# The British Sundial Society


# BULLETIN

VOLUME 17(iii) SEPTEMBER 2005

*Front cover: The vertical dial on the Moot Hall, Aldeburgh, Suffolk. The hall now contains a local museum and is right on the edge of the beach. The dial declines 11° west and once appeared fleetingly in the "tell Sid" British Gas TV commercial. Photo: J. Davis.*

*Back cover: The dial set in the south wall of the church at Great Bricett, Suffolk. The church, which is attached to a house, is around 600 years old but the dial may well come from the ruins of an old abbey a few miles across the fields. It appears to have been rotated slightly: note the noon cross in the 7 o'clock position. Photo: J. Davis.*

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# VOLUME 17(iii) - SEPTEMBER 2005

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# B U L L E T I N

## OF THE BRITISH SUNDIAL SOCIETY


## ISDN 0958-4315

## VOLUME 17(iii) - SEPTEMBER 2005


## EDITORIAL

The Bulletin is fortunate to have now an Assistant Editor, in John Davis - knowledgeable, thorough and meticulously careful. His address is on the below: yes, that's right, he is our Society's Treasurer too.

*From now on please send to* ***John Davis*** *your contributions by mail or, preferably, e-mail; the articles, photos, diagrams, inventions - keep them coming!*


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Our Chairman was concerned that the tasks of the Secretary, Registrar and Editor might be more that one pair of hands and of eyes could manage. The Secretary now has John Foad as Minutes Writer, and the work of the Registrar may soon be decreasing. The Editor now has an Assistant: fine. How good that the Society is large enough to ensure a wide spread over areas of geography and fields-of-interest; yet is still small enough to enable our Chairman to know the type and amount of work which each member of the Council is doing.

# THE EQUATION OF TIME: THE INVENTION OF THE ANALEMMA A brief history of the subject - Part 1

CHRISTOPHER St J H DANIEL

**SYNOPSIS**

Historically, the word *analemma*, derived from the Greek, may be understood to mean a supporting device or subsidiary graphical construction, as with an orthographic or stereographic projection of the celestial sphere, assisting the achievement of a primary work, by means of an instrument such as 'The Analemma' of Benjamin Donn.[1] (see Fig. 1.) In the science of *gnomonics*, or the art of dialling, as it was called in England, the *analemma* is the projection of the 'figure-of-eight'- shaped curve that represents the variation in the equation of time during the course of the year. (Whilst the term *lemniscate* has been applied to this construction, it is a rarely used appellation.) When delineated on a sundial, the *analemma* enables the correction for this phenomenon to be applied directly to the dial-plate, such that the dial will indicate *local mean time*, i.e. 'clock' time. The invention of this device has been attributed to Jean-Paul Grandjean de Fouchy, in about the year 1730; but there is evidence that suggests that the *analemma* was actually first constructed some fifteen years earlier in Germany by Johann Philipp von Wurzelbau.

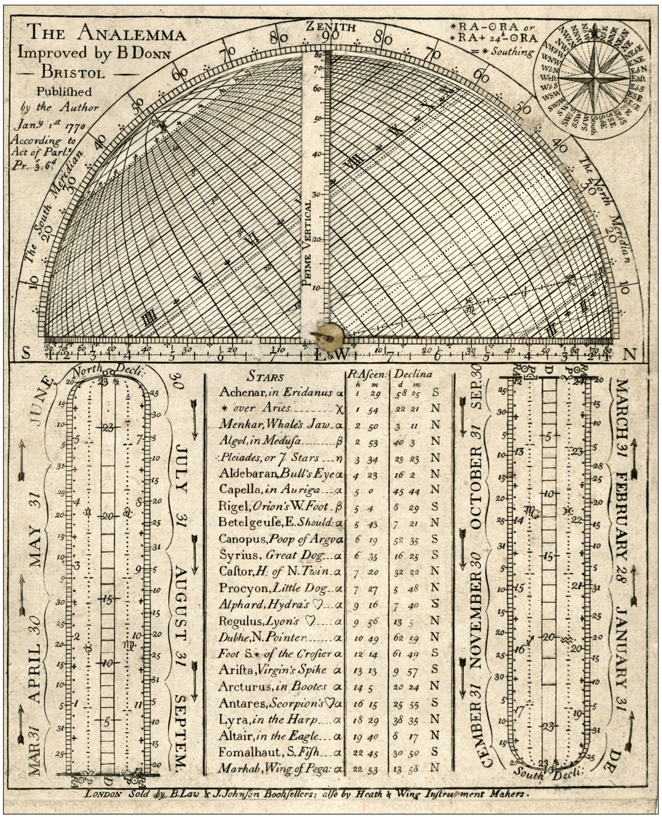


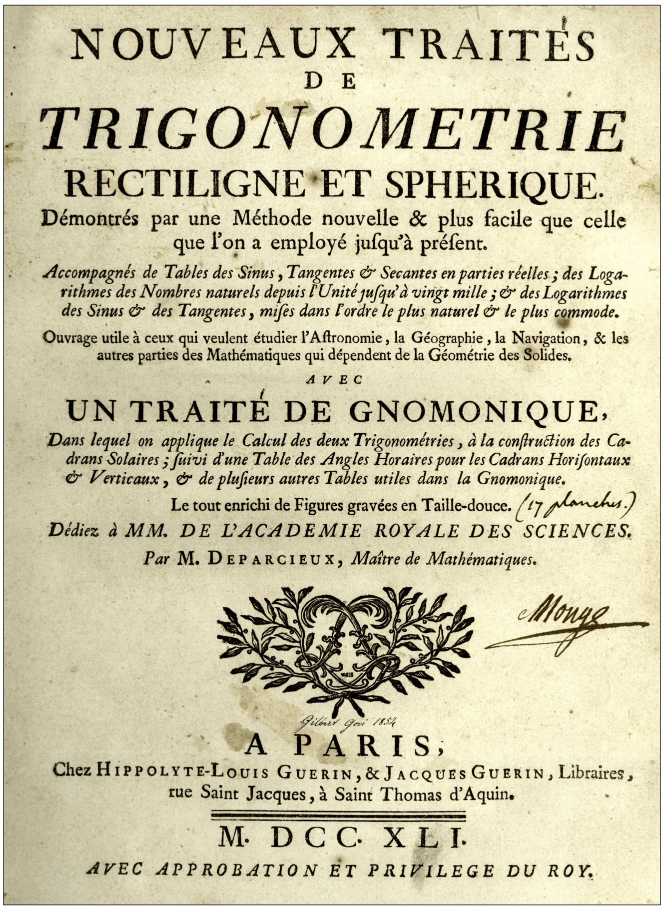

*Fig. 1. The 'Analemma' of Benjamin Donn.*

## INTRODUCTION

On the 4th November 1669, John Flamstead (*sic*) (Fig. 2) later to become the first Astronomer Royal, wrote to the Lord Brouncker, President of the Royal Society, on matters concerning the more notable celestial phenomena that would be visible in England during the forthcoming year, "if the Heavens be clear". In this communication, Flamstead wrote[2] "Nor need we scruple about the *Æquation* of *Natural days*: I have fully demonstrated the Æquations, so that I am persuaded, no one hereafter will controvert them; and I shall ere long, if God will, commit them to your and the public censure."

*Fig. 2. The Reverend John Flamsteed, the first Astronomer Royal of England.*

Much has been written about the Equation of Time, (termed the 'Equation of Natural Days' in 17th and very early 18th century English publications) and the *analemma*, since Flamstead made this statement, not least in the *Bulletin* of the British Sundial Society.[3-6b] However, the origin of the



NOUVEAUX TRAITÉS DE *TRIGONOMETRIE* RECTILIGNE ET SPHERIQUE.

Démontrés par une Méthode nouvelle & plus facile que celle que l'on a employé jusqu'à présent.

*Accompagnés de Tables des Sinus, Tangentes & Secantes en parties réelles; des Logarithmes des Nombres naturels depuis l'Unité jusqu'à vingt mille; & des Logarithmes des Sinus & des Tangentes, mises dans l'ordre le plus naturel & le plus commode.*

Ouvrage utile à ceux qui veulent étudier l'Astronomie, la Géographie, la Navigation, & les autres parties des Mathématiques qui dépendent de la Géométrie des Solides.

*AVEC*

UN TRAITÉ DE GNOMONIQUE,

*Dans lequel on applique le Calcul des deux Trigonométries, à la construction des Cadrans Solaires; suivi d'une Table des Angles Horaires pour les Cadrans Horisontaux & Verticaux, & de plusieurs autres Tables utiles dans la Gnomonique.*

Le tout enrichi de Figures gravées en Taille-douce. (17 planches.)

*Dédiez à MM. DE L'ACADEMIE ROYALE DES SCIENCES.*

*Par M.* DEPARCIEUX, *Maître de Mathématiques.*

A PARIS,

Chez HIPPOLYTE-LOUIS GUERIN, & JACQUES GUERIN, Libraires, rue Saint Jacques, à Saint Thomas d'Aquin.

M. DCC. XLI.

*AVEC APPROBATION ET PRIVILEGE DU ROY.*

*Fig. 3. The title page of Antoine Deparcieux's major work on trigonometry and gnomonics, published in Paris in 1741.*

invention of the *analemma*, i.e. the 'figure-of-eight' equation of time correction curve, has scarcely been discussed, perhaps because its attribution has seldom been questioned.[7]

### THE EARLIEST PUBLISHED WORK PORTRAYING THE ANALEMMA

The first work, of which I know, that portrays the analemma, as a means of indicating mean time (i.e. 'clock' time) on a sundial, is the gnomonical treatise that forms an integral part of the major work on trigonometry by Deparcieux (Fig. 3), published in Paris in 1741.[8] It portrays the analemma as delineated for a horizontal meridian line, i.e. a noon-mark, which is consistent with the interest in horizontal meridians that had already been constructed in churches and cathedrals, notably in Italy and later in France, by the Italian-French astronomer Giovanni Domenico or Jean Dominique Cassini (1625-1712), shown in Fig. 4.

