth's surface does a perpendicularly suspended rod appear largest?' (The name of Regiomontanus will need little introduction to most members. Born in Königsberg in 1436 as plain Johannes Muller, Regiomontanus was his Latin name, derived from the name of the town of his birth, meaning, 'Man of the King's mountain'. He was an astronomer and diallist, and he died in Rome in 1476.)

To make its meaning clearer his problem is more usually posed in the form. 'From what distance will a statue on a plinth appear largest to the eye?' For diallists, simply read 'dial' for statue and 'wall' for plinth.

Looking at Fig. 1 it is clear that if one stands too close to the wall the dial is viewed at a steep angle and appears foreshortened, whereas if one stands too far away the angle is shallower but the dial is now very distant. Where is the best place to stand?

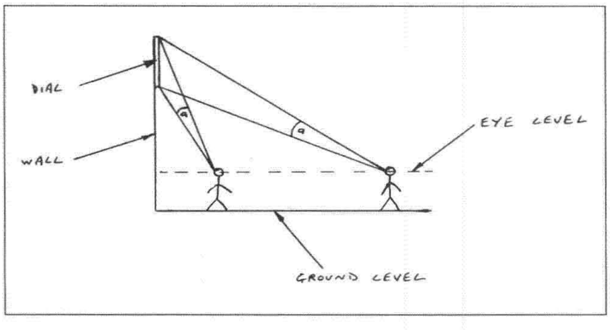

Fig.1 Wrong positions

Looking now at Fig.2:

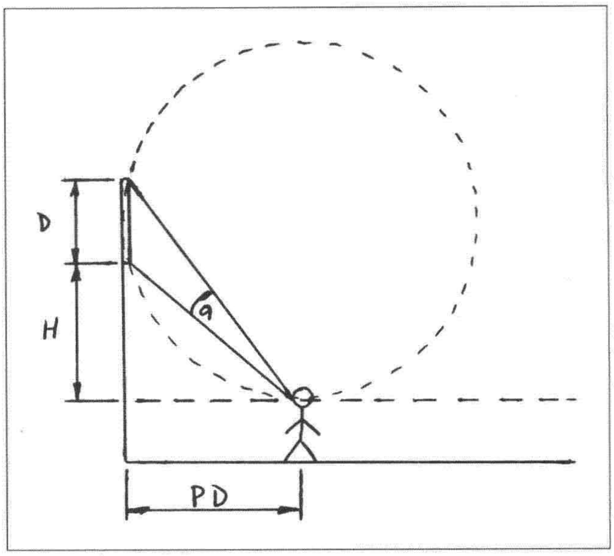

Fig.2 A good position

D = Vertical dimension of dial

H = Height above eye level

a = Apparent angular size of dial

$PD = \sqrt{D*H+H2}$ (Optimum viewing distance)

This is the answer to our question. To see the dial so that it appears at its largest to the eye the photographer should stand 'PD' distant from the wall. Interestingly, this point is where the line of the photographer's eye level is a tangent to the circle which passes through the top and bottom of the dial. (The dial is assumed to have negligible thickness which is exaggerated here for clarity).

As well as being of use to observers of sundials and statues, this is also the solution for the rugby player who needs to decide from where to kick a conversion (here the eye level becomes the line from which the kick must be taken, and 'D' is the distance between the goalposts).

Does this mean that we sundial photographers, (and presumably rugby coaches). will need to pack calculators before we set out? Happily I think the answer is no, there is an easier way.

Fig. 3 is a simple nomogram which you may find helpful. After estimating 'D' (the vertical dimension of the dial) and 'H' (the height of the base of the dial above eye level) lay a

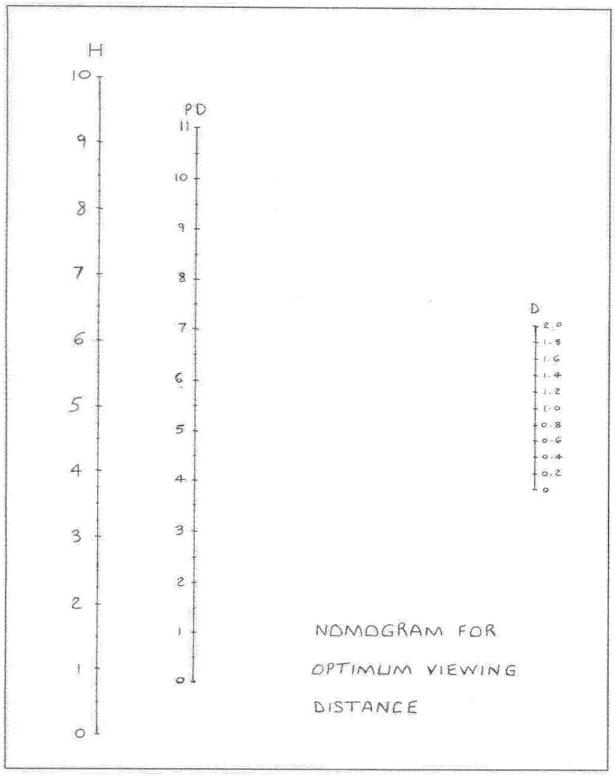

Fig.3 Nomogram

straight edge across the scales intersecting the 'D' and 'H' scales at your estimated figures.

Where it cuts the 'PD' scale is the optimum distance from the wall, which can then be paced out. (This procedure will work for any units but I had metres in mind when I numbered the scales.)

Whether following this procedure will increase your enjoyment of sundials or result in better photographs only time will tell, but at least you may have the satisfaction of viewing your favourite dial from a mathematically 'correct' position.

Happy sundial-hunting!

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2. D. Wells *You Are a Mathematician,* 202-204. Penguin, London. 1995.
3. M. Parry, (Ed.) *Chambers Biographical Dictionary,* Chambers Harrap. Edinburgh & New York. 1997.

THE PEMBROKE COLLEGE WALL DIAL

FRANK KING

[This vertical declining sundial by Eric Parry, Architects, was the winner in the Professional Class of the 'Awards 2000' design competition of the BSS. Dr. Frank King was chiefly responsible for the design; he describes, in an article published below in slightly shortened form, the problems and pleasures associated with the design and making of this dial. –Ed.]

The Pembroke College Wall Dial has already become a Cambridge landmark. Cut into a smooth limestone wall above a pair of first-floor windows adjacent to Tennis Court Road, it catches the eye even on a dull day. The aesthetic aspects of the design are due to Lida Cardozo-Kindersley of the Cardozo-Kindersley Workshop in Cambridge. Her workshop has made many fine dials over several decades and the Pembroke dial is far from a one-off. While the aesthetic appeal of the dial is immediately obvious, many technical aspects are much less so and some are deliberately hidden. As the person responsible for most of the technical side, I offer this account in which I highlight some of the special difficulties associated with executing a very large dial, and outline the architectural and engineering steps taken to overcome them. One more name must be noted, Eric Parry, architect of the new Pembroke building. Eric readily admits to limited sundial expertise but he made a number of important decisions. Crucially, he decided that the building should have a sundial and that he should seek professional advice. If only more architects were like this! He also entered the finished dial for the BSS award, which is why 'Eric Parry, Architects' is properly recorded as the name of the winner.

DESIGN CONSTRAINTS AND COMMENTS

1. The dial had to be cut into the wall of a new Cambridge building, latitude a little over 52° north and the wall declining roughly 14° east of due south.
2. The area of wall designated for the sundial measured roughly 7m by 3m.

3. The wall was made of coarse-grained limestone which, though dressed, is slightly rough to the touch.
4. The sundial must require little or no maintenance.
5. The most obvious viewpoint would be from the pavement in Tennis Court Road, so that the dial is decidedly to the left of the observer rather than straight ahead.
6. The sundial must have an educational role

The large size of the intended dial, the coarse surface of the stone (which incorporates natural flaws in the form of pits up to 5mm deep), and the low-maintenance requirement, dictated that the hour lines and other dial markings should be deep V-cuts which would not be painted or gilded. In sunlight, the shadow cast by one edge of a V-cut into the cut itself contrasts strongly with the brightness of the surrounding stone. The sundial as a whole comes to life when the sun shines. To accommodate the deep V-cuts, Eric specified that the stone blocks in this part of the building should be 150mm thick rather than 75mm, the thickness elsewhere in the building. Standing at the most convenient viewpoint, the dial is on the observer's left and it declines to the east. This turns out to be a happy coincidence which Lida took advantage of by arranging for the gnomon and 12 noon hour line to be well to the right (east) of the centre of the 7m width of the dial as a whole.

This brings the gnomon closer to the observer, which eases readability and gives extra space for the morning hour lines of which there is a natural preponderance on an east-declining dial. Here is a nice example of deliberate asymmetry leading to a balanced design. In a Cambridge context, seeking an educational role for a sundial needs no justification. We wanted a sundial which the uninitiated would find easy to read and understand. To eliminate extraneous shadows, there would be a free-standing rod-gnomon without visible structural support. A rod-gnomon has two particular merits: the hour lines radiate from a single point on the dial and it is the centre of the shadow which has to be estimated when reading the time rather than a fuzzy edge.

We also wanted the nodus to be immediately obvious and not appear as an almost invisible notch or blob, especially in a photograph. An uncluttered design was needed but with sufficient features to allow a first lesson on gnomonics. In consequence, no subdivisions of hours are shown, just hour lines alone, and here it is worth noting another happy coincidence. In Cambridge, most lectures are given in the mornings and run from five minutes after an hour to five minutes before the following hour. There is a hectic rush in the ten minutes between lectures and a good many science students cycle past the sundial almost exactly on the hours of 9, 10, 11, 12 and 1, the central range of hours on this east-decliner!

Even cycling at high speed, it is easy to see whether sundial time is ahead of or behind clock time and, over a year, gain a feeling for the equation of time. To reinforce this understanding, a graphical representation of the equation of time is cut into a separate stone panel below the main dial.

EARLY DESIGN WORK

A mathematical model was made to simulate the motion of the shadow during the course of a day for any given declination of the sun. It was at this stage that the principal features of the dial were decided:

1. The hour lines would run from 6 am to 4 pm.
2. There would be a horizon line, an equinoctial line and winter and summer solstice lines.
3. There would be a rod-gnomon 30 mm in diameter whose visible part would be about 1900mm long.
4. The nodus would be a spherical ball 100mm in diameter, mounted on the gnomon with its centre a distance of 800mm from the root of the gnomon.

The model showed that around midday at the time of the winter solstice, when the shadow of the gnomon is at its shortest, the shadow extends about half-way down the dial. It would not be sensible for the gnomon to be much shorter but if it were much longer it would be unwieldy.

GNOMON DESIGN AND MOUNTING DETAILS

Perhaps the most important work undertaken before the wall was built was the design of the gnomon. Realising a free-standing gnomon required substantial engineering and architectural ingenuity. As well as being straight and stiff the gnomon had to be adjustable but there was to be no visible mounting. Jane Wernick of Ove Arup designed a mounting plate which was to be fixed to the inner concrete leaf of the cavity wall. Only the outer leaf, on which the dial face was later cut, is limestone.

In outline, the arrangement of the gnomon and its mounting plate is shown in Fig. 1. The plate is attached to the concrete by four screwed rods (not shown) which pass through the four slotted holes (which are shown). The gnomon, fittings and nodus were all fabricated from stainless steel to Jane's design by B & H (Derby) Ltd. The design even ensured that the gnomon had a natural frequency of vibration which would not coincide with the frequencies generated by turbulence in high winds. The large gap in the outer leaf shown in Fig. 1 indicates where a limestone block would be left out until the dial had been completed. The overall arrangement means that the mounting assembly is entirely out of sight in the finished sundial and that the heavy gnomon is firmly attached to a substantial slab of concrete.

The writer then describes the problem of differential thermal expansion between the inner and outer leaves of the wall. The problem was overcome by the addition of a lintel, supporting just the upper parts of the stone outer and the concrete inner leaf. He continues:

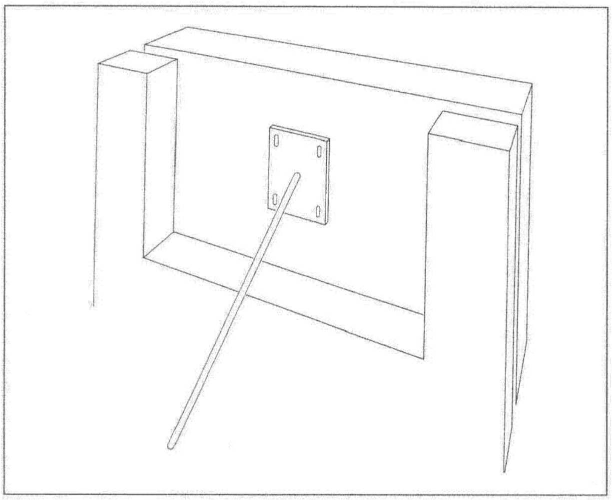


Fig.1. Base-plate for gnomon, on inner wall-leaf

The gnomon is not directly welded to the mounting plate. It is threaded and screws into a slightly wider-bore stainless steel tube which is welded to the mounting plate. This arrangement was to allow the gnomon to be removed when the lines on the dial were being cut.

An important point, marked *0* in Fig.2, is where the centre-line of the gnomon coincides with the plane of the wall. All the hour lines radiate from point *0* which is the origin of the co-ordinate system used for marking out the dial.

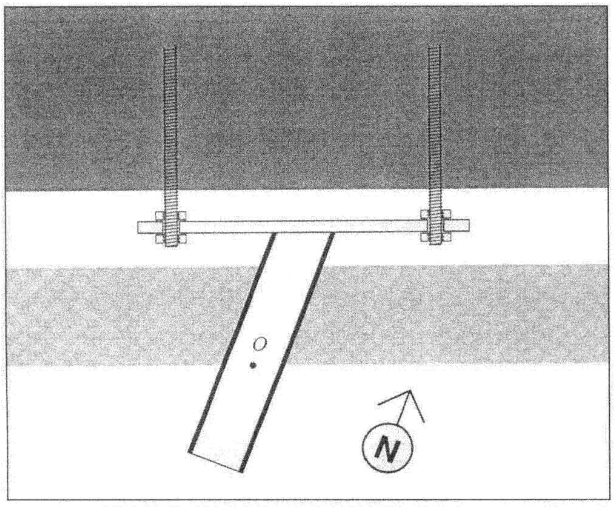


Fig.2. Base of gnomon seen from above

The plan was for the orientation of the gnomon to be adjusted by appropriately screwing in one side of the plate further than the other and by screwing the top of the plate in further than or less than the bottom. Unfortunately, each such adjustment would shift the position of point *0* but this turned out to be only a minor irritation!

SURVEYING THE WALL

Only when the building had reached its full height was it possible to start work on site. For a simple academic, working on a building site was quite a culture shock. Half a dozen different trades were active: electricians, plumbers, plasterers, joiners and so on. The vocabulary was decidedly colourful and decades of political correctness seem not to have extinguished the wolf-whistle!