### ANTOINE DEPARCIEUX

Antoine Deparcieux (1703-1768) came from a poor farming family and was orphaned at an early age. Nevertheless, since Antoine exhibited evidence of exceptional abilities, his elder brother, Pierre, had him educated and sent him to the Jesuit College at Alès. In 1730, he went to Paris where he quickly became established as a maker of fine sundials. These were of such excellence that he soon gained a reputation that brought him easier circumstances and allowed him to further his practical mathematical researches, resulting in his treatise on trigonometry and sundials. In 1746, he was admitted to membership of *l'Académie Royale des Sciences de Paris.*

In his gnomonical treatise, Deparcieux makes the following statement: "M. Grand-Jean de Fouchy, de l'Academie Royale des Sciences, est le premier que je fçache avoir parlé de cette Méridienne, qui n'est pas bien commune; je n'en connois encore que trois; la premiere est celle que M. de Fouchy traça chez Monseigneur le Comte de Clermont; & deux que j'ai trace l'année derniere, l'une chez M. le Marquis de Bonnelle, & l'autre chez M. le Marquis d'Hoüel." It is clear from these remarks that he credits the noted French astronomer Jean-Paul Grandjean de Fouchy as being the first to speak of this form of meridian and as being the first person to construct such a meridian. He goes on to say that, in the last year, he has himself constructed two meridians of this kind.

Since his trigonometrical treatise received official approval for publication in 1738 and since the gnomonical volume

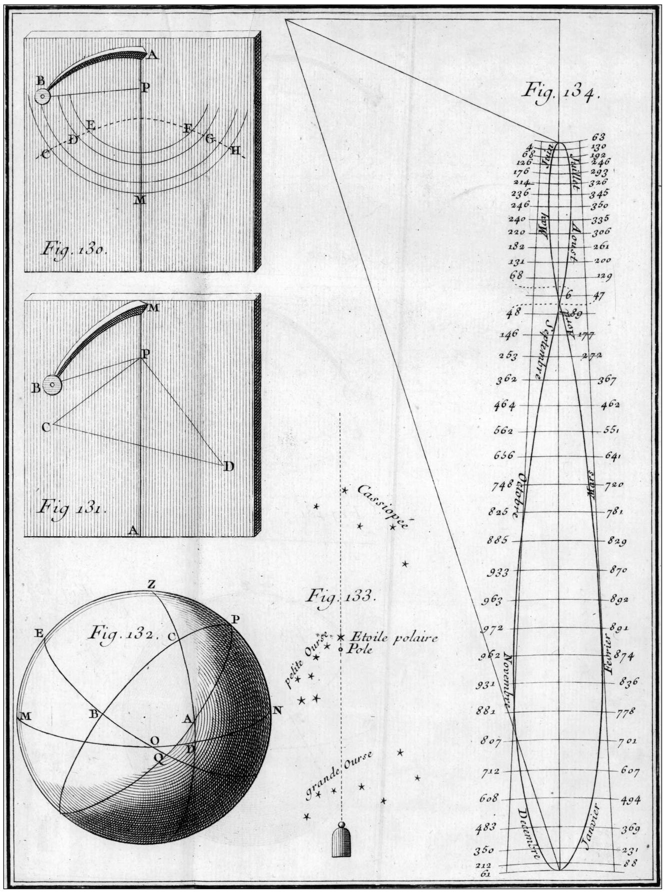



*Fig. 4. The first known illustration of the analemma, in this case delineated for a horizontal meridian line, (Deparcieux, Paris, 1741.)*

received approval in 1739, prior to the book's publication in 1741, one may reasonably assume that Deparcieux was still writing his gnomonical treatise in 1738. Thus, he must have constructed his two mean time meridians in 1737, if not earlier. Furthermore, since the illustration in his work depicts the analemma as delineated for a horizontal meridian line, this would suggest that both his noon-mark sundials were constructed on the horizontal plane.

### THE ANALEMMA: invention & history in French gnomonical literature

M. Jean-Paul Grandjean de Fouchy (1707-1788) evidently conceived the idea for this form of sundial about the year 1730 and subsequently constructed the first horizontal mean-time meridian dial for M. le Comte de Clermont.[9] Jean-Dominique Rivard, Professor of Philosophy at the University of Paris, also produced a treatise on gnomonics, which was published in Paris in 1742, just a year after the publication of Antoine Deparcieux's work on the subject. In this, he too illustrates the analemma as delineated for a horizontal mean-time meridian sundial; but he actually

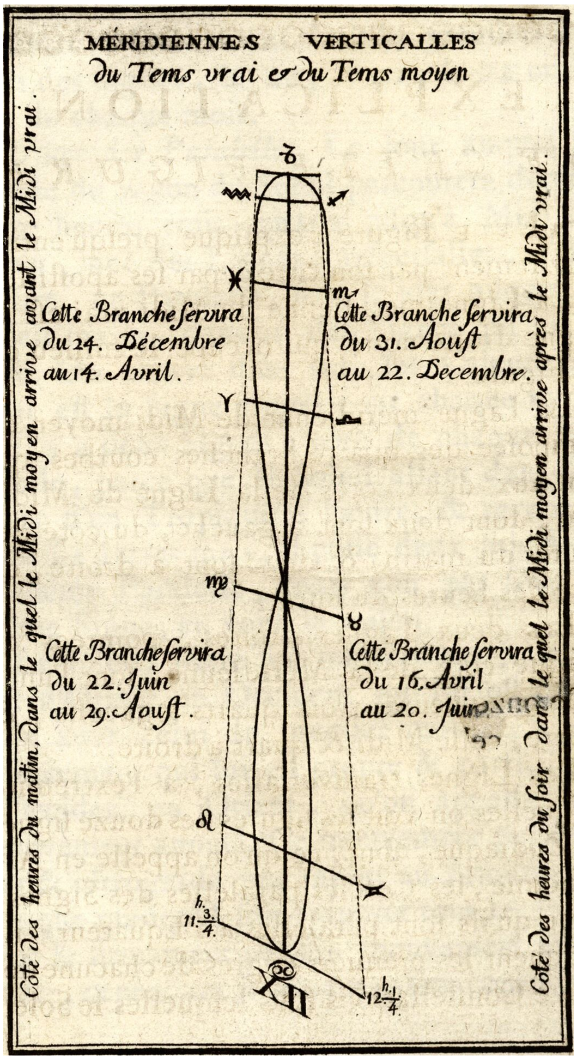
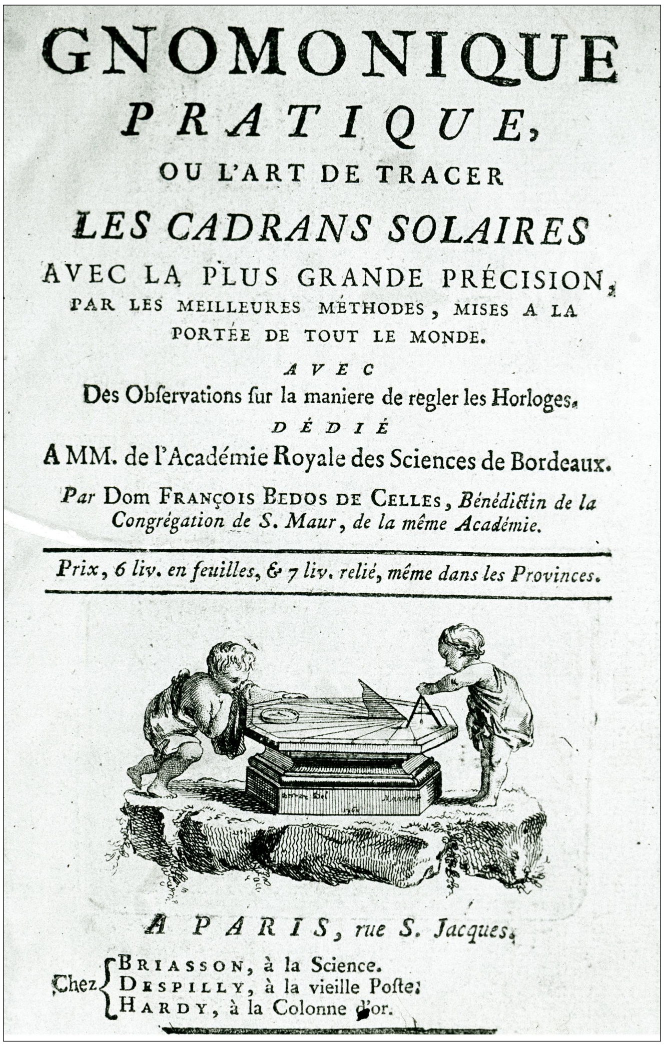



*Fig. 5 The first known illustration of the analemma, delineated for a vertical meridian line on a declining wall, (after Anon, Blois, 1757.[11])*



GNOMONIQUE
PRATIQUE,
OU L'ART DE TRACER
LES CADRANS SOLAIRES
AVEC LA PLUS GRANDE PRÉCISION,
PAR LES MEILLEURES MÉTHODES, MISES A LA PORTÉE DE TOUT LE MONDE.
AVEC
Des Obſervations ſur la maniere de regler les Horloges.
DÉDIÉ
A MM. de l'Académie Royale des Sciences de Bordeaux.
Par Dom FRANÇOIS BEDOS DE CELLES, Bénédictin de la Congrégation de S. Maur, de la même Académie.
Prix, 6 liv. en feuilles, & 7 liv. relié, même dans les Provinces.
A PARIS, rue S. Jacques,
Chez { BRIASSON, à la Science. DESPILLY, à la vieille Poſte. HARDY, à la Colonne d'or.

*Fig. 6 The title page of the popular work on gnomonics by Bedos de Celles, first published in Paris in 1760.[13]*

states[10]: "M. de Fouchy de l'Académie des Sciences, qui est l'Inventeur de la méridienne du tems moyen, a bien voulu me communiquer un mémoire sur cette matiere, dont j'ai profité." Thus, he also establishes M. Grand-Jean de Fouchy as being the *inventor* of the *analemma.*

Most subsequent French gnomonical works now discussed and illustrated the mean-time meridian in its various forms. The first treatise, of which I know, that illustrates the analemma as being delineated for a *vertical* mean-time meridian sundial (see Fig. 5) is that of an anonymous author, published in Blois in 1757.[11] This little work is principally devoted to the construction and use of the mean-time meridian, for the purposes of regulating clocks and watches. Likewise, in 1759, Ferdinand Berthoud (1727-1807), the eminent French horologist and clockmaker, produced a similar work, that was also solely concerned with the regulation of timekeepers. This popular little horological book ran to several editions, the 4th edition of which, containing an illustration of a horizontal mean-time meridian, was published in Paris in 1811.[12] The 6th edition was published in Brussels in 1836 and the last, the 7th edition, in Paris in 1841.