In the context of the sundial, the most important trade was scaffolding. Given that the dial face was to be about 3m high, I had asked for two platforms, one for the main part of the dial and the other for access to the gnomon mounting assembly. It was important to have these platforms fairly stiff so that fixed reference points could be established from which measurements could be made.

The scaffolders had duly doubled up on the number of vertical poles and the structure was nice and firm. At this stage, the only evidence of an embryonic sundial was the missing stone block and four screwed rods protruding from the concrete inner leaf.

Although there was no gnomon, there was a plethora of shadows from the scaffolding poles and I was quickly in for a shock. It didn't take long to work out that the gnomon and 12 noon hour line were going to be in the same meridian plane as one of the structurally important vertical poles. Understandably, the chief scaffolder was reluctant to move it. He couldn't believe that a pole that was over five feet from the wall could possibly be in my way. When I explained that it was really in the way of the sun rather than me he was even more doubtful; the sky had by then clouded over. I attempted a fuller explanation, pointing out that it was around 1 o'clock (BST) that I would be particularly inconvenienced. He countered this by suggesting that I should take my lunch break at 1 o'clock!

The first serious task on site was to survey the wall and, most urgently, establish its declination reasonably accurately. Like navigation, surveying is a topic that interests many sundial enthusiasts and in recent years survey technology has advanced rapidly.

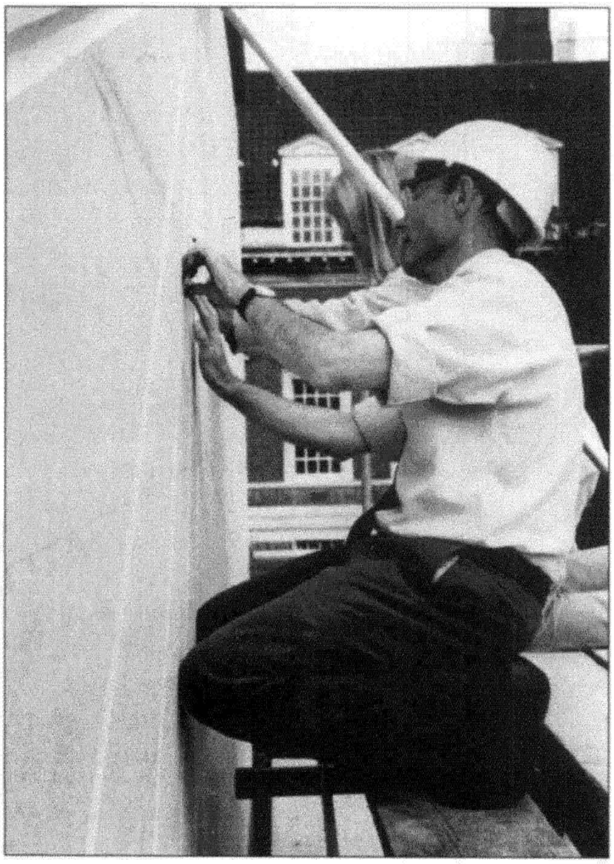
A specialist company, A & B Surveys, was engaged to survey the wall and they made use of the Global Positioning Satellite (GPS) system. By using differential

GPS, A & B Surveys claimed an accuracy of ±3 seconds of arc in both latitude and declination of wall. None of the more traditional techniques available to me gave any reason to doubt the figures supplied by A & B Surveys and their results were duly taken as gospel. For the purposes of the mathematical model I could now make some reasonable assumptions:

1. The surface of the stone wall is a true plane.
2. This true plane is perfectly vertical.
3. The wall is at latitude 52° 12' 6" N
4. The azimuth of the normal to the wall is 158° 38' 2" (clockwise relative to true north).
5. The centre of the nodus coincides with a point on the centre-line of the gnomon which is 800mm from the point where the centre-line of the gnomon coincides with the plane of the wall.

The writer then describes how these assumptions were checked, and mentions the limitations in the use of ordinary surveying equipment: a straight-edge, a spirit level, and, later, a steel tape measure.

The gnomon was then fitted. He continues:



The Author at work on the Pembroke Sundial

GNOMON ADJUSTMENT - AZIMUTH

With reliable values for the latitude and declination of the wall, the angles corresponding to the sub-style distance and sub-style height could readily be calculated. Fitting the gnomon over the four screwed–rods and securing it with the eight nuts was a five-minute job. Making fine adjustments to the orientation took about five weeks! With a free-standing gnomon, there is no prospect of setting out the sub-style and mounting the gnomon on that. I preferred to think of the orientation of the gnomon as having two components: azimuth and dip. The azimuth is simply the bearing relative to true north. The dip is the angle to the horizontal and this should be the same as the latitude.

I proposed a two-stage process: get the azimuth right and then get the dip right. Setting the azimuth ought to have been easy. I imagined checking the shadow during the half hour leading up to local sun noon and tweaking the nuts on the mounting plate to advance or retard the shadow as necessary. If the shadow were truly vertical at noon then the gnomon would be in the meridian plane. It would have the correct azimuth even if the dip were wildly wrong. This approach was eventually successful. (The chief difficulty was the seemingly simple matter of drawing an accurate vertical line on the wall.)

To set the azimuth of the gnomon, it was expedient to draw short lengths of time lines at two-minute intervals from 11:30 to 12 noon. The intention was to observe the shadow at 11:30 and seeing (say) that it was a little slow, climb up the scaffolding and adjust the nuts so as to advance the shadow, and then get in position to check the shadow at 11:32. This procedure took most of the two minutes available and could be repeated up to 15 times before the crucial 12 noon observation.

Calculating the angles of time-lines by computer is a simple task compared with actually marking them out. Protractors suitable for a 7m by 3m dial are not readily available! There was no question of marking angles; instead each angle was translated into a left or right off-set along a horizontal baseline drawn 2m below point *0*. Once the technique had been perfected, setting the azimuth really was straightforward. The task of setting the dip was altogether more tedious.

GNOMON ADJUSTMENT - DIP

To set the dip, I proposed recording the position of the shadow at various widely separated times and, for each time, comparing the recorded position of the shadow with where it ought to have been.......The main difficulty did not lie so much in the trigonometry as in the seemingly simple matter of deciding where the shadow was at a given time. .

The writer explains in detail the difficulties of setting the dip of the gnomon and how they were overcome

After considerable persistence, the dip was set satisfactorily. The point of intersection of the shadow and the 2m base-line was recorded many times over several days and the data were subjected to a good deal of error analysis. The analysis confirmed that the principal errors were in reading the position of the shadow rather than in gnomon orientation.

MARKING OUT THE HOUR LINES

Eleven hour lines were to be cut, and all except the first and last extend downwards below the 2m base-line. A second base-line, 1m below point *0*, was drawn for the hour lines which did not reach the 2m line. After translating angles into off-sets along the base-lines, ticks were made on the base-lines for each hour line that was to be cut.

Given that the gnomon was now accurately orientated, it could itself be used as an aid to marking out. First, a length of string was tied round the gnomon near its root and, for a typical hour line, the string was stretched across the tick marks on both the 1m and 2m base-lines. For most hour lines this procedure was carried out at the local sun time in question to verify that the centre-line of the shadow intersected the base-lines at the ticks and to ensure that the string lay along the same centre-line and was not radiating from a false origin. Only the 6 am hour line wasn't checked in this way. A couple of early-morning site visits confirmed that neighbouring buildings prevent the sun ever reaching the dial at that hour. With the help of a straight-edge it was easy to draw the centre line of each hour line. The V-cuts were to be 30mm wide, so flanking lines 15mm either side of the centre line had to be drawn.

Taking care not to disturb the mounting assembly, the gnomon was unscrewed and removed during the cutting of the hour lines and numbers. For a couple of weeks the dial was in the hands of Lida Cardozo-Kindersley who marked out the elegant numbers at the ends of the hour lines and embarked on the stone-cutting. Large Arabic numerals were used: large because they had to be read at some distance and because of the coarse grain of the stone, and Arabic simply because Roman numerals would not look right on this modern building.

OTHER DIAL FURNITURE

After the hour lines and numbers had been cut, the gnomon was screwed back in place and secured with grub-screws, never to be taken off again. The vertical reference line and 1m and 2m base-lines were redrawn ready for the next part of the work, marking out the constant declination lines.

Using another spreadsheet, each curve (solstices and equinox) was tabulated as a set of X-Y points with *0* as the origin of the co-ordinate system. It was then fairly straightforward to mark off abscissae (X-values) along the two base-lines and, for each tabulated point, drop an ordinate (Y-value) down from the upper base-line towards the lower. Of course, not all points lay between the base-lines and occasional extrapolation was necessary. As a trial run, a constant-declination curve was tabulated and plotted for a date in late July, a couple of days ahead of the actual date. The calculations assumed that the centre of the nodus was 800mm out from the root of the gnomon, point *0*. It is quite hard to measure this 800mm because both centres are inaccessible. On the day itself, the nodus was first shifted slightly so that its shadow fell on the early part of the curve. For the rest of the day, the shadow of the nodus obligingly followed the plotted points beautifully. After the pain of orientating the gnomon, it was rewarding to get such a good result with very little effort.

The summer solstice curve was the first proper curve to be marked out as a sequence of (scores of) points. A long strip of flexible wood was then offered up to these points (five people were needed for this task) and a smooth pencil line was drawn through them. Flanking lines for the stone-cutters were then drawn 15mm either side of the centre-line. The winter solstice line was marked out likewise but, since the points on this line all lay above the 1m base-line, a third base-line was drawn at 0.75m.The equinoctial line was also marked out in a similar way but, being a straight line, only two points are needed to specify it. (In practice, four points were marked). As an aid to marking out, the position of the sub-style was drawn (as though it were another time line) and checks were made to verify that the equinoctial line was perpendicular to the sub-style. This was almost the only use made of the sub-style, though secondary checks were also made to verify that the two solstice curves intersected the sub-style at right-angles. The best estimate is that the slope of the equinoctial line is within one minute of arc of its computed slope of 15.78° to the horizontal.

The intersection of the equinoctial line and the 6 am hour line determines the horizontal level of the horizon line and this line was duly marked out horizontally through that point of intersection. The horizon line is 20mm wide, a little thinner than the hour lines and the constant declination lines, and is subtly ornamented...

The 11 hour lines are all taken from the outside edge of the rectangular frame of the dial to points above the horizon line (but they stop well short of the root of the gnomon). The hour lines take priority, and the horizon line is interrupted wherever a time line runs through it.

SUNRISE AND SUNSET

The triple point where the horizon line, the 6 am hour line and the equinoctial line meet indicates that 6 am is the time of sunrise at an equinox. The winter solstice line begins and ends on the horizon line and, by noting the secondary markings, it is easy to see that, in Cambridge, the time of sunrise at the winter solstice is roughly 8:15 am and the time of sunset is roughly 3:45pm.

Too much should not be made of this sundial as a sunrise/sunset indicator. Clearly the time of sunrise can be estimated only in the winter months (roughly the period between the autumnal equinox and the following vernal equinox) and the time of sunset can be estimated only close to the winter solstice.

Nevertheless, thinking of the educational rôle of the sundial, there are sufficient markings for a lecturer to introduce more ambitious possibilities for estimating the times of sunrise and sunset.

FINISHING

It proved unnecessary to remove the gnomon and nodus to cut the remaining dial furniture but, after the cutting had been completed, there were still three outstanding tasks. First, the mounting assembly was sealed in resin so that there was no possibility of nuts loosening over the years. Secondly, the missing stone was replaced. This involved cutting out a slot so that the stone could be placed over the gnomon and then filling the slot below the gnomon with a small piece of specially cut stone. Finally, some flexible grouting was injected into the annular space between the gnomon and the stone.

THE AT&T WEB PAGE

Not long after the dial was finished, the neighbouring AT&T Research Laboratory took an interest. They have an attic room from which there is a good view of the new Pembroke Building and they decided to point a digital camera at the dial.

Using advanced image~processing techniques they can detect the shadow of the gnomon when it is visible. Moreover, knowing the geometry of their viewpoint relative to the sundial, they can compute the local sun time as indicated on the dial.

By allowing for the equation of time and the longitude east of Greenwich they can then estimate GMT. Since all this happens automatically, and they update their image at frequent intervals, there has been substantial post~installation monitoring.

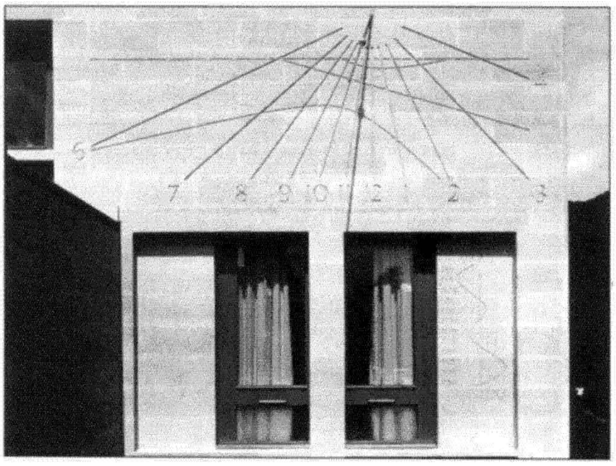
AT&T claim that the sundial is always correct to within two minutes. This, of course, is the system end-to-end accuracy. There are a number of errors inherent in the image-enhancement software and in the software associated with the edge detection of the shadow of the gnomon. Occasionally the system has been known to lock onto the gnomon itself rather than its shadow!

Interested readers can look at the appropriate AT&T Web Page at:

http: //www.uk.research.att.com/sundial

THE EQUATION OF TIME PANEL

The year after the main dial was finished, a graphical representation of the equation of time was cut into a separate stone panel below the eastern end of the dial. The panel is about 3m high and 1m wide. Time-of-year runs downwards (and is indicated by the abbreviated names of the 12 months of the year from JAN to DEC) and the equation of time runs across. As a subtle way to mark the year 2000, it was felt fitting to cut a curve which as closely as possible indicates the equation of time for this year.... The curve is sufficiently precisely marked out that a future forensic archaeologist would be able to deduce that the curve relates specifically to the year 2000.



The Pembroke Sundial and the Equation of Time Panel

Dr. Frank H. King
Dept. of Computer Science
New Museums Site
Pembroke Street
Cambridge
CB2 3QG

NEWBURY 2000 - A GRAND DAY OUT

JOHN MOIR & PETER RANSOM

David Pawley once again organised a superb day for the Newbury Conference at the Mary Hare Grammar School. With help from Sally and Tony Ashmore on the desk everything was up and ready for visitors by 9.30. As people arrived they helped themselves to drinks and biscuits and occupied the exhibition tables. As always at Newbury there was a very friendly atmosphere, and in such conditions it takes quite a while to get started! One does not want to miss out on items that are being displayed, yet still wants to display one's own materials and trophies of the dialling world. Just over an hour later David approached Peter Ransom to chair the day, and with his usual aplomb handed him a list of speakers with their topics.

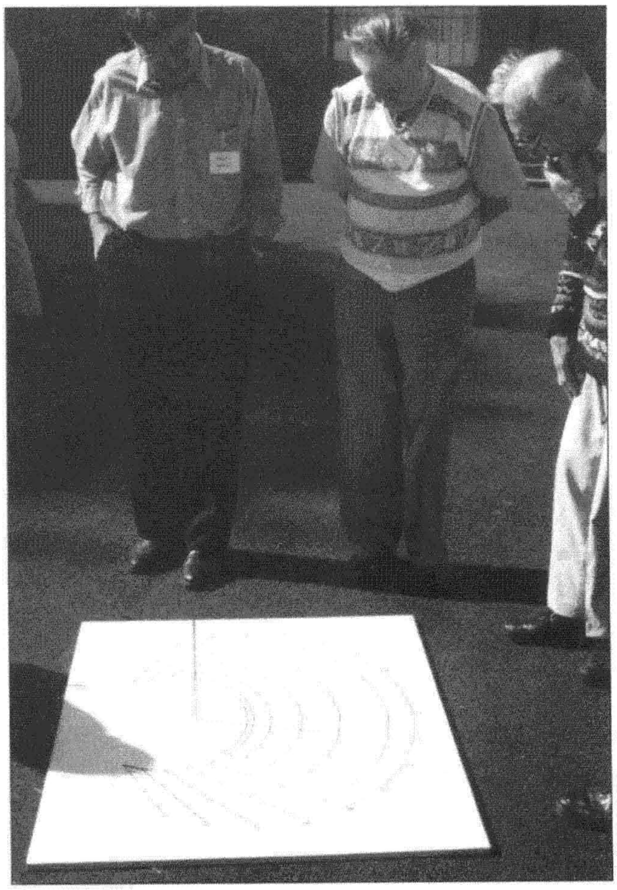
Peter brought everyone together with details of the competition running throughout the day. He had brought along all the very valuable pieces of material that he had stored in his house until his wife had threatened arson. This included things such as 30+ Pringles containers and the open lids from McFlurrys (which are very conveniently divided into 12). Margaret Stanier had also been through her glory hole to add bits such as a broken magnifying glass and fascinating bits of shaped wood and card. The aim of the competition was to fashion a working dial by the end of the day, for which there was a prize.

Today the emphasis was on garden dials. We had already seen and admired Tony Baigent's "Gregory" dial at Newbury '99 and this year we were introduced to further dials featuring Vikings, Rip Van Winkle and even an impaled Monk. Much of Tony's materials have been "liberated" from dumps, including Shove Ha'penny boards, Chubb keys and Halloween masks. His book *My Garden Dials*, etc was available at a ridiculously low *£1.50*, and that includes colour photos.

Tony Ashmore then gave a short but well explained introduction to a subject we all know but find hard to put into words- the Equation of Time. His "tour de force" was to combine the two constituent curves into one, on the flip chart, freehand, with no crib sheet to guide him!

We then had a break for lunch, which gave us the opportunity to catch up with the chat and continue viewing the exhibits. Martha Villegas had brought an excellent display of Mexican sundials on discs and photographs, but unfortunately the only version of Powerpoint available was not recent enough for us to view the work she has done in restoring dials in Mexico. At least we had the photos to see! Before the talks continued we went outside for the group photograph. This gave us the chance to see the outside exhibits. John and Barry Singleton demonstrated their helix sundial with gearing to compensate for the equation of time. They compared this to the gearing by Pilkington of Pilkington and Gibbs heliochronometer fame. A model of the gearing was also on show inside, and John and Barry seemed always to have an audience.

An analemmatic dial with fixed gnomon and family of scaled ellipses was impressive both in size and clarity. This was a large white board with a vertical gnomon, the shadow of the tip of which gives the time and month. It looked like the one described by John Singleton on page 26 of *Bulletin 98.1*.



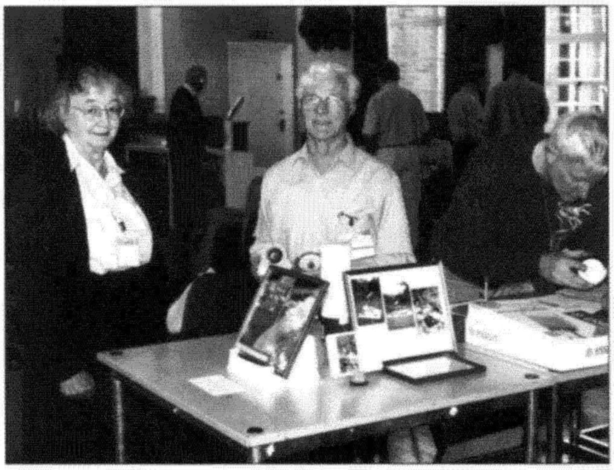
The analemmatic dial with fixed gnomon and family of scaled ellipses is examined by Colin Davis, David Young and Ian Wootton

Graham Stapleton demonstrated his Equinox Day, Hour and Azimuth Dial where the shadow of the ball on a wire gives the time and compass bearing simultaneously. He had managed to find some right-angled card, and put it to this super use.

John Moir had his rainbow dial on show. When sighted onto a rainbow a plumb line indicates the time on an altitude/date nomogram. When there is no rainbow the time can be obtained by sighting onto one's shadow. Another of his models was a bifilar dial based on F. W. Sawyer's article *Bifilar Gnomonics* in the *Bulletin 93.1,* but replacing the threads with the edges of two vertical perpendicular planes. The planes in the model were represented as fences over which two (unidentified) gentlemen were chatting. The intersection of the fence shadows gave the time on the equiangular scale. John also had on display a cycloidal dial, simulating an old unrolled manuscript, the shadow of the edge of a cycloid projecting onto equally spaced hour lines. John's dialling ingenuity is always wonderful to behold at Newbury.

Graham Stapleton, John Moir and David Young examine the bifilar model and the cycloid dial

Maurice Kenn kicked off the afternoon session and continued the garden dial theme with slides of a "Classic Art" armillary sphere that he bought through a Sunday supplement for £39.95. Inevitably he found the dial rigidly set for a non-UK latitude of 38° (plus ça change). Ever ready to accept a challenge, Maurice hacked out the "arty" part and re-positioned the fixing bolt. Needless to say his complaint to the supplier has gone unanswered. Maurice also raised the question of small clouds casting a shadow. His slide showed a clear shadow as seen from a plane, but what would it have been like to a terrestrial observer? Finally he showed two spirit levels that can be used to measure slope: very handy for measuring the gnomon angle! Maurice and Rosemary also had a display about his remedial work on the rogue dial, and a Shepherd's dial made from Andrew James' sheet that was acquired at Newbury 99 to fit a Pringles container

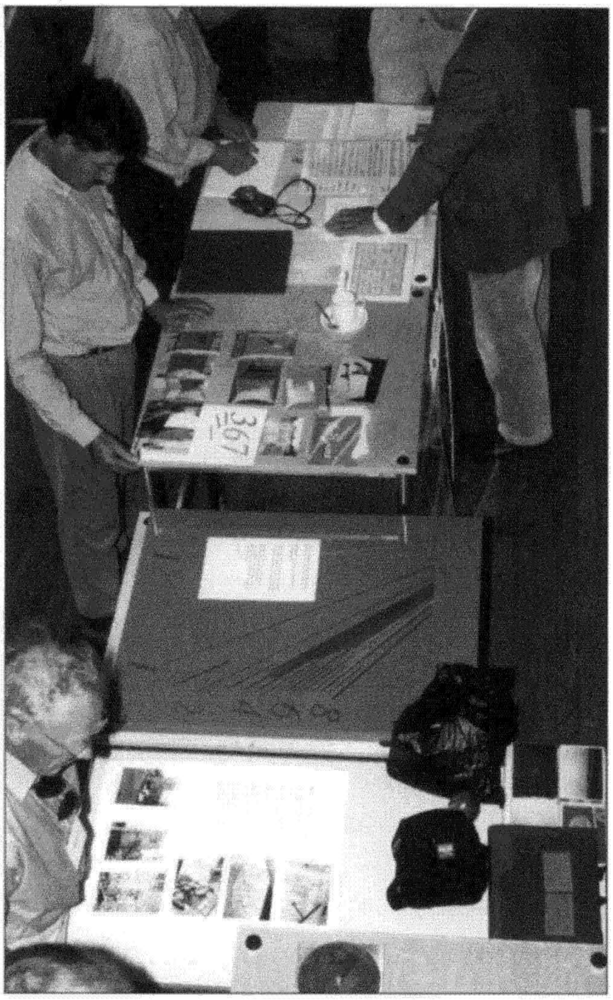


Rosemary and Maurice Kenn display their wares

There were other visual displays on show. Andrew James had a sparkling array of Dorset sundials and David Pawley demonstrated his restoration of the sundial at Cockinge Church near Wantage. Paul Rainey had an excellent 2 dimensional explanation of why the Earth's movement around the sun gives rise to the equation of time. The diagrams helped explain the part of the EOT due to the ellipticity of the orbit, and the part due to the inclination of the axis.

Michael Maltin, after a brief allusion to his recent appearance on page 3 of the *Sun,* posed a question to the meeting. Could anyone hazard a date for a horizontal dial he'd brought along? He described the barely visible vernier scale that made it accurate to the minute, but copious verdigris prevented decipherment of maker's name or date. It was suggested by some that the accurate scale would make it early rather than late in age. Those present could examine it after the talks, and it was immensely coveted. As it was too big to fit in the pocket nobody but Michael managed to take it home with them.

Some years ago Doug Bateman made a vertical declining dial for our American member Jim Holland. Due to subsequent damage Doug was asked to repair it and today he showed us the results of his work. The dial plate of blue perspex contrasts perfectly with the gnomon, hour lines and numbers in gold plated stainless steel. Fixing holes were



Members examine some of the exhibits on display

elongated to allow for expansion and a safety chain provided to arrest the drop should it be knocked from the wall. With such attention to detail the dial should last many a year. People were able to examine it closely throughout the day.

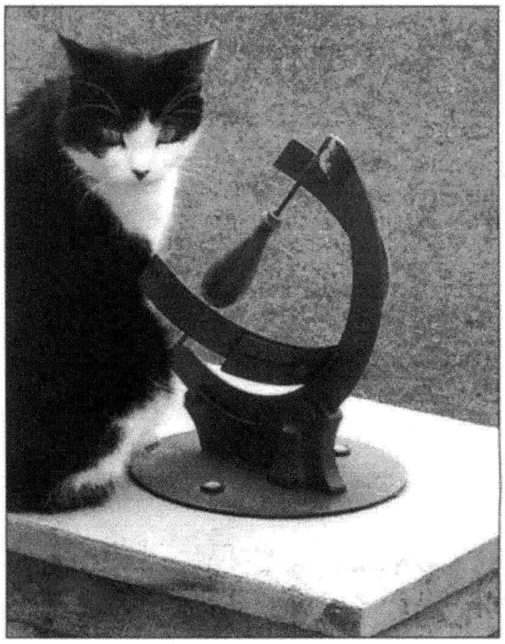
Piers Nicholson brought us back to garden dials with his prototype of a horizontal dial with a slit in the gnomon to enable very accurate alignment, working backwards from clock time. The opportunity to examine it closely was undertaken by many during the day. We look forward to seeing it on the market in the near future. He then gave an update of *Sundials on the Internet* and announced a new $100 prize competition for the best sundial trail, which he hopes we will be tempted to enter.

Next, Tony Wood reported on progress with the mass dial register. There is still a lot to be done to coordinate existing records and one question is whether to tackle the job county by county or go for straight coverage of the whole country, which would take a lot longer to complete as well as incurring considerable expense. Tony also had a selection of dials on display, including a paperweight dial that he had produced. His display was called *3 Cheap and Cheerful Dials*. These were a Spanish sundial tile, the award winning dial by Noel Stephens and his own paperweight dial based on one by Allan Mills. Many people left with one, at a bargain price due to Tony's generosity.

Peter Ransom's exhibits included a sundial biscuit tin by Crawfords, a postcard of the sundial at Conway church with reference to the sundial in the message on the back, and a sundial safari leaflet for Test Valley in Hampshire. He also had a collection of sundials on stamps that he had photographed individually and blown up to A4 size.

To end a most rewarding day, David Young took us back to the '99 eclipse with a photo which showed the familiar crescent image of the sun but also clearly demonstrated how the narrowed light source produced shadows that were much sharper in one direction than the other. As David rightly said, we all know these things happen but part of the excitement of dialling is to marvel at such phenomena at first hand. David also had details about a proposed Welsh trip (2001 - year, not price), a request for information about a dial at Perth (Scotland), the sundial formed by the Church at the top of the Mt. St. Michel and copies of the *Ancient Sundials of Ireland* for sale in the exhibition section.

The winner of the Make a Sundial competition was Tony Baigent with John Moir a close second. However all who attended were winners as the day was such a fantastic celebration of dialling. Our most grateful thanks to David Pawley for another tremendous meeting.



Buttons checks SRNO 2901 to see if it's tea-time.
(Photo: J.M. Shaw)

BOOK REVIEW

BSS SUNDIAL GLOSSARY
Editor: John Davis
British Sundial Society, 2000
Pp. 43
ISBN 0 9518404 3 6
Price (inc.p+p): £6.50 UK, £7.00 EU, £7.50 USA/world
Electronic version free at www.sundialsoc.org.uk

This publication resulted from requests during 1999 for a sundialling glossary.

I was first aware of its development through the sundialling email groups when John Davis mentioned it, and members worldwide contributed to the electronic version that can be seen at www.sundialsoc.org.uk.

The glossary provides newcomers to dialling (and oldcomers too) with a reference document that fills a much-felt gap. It also aims to produce definite meanings to the terms used by diallists, and to provide a standardised set of symbols. This it does admirably. As well as terms related to dials and dialling there are terms from related sciences.

The contents start with an alphabetical listing of the terms. There are subsections on coordinate systems, dial types, hours (types of) and time (types of). This alphabetical listing is followed by a list of symbols and abbreviations, equations, chronology, sources and credits. Finally, there are eleven appendices on the following: Signs of the Zodiac, Anglo-Saxon tides, Roman Octaval system, Canonical hours, Domifying lines, Greek and Roman Seasonal hours, Architectural and Ecclesiastical terms used in dialling, Planetary hours symbols, Magnetic variation, Astrolabe terms, and the Ordnance Survey Grid.