In the year 1760, published in Paris, there appeared the lavishly illustrated work on gnomonics by Dom François Bedos de Celles, (Figs. 6 & 7) of the Benedictine Order. This excellent book discusses the construction of horizontal, vertical and vertical declining mean-time meridian sundials (see Fig. 8) in great depth, portraying them with large, fine and clear engravings.[13] Perhaps not surprisingly, this work also ran to several editions. Whilst there is no mention of Grandjean de Fouchy in the first edition, this was remedied in later editions. Indeed, in the second edition of 1774, as in those that followed, there is printed an extract from the *Register* of l'Académie Royale des Sciences, in the form of an analysis of Bedos de Celles's work, dated 27 Avril 1774, evidently signed by Le Monnier, which also bears a statement of authentication, dated 19 Mai 1774, by Grandjean de Fouchy.[14,15] This was followed by the work of M. de la Prise, first published in Bayeux in 1780 and in Caen in 1781.[16] The first volume of the book was devoted to sundials, with a chapter on the construction of mean-time meridians, with engraved plates to illustrate them, whilst the second volume concerned barometers. These works appear to have established something of a pattern for gnomonical books produced in France in the 18th century. However, as is so often the case, the name of the inventor of the mean-time meridian sundial was almost lost in history!

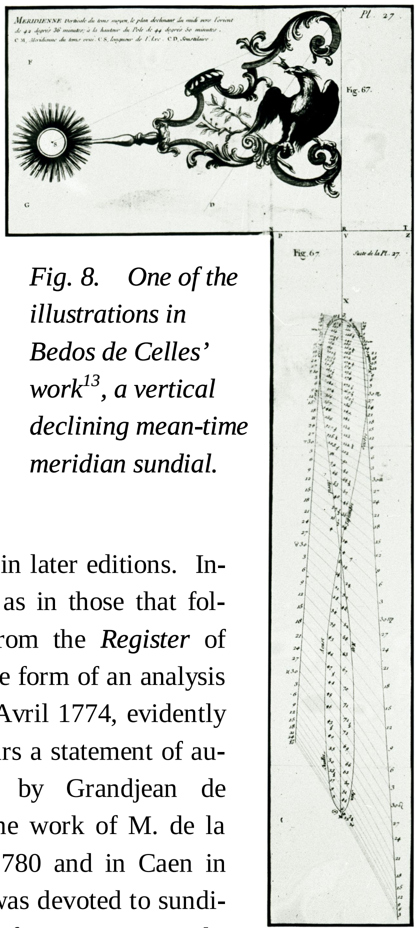


*Fig. 8. One of the illustrations in Bedos de Celles' work[13], a vertical declining mean-time meridian sundial.*

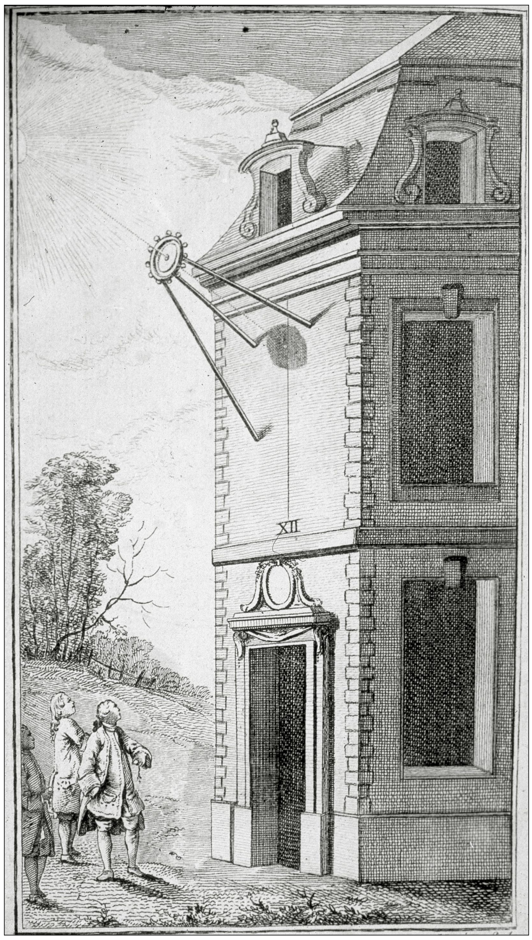



*Fig. 7. The frontispiece of Bedos de Celles' work[13], showing gentlemen checking their watches by use of a noon-mark.*

In the 19th century, a number of French mathematical authors continued to produce distinctive gnomonical works that described and illustrated the construction and practical application of the analemma, as delineated for the various forms of mean-time meridian sundial. E. F. Imbard (Imbart), in a little work first published in 1828, describes a portable device for the construction of vertical mean-time meridians; but this is also solely for the purposes of regulating clocks and watches.[17] In 1854, Général Dufour produced a short treatise on gnomonics, published in Geneva, that illustrated not only the horizontal and vertical mean-time meridian sundials, but also vertical declining and vertical declining-inclining/reclining dials of this kind.[18] There does not appear to be any mention in this gnomonical literature of the origin of the mean-time meridian sundial.

It is not until the 20th century that Grandjean de Fouchy again receives credit for inventing the 'courbe de huit', with the production of a work on the construction of sundials by Abel Souchon, a member of the French Bureau des Longitude, published in Paris in 1905.[19] Likewise, he is mentioned again in the work on sundials of G. Bigourdan, first published in 1922.[20] However, in both of these books, Grandjean de Fouchy is referred to in a footnote. In the former work, he is credited with being the first to construct such meridian dials; in the latter with having conceived the idea for them, although he is also given credit by Souchon, in his illustration of the vertical mean-time meridian, for proposing them.

Whilst French gnomonical literature continues to discuss and illustrate the construction of mean-time dials in modern works, it is only relatively recently, so far as I know, that this instrument has been given the attention it deserves in other European countries.

**INTRODUCTION OF THE ANALEMMA TO OTHER COUNTRIES AND INTO ENGLAND**

Italy was perhaps the next country to include the mean-time meridian in gnomonical publications in the late 18th or early 19th century, possibly followed by Germany, Spain and the Netherlands. However, I think that the earliest appearance of the analemma in an English dialling work must be the illustration in the second edition of Mrs Alfred Gatty's famous book on sundials, published in 1889.[21] Seventeen years later, on the 20th June 1906, Mr Joseph Alfred Hardcastle MP, the grandson of Sir John F. W. Herschel, read a short paper, entitled 'A Greenwich Mean Time Sundial', at a meeting of the British Astronomical Association. This described the vertical south-east declining mean-time sundial that he had designed for his house at Crowthorne in Berkshire.[22] Hardcastle's dial was probably the first of its kind to have been delineated in England, not only with the analemma for a vertical mean-time meridian, but also with analemmas for all the hour-lines on the dial. Thus, at the time, it may well have been unique to Britain and, indeed, I know of only one other such dial, a contemporary work, that is extant to-day.[23]

Modern contributions to the study of the analemma have considered the phenomena that cause it, its shape and the changes to this shape for remote epochs.[24,25] The sun itself has even been spectacularly photographed to illustrate the shape of the analemma.[26] However, the revival of interest in its history and its invention is in no small measure due to the endeavours and tenacity of Madame Andrée Gotteland, a leading member of the Commission des Cadrans Solaires of the Société Astronomique de France, who has written extensively on the subject and who has raised the profile of Jean-Paul Grandjean de Fouchy.

*Fig. 9. M. Jean-Paul Grandjean de Fouchy – the portrait painted by Dom Lyon in 1736. (Courtesy Paris Observatory)*

**GRANDJEAN DE FOUCHY – inventor of the meridian dial analemma**

Jean-Paul Grandjean de Fouchy was born in Paris on the 17th March 1707 and, at an early age, he evidently proved to be a brilliant scholar, with a passion for astronomy and physics. In 1724, he became a pupil of Joseph-Nicolas De Lisle (1688-1768), Assistant-Astronomer of l'Académie Royale des Sciences since 1716, with whom he evidently discussed the construction of meridian sundials, i.e. noon-marks, for the purposes of regulating clocks and watches.[27] His portrait, (Fig. 9) painted by Dom Lyon in 1736, hangs in the Paris Observatory, a testimony to his standing as a distinguished French astronomer, when he was yet only 29 years of age.[28] In 1727 he joined the newly formed Société des Arts; but, in 1731, on the 24th of April, he was appointed an assistant supernumerary astronomer at the observatory, in which year he left the society for the more prestigious l'Académie des Sciences. Two years later, on the 30th March 1733, he was appointed an assistant mechanician, presumably with some responsibility for the maintenance and improvement of the astronomical instruments. In this same year, on the 16th December 1733, he was promoted to assistant astronomer and eight years later, on the 5th February 1741, he became an associate astronomer. In 1743, at the age of 36, he was nominated Permanent Secretary (Secrétaire Perpétuel) of l'Académie Royale des Sciences, although he did not take up this office until the 8th January 1744.[29]

Grandjean de Fouchy rose to become the Deputy Director (Sous-Directeur) of l'Académie Royale des Sciences in 1769 and a year later, in 1770, he was appointed Director. He retired, after six years in the post, on the 24th July 1776, when he became a veteran pensioner (pensionnaire veteran) with the role of Secrétaire Perpétuel Honoraire. Following a reorganisation, he relinquished this position on 23rd April 1785; but remained a veteran pensioner until his death on the 15th April 1788, at the age of 81 years.[30]

Despite a long and no doubt successful career, Grandjean de Fouchy is known principally for his invention of the analemma, in about the year 1730, when he was but 23 years old and when he was yet to receive his first appointment as an astronomer. Unlike his contemporaries, Nicolas Louis de Lacaille (1713-1762), Pierre Charles Lemonnier (1715-1799) and Joseph Jérôme Lefrançais de Lalande (1732-1807), his name is not well known abroad. This may be due, in part, to the stifling conservative influence of the Cassini dynasty of five successive generations, who dominated French astronomy during the 18th century.[31] Thus, Grandjean de Fouchy may have been somewhat overshadowed by the Cassini family during his chosen career as an astronomer. Nevertheless, his contribution to the science of gnomonics, by his invention of the analemma, most notably in France, should not be underestimated.

## THE APPLICATION OF THE ANALEMMA TO MERIDIAN SUNDIALS

As already mentioned, Jean-Paul Grandjean de Fouchy is known to have delineated, if not physically constructed, a number of mean-time meridian sundials, the first for the Comte de Clermont, Louis de Bourbon-Condé, Patron of la Société des Arts, at his home, or that of his grandmother, at l'Hôtel du Petit-Luxembourg, sometime between 1730 and 1733.[32] The gnomon was evidently a metal plate, set in a south-facing window, where a ***nodus***, in the form of a small circular aperture, projected the sun's image, as a spot of light, onto the meridian line, delineated on the floor of the room. Although it is recorded that this noon-mark or meridian sundial was the first to be delineated with the analemma, unfortunately, the dial itself no longer exists.[33] Nevertheless, there is one which is believed to be of similar construction, delineated on the floor of a room, at the l'Hôtel de Bauffremont at 85 rue de Grenelle in Paris, thought to date from about the year 1742, which might also be attributed to Grandjean de Fouchy.

It was Antoine Deparcieux, of course, who first publicised this invention and who also engaged in the construction of such mean-time meridian sundials himself, namely those for the stately homes of the Marquis de Bonnelle and the Marquis d'Hoüel. However, curiously, impetus may have been given to this invention by the remarkable fact the king of France, Louis XIV, le Roi-Soleil, gave an edict that all public clocks should be regulated to "follow the course of the sun", i.e. to show *apparent solar time*! [34] It appears that it was not until the year 1816 that the clocks of Paris were at last set to show mean-time.[35] Nevertheless, this proclamation caused French horologists to attempt to make clocks that kept 'true' apparent solar time. In this state of confusion, there must have been a demand, albeit an unofficial one, particularly by scientifically minded people, for a sundial that would indicate 'clock' time, i.e. *mean solar time*. Thus, in this extraordinary climate, as numerous French gnomonical works show, Grandjean de Fouchy's invention, which provided the means for the practical application of the equation of time correction to a sundial, to which he never actually laid claim, was not only accepted, but grew and flourished.

## THE APPLICATION OF THE ANALEMMA TO EQUINOCTIAL SUNDIALS

Since the publication of Deparcieux's work in 1741, as has already been shown to be the case, French gnomonical literature has almost invariably continued to illustrate the different forms of the mean-time meridian sundial, and, likewise, practitioners of gnomonics in France have continued to construct such sundials into the modern era. Nevertheless, one should mention one particular application of the analemma that is of some note, namely its application to the ***equinoctial*** sundial, i.e. the equinoctial mean-time sundial, and more particularly to that form of equinoctial mean-time sundial termed a ***heliochronometer***.

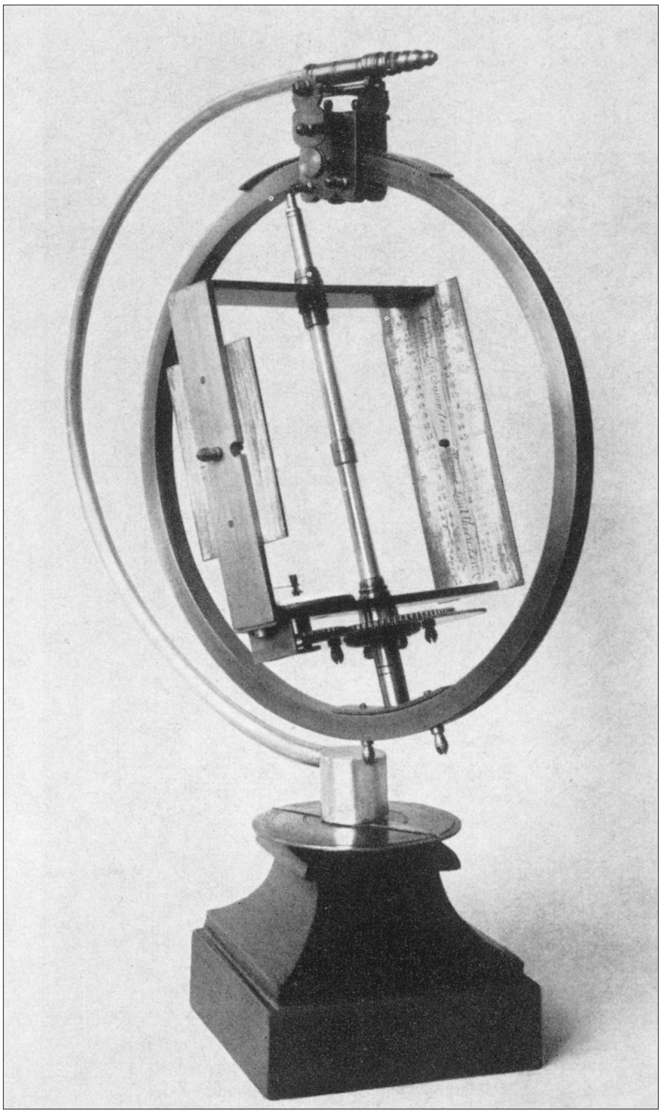


*Fig. 10. The first known heliochronometer, made by Phillip Mathias Hahn, the German clockmaker in 1763.*

## THE HELIOCHRONOMETER

The heliochronometer is essentially a 'universal' mechanical equinoctial mean-time sundial, that incorporates a mechanism to apply the equation of time correction and which may allow for the difference in longitude from a standard meridian, which will directly indicate standard 'clock' time.[36] Just when the first heliochronometer made its appearance is uncertain; but, in the year 1763, the celebrated German clock and watchmaker Phillip Mathias Hahn (1739-1790) devised such a mechanical equinoctial sundial.[37,38] It is shown in Fig. 10 and is a somewhat cumbersome instrument in appearance, comprising a heavy brass meridian ring, graduated with a 90-degree 'latitude' scale in one quadrant, suspended from a curved supporting arm, which may be turned in azimuth about a graduated circular plate, fixed to a heavy wooden base. The meridian ring, which may be set for the latitude of the place of observation by use of the graduated scale, is furnished with a fixed steel rod, passing through its centre and lying in the polar axis of the instrument. Within this assembly, a rectangular frame, fitted with a plate at each end, may be rotated about the steel rod, in the plane of the equinoctial. One of these plates is pierced by two small circular apertures or 'pin-holes', as a *nodus*, such that when the rectangular frame is aligned with the sun, two spots of light will be projected onto the opposite plate, engraved with a zodiacal declination scale and with an equation of time correction curve, in the form of the *analemma*. Since the rectangular frame is geared to drive the hands attached to a clock, when the two spots of light are projected, so as to be aligned with the declination for the date in question, on the scale of zodiacal signs, and also to coincide with the appropriate point on the analemma, the correct time will be shown by the clock.

Instruments of this kind, developed from the self-orienting dial seen in Fig. 11 and ascribed to the brilliant English mathematician William Oughtred (1575-1660) (Fig. 12), the universal equinoctial ring dial,[39] with an alidade and pin-hole sights or a combination of lenses, fitted with gears


*Fig. 12. William Oughtred, the brilliant English mathematician, who invented the universal equinoctial ring-dial.*

*Fig. 11. An 18th century universal equinoctial ring-dial, in use.*

*Fig. 13. Early 17th century mechanical equinoctial sundial in the National Maritime Museum at Greenwich. (NMM.)*

to drive the hands of a clock, were not uncommon in the 17th century. However, Phillip Hahn's mechanical equinoctial sundial (see Fig. 13), incorporating the analemma as a means of correcting for the equation of time, would seem to be the first of its kind that may be truly described as a *heliochronometer*. The use of the *analemma*, as a device for applying this correction directly to a sundial, at the time when Phillip Hahn first constructed such an instrument, would, no doubt, have been common knowledge in German sundial-making circles. What may seem somewhat surprising, however, is that the heliochronometer did not first make its appearance in France!

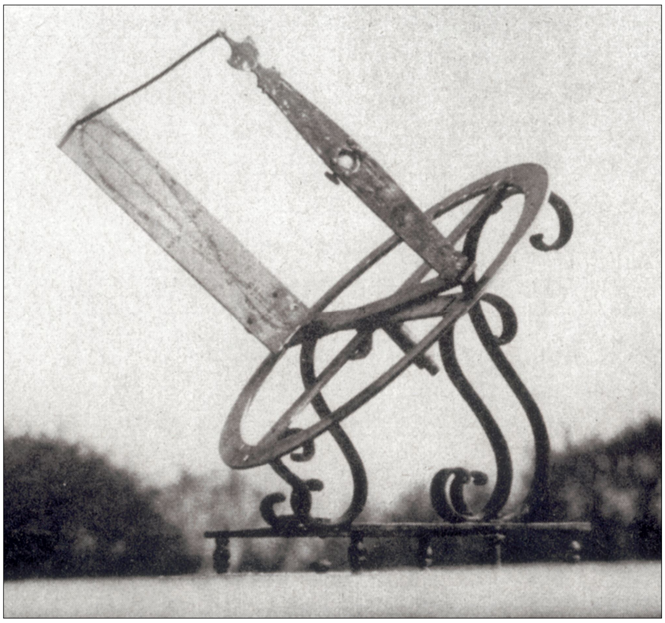


*Fig. 14. The heliochronometer invented by L'Abbé Guyoux in about 1827. (after Charles Pommier, L'Astronomie.[43])*

In about the year 1826 or 1827, L'Abbé Jean-Marie Victor Guyoux (1793-1869) invented what must be one of the simplest of all heliochronometers.[40,41] Shown in Fig. 14, it comprises a basic rectangular frame, constructed as an alidade or sighting arm, fitted with two tall perpendicular vanes, one containing a small circular aperture at its centre, through which the sun's rays may pass to project a spot of light onto the other vane, the latter being engraved with the equation of time curve in the form of the analemma. This sighting arm is pivoted on the equinoctial hour-ring of the sundial, which, in turn, is mounted on a simple supporting frame, manufactured specifically for the latitude of the particular site. Thus, the sighting arm may be turned, until the projected spot of light coincides with the date on the analemma, when the correct 'clock' time will be indicated by a pointer on the equinoctial hour-scale. Whilst alidades of various forms, fitted to equinoctial sundials, were in common use in the 16th century, as illustrated, for example in the works of Clavius,[42] it is quite probable that L'Abbé Guyoux conceived the idea for his instrument from the system devised by Phillip Hahn.[43] Nevertheless, much to his credit, Guyoux's heliochronometer won commercial medals of honour in 1841 and in 1855. It is understood that a number of these sundials may still be found today in the gardens of some of the more historic properties of France. Furthermore, his instrument may well have been the inspiration for the elegant and sophisticated, but similar 'universal' heliochronometer, first made in 1860 by M. Fléchet, an engineer in Paris.[44] Fléchet's heliochronometer, shown in Fig. 15, was an instrument of great precision, which was used by the French railways in the late 19th and early 20th centuries, to regulate their station clocks and to ensure that their trains ran on time. The earliest illustration of it in an English publication, of which I know, is that which appeared in a little book on popular astronomy in 1882.[45]