One of the most useful sections to me is the Sundial Equations. Here one can find the useful equations for horizontal, vertical (direct south, and declining dials) and declining-reclining dials, though it was surprising that the equations connected with analemmatic dials were not there. Then came Equations for sun's azimuth, altitude and sunrise/set with best fit equations for the equation of time and sun's declination. This section finished with equations for the sun's refraction, Babylonian, Italian, and temporal hours. (On checking the equation for the sun's refraction with Meeus Astronomical Algorithms I found a discrepancy, probably due to missing brackets.)

The diagrams are clear and informative, though some are rather small. With nearly four blank pages at the end, perhaps the diagrams could be made larger if there is another edition. I noticed 14 places where the glossary was not quite alphabetical, and a missing = sign. This suggests that the work would have benefited from another proofreader.

This is an essential work for anyone interested in dialling, and John Davis has produced a great and valuable reference work in a short time. Considering that there were contributions from the 29 named people, it is a great achievement to have produced something accepted by all these experts of the dialling world.

Peter Ransom
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THE GLOSSARY AND THE GNOMOMIC NOVICE

A. F. BAIGENT

As one of the members making the original suggestion, I was very pleased to see the publication of John Davis' B.S.S. Sundial Glossary. I feel that he has done an excellent and necessary job, which will become a very useful reference work for all of us. However, it will probably be of greatest value to the dialling novice. When I first became interested in gnomonics, no such book could be found and definitions had to be gleaned from trying to make sense of sundial articles. My interpretation often turned out to be incorrect.

It seemed sensible therefore to put the glossary to the test. I considered that a new member would probably wish to read the Bulletin with a reasonable degree of understanding, and to complete dial record forms, and perhaps to design, calculate and make a simple horizontal dial.

Having reread dial record sheets, and random articles from back numbers of the Bulletin, I noted terms which might need further explanation. These included many words with a common English usage but with specific dialling definitions.

Six 'volunteers' were selected, four of whom had no previous knowledge of sundials, and two who had shown a passing interest. The group included: a training officer, a retired chemistry teacher, a research scientist, a fire officer, a builder and businessman, and a teacher from Mauritius (whose first language is French, but who has an excellent understanding of dictionary English).

All of the 'guinea pigs' were interviewed individually for two hours and asked for their understanding of the twenty selected terms. They then read the Glossary definitions and in their own words they then explained their new understanding in relation to gnomonics.

It was significant that those with a little previous knowledge fared better than the other four. The diagrams were well used, and most of the subjects commented that more diagrams would have been helpful. Of the twenty words, all six people were able to gain some degree of understanding, with the exceptions of 'style' and 'nodus', which caused considerable confusion. A very common, and oft repeated, answer was "I thought I understood when I read the first sentence, but wasn't so sure after reading the full explanation" (particularly 'Gnomon' and 'L.A.T.'). The Mauritian lady was able to cope as well as the others and, in the case of 'Azimuth', she was at a distinct advantage, due to a local French saying.
The diagram of the horizontal sundial was frequently referred to, and it is obvious that it would be an advantage if this and other diagrams could be printed on flaps at the front and back of the Glossary. This would enable them to be seen irrespective of the page being consulted, as one diagram assists in the explanation of several different terms.

I appreciate that it is not possible to draw firm conclusions from such a small sample but, to be fair to the Glossary, it is unlikely that someone with no previous dialling knowledge would suddenly decide to join the B.S.S. Most new members would be at least in the 'passing interest' phase and, in my study, these coped relatively well. All six volunteers did much better than I had anticipated and would probably have been more successful had I thought originally to be more realistic by including the words in a paragraph on sundials.

From my own perspective, and with hindsight, I would like to see a few more tables added to the appendix, as in Albert Waugh's 'Sundials': for example Equation of time, Declination of the sun; and, of course, additional diagrams, perhaps Declination of a wall, Altitude, Time zones, The Earth with tropics. However, nothing is perfect and I feel we owe a big debt of gratitude to John Davis for all his hard work. Thank you, John!

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NOTE FROM EDITOR
Mr. Baigent sent some information about his subjects. ‘Different backgrounds helped. One person had an old-fashioned Station Master for a father—with a pocket watch to check the trains. He therefore knew about Railway Time, L.A.T., L.M.T ,G.MT. etc Another had a father who did a lot of sailing and had made his own sextant. He knew about altitude and navigation terms. A third was interested in architecture and was keen to study Appendix VII, whilst the Mauritian lady searched her memory for Greek, Latin or French derivatives of the terms’.

The words selected from the Glossary for testing on the subjects were:Altitude, Azimuth, Centre(of dial), Declination(of wall), Dial Plate, Equation of Time, Furniture, Gnomon, Hour Angle, Hour Line Angle, Local Apparent Time, Longitude Correction, Nodus, Noon, Noon Gap, Prime Meridian, Resolution, Style, Transit(of sun), Tropics.

JOURNAL REVIEW

COMPENDIUM, JOURNAL OF NASS. VOL, 7 NO.1
This issue is preoccupied with the practical and mathematical challenges of reinstalling sundials which have been designed for a given latitude and which may have been delineated to include a longitude correction so that they will then function correctly when transplanted to an entirely different location. Bill Gottesman describes a practical method of adjusting a Horizontal Dial, originally from another latitude, to read Standard Time. The tilting of the dial plate to adjust the gnomon angle is achieved by a very precise system of three screws that replace the more conventional wedge. Less familiar to UK dialists is the rotation about the style edge which is necessary to persuade the sundial to behave is if it was located at the longitude of the time zone meridian rather than its installation longitude. This is achieved by further adjustment of the screws. The

careful article is well illustrated with clear diagrams and enough mathematical formula to justify the method.

Fred Sawyer gives a full answer to his Quiz on Nicole's Wedge that considers a similar problem. A horizontal dial designed for one Time Zone meridian is to be moved to a new latitude and installed several degrees off another Time Zone meridian where, in addition, it is required to indicate Daylight Saving Time within the range of the Equation of Time variation. Here the preferred solution is a wedge which provides the combination of geometry necessary to place the style in the meridian, whilst leaving the physical dial plate and its gnomon in a rather unnatural (but correct) position. Unfortunately the author has taken a large stride from the wedgeless option of the dial in space to introduce the complex wedge so that the novice is left frowning for a while in search of a (missing) diagram which would greatly assist this mental move. The mathematics that follows defines the geometry of the wedge and dial placement upon it. The digital version of the Compendium includes a small program to calculate the angles for any major relocation.

This transplant theme is continued by J Vinck. Several equations are stated derived from spherical trigonometry which would have been easier to reconcile if there had been more supporting diagrams. Spherical trigonometry is always very difficult to illustrate unambiguously in a single plane and I am sure that novices would appreciate more detail in the construction of the diagrams.

These mathematical analytic exercises are both educational and good fun, founded as they are on the basic astronomy but I can only wonder if such transplanted sundials can ever be aesthetically pleasing, especially to those who feel more comfortable when their sundials simply show local solar time.

Mac Oglesby describes three shadow plane dial models as a footnote to a two-part article, of which he was a co-author; these were described in some mathematical detail in the two previous issues of Compendium. Two of these models are quite beautiful and, as Mac suggests, may one day be scaled up to a civic monumental size.

Such large civic sundials are described by Reinhold Kriegler in an account of his visit to Japan in 1999, where he found a recent enthusiasm for the erection of large public sundials. At Keihanna he was shown at huge horizontal sundial with a gnomon 35 m. long with an elevation of 20 m., designed by a Tokyo architect, Mr. Minohara. The author describes how he was comfortable, against expectations, in the presence of such a daunting structure which, well sited, indicates local solar time for three Japanese cities. At Shinkansen there is a excellent human scale equatorial dial, called the Citizen Dial, with analemmae on each of the hour lines, and, amazingly, at ten minute intervals, within each hour as well! At Minami-mura a new conference centre has been designed with a flat roof to receive the shadow of an enormous 37m. long gnomon. So huge is the building that to read the dial you must first climb a nearby hill to look down on the roof, or, if short of local solar time, then hire a helicopter, as the photographer did to provide the front cover picture for the Compendium.

COMPENDIUM JOURNAL OF NASS, VOL. 7 NO. 2

The Sundial Mailing List, established and maintained by Daniel Roth, (University of Cologne) is one of the most important developments in the renaissance of Gnomonics. By this means the great wealth of individual dialling knowledge is developed and shared internationally and very quickly. It is a forum for every dialist, from novices to experts, to ask or listen, a place of debate and impulsive invention, of authority, misunderstanding, awful wit, but never impolite or angry. In Volume 7 there is a report of an event which was publicised via the Mailing List in September 1998. It was a sundial design competition seeking "the most artistic creative and original design" for a location in the town of Reutte, Austria, open to all. Competitors were to submit their entries in any form, drawings, scale models, sketches. Claude Hartman of NASS, gives "A Personal Perspective" of the competition for which he designed and modelled a most imaginative horizontal dial, a skylight dial which is read from underneath, the time indicated not by a shadow but by a slot beam of sunlight, Italian hours, analemmae on hour lines, nodus and solstice lines. Space prevents a deeper description but Mr. Hartman was, with some justification, awarded second prize in a field of 40 entries. It is interesting that a successful competition can be held this way, enabling worldwide entries to compete at very low cost: a practical illustration of the power of the Sundial Mailing List.

Stephen Luecking contributes a well researched article on "Leonardo's Ellipse" in which he speculates that a certain drawing by Leonardo DaVinci reveals a graphical method by which Leonardo may have delineated a sundial. Leonardo's construction shows how a circle may be projected onto a plane at an angle to the axis of the cylinder (of which the circle is a section). The author then describes clearly by text and diagram just exactly how the ellipse is plotted. However some speculation is required to derive a sundial from Leonardo's actual drawing in that to delineate a sundial, the quarter circle must be divided into six parts not eight as in Leonardo's drawing, the angled plane which receives the projection must be at latitude, and the hour lines must be added because they do not occur naturally in the graphics of the construction of the basic ellipse. So it is not certain that Leonardo was working on a sundial . He may have simply had an architectural problem in mind or perhaps he was examining the shape of the hole required by a cylindrical support strut in the fabric of the wing of an aeroplane!

The theme of ellipses is continued in the answer to Fred Saywer's quiz: "Jacques Layout". These gnomonic puzzles are a major feature of the Compendium. In the previous issue the problem is stated, often it is a real historic problem, as in this case, it was posed by Jacques Ozanam in the 17th C. Readers are then challenged to produce viable solutions which are then discussed by Mr. Sawyer in the following issue. Thus an opportunity is created to visit and explore an historic problem in gnomonics, to restate it in more readable modern algebraic notation and, best of all, (to the envy of the originator), to explore by software calculation, the full range of possibilities which were generally denied originally by the sheer burden of manual calculation. The author, well known to BSS members, has made an extensive study of many important historic dialling works and it is this background which informs the quizzes and the many unusual sundial designs produced by Fred.

A nice feature of the Compendium is "Sightings". This is a page or two of photos and descriptions of dials known to the contributor, in this case Sebastian Robiou-Lamarche. This edition features three sundials in The Antilles. The Pillar Dial at La Fortaleza was erected in 1645 and is thought to be the second oldest sundial in the New World; it has four direct dial faces, carved on a large rock cube. A line drawing appears on the cover of the Compendium. Another interesting dial featured is a massive cube with vertical declining dials at Santo Domingo built in 1753. A solid equatorial plate was added on top in 1787. It is documented that this sundial was used as the time standard during the Spanish colonial years in order to regulate mechanical clocks.

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CD-ROM REVIEW

THE NORTH AMERICAN SUNDIAL SOCIETY REPOSITORY

CD-ROM available from F Sawyer, 8 Sachem Drive, Glastonbury CT 06033, USA. Price $30, plus $2 if outside the USA.

If ever a demonstration of the vast storage capacity of the CD-ROM was required, the NASS Repository would surely provide it! The contents may largely be available elsewhere, at not inconsiderable cost in some cases, but the convenience of having it all brought together cannot be overemphasised, especially with the cross-referencing facilities now available. It is worth stating these contents in some detail.

NASS Compendium:- This was, I think, the major driver for the Repository project. The full contents of all 27 issues of the Compendium since the inception of the NASS are included, with the bonus that the pictures are now in colour, all known errors are corrected, and the associated computer programs distributed with the digital edition are linked in.

Aked/Severino Gnomonics Bibliography:- This large collection (over 10,000 entries) of dialling references was assembled by our own, sadly missed, Charles Aked together with Nicola Severino. Very few paper copies were printed, so this represents and invaluable reference source.
BSS Sundial Glossary:- Only recently published, this version is the same as that on the BSS website, with the advantage that there is no need to run up telephone bills to browse it. An addition is that many of the entries are now directly linked to relevant articles available elsewhere on the CD.

Cyclopaedic Diallist:- An extended article on dialling from the 8th edition of the Encyclopaedia Britannica (1852-1860). This is augmented by exerts from the article in the 9th edition, together with extracts from a 1770 lecture by James Ferguson. This compilation is presented to diallists for the first time here, and has been annotated and given modern mathematical formulation by Fred Sawyer. Thus it presents a broad foundation course into the principles of dial design and operation, with many advanced types described. As an example, not many modern sundial textbooks cover Lambert's dial, but the Britannica article does and the added footnotes also refer to Gordon Taylor's Herstmonceaux dial.

Dialling Universal:- The NASS edition of George Serle's 1657 book. This introduced a comprehensive set of dialling scales on a ruler, and is effectively an instruction book of how to design a dial mechanically. A 6" aluminium reproduction of the scales is available separately.

NASS Sundial Registry:- The list of known sundials in America, some with photographs. It is similar to the BSS Sundial Register. There are far fewer dials than in the UK but most of them are impressive monumental designs. This section should definitely be consulted before planning any trip to America.

Sciatheric Notes I:- A collection of ten of Fred Sawyer's articles published in the BSS Bulletin over the period 1991 to 1997. These key articles provide much of the deeper understanding of dialling needed by modern readers.

Dialing Software:- This section makes available seven of the main sundial design programs, including the latest Windows-compatible version of the widely used Zonwvlak suite. The very useful Dialist's Companion for real-time output of solar and temporal parameters is also included.

Selected Patents:- I was surprised to see that there have been over 60 sundial-related patents in the USA since 1974. They are presented here with their full text and images, and provide fascinating reading once the strange language used for all patents is mastered. Although the patents were all filed in the USA, some originate from overseas, such as the "dial in frustrum of cylinder with fluted edges", from Russell Ousley of the UK in 1976, which was new to me.