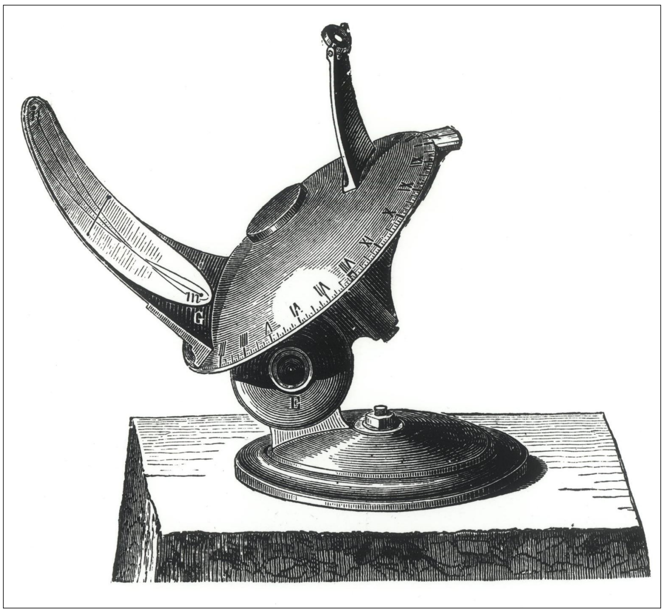


*Fig. 15. Fléchet's elegant heliochronometer, first made in 1860 and used by the French railways to regulate their clocks.*

**THE HELIOCHRONOMETER IN ENGLAND AND SCOTLAND**

In England, in the tradition of the English *Art of Dialling*, the heliochronometer was invented independently, without any evident knowledge of the analemma, by George J. Gibbs, just before the turn of the 19th century, and was patented in 1906. Shown in Fig. 16, it was manufactured by Messrs Pilkington & Gibbs of Preston and was much in demand, being exported to many countries around the world. This magnificent instrument had the usual sighting vanes; but its ingenuity lay in the hidden cam, beneath the date-setting disc on the equinoctial dial-plate, which allowed for the equation of time correction when the instrument was set for the particular date, by adjusting one of the sighting vanes.[46] At about the same time, William M.

*Fig. 16. The famous Pilkington & Gibbs heliochronometer, patented in 1906 and exported widely around the world.*

Homan, a Scottish civil engineer working in the Orange River Colony (now the Orange Free State) in South Africa, also invented a heliochronometer, which he evidently manufactured when he returned to Scotland and set up in business in Glasgow, as a sundial-maker, in about the year 1910. This instrument has a certain resemblance to that of the Pilkington & Gibbs heliochronometer; but it works on a similar system to Fléchet's instrument and incorporates the analemma on the receiving surface of the lower 'sighting' vane. I know of only two examples of this particular form of Homan heliochronometer, one of which is set on a fine baluster pedestal, bearing the date 1911, in the garden of an estate in Scotland.[47] By comparison with those of Messrs Pilkington & Gibbs, it must be something of a rarity.

*NB. A dial based on the same principle as Guyoux's heliochronometer, and somewhat resembling it, was constructed such that it was fixed to the inclined edge of the gnomon of a horizontal sundial at Lyme Hall, the seat of Lord Newton, some one hundred and sixty years earlier in 1683.*

***To be continued.***

**REFERENCES**


1. B. Donn (1729-1798): *The Analemma Improved*, published by the author, Bristol, January 1st, 1770.
2. J. Flamstead (sic): *Philosophical Transactions* [of the Royal Society] No. 55, (p 1104.) January 17. 1670.
3. P. I. Drinkwater: 'The Analemma of Vitruvius', *BSS Bulletin*, No.93.2, (pp 18-20.), June 1993.
4. D. W. Hughes: 'An Introduction to the Equation of Time', BSS *Bulletin*, No. 93.3, (pp 8-12.), October 1993.
5. A. Mills: 'More about the Equation of Time and the Analemma', *BSS Bulletin*, No. 94.1, (pp 30-31& p 40.), February 1994.
6. F. W. Sawyer III (U.S.A.): 'Of Analemmas, Mean Time and the Analemmatic Sundial – Part 1.', *BSS Bulletin*, No. 94.2, (pp 2-6.), June 1994.

6a. J. Davis: 'The Equation of Time as represented on Sundials' *BSS Bulletin*, 15(iv), pp 135-144, (2003).

6b. J. Davis: 'More on the Equation of Time on Sundials', *BSS Bulletin*, 17(ii), pp. 66-75, (June 2005).

7. C. Daniel: 'A question of time', (The Sundial Page), *Clocks*, Vol. 14, No. 8, (p 47.), January 1992.
8. A. Deparcieux: *Nouveaux Traités de Trigonométrie Rectiligne et Sphérique avec un Traité de Gnomonique* , (Pl. XVII. Fig.134.) Paris, 1741.
9. A. Gotteland: 'Le rôle joué par les Instruments Solaires au XVIIIe Siècle', *Paris Tête d'Affiche*, (La Célébration du Bicentenaire de La Révolution Française), (p 35.) Mairie de Paris, 15 Avril/ 15 Juillet 1989.

9a. A. Gotteland: 'Grandjean de Fouchy, inventeur de la méridienne du temps moyen', *Horlogerie Ancienne*, No 27, (p 106.) 1er Semestre 1990.

9b. A. Gotteland et Georges Camus: *Cadrans Solaires de Paris*, (p 197.) Éditions du C.N.R.S., Paris, 1993.

9c. A. Gotteland: *Les Méridiènnes du Monde*, (Extrait du chapitre 3), M.S. 2004.

10. J-D. Rivard: *La Gnomonique, ou L'Art de Faire des Cadrans*, Paris, 1742. (p 296 & Pl.2. Fig.12.) The information given and the quoted text were taken from the third edition of this work, published in 1767. It is believed that there are no substantial differences.
11. Anon. *Regle des Horloges, et Explication des Deux Meridiennes du Tems-Vrai et du Tems-Moyen*, (Pl. p 34.) Blois, 1757.
12. F. Berthoud: *L'Art de Conduire et de Régler les Pendules et les Montres*, (Pl. V.), 4th Edition, Paris, 1811. (This is the first edition of this work augmented with the 5th plate that shows the construction of the analemma for a horizontal mean-time meridian line to correct for the equation of time.) (First Edition: Paris, 1759.) 6th Edition: Bruxelles, 1836 & Paris, 1841.
13. F. Bedos de Celles: *La Gnomonique Pratique, ou L'Art de Tracer les Cadrans Solaires*, (Ch IX Sec IV pp 240-278.), Paris, 1760. 2nd Edition: Paris, 1774.
14. A. Gotteland : 'Grandjean de Fouchy, inventeur de la méridienne du temps moyen', *Horlogerie Ancienne*, No 27, (p 120.) 1er Semestre 1990.
15. F. Bedos de Celles: *La Gnomonique Pratique, ou L'Art de Tracer les Cadrans Solaires*, (Preface p xvj. & pp 505-509.) New (3rd) Edition, Paris, 1780. 4th Edition: Paris, 1790.

16. R. Gervais de la Prise: *Méthode Nouvelle et Générale pour tracer facilement des Cadrans Solaires*, ( Ch VII pp130-151.) Caen 1781.

17. E. F. Imbard: *De la Mesure du Temps, et Description de la Méridienne Verticale Portative du Temps Vrai et du Temps Moyen, pour Régler les Pendules et les Montres,* (*1827.*) (Pl.) Versailles, & Paris, 1828. 2nd Edition: Paris, 1857.

18. Général G. H. Dufour: *Mémoire sur la Gnomonique* [1854.] ('Gnomonique. Mémoire présenté à la Classe d'Industrie de Genève par le général Dufour.'), (Pl. 3 & Pl.4.) Genève, 1854.

19. A. Souchen: *La Construction des Cadrans Solaires*, (p 17 – Footnote. Also Pl.1 & Pl.2. Fig. 7. - Méridienne [vertical déclinant à l'Est] du temps moyen (Lemniscate) proposée par de Fouchy.), Paris, 1905.

20. G. Bigourdan: *Gnomonique ou Traité Théorique et Pratique de la Construction des Cadrans Solaires*, (p 111. Fig 62. – Partie d'un Cadran solaire tracé à l'École Polytechnique. & p 113 – Footnote. Also p 115. Fig. 63. – Cadran [vertical direct] méridional avec sa méridienne de temps moyen.), Paris, 1922. 2nd Edition: Paris, 1956.

21. A. Gatty: *The Book of Sun-Dials*, 'Appendix on the Construction of Sun-Dials' by W. Richardson, (Pl.III. Fig. 8. - Equation of Time.), New and Enlarged Edition, Edited by H. K. F. Gatty and E.Lloyd, London, 1889.

22. J. A. Hardcastle: 'A Greenwich Mean Time Sundial', *The Journal of the British Astronomical Association*, Vol. XVI., No. 9, (pp 348-352. Fig. 5.), London, July 26, 1906.

23. C. Daniel: 'A mean-time dial', (The Sundial Page), *Clocks* Magazine, Vol. 13, No. 4, (p 39.), September 1990.

24. K. L. Franklin: 'The Analemma - The Astronomer's Odd Figure 8', *Contributions of The American Museum – Hayden Planetarium*, Series 1, Publication 7, (pp 8-15.), (Reprinted from Natural History Magazine, The American Museum of Natural History), New York, October 1962.

25. B. M. Oliver: 'The Shape of the Analemma', *Sky and Telescope* Magazine, Vol. 44, No. 1, (pp 20-22.), July 1972.

26. H. J. P. Arnold: 'Portrait of a year', *The British Journal of Photography*, No. 6705, (pp 21-23.), 16 February 1989.

27. A. Gotteland: 'Grandjean de Fouchy, inventeur de la méridienne du temps moyen', *Horlogerie Ancienne*, No 27, (p 106.), 1er Semestre 1990.

28. *Ibid*., (p 105.)