The contents of the CD are read through the use of the Adobe Acrobat Reader program. Since this is also included on the CD, its use presents no difficulties. It has all the normal facilities for viewing and printing, plus a tremendously useful "Search" facility. I suffered some teething problems with this, but Fred Sawyer has now got them fully sorted, with the result that it is one of the most powerful features of the Repository. It is possible to enter a key word and within a few seconds a list of its occurrences is presented, whether they are in an edition of the Compendium, the Glossary or so on. Limitations with the source material mean that items in the Patents cannot be located, but this is a minor annoyance. (But see note below) As an example, a search for "Oughtred" found references to nine editions of the Compendium, the BSS Glossary definition of the Oughtred double horizontal dial, the manual for the Zonwvlak program for drawing the dial, and a reference to William Oughtred in the Aked Bibliography. Each of these could be reached with a click of the mouse. The Acrobat Search facility also has a "sounds like" feature. This does have limitations though; when I looked up "alhazen" instead of "Al-hasan" I got an unlikely number of matches, but these all turned out to be for "alignment!
The NASS Repository is a "must-have" for any diallist with a computer. We should all be grateful to Fred Sawyer for the huge amount of work that has gone in to compiling it. It is planned to update it periodically, mainly to add new editions of the Compendium. However, I would not be surprised to see other gems appear, as the disk is currently only a third full. Purchasers will be able to return their CD's for an upgrade at reduced cost. Any niggling criticisms - and there are very few - are really directed at the various source documents rather than their presentation here, which is generally better than the original. For example, the organisation of the Bibliography, and its large amounts of Italian and/or Latin text, makes locating documents difficult.

Two versions are available, a CD-RW and a CD-R. These are the same price and have the same contents. The only advantage of the CD-RW is that the cost of upgrades will be $12 (outside the USA) versus $15 for the CD-R version. For readers whose CD drive is older than about 18-months - ancient in computer terms - my advice would be to go for the CD-R version as not all of the older drives can read the re-writable disks reliably.

The Repository will not replace my valued collection of journals and books, mainly because I prefer reading from paper than from a screen. However, it is a major step forward for dialling publications, providing instant access to a huge array of key material and pointing the way forward for other dialling publications.

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[John Davis reports that the latest edition of the NASS Repository CD does have the Search facility for the Patents Section - Ed.]

READERS' LETTERS

BEDE'S TIME KEEPING

The most informative letter from Mr. J. P. Lester concerning Bede in the last Bulletin may have erred in supposing that Bede had access to an hour-glass. We know that there was glass in Jarrow during Bede's time (some survives) but it is most improbable that there were sand-glasses of any kind. When Prof. David Waters gave the 1999 BSS Andrew Somerville Memorial Lecture in Dunchurch he stated that the first known illustration of a sand-glass dates from 1350. In his book, 'The Art of Navigation in England in Elizabethan and Early Stuart Times' (London: Hollis and Carter, 1958) Waters writes (p.308): "It is not known when or where sand-glasses were invented but in the light of existing evidence it seems likely that they were developed in the western Mediterranean in the eleventh or twelfth century as nautical time-keepers." He goes on to describe how irregularly many of the early "running-glasses" performed.

Lester cites the 1985 Jarrow Lecture of Wesley Stevens. Here, Stevens notes that Bede declared that Pliny was in error in believing that the tidal interval between high water on one day and the next was 24 hours 47 1/2 minutes; he said that the correct interval was 24 hours 48 minutes. (In fact the correct average value is nearer 24 hours 50 minutes.) But it is not necessary to have an hour-glass to make this fine distinction, only to count the number of high waters in a large number of days.

Bede also discussed the times of high water at different places. Since the full moon transits close to midnight it is possible with a timekeeping device to discover the tidal establishment of a port, that is, the interval between transit and the next high water at full and change of the moon. This is a constant value from which other tide times can be derived. The port establishment of Jarrow is 3 hours 18 minutes. Would an Anglo-Saxon sundial have given any useful accuracy, especially as the daylight transit of the new moon cannot be observed and there is no sun at midnight? If we consider the eighth century dial at Escomb the answer (apart from the fact that that dial is six metres above the ground) is, probably, no. I feel we should be postulating a different timekeeping device but not an hour-glass.

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NOON DAY STONE

With reference to Tony Wood's most interesting article about the Noon Day Stone (BSS Bull, 12,70), I must write that I, like most Mass Diallers when visiting churches, spend most of my time looking at the exterior of the buildings, giving less attention to the churchyard north of the building. The excursions of the shadow of the tower did not seem to be significant. Why would anyone want to erect a Noon Day Stone to mark the position of a shadow on the ground, when a vertical noon line could be more easily seen, and a sundial on the tower would seem to be more useful? I would like to suggest a reason for the stone.

In the early days of mechanical timekeeping, the person who set the church clock would have used a sundial or a vertical noon line as his standard. Transferring the sundial time to the church clock via a pocket watch was straightforward, but watches were expensive. Perhaps the answer was a friend who could see the sundial and shout the appropriate time up to him at the clock-room window. Or perhaps he could estimate the time he took to ascend the stairs, adding it to the observed time on the sundial.

Surely a very useful practice would be to note the position of the shadow of the tower when it was midday by the sundial. It may have fallen naturally onto a particular grave marker, or a stone in the church wall. But if there was nothing distinctive, he could bang a peg into the ground, or better still, erect a stone marker. Ascending the tower a little before noon, he could have looked out on the graveyard to observe the progress of the tower's shadow. When it arrived at his marker he would set the clock for midday.

I suggest that this is the likely reason for the Noon Day Stone, which appears to have been designed for a bird'eye or 'clock-winder's eye' view. If the Noon Day Stone is of the date of the original church clock or later, this would seem add evidence in favour of the theory. In any event, I think the possibility of more Noon Day Stones, or similar markers, is an exciting prospect.

P.S. Tony Wood informs me that he has been contacted by Michael Maltin from Woodchester who has photographs of the original stone and they hope to investigate further. Watch this space.

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BEDE AS A DIALLIST

I was glad to read the views of other correspondents on the question of Bede's use of the sundial, since, following my last letter to the Bulletin, I have had the opportunity to exchange ideas with some of those who are interested in the problem, and who have corrected me on various points. The recent appearance of Faith Wallis's translation of *'De Temporum Ratione'* has done away with my assertion that nothing apart from his Ecclesiastical History had been translated. David Scott tells me that his Life of Cuthbert and Lives of the Abbotts of Wearmouth and Jarrow are also available in English. He also pointed out to me that some of the assertions in Stevens' Jarrow Lecture of 1985 are probably conjectures and are not backed up by documentary evidence. So far, it seems that there is no written evidence that Bede actually used a sundial himself but I find it difficult to believe that he did not.

Miss Wilson mentions the reference in Mrs. Gatty to a work by Bede entitled *Libellus de Mensura Horologio* printed in an edition of his works in Cologne in 1612. I too picked up this reference and thought it would provide all the answers. Sadly, it doesn't. I sought this work in the edition produced by Rev. J.A.Giles in1843 and found it listed there as one of the works mistakenly attributed to Bede; and I think that we must accept that later scholarship is probably correct. It is surprising that Mrs Gatty did not consult the Giles edition.

If Bede used a sundial it may well have been a shadow stick used in conjunction with a set of tables for the appropriate latitude. My evidence for this suggestion is a passage in Chapter XXXVIII of *De Temporum Ratione* which reads in Faith Wallis's translation: "....he who did not learn to recognise the constellations in his elementary schooling can at least discover what he wants to know by the lines of the sundial on the ground." *(...ut qui caeli signis intendere puerili in scola non didicit, saltim horologii lineis in terra, quae necessaria quaerit, apprehendat)* What else but a shadow stick would cast its shadow on the ground?

Another question has been raised by correspondents which relates to the measurement of equinoctial hours. It is easy to see how Bede could have identified noon and the hours of 6 am and 6 pm , but how, with the means available to him, did he subdivide these intervals equally? Is there some obvious solution which I have missed? There may be some connection with the fact that, in later centuries, mass dials tended to be placed on smaller churches rather than on large ones or on monastic buildings. Did the presence of extra personnel in these larger establishments make it possible for someone with a suitable device corrected occasionally by the sun, to be designated as official timekeeper?

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'AN EDUCATIONAL HELIOCHRONOMETER'

With reference to my article on this subject in Bull BSS. June 2000, Mr. Scott-Kestin has written to me pointing out that I have reversed the signs for the Equation of Time, in Diagram 3 for the graph. This of course gives a reversed analemma. I expect several others have noticed this error, and I apologise for the mistake. I hope it did not cause confusion, as I consider this a worthwhile project.

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BEDE'S SUNDIAL

Early in the eighth century Bede wrote to his friend Wicthed - a priest at an unidentified monastery where he had once stayed as a guest -mentioning in reply to a question about the spring equinox, 'Inspection of the sundial will demonstrate the correct date '.

The only eighth-century sundials in Northumbria, of which we have evidence, are the semicircular wall dials, such as the ones surviving at Escombe and Bewcastle. They would show the longest and shortest mid-day shadows, and thus the solstices, but were too small, and generally too high above the ground, to give more than an uncertain date, and they did not mark the equinoxes.

Bede knew from earlier writers about observations made by the eastern Church, on shadows cast by vertical gnomons to determine the date of the spring equinox, and it may be that he regarded gnomons and sundials as the same thing.

For, among other things, comparing the length of daylight at different seasons of the year in England and in different parts of the world, Bede realised that a standard unit of time was needed. From antiquity astronomers had used one twenty-fourth of the whole day as this unit, but one twelfth of the daylight period at the equinox served the same purpose and was adopted as the equinoctial hour. It is difficult to imagine how equinoctial hours would have been measured by Bede, and they probably remained an abstract quantity used for computation.

For most people in eighth-century England the day began at dawn and ended at dusk, which could be seen whether the sky was clear or overcast, and there was little interest in dividing the period between sunrise and sunset into equal intervals. Within a monastery, however, there was such a need for managing the daily round.

The early Anglo-Saxon sundial was divided into four equal segments, but it did not divide the daylight period into equinoctial or seasonal hours; that was not its purpose. The only evidence for time-measurement at Jarrow is a table of human-shadow lengths, attributed to Bede and reproduced in a sixteenth-century copy of his book De Temporum Ratione. The shadow lengths were given to the nearest 'foot' for each seasonal hour, from the end of the first hour after sunrise to the beginning of the last hour before sunset, at the middle of each month. Shadow schemes have a long history and were based on the assumption that a man' s height was six times the length of his foot, with the shadow increasing in length over the mid-day minimum at a uniform rate throughout the year.

Human-shadow sundials were simple and portable, albeit imprecise time markers but satisfactory for the needs of a monastery, marking the times for prayer and for administration. The seasonal hours marked by human shadows represented the lived experience of time-measurement, as distinct from equinoctial hours which did not.. No doubt shadow lengths were quickly memorised by the monks, an easy task by comparison with the complex rules for finger counting ,which they were obliged to learn by heart.

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[Correspondence on this subject is now closed---Ed.]

AN EASILY MADE HORIZONTAL GARDEN SUNDIAL

ALLAN A. MILLS

Many people would like a working garden dial, but are repelled by the poorly made brass objects, of indeterminate latitude, offered by the average garden centre or mail order catalogue. This article explains how to make a simple horizontal dial by copying and laminating techniques that are now widely available.

THE MASTER PATTERN

A basic design is given in Fig. 1. It is calculated[1] for longitude zero at a mid-England latitude of 52.5°N, but may be used anywhere in the country by slightly tilting the entire instrument on its mounting plinth so that the stile of the gnomon points at the north celestial pole, which for this purpose is sufficiently closely approximated by the Pole Star.[2]

The Roman numerals on the master pattern follow the traditional orientation whereby the observer is considered to move around the dial looking towards its centre. Space is available below the gnomon for constructors to add an individual latitude, date, motto or dedication if desired.

THE CORRECTION CURVE

Any respectable sundial should be accompanied by a correction table or graph for the equation of time.[1,3] The additional correction for longitude may be included in the

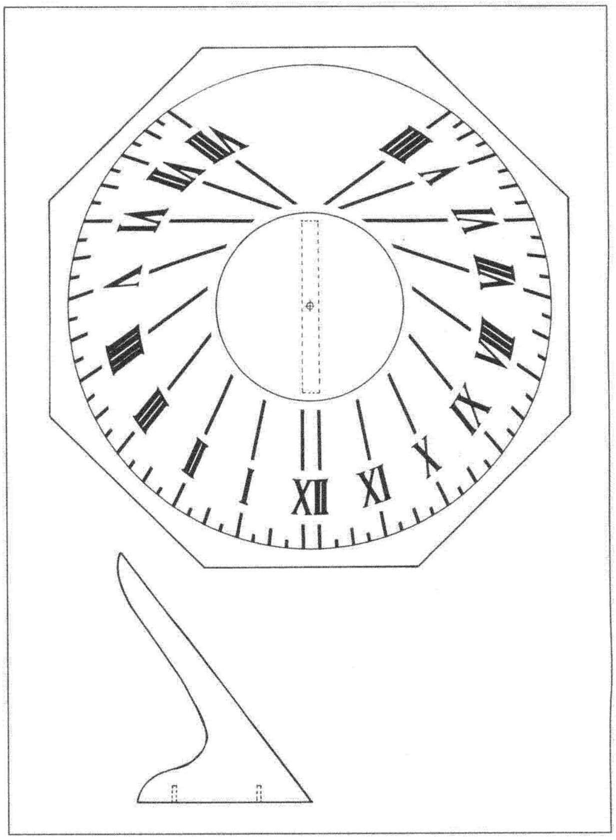

Fig. 1. Pattern for a horizontal sundial computed for latitude 52.5° N, longitude 0 ° 0'.

initial computation of the dial pattern, but that shown in Fig. 1 is calculated for longitude zero – the Greenwich meridian. It is therefore necessary to allow for the fact that, compared with GMT, a basic local solar time dial will appear to be 4 minutes slow for every degree that its site is west of Greenwich. The two corrections may conveniently be combined in a single correction curve for your own site: that for Leicester (Long. 1°05'W) is shown in Fig. 2. In the absence of ready access to 'Equation' tables in a sundial construction book, the curve for your locality may be derived from Fig. 2 by noting the difference between your longitude (from an atlas or large scale O.S. map) and 1°05' W. Convert it to time by the relationship quoted above.

It will be observed that for much of the year the sundial will appear to be slow when compared with a good watch, and this lag will be greater the further west it is installed. It may be shown that any uncorrected solar time dial installed west of the 4.1°W meridian (sufficiently represented by a line joining Plymouth and Inverness) is *always* slow relative to civil time, reaching a maximum (when on the above meridian) of 31 minutes slow in mid-February.

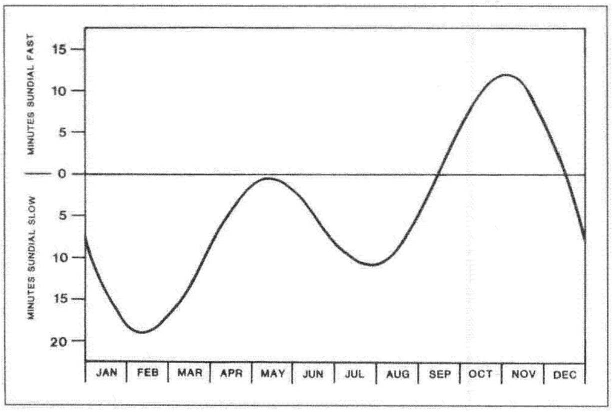

Fig. 2. Correction curve combining the equation of time with the longitude difference for a site at 1 ° 05' W.