29. In memoriam – Liste alphabétique F –'Fouchy (Jean-Paul Grandjean de) 17 mars 1707-15 avril 1788', *Les Membres de l'Académie des Sciences* – (p 5.), 12/01/2005.

30. *Ibid*.

31. I. Asimov: *Asimov's Biographical Encyclopedia of Science and Technology*, 92 (pp 92-93.), New York, 1964.

32. A. Gotteland: 'Grandjean de Fouchy, inventeur de la méridienne du temps moyen', *Horlogerie Ancienne*, No 27, (p 116.), 1 er Semestre 1990.

33. *Ibid*.

34. *Ibid*., (p 107.)

35. *Ibid*., (p 122.)

36. C. Daniel: 'Heliochronometers', (The Sundial Page), *Clocks* Magazine, Vol. 24, No. 11, (p 34.), December 2001.

37. E. Zinner: *Deutsche und Niederländische Astronomische Instrumente des 11.bis 18. Jahrhunderts*, (pp 91 & 352.), München, MCMLVI.

38. H. Wynter and A. Turner: *Scientific Instruments*, (p 143.- Fig. 167.), London, 1975.

39. *Ibid*., (p 119.)

40. C. Pommier: 'Cadrans Solaire A Équation', *l'Astronomie*, Vol. 92., (pp 283-287.), Juin 1978.

41. C. Pommier: 'Les Cadrans Solaires', *Société Astronomique de Lyon – Revue Trimestrielle*, (p 39 & '57'.), Hors série no 2 – 1981.

42. C. Clavius: *Fabrica et Usus Instrumenti ad Horologiorum*, (p 7, 8, 10 & 12 Ibid.), Rome, 1586.

43. C. Pommier: 'Cadrans Solaire A Équation', *L'Astronomie*, Vol. 92., (p 286.), Juin 1978.

44. C. Pommier: 'Les Cadrans Solaires', *Société Astronomique de Lyon – Revue Trimestrielle*, (p 39.), Hors série no 2 – 1981.

45. H. Frith: *Marvels of Astronomy*, (p 155 – M. Flechet's Solar Chronometer.), London, 1882.

46. C. Daniel: 'The heliochronometer of G J Gibbs', (The Sundial Page), *Clocks* Magazine, Vol. 13, No. 11, (p 38), April 1991.

47. C. Daniel: 'Another P&G connection [?]', (The Sundial Page), *Clocks* Magazine, Vol. 25, No. 6, (p 28), July 2002.

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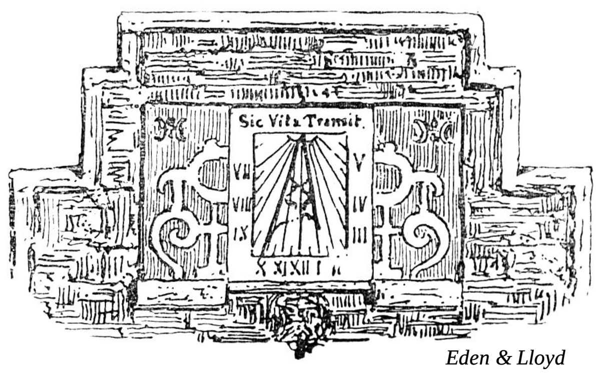


*Eden & Lloyd*

*Dial on the house of Compton Wynyates, Warwickshire.*

# A CLOSE LOOK AT A SALISBURY DIAL


## HARRIET JAMES and JOHN DAVIS


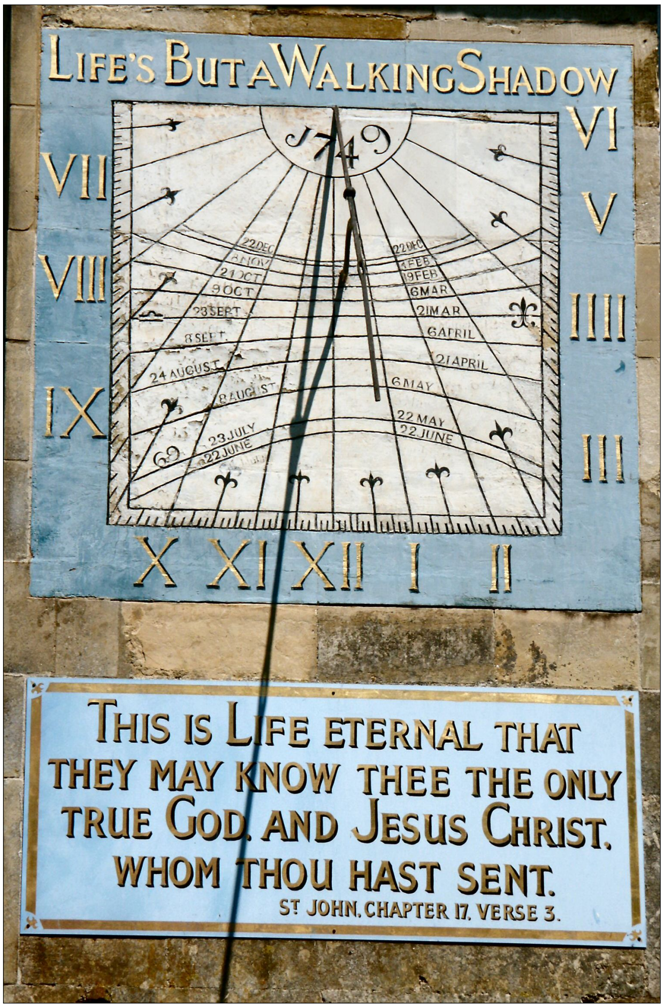


*Fig 1. The sundial at Malmesbury House.*

The handsome and well-known sundial on the south wall of Malmesbury House in the Cathedral Close, Salisbury, (SRN 2028) is attributed to James Harris (1709-1780). Inheriting the house in 1733, he became a county magistrate and Member of Parliament. He wrote treatises on grammar, art, music, painting, poetry and happiness and was a playwright. He was also a great lover of music and a friend of Handel.[1]

The sundial, shown in Fig. 1, is dated 1749. It is painted directly onto the stone ashlar of the house facing North Row, near the entrance to the Close at St. Ann Gate. A restoration in 1989 appears to have been faithful to the sundial's original 18th century colour-scheme of blue, black, white and gold.

The motto at the top of the sundial, 'Life's but a walking shadow' is from Shakespeare's 'Macbeth' and is part of Macbeth's speech just after he has heard of the death of Lady Macbeth[2]:

*She should have died hereafter;*
*There would have been a time for such a word.*
*Tomorrow, and tomorrow and tomorrow,*
*Creeps in this petty pace from day to day*
*To the last syllable of recorded time,*
*And all our yesterdays have lighted fools*
*The way to dusty death. Out, out, brief candle!*
*Life's but a walking shadow, a poor player*
*That struts and frets his hour upon the stage*
*And then is heard no more; it is a tale*
*Told by an idiot, full of sound and fury,*
*Signifying nothing.*

The negative tone of the speech is quite a contrast to the biblical inscription in the panel below the sundial.[3]

The sundial declines about 2º west of south and seems to be correctly delineated with five-minute divisions of the hours in a border. A gap in the divisions at 12.15 pm accommodates the thickness of the gnomon, which appears to be original.


*Fig. 2. Close-up of the gnomon (above) with its nodus and 'eye' and the resulting shadow (right) just after noon on 9 July. Note also the gnomon gap.*


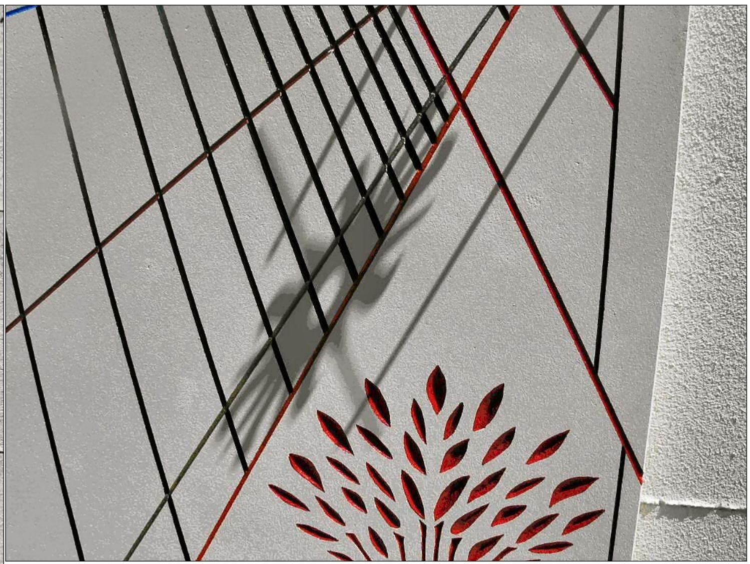

*Fig. 3. A clear elliptical spot of light but fuzzy shadow of the gnomon bar before 1pm on a modern great decliner.*

The observer reads the time from the shadow of the leading edge of the square section gnomon bar, rather from the centre of the shadow. This is a common layout, but on further inspection one can see that the gnomon bar has a bulge in it below the joint with its supporting foot, and that the bulge has a slot in it which allows an ellipse of light to fall on the wall below the sundial. This 'eye' in the gnomon is at twice the distance (approximately) from the dial origin as the ordinary spherical nodus. The close-up photograph of Fig. 2, taken at five minutes past noon on 9$^{th}$ July this year, shows the centre of the ellipse of light positioned just above a black dot in the border of the panel with biblical inscription below the dial.[2] Although it was not observed on the summer solstice, the position of the ellipse on 9$^{th}$ July strongly suggests that its centre should lie over the black dot at noon on the solstice. On the equinoxes, the ellipse of light is expected to lie in the 5-minute border at noon. It is possible that the shadow of the tip of the gnomon touches the black dot on the winter solstice. If this is correct the sunspot device seems to be used as a link between the biblical inscription and the sundial above. Even if this is not the case, it is clear that the designer thought about this unusual gnomon very carefully.

Although the use of a spot or shaft of light is not common on vertical sundials it was used for meridian lines in medieval cathedrals and is still used by modern sundial designers, for example by Piers Nicholson on his 'Spot-on' sundials[4] and John Moir on his Armillary Octahedron[5]. The advantage of using such a spot of light is that it seems to be clearer to read even when there is penumbra around its edge, because the brain's optical processes can easily determine the centre of a bright spot within a surrounding shadow.