COPYING

The master pattern of Fig. 1 is intended to be photocopied at 1:1 on an A4 sheet of the coated transparent Mylar sold specifically to make xeroxed transparencies for use on an overhead projector. Most copy shops can do this. At the same time, have your correction curve reduced to a convenient size, and then have it too copied on the transparent OHP base. Of course, a photocopier with a zoom lens may also be employed to produce dials of other sizes, but the 7" diameter given here fits conveniently on an A4 sheet and is a good size with which to begin.

Cut both dial and correction plaque with a sharp craft knife. The octagonal outline provided for the former is probably the easiest. Carefully store the gnomon outline accompanying the given dial.

LAMINATION

The cut-out dial and its accompanying correction chart must now be protected against the weather by lamination. This process heat-seals an original between clear plastic sheets, and is offered by most copy shops. A matt plastic should be specified, for otherwise you will get the standard glossy product – and shiny surfaces are unsuitable for sundials since they do not give a sharply defined shadow over a range of viewing angles.

Cut out the encapsulated dial and correction plaque, leaving a 3/16" to 1/4" border around the inner transparencies. This is essential to prevent the ingress of moisture and mould along an inadequately sealed edge.

ASSEMBLY

The idea is that the laminated dial, with its black numerals on a translucent ground, should be mounted upon a rigid plinth of suitable colour and a gnomon of the same material added. Grey PVC board[4] is recommended, for it is waterproof, easy to work, and its homogeneous colour resembles slate or patinated lead. 1/4" material is required for the gnomon and correction curve plaque, and may be stuck face-to-face if a 1/2" thick dial is desired. Saw or turn to a size to suit your dial, allowing for its laminated border. Cut out the gnomon following the pattern accompanying the xeroxed dial, and carefully sandpaper it to be smooth matt all over, making sure the edges are square.

Fix the laminated dial upon the abraded surface of the PVC plinth with a two-component polyurethane cement (e.g. 'Bisonite'), clamping it tightly between polythene sheets and flat boards to expel air bubbles along with excess adhesive. Then drill through at two points to accommodate M4 countersunk brass or stainless steel screws entering tapped holes in the base of the gnomon – or use self-tapping screws. Adhesive will give extra support, and if also applied over the screw heads will prevent corrosion.

MOUNTING

The finished sundial (Fig. 3) is to be attached to a suitable wood, stone or concrete pedestal with blobs of a thick 'nail substitute' cement, wedging and weighting to the correct altitude and azimuth until the adhesive has set. Mount the plaque bearing the correction curve nearby.

The most direct way of measuring the slope of the stile is with a clinometer, but it is hardly worth acquiring such an instrument for a few sundials. An alternative is to calculate by plane trigonometry the height of wedge required to prop the octagonal type of dial to the correct angle when it is installed on a spirit-levelled pedestal. Good support is provided by a 3" length of plastic knitting needle stuck

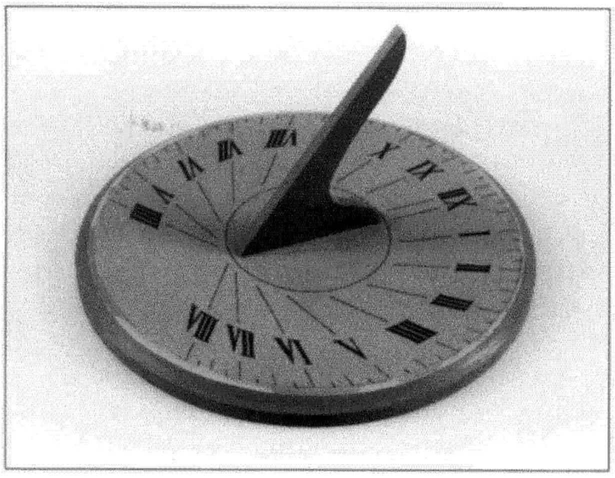

Fig. 3. A finished dial.

along the dial edge above or below the gnomon as appropriate: select the correct diameter of needle with a micrometer or vernier gauge. For separations below the thinnest needle, or in the absence of a gauge, stick together a stack of narrow strips cut from corrosion resistant materials of controlled thickness, such as CDs (0.045"), credit cards (0.03") or the Mylar OHP film used above (0.004"). When set, place the dial on the horizontal pedestal and, in sunlight, rotate it until the time displayed equals GMT when note is taken of the correction curve (and BST, if applicable). Secure it with a blob of gap-filling adhesive beneath the dial.

TESTING

Test examples prepared as above have so far successfully withstood 12 months of outdoor exposure, but an epoxy adhesive was not satisfactory where exposed to sunlight. The product may not be as impressive as a metal dial individually made by a craftsperson to suit a given location, but will probably be more accurate than many old 'country-made' instruments. And both maker and user will learn a lot about sundials!

ALTERNATIVES

Mounts of tinted paper or metallised card tend to fade in sunlight, and cut edges along the gnomon cause problems. However, it would appear practicable to coat the reverse of the laminated OHP copy with house paint, and then mount it upon a plinth of waterproof birch plywood that has been soaked in preservative, primed, and finally coated overall with the same paint. The gnomon could be cut from plywood and treated in the same manner. I have not tested this scheme though.

REFERENCES

1. F.W. Cousins, *Sundials,* Baker, London, 1969.
2. AA. Mills, 'Aligning the Gnomon', **Bull. BSS** 91.1 10 (1991).
3. A.A. Mills, 'More about the Equation of Time and the Analemma', **Bull. BSS** 94.1 30 (1994).
4. Off-cuts may be available from engineering works, plumbing contractors, etc.

DIAL DEALINGS

MIKE COWHAM

The summer months were quiet as usual with thoughts of holidays taking precedence over sales of sundials.

One of the few summer sales, was the one at Philips on 18 July, had an unusual item. It was a type of flow chart describing the processes in making a sundial, and because it was not illustrated in their catalogue, many potential buyers probably overlooked it. The chart was printed on a sheet about foolscap size and has subsequently been dated to just before 1700. (Fig. 1.) It was entitled ***'HOROLOGY or DYALLING'*** and was dedicated ***'To the Worfhipfull Thomas Stringer of Ivy Church near Salifbury in Wiltfhire Efq'.*** (Note that I have used the modern f in place of the old style s). Two typical 'flow' routings across the chart give the following interesting examples :-

1. *Horology, or Dyalling: may be considered in thefe three parts || Regular; are fuch yt. are defcribed in a Plaine, difpofed towards fome one determined chiefe part of world. vis. || direct West || of thefe Regular ye. Principall are the || East Meridian || each of which have their feverall wayes which are Equidistant from ye Meridian Circle.*

2. *Horology, or Dyalling: may be considered in thefe three parts || What things in generall are nefsefsary to be known for the framing fundyalls || Inftruments nefsefsary for ye makeing Dyalls || ye Astronomicall Quadrant.*

Sotheby's should be complimented on the excellent catalogue for their sale of 21 September 2000. In this they have set it out like a coffee table book of instruments with headings like 'Renaissance Instruments', 'The Age of Classical Science', and 'In an Industrial Era'. This approach makes it a particularly attractive and informative reference

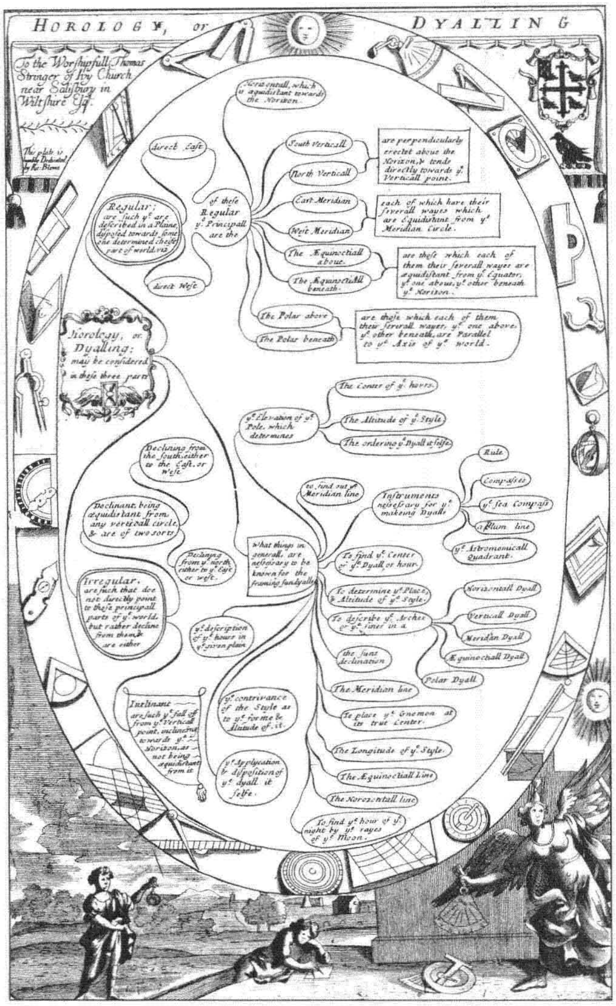

Fig. 1. Sundial Makers Flow Chart

Fig. 2. Scaphe Dial/Astrolobe

book on the subject. In this sale there were several good quality dials on offer. In particular the most important item was a scaphe dial combined with an astrolabe, signed '*Regenerus Arsenius Nepos Gemmae Frisy fecit Louany Anno 1563*'. (Fig. 2.) Gulaterus Arsenius, (Walte of Arsens), was well known for his astrolabes and other early instruments. This is the first schaphe dial/astrolabe combination recorded, also the first scaphe dial known from any Flemish workshop. It sold for £185,000, just above its lower estimate, although I would have expected much more. The other dial that took my attention was a universal equinoctial dial by Antoine-Joseph Meurand, 1784. (Fig. 3.) It sold for £4,800. The Sotheby's catalogue gives an excerpt from Bedos de Celle's contemporary description of how this dial should be used.

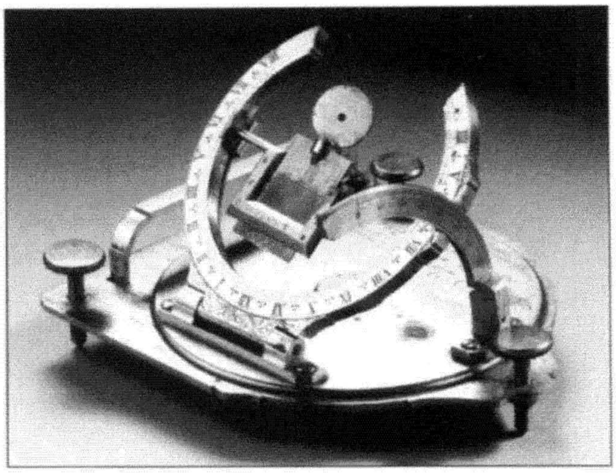

Fig. 3. Universal Dial by Meurand

'The determining characteristic of the dial is that it does not require a compass, but is self-orienting. In use the plaque containing the sighting point is adjusted in its bracket for the degree and minute of solar declination (found from an almanac or from the tables given by Bedos) for the date of use, and the bracket is turned so as to be at right angles to the hour ring. The sighting hole is placed above the ring during the summer months, below during the winter months. The hour ring is then adjusted for the latitude of the place of observation against the co-latitude arc. The dial is leveled and, the base being held firm by the hand, the upper plate carrying the dial is rotated until a spot of light passes through the aperture gnomon to fall precisely on the centre line of the hour scale to indicate the time'.

Fig. 4. Southern Hemisphere Dial

There were other fine dials in this sale by makers such as Tobias Volckmer, Bartholomew Koch, Johann Jakob Solms, Godfried Weis, Thomas Heath and George Adams.

Christie's South Kensington had various dials in their sale of 7 December 2000, although nothing really spectacular. Perhaps the most interesting for me were two Southern Hemisphere dials, although not catalogued as such. Did anyone else notice? One was almost identical to the one that I described in 'Dial Dealings', Bull.BSS. **12(i)**, 22-25, Fig. 7. (2000), but this dial had the name '*CASELLA LONDON*' printed on it. The other was catalogued as 'a reproduction brass dial'. The photograph, (Fig. 4.), shows this reproduction horizontal dial with its mixture of Spanish and English captions, and unusual way of showing the Equation of Time. It failed to sell.

I do not like the way that Christie's are placing several dials into individual lots, presumably to make the lot values around £1000. This makes it more difficult for the private collector to acquire a particular dial, and gives the dealer an increased advantage. It also means that the seller is likely to get a lower return than if the dials are sold individually. A typical example, (Fig. 5.), of Lot 127, groups together three completely different items, a poke dial, an altitude dial and a perpetual calendar. These are all nice items, but very few collectors would want all three. In the event this trio of items sold for £1645. I can see their reluctance to sell low value items individually, but feel that the single item limit should be much lower, perhaps £250. I hope that Christie's will reconsider this approach in their future sales. Just before Christmas, 19 December 2000, Sotheby's had a major Clock Sale that included six portable dials. The clocks realized very good prices, but the instruments seemed on the whole undervalued. There was nothing exceptional about the dials, the most interesting being a string gnomon sun and moon dial by Johann Martin of Augsburg. (Fig. 6.) It sold for £3000. The lunar indication is given from the inner ring which is rotated against the age-of-moon scale. It is a relatively simple solution to the problem of making a moon dial, and frequently used. Imagine how difficult it must be to try to read from the shadow of a thin string gnomon in moonlight.