One of us (HJ) has recently used a similar idea on a vertical sundial facing almost due west. A conventional bar gnomon was almost useless on this sundial between noon and 1pm as the 'shadow' cast by it was practically invisible, consisting almost entirely of penumbra, because of the extreme angle of the sun to the dial face. An elliptical hole cut in a tilted sun shape casts an elongated spot of light around noon which gradually becomes rounder as the afternoon progresses, but whatever its shape it is still possible for the eye to determine the centre of that shape (Fig. 3).

*Fig. 4. The sign for Aries combined with the 3:30 fleur-de-lis on the Malmesbury House dial.*

The ordinary spherical nodus on the gnomon at Malmesbury House tracks a set of eleven declination curves. The upper declination curves labelled 22nd December and 8th November/4th February do not seem to terminate along the line of the horizon as they should in theory. This may be because the designer did not want the curves to terminate in empty spaces between seven and eight am and four and five pm, or perhaps a restorer at some stage was uncertain of the detail.

The half-hour lines terminate in fleurs-de-lis, a common decoration on 18th century sundials. However the terminal for 3.30 pm (see Fig. 4) which crosses the declination line for the equinoxes has been cleverly amalgamated with the zodiac sign for Aries (♈) to make a larger, upright fleur-de-lis.

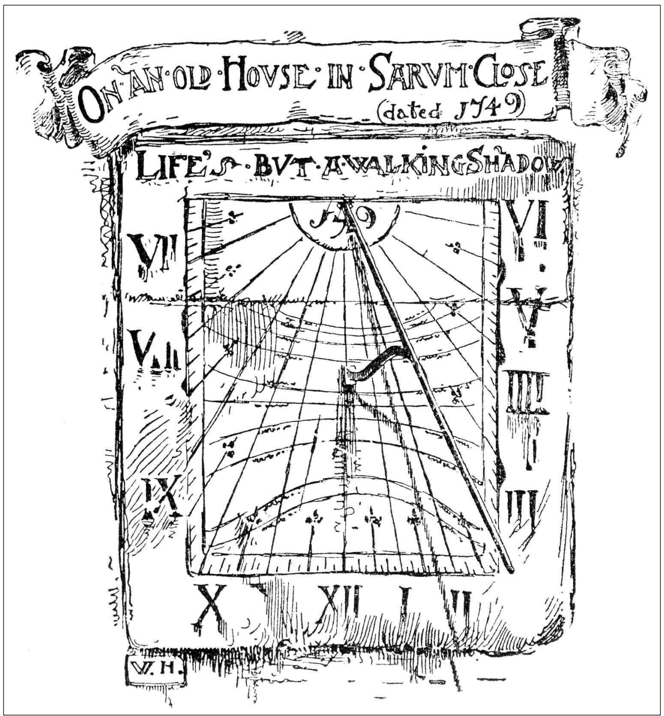


*Fig 5. Warrington Hogg's record of the Malmesbury House sundial from Mrs. Gatty's book.*[6]

The letters and numerals on the sundial are gilt with a black shadow to give them a three-dimensional appearance, a trick commonly used by signwriters. One curious exception is the date which appears to be carved into the stone and painted black. The style of the date's numerals is distinctly 18th century with curled tails to the 1 and 9, whereas the lettering style of the biblical inscription and motto suggest a later date. Warrington Hogg's drawing of the sundial in Gatty[6] (Fig. 5) shows a different style of lettering on the motto (with pointed 'V's) suggesting that changes were made upon repainting.

Mrs. Gatty writes, 'The same motto is on Woodborough Manor House, Wiltshire, and on a vertical dial on the stables at Arbury, Warwickshire'.[7] She describes the dial as being an 'erect' (sic) south dial and the text incorrectly gives the date as 1769, in contrast to the drawing. The drawing also seems to show that the declination curves terminate along an horizon line. The biblical inscription below the sundial is not shown.

A modern plaque beside the sundial, erected after the restoration of the sundial in 1989 reads:

'An important timely point
of interest to the passer by..
In the year of our Lord 1752 the Reformation of the Calendar took place – See the Wall Dial above dated 1749. This Julian Calendar made the year too short, thus the accumulated error amounted to eleven days. England adopted the Gregorian or Reformed Calendar, so the next day after Sept. 2nd 1752 became Sept. 14th 1752.'

Although the sundial is dated from before the calendar change, the declination curves on the sundial are be labelled with the approximate Gregorian dates for the entry of the sun into the constellations, rather than the earlier Julian ones. This suggests that the labels of the lines (which would still have the same values of the sun's declination) were updated in one of the post-1752 restorations. Signs of the earlier paintings are still visible in some places. This subtle dial is still a fine tribute to its original maker.

**REFERENCES AND NOTES**

1. www.salisburycathedral.org.uk/cathedralclose and Encyclopaedia Britannica (1911)
2. Macbeth, Act 5, Scene 5.
3. 'THIS IS LIFE ETERNAL THAT
   THEY MAY KNOW THEE THE ONLY
   TRUE GOD, AND JESUS CHRIST.
   WHOM THOU HAST SENT.'
   ST. JOHN CHAPTER 17. VERSE 5'
4. www.spot-on-sundials.com
5. J. Moir & J. Davis: 'An Armillary Octahedron', *BSS Bulletin* 15(iii), pp122-123, (Sept 2003).
6. A. Gatty and H.K.F. Eden & E. Lloyd (Eds): *The Book of Sun-Dials,* 4th edition, Bell & Sons, London (1900).
7. The Arbury Hall dial is SRN 3370 but the Woodborough dial appears not to be recorded in the BSS Register.

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# READERS' LETTERS

**DUAL SHADOWS**

I have been reading 'A Pair of Blue Eyes' by Thomas Hardy, in which I came across the following passage towards the end of Chapter XIX. The event takes place on a Sunday evening in August.

> They were walking between the sunset and the moonrise. With the dropping of the sun a nearly full moon had begun to raise itself. Their shadows, as cast by a western glare, showed signs of becoming obliterated in the interest of a rival pair in the opposite direction which the moon was bringing into distinctness.
>
> "I consider my life to some extent a failure," said Knight again after a pause, during which he had noticed the antagonistic shadows.

I believe that Hardy was quite knowledgeable about scientific matters, but the effect described above seems to me to be most unlikely. If the setting sun is bright enough to cast shadows, it must be many times brighter than the rising moon. Is it really possible for two sets of shadows to be visible under these circumstances? Has anyone actually observed this phenomenon? In view of the comments on the brightness of moonlight by Michael Lowne ('Moondials and the Moon', *Bull. BSS* 17(i), pp. 3-12, March 2005), I think that the answer to both questions would be emphatically 'No'.

*Ken Head*
*COBHAM, Surrey*

*Michael Lowne replies:*

At first sight the phenomenon certainly appears to be most unlikely, but by making a few assumptions can be brought within the bounds of possibility. Firstly, the moon is said to have been 'nearly full'. If this was judged visually by the non-circular appearance of the disc, it is probable that the moon's phase was at least two days before full and it could therefore have risen by more than an hour before sunset. It would then be clear of the eastern horizon but could still be said to have 'begun to raise itself'. Secondly, the shadows were cast by a 'western glare', not necessarily the sun itself: perhaps the sun had just set and the sunset sky-glow was both bright and concentrated enough to cast diffuse shadows. As the glow faded and became similar in intensity to the moonlight, these shadows would also fade and be replaced by those from the moonlight. There could be a period, longer or shorter depending on how rapidly the glow faded, when both sets of shadows were visible. The effect would be similar to that shown by the shadows of a person walking between two street-lamps: at first the nearer lamp casts a much stronger shadow, mid-way between the shadows are equal, but as the second lamp is approached the first shadow becomes weaker until it is no longer visible.

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**SUNDIALS DEPICTED IN STAINED GLASS WINDOWS**

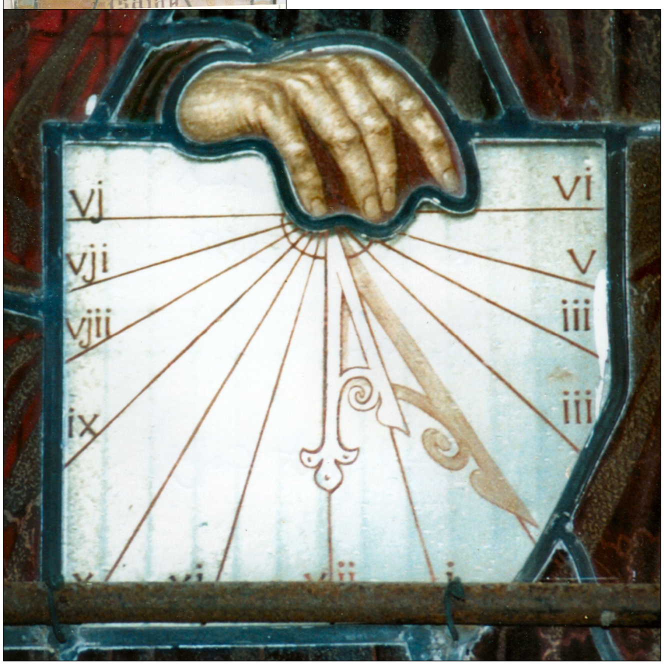
During the course of my visits to various churches in search of sundials and mass dials, I have discovered two stained glass widows with sundials depicted within the design, These are at:

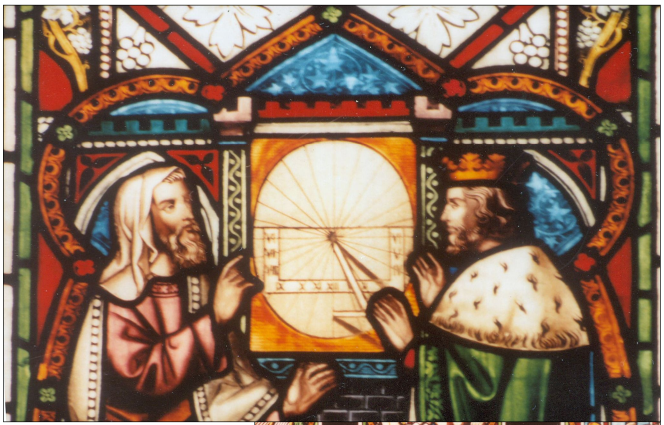
St Mary Magdalene church, Newark, Nottinghamshire

St Andrew & St Mary church, Grantchester, Cambridgeshire.