Fig. 5. Group of Dials sold for £1645

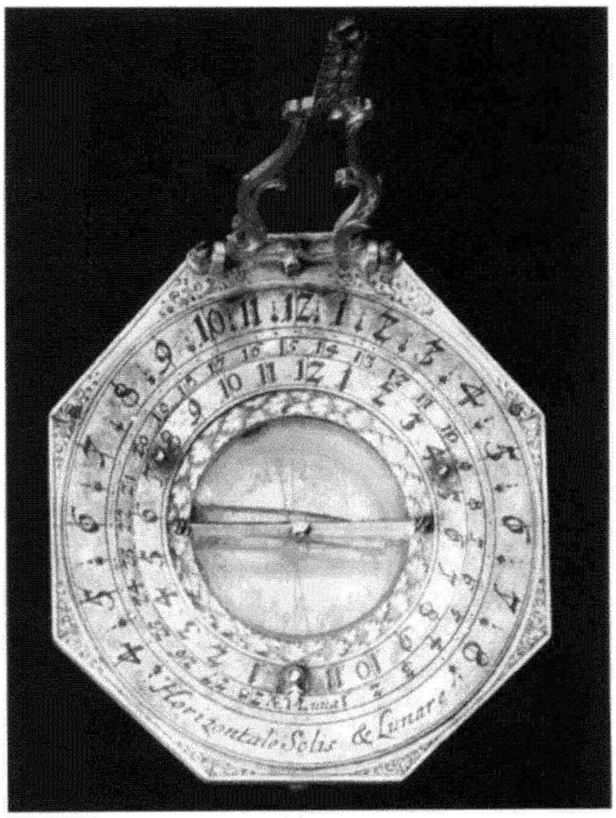

Fig. 6. String Gnomon Dial by Johann Martin

The major salesrooms often have a quantity of dials on offer in their instrument or clock sales, but it is rare to find more than the occasional dial in a provincial salesroom. Neal's of Nottingham had 14 lots with dials in their 27 October sale. There was a nice ivory diptych by Leonhart Miller, another small one probably by Karner, a brass Butterfield dial - (probably a later post-revolution copy), and two Augsburg dials. The most interesting item was an unusual equatorial dial inscribed '*Joan. Renard Inv. 1764, Florence*'. Although estimated at a low £120/£150 it made £900, still reasonable considering its rarity. Being a provincial salesroom the hammer prices were generally well down on London prices, but it was obvious that one London dealer was bidding for dials because at least two lots made almost London prices.

Another sale by Heathcote Ball & Company of Leicester, at the Old Rectory, Ufford near Stamford on 19 May 2000, had a nice early 14" octagonal garden dial by *'Hilkiah Bedford in Fleet Street'*. This sold for £1500.

Dials also come up occasionally at antique fairs. At the large 'Antiques for Everyone' fair in late November at the NEC Birmingham, I spotted an unusual Butterfield type dial, (Fig. 7.), offered by Abbey Antiques. This one was brass, made by *'LE FEVBRE APARIS'*, with the usual Butterfield features, but instead of the small bird's beak pointer for the latitude scale of the gnomon, this used a rather delicate swan. This is the first time that I have seen a 'Butterfield' dial with this feature.

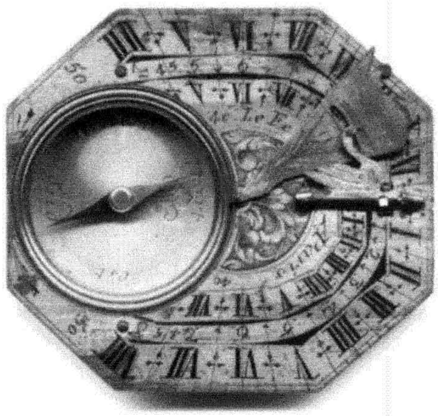

Fig. 7. Dial by Le Febvre AParis

FORTHCOMING SALES for 2001

As these dates can change, check before travelling to view.

Christie's South Kensington.	Tom Newth - 020 7321 3147 5 April, 7 June, 13 December
Sotheby's	Catherine Sothon - 020 7293 5209 April/May 2001 On-line sales at <sothebys.com>
Philips	James Stratton - 020 7468 8364
Bonhams	Alexander Crum-Ewing - 020 7393 3950
Scientific Instrument Fair Radisson SAS Portman Hotel, London.	Stuart Talbot - 020 8969 7011 29 April 2001 28 October 2001

ACKNOWLEDGEMENTS

I would like to thank the following for their permission to use their photographs. These remain their copyright. Philips for Fig 1, Sotheby's for Figs. 2, 3 & 6, and Christie's South Kensington for Fig. 4 & 5.

'Two youngsters on a good day out'
Our Patron, the Earl of Perth, with the first Secretary of the BSS, David Young: 7 June 2000.
(Photo: Edward Kinniard)

ADVERTISEMEMTS

A MOSIAC SUNDIAL FOR EBRINGTON, GLOUCESTERSHIRE

SIMON FRY

Like many communities the village of Ebrington, Gloucestershire, wished to celebrate the Millennium. Towards the end of 1997 we held a meeting to decide what we might do. My idea for a permanent monument was received quite enthusiastically, and the finished piece was unveiled on Midsummer Day, 24th June 2000.

The idea was a simple one: a modest-sized mosaic pavement including in its design a map of the parish, a legend around its circumference in brass letters, the co-ordinates of the location in the world, and a sundial to tell the time.

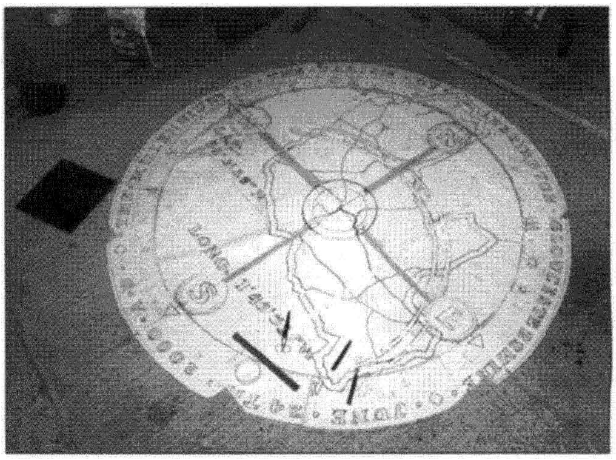

Photo 1. Final full-scale drawing

The obvious location seemed to be the churchyard, one reason being that the proposed armillary sphere sundial at its centre might prove too tempting to the dishonest. However the Gloucester Diocesan Advisory Committee felt that it was inappropriate for a churchyard so we had to think again. I was determined to have a sundial in its

Photo 2. Cutting the moulds

design, and I had an idea. If there were a hole in its centre one could place a walking-stick (or any stick) into it and read the time from a sundial built into the pavement.
The village is on several footpaths and roads; walkers, riders on horse and bicycle, tourists and motorists on their way to nearby Hidcote Gardens, often stop at the village pub, outside which is a small green dominated by three oak trees. Our Millennium Committee decided that this was the best spot. Once all the permissions had been granted, it was over to me!

I found myself confronted with two main problems: accurately setting a sundial, and making a mosaic, neither of which I had done before. Joanna Migdal and Peter Drinkwater (who lives locally) solved most of my sundial problems. For practical purposes, the pavement had to be viewed as a huge jig-saw, to be made in my studio and assembled on site. The pavement had to be as flat as possible, and with over 120 brass letters and ornaments to set into it, the idea of getting it perfectly marked-out in the open, with the vagaries of the English Summer weather, ruled out an on-site method.

The first trial slab or section was made nearly two years ahead of the final stage. This one-inch-thick piece, quite unaffected by two summers and winters, still lies in my garden. But now came the real thing: just before Christmas 1999 I made the first of the 23 sections that were needed.

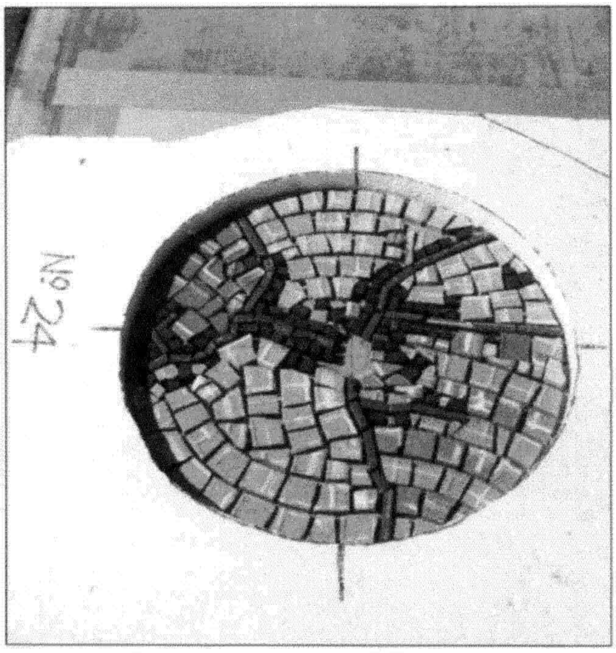

Photo 3. 'Village Centre' slab with mould in place. Note space left for gnomon-hole tube at centre, and alignment-lines

The tesserae are of Italian Porcelain, very hard and frost-resistant, and each 30cm-square tile was sawn and then cut by hand. They came in a range of beautifully subtle colours, which suited me - and the village critics - perfectly. By March the production of the slabs was going well. Some ladies on the Committee came along and made some of the outside sections, and some children from the village school helped with one of the picture pieces.

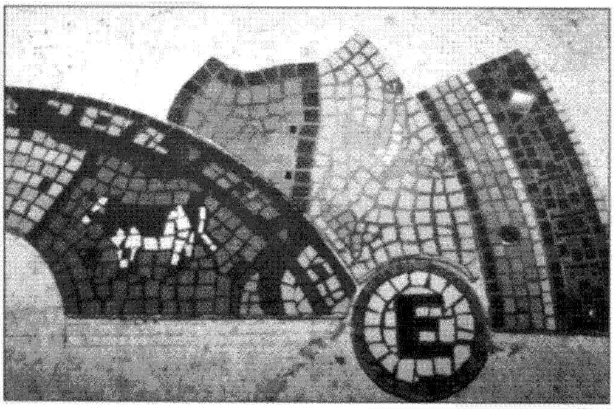

Photo 4. First slabs laid out to check for fitting. Note sundial from 12-6.00pm with hour and half-hour markers.

For the surface to drain successfully the pavement needs a slight slope. The whole mosaic slopes to the south, the northern edge being one inch higher than the southern. This is an inclination of almost exactly 2°. Ebrington is at Latitude 52° 3' 26". So the brass gnomon-hole-tube had its

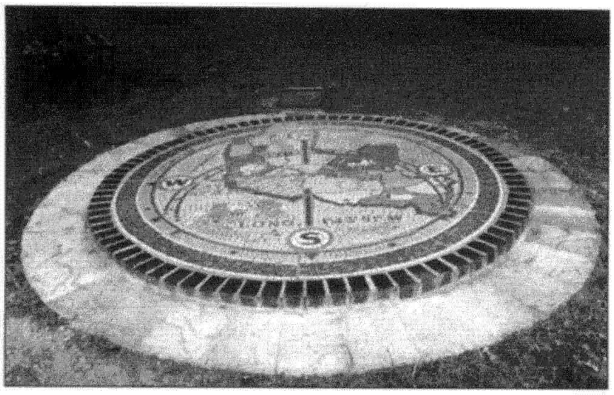

Photo 5. Village location

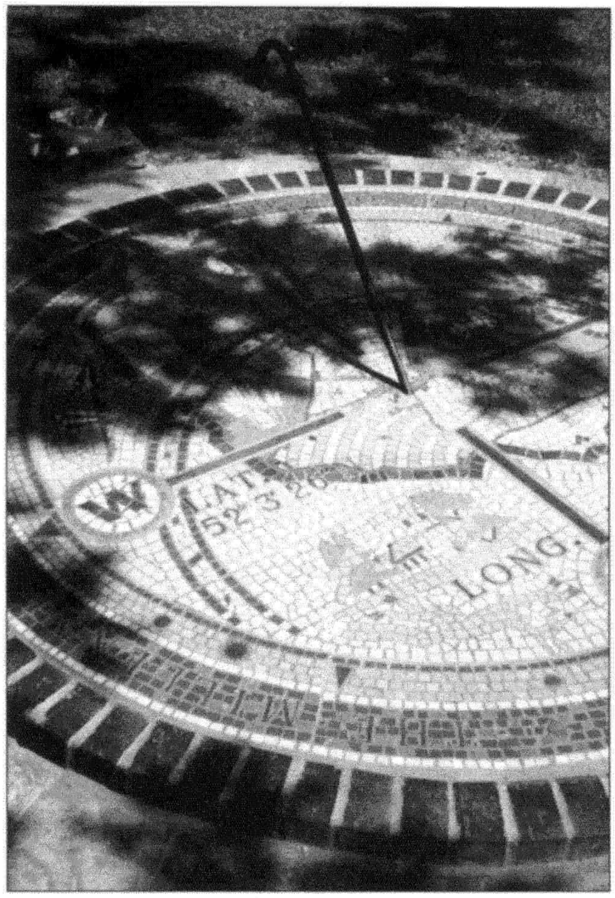

Photo 6. With walking-stick gnomon from SW

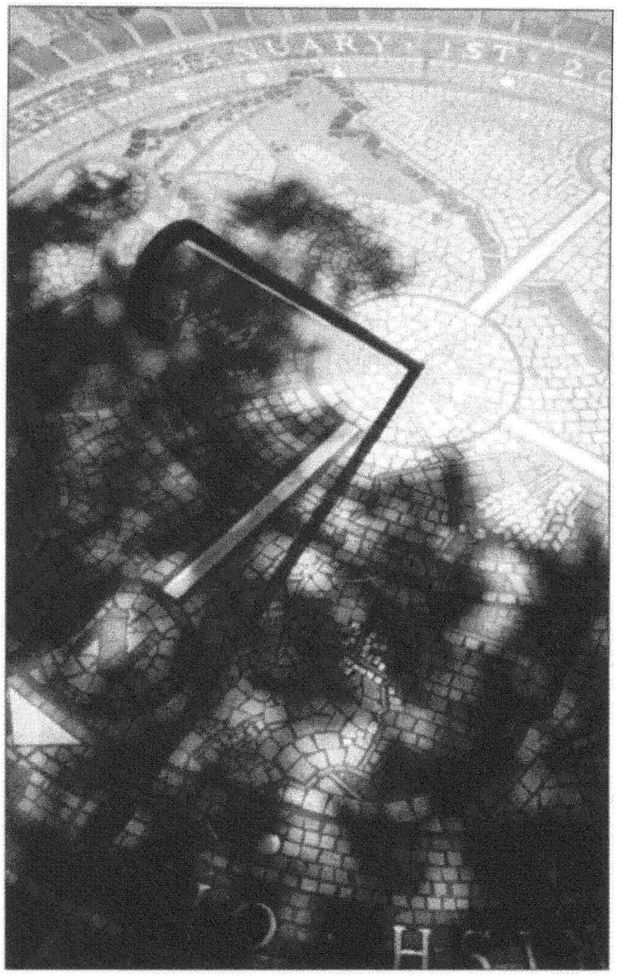

Photo 7. With walking-stick gnomon from SE. Even though partly shaded by trees, the shadow of the stick shows clearly.

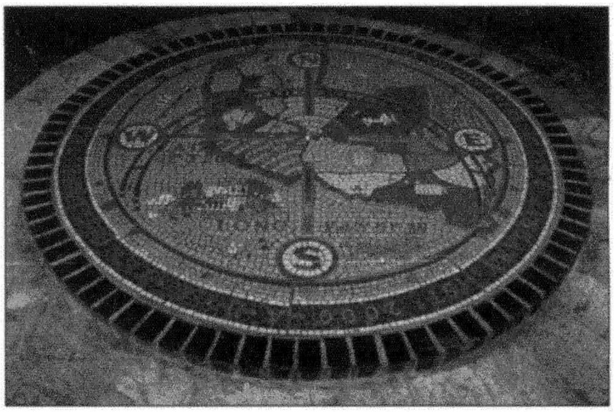

Photo 8. 'Mosaic' Flyer

surface angled to just over 50°. Perhaps the trickiest moment in the whole project was aligning the "hole". The mosaic slabs were made in reverse, that is, face-downwards on a flat board, to be certain of a nearly mirror-flat surface. The gnomon-tube had to be positioned in the centre of the 'village-centre' slab, perfectly aligned N-S, and held at an angle of 50° for the length of time it took to pour the cement into the mould, and for it to set. Whether or not I had been successful was unknown until a sunny day 3 months later!

The site under 'The Oaks' was cleared for putting down the concrete base and brick circle (for protecting the edge) at the beginning of April 2000, shortly after which I set the sundial. We set the mosaic slabs into the circle four days before the Unveiling, in a frame tent erected over the site. The centre-circle with the gnomon-hole went in first. I put a light-weight tube into the hole and hung a plumb-line from its end over the North marker, to check horizontal alignment; vertical alignment was checked with a 50° set-square against a spirit level.

Around the circumference of the design is a legend in brass letters commemorating the Millennium. Inside this is a circle containing 16 points of the compass and four suns to mark the rise and set at the solstices. It is a sidereal sundial and brass strips mark N-S and E-W. The sundial is marked only in hours and half-hours as it was too difficult to cut tesserae small enough for shorter divisions of time.

The line of the dial as it crosses the map avoids all populated areas, and starts and finishes at the rising and setting winter suns.

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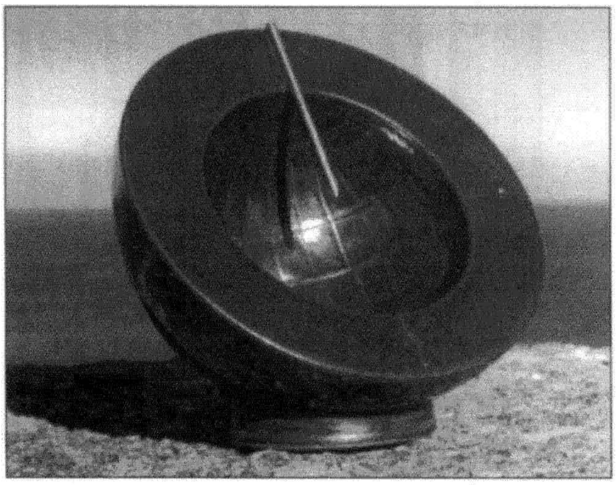
MILLENNIUM SUNDIALS FOR NOTTINGHAMSHIRE SCHOOLS

DONALD J. BUSH

Early in 1999 the Education Dept. of Nottinghamshire County Council launched a competition for schools in the county to mark and celebrate the new millennium. The theme was to be "the meaning of time, or the significance of the millennium," and entries broadly based on the curriculum were invited from schools covering all age ranges. The prizes for the six winning schools were to be sundials, and it was decided that they should be made in ceramic by the County Council's Craft and Ceramics Centre at Rufford Park.

I was consulted on the design, and chose an updated version of the ancient hemicyclium, whereby a broad-rimmed hemispherical bowl rests on a plinth so that the plane of its open face makes the angle of latitude with the horizontal. The gnomon is a rod fastened across the rim at the top, with its sharpened point at the centre of the open face.



Photograph of pottery sundial

If such a dial faces directly south the longitudinal hour lines, which are the intersections of great circles including the gnomon in the diameter, will indicate equal hours according to local sun time. The equinox line and summer and winter solstice lines were also marked inside the bowl, so that a rough estimate of the date may be made.

The principal potter involved, Darrel Sherlock, duly produced six dials similar to the one illustrated; quite elegant pieces of contemporary ceramic art. It must be owned that he had some difficulty with marking the lines internally - I had recommended the use of two semi-circular templates suitably marked out, but these were not easy to use. Nevertheless, the results were acclaimed by the Education Dept. and have now been presented to the six winning schools, together with a booklet explaining how to set up and read the dial. It is hoped the schools will find them useful learning tools.

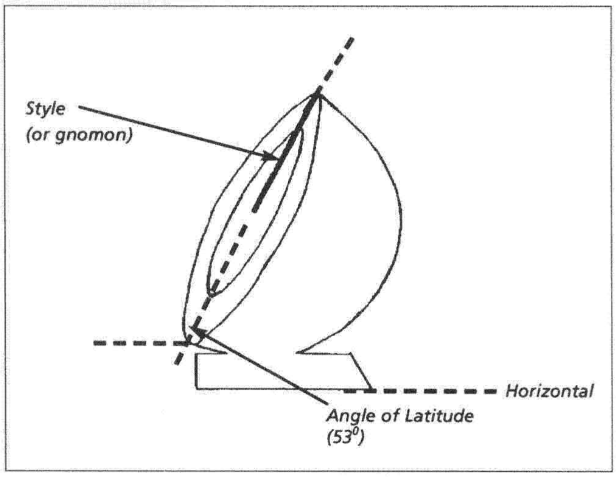


Diagram showing dial set-up

As a follow-up to the competition, prize-winning and short-listed entries, along with one of the dials, will be included in a touring exhibition to visit public venues in Nottinghamshire and finally the Millennium Dome in Greenwich.

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THE 'UNIVERSAL EQUINOCTIAL' SUNDIAL, THE BSS EMBLEM

The emblem of the British Sundial Society is a stylised representation of a basic form of sundial fundamental to the *Art of Dialling*.. It is described in the words of Thomas Stirrup (1652): 'This Diall, though, of all others, he be the Simplest, yet is he the mother of all the rest…'. Christopher Daniel's interesting article (Bull.BSS 95.2 36-38, 1995) includes clear photographs of a modern reproduction of a handsome 18th century version of this dial; and from these photographs its mode of action can be deduced. This short note summarises the function of our emblem, mainly for members who have joined the Society in the last 5 years and who therefore may not have ready access to the 1995 Bulletin.

The dial consists essentially of three parts: an *hour ring* (HR in sketch shown in Fig.1), a narrow band of metal curved into a nearly-complete circumference of a circle, on the inner (concave) surface of which the hour-lines are engraved; a *gnomon* (G), carried on the centre of a horizontal *gnomon-rod* (GR), whose ends are placed at the 6a.m. and 6p.m lines on the hour ring, in a slot at one end, spring-loaded at the other; and a quadrant *latitude-arc* (LA) set up alongside the hour ring and graduated in degrees from 0° at the top to 90° at the base. When the instrument is in use the upper end of the latitude arc passes through a slit (S) on the hour ring made by a small staple fixed onto the outer (convex) surface of the hour ring behind the 6p.m. mark. A thumbscrew (T) on the staple enables the hour ring to be clamped opposite any degree-mark on the latitude arc.

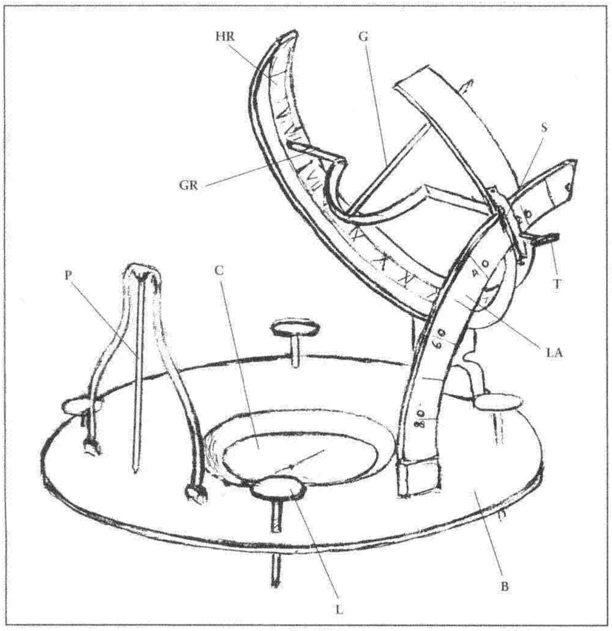

Fig.1. Sketch of Universal Equinoctial Sundial (for letters, see text)

The hour ring and latitude arc are carried on hinged blocks on a base-plate (B), in the centre of which is a magnetic compass, (C). Levelling-screws, (L) and a plumb-bob (P) ensure that the base-plate can be made perfectly horizontal when the instrument is in use. The hinges at the base of HR, P and LA allow the instrument to be packed flat for storing and transport.

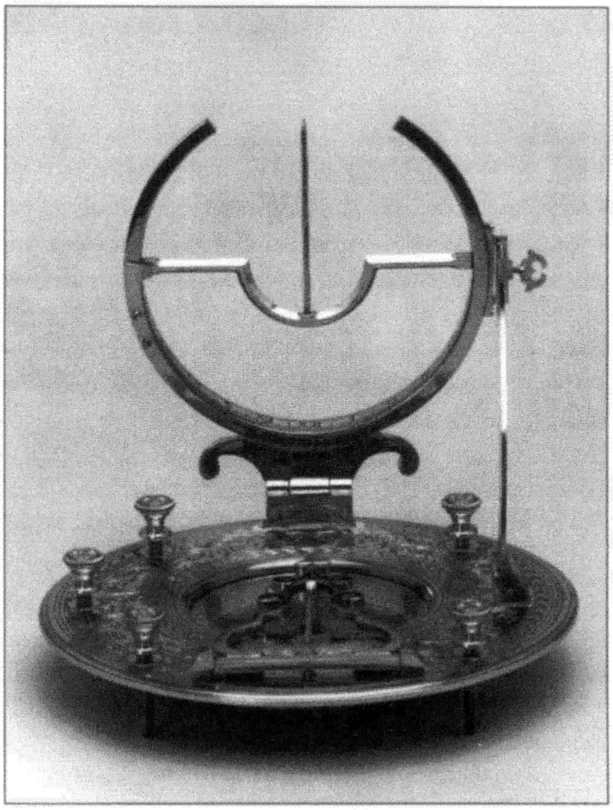

Fig.2. The Dial before use

When the dial is unfolded and first set up, the base-plate is levelled and orientated on the N-S line by the compass. The latitude-arc is in position, and the hour ring and gnomon are standing vertical and co-planar, exactly as in the BSS emblem. The hour ring is moved on its hinged base to the appropriate position along the latitude arc, and fixed there by the thumbscrew. The gnomon is now turned against a spring device so that it snaps into position in the plane at a right-angle to the hour ring, its tip now pointing to the north celestial pole. The centre of the shadow of the gnomon on the hour circle now gives local solar time. The U-shape in the middle of the gnomon rod ensures that the shadow of this rod will not obliterate the gnomon's shadow when readings are taken. When the apparent sun is south of the celestial equator, the position of the gnomon can be reversed, to snap into position to point to the south celestial pole. (In an earlier version of the instrument, with a straight support rod and north-and-south parts of the gnomon of equal length, problems arose in taking readings at the equinoxes.)

The dial 'can be set up for any latitude in the northern hemisphere. With a little ingenuity, it can also be used equally well in the southern hemisphere, hence its "universal" qualification.' (Daniel). The photographs are taken by permission from Christopher Daniel's article. Fig. 2 shows the dial before use; the plumb-bob is still folded down so that the gnomon can be clearly seen in the photograph; the hour-ring and latitude arc are seen 'edge-on'. In Fig. 3 the dial is set up for latitude 49°N, and in Fig.4, for 27°N.

Fig.3. The dial set up for use at 49° N

Fig.4. The dial set up for use at 27° N

ACKNOWLEDGEMENTS:

I am grateful to Maurice Kenn for a suggestion and to Christopher Daniel for advice.

Margaret Stanier

'Well, by my watch it's eight and a half minutes slow'
The Prime Minister inaugurates the Millennium Sundial at Ferryhill, County Durham, commissioned by the Ferryhill Town Council for a garden in front of the Town Hall.
The brass horizontal Dial was designed and made by Tony Moss, (seen standing beside Tony Blair in the photo). It incorporates the theme of the Wild Boar, from the town's coat-of-arms.
(Photo: Maureen Moss)

Peter Anton Lamont
28th March 1910 – 3rd December 2000

Grieve not that I have Died, Rejoice that I have Lived

David G. Morrison writes:

Peter Anton Lamont was born March 28th, 1910 in Glasgow, the eldest son of James Lamont of Forfar, Scotland and Clara Schmidiger Lamont of Brienz, Switzerland. The eldest of 6 children, he and his family moved to Stockport in 1917 where he attended Stockport Grammar School, matriculating with honours. He went on to take first class honours in Engineering and a Masters of Arts degree at Corpus Christi College, Cambridge.

He joined the staff of the Cambridge Water Company in 1933. He married Marjorie Keys of Cambridge in April 1940 before volunteering for the Army. During WWII he served with distinction as a major in the Royal Engineers in West Africa and Burma where he was wounded, and twice mentioned in dispatches.

After the war he returned briefly to Cambridge before moving on to the Spalding (Lincs) Waterworks as Chief Engineer. In 1959 he was appointed Chief Engineer for the East Worcestershire Waterworks in Bromsgrove, where he remained until retiring in 1975. In both areas he built major watertowers to enhance the water supply. He was also awarded the prestigious Telford Premium by the Institute of Water Engineers for his work on pipe friction.

He was an active member and past president of the Spalding and Bromsgrove Rotary Clubs until retirement and then became an enthusiastic member of the Droitwich Probus club, serving as their entertainment director for many years. He was a Fellow of the Institute of Water Engineers; Fellow of the Institute of Civil Engineers; a member of both the British and American Sundial Societies.

He will be greatly missed by his beloved wife Marjorie; son, Peter J. Lamont; a daughter, Patricia Ann Roloson; his four grandchildren, Beth, Michael, Robert and Marie; his brother; James Lamont; several cousins and a host of friends and colleagues.

David Young writes:

Some time in 1991 while returning home through Bromsgrove, south of Birmingham I spotted a sundial on the front of a private house standing some way back from the road.

I did not have time to stop and call at the house but took a hurried telephoto shot from the car and later recorded the dial as "a good home made dial" (SRNO 0994). It was not till three years later, in May 1994 that I received a letter from Peter Lamont enclosing a series of photographs of dials that he had made, one of which I recognised as the vertical I had recorded. He said he hoped the pictures would be of interest although he was too old to join yet another society. However my wife and I called in to see him shortly after that when he showed us many of his beautifully made dials. I did manage to persuade him to join by quoting our oldest member George Higgs, then over ninety!

I am sure he did not regret this decision and has greatly enjoyed his membership. Many members will remember his talks at our meetings and the dials he exhibited - notably his 'open book' polar dials, which were his favourites. He was an innovative and enthusiastic member and a true gentleman. He will be greatly missed.

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