The depicted dial at Grantchester is within a series of windows and is being held by the prophet Isaiah. This would seem to suggest a possible attribute of Isaiah where he was able to "turn back the shadow of the sundial of King Ahaz by ten degrees" (Bible: Isaiah 38, v.8; also Kings II 20, v.9-11). The dial at Newark similarly suggests the prophet Isaiah.

*Part of the series of prophets shown in the stained glass windows of St Andrew & St Mary church, Grantchester.*





*The sundial in the stained glass window at Newark, Notts. The inscription for the window gives a date of 1859.*

Although not strictly a *functional* stained glass sundial that could be recorded by our Fixed Dial Register, I feel that these items should be recorded due to their direct representation of a sundial. Perhaps other members of the Society may have found similar depictions during their visits to churches. I would be most interested to hear of any findings and would be quite happy to act as a recording-point for such depictions. Perhaps members could also look out for these when on a dial safari in the future.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**'JGP'**

In his article on the Equation of Time in *Bull.* 17(iii), John Davis mentions the source 'JGP' of F.W. Cousins' EoT table. The initials are those of the late Dr John Guy Porter, Principal Scientific Officer in HM Nautical Almanac Office at Herstmonceux, which explains why his values of EoT are given in the astronomical convention of 'Apparent Time *minus* Mean Time'. Of course in this way a plus sign to EoT implies 'dial fast' on mean time and a minus sign 'dial slow'.

Porter also contributed the sundial formulae to Cousins. He may perhaps be remembered as the presenter on the 1950s of a monthly astronomy programme 'The Night Sky' on BBC radio.


*Michael Lowne*
*Hailsham, East Sussex*


**THE BSS IN NATIONAL SCIENCE WEEK**

For several years now, the BSS has exhibited at the National Maritime Museum during National Science Week, and this year was no exception. It was also our most successful on yet. Formerly, we were located in the splendid isolation of the Old Royal Observatory, while the focus of events was in the main museum. This time (and hopefully in the future) we were on the new mezzanine floor of Neptune's Hall, adjacent to a very long display case containing a banquet of sundials and astronomical instruments.

The BSS display complemented these, thanks to the enthusiasm of several members. Ray Ashley brought along several of his eye-catching creations, while Leonard Honey – assisted by Jane Apfel – had an astonishing range of scientific model kits and replica instruments to view. Kevin and Irene Barrett were kept busy looking after the sundial-making area. The museum supplied copies of their paper cut-out horizontal sundial for visitors to make up. Over the weekend, some 260 were made on the spot and a further quantity taken away to be duplicated for schools and scout groups.

It would be good if we could build on this success for next year, to which end offers of assistance from members would be welcomed. The next event will most probably be 11/12 March 2006. Among the things needed will be:

* 2/3 people each day to look after the stand
* larger colour pictures of dials
* large, robust sundial models and devices to explain their working – ones that can be handled are urgently needed.

Many of the museum visitors have some idea of the existence of sundials, but their lack of knowledge seems to make them shy about stopping to talk. There also seems to be a large number of people apparently unaware of the sun's apparent motions and how they can be used. It is for these reasons that simple, hands-on models which will be a talking point are especially needed. Although we have some six months before the next event, *Tempus Fugit*; therefore the earlier anyone minded to assist can contact me, so much the better.


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# MAJOR LUNAR STANDSTILL

## FIONA VINCENT

The term “lunar standstill” was apparently coined by Alexander Thom, in his 1971 book *Megalithic Lunar Observatories* (Oxford University Press). It is analogous to the term “solstice”; in neither case does the moon or the sun actually stand still.

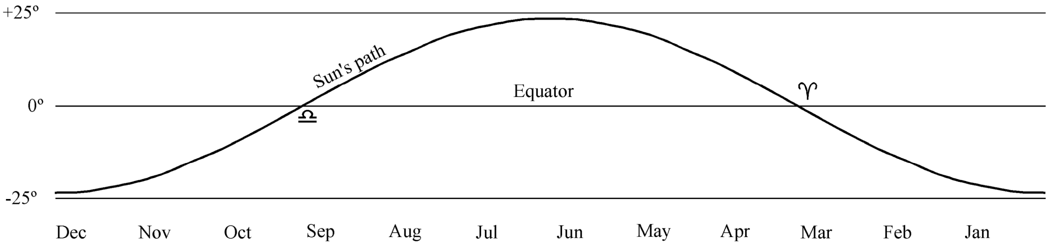


*Fig. 1. The sun’s yearly path.*

Consider the sun first. Figure 1 will be familiar to most readers: it shows how the sun’s declination changes relative to the earth’s equatorial plane, reaching extremes of ±23.4° at present (the obliquity was a little greater in Megalithic times). For a common-or-garden sundial with a gnomon pointing to the North Celestial Pole, this changing declination doesn’t affect the sun’s time-keeping. But it has some secondary effects.

The sun’s altitude changes from day to day, changing the length of the shadow. If we place a nodus on the gnomon, its shadow will trace out a line across the dial from sunrise to sunset; the line will be near the middle of the dial in summer, when the shadows are short, but further out in winter. Many dials have midsummer, midwinter and equinox lines marked in this way.

The sun’s changing declination also affects the times of its rising and setting, and a dial should be designed to show all the hours for which the sun may be visible in midsummer. In southern England, most horizontal dials are marked from 4 am to 8 pm, but in Scotland we generally need hours from 3 am to 9 pm. The direction of the sun at rising and setting also varies with its declination, and it is this which is probably easiest to observe without instruments. At the March equinox (marked ♈ on Fig. 1) the sun rises due east and sets due west; but over the following weeks, for observers in north temperate latitudes, the rising and setting points move northwards along the horizon. This movement slows down and halts at midsummer, before reversing; in this sense the sun “stands still” at the midsummer solstice.

So what about the moon? To a first approximation, it is simply a high-speed mimic of the sun, repeating the sun’s annual north-south cycle in every monthly orbit. For example, in September the last-quarter moon, being 90° west of the sun, shows us roughly how the sun was behaving three months ago, in June.

But the moon’s motion is not that simple. Its orbit doesn’t quite coincide with the plane of the earth’s orbit; it’s tilted by 5.1 degrees. So for most of the time, the moon travels either north or south of the sun’s path. It crosses it only twice in each orbit, at the ascending and descending nodes (marked ☊ and ☋ on Figures 2 and 3). Figure 2 shows the moon’s orbit in the year 1995. The ascending node of the moon’s orbit on the ecliptic lay just to the east of the September equinox ♎; the descending node lay just to the east of the March equinox ♈. The figure also shows that, in 1995, the extreme northern and southern declinations of the moon were *less* than those of the sun. So on a sundial with a nodus, the moon’s shadow would never quite reach the midsummer or midwinter lines.

But the nodes of the moon’s orbit do not remain fixed: they drift steadily westwards, taking 18.6 years to make one complete circuit. Two years after Figure 2, in February 1997, the moon’s nodes had moved westwards, and lay exactly on the equinoxes. As a result, the moon’s motion in declination was reduced to its minimum, ±18.28°; this is what Thom calls a *minor standstill*.

By contrast, Figure 3 shows the moon’s orbit at the start of 2005: the *ascending* node was then a little way east of the March equinox, and the descending node was approaching the September equinox. And the extreme northern and southern declinations of the moon were now *greater* than those of the sun. When we reach June 2006, the nodes will again coincide exactly with the equinoxes, and this time we shall have a *major standstill*: the moon will reach declinations of ±28.6°, and its shadow on the dial will fall well beyond the midsummer and midwinter lines.

“As I write this (1969)”, said Thom, “the Moon is coming through a major standstill. One cannot fail to be surprised to see it set and rise almost in the north. A fortnight later

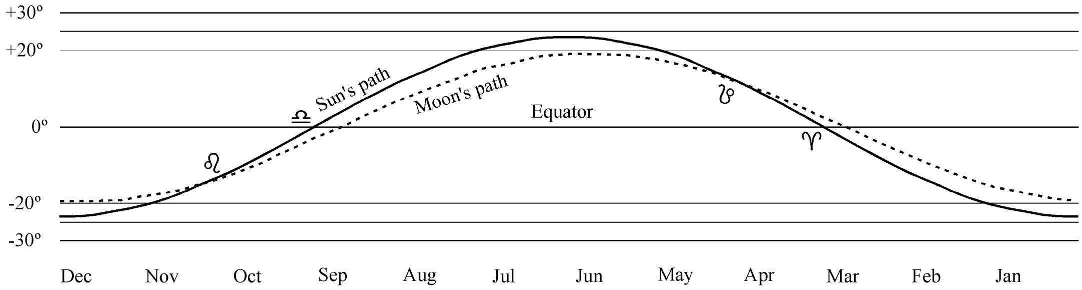


*Fig. 2. The moon's path in 1995.*

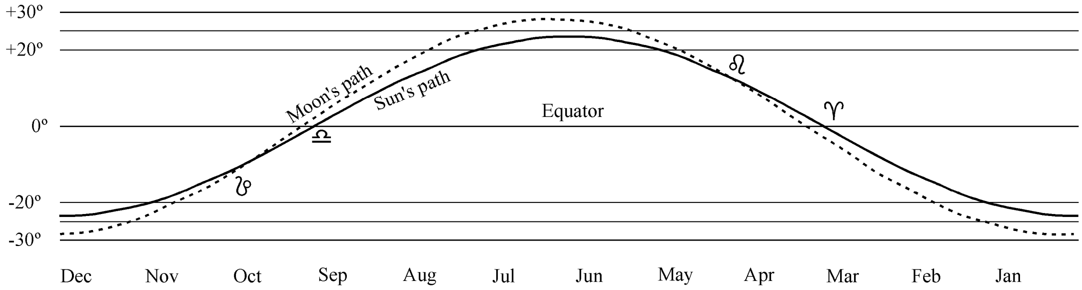


*Fig. 3. The moon's path in 2005.*

one is again surprised to see how far to the south are the rising and setting points, and how very low it is at transit." (*Megalithic Lunar Observatories,* p.22.) Today, keen sky-watchers may already have noticed that the moon is again behaving oddly. At my latitude of 56½°N, the midsummer sun rises at azimuth 49°, almost north-east; so I am used to seeing the moon rise there occasionally, too. But last winter the waxing gibbous moon was rising much further left, at azimuth 38°. At major standstill, the moon will be able to rise at 34°, and set at 326°. And if I wish to use my garden sundial as a moon-dial, it will really need to read hours from 2 am to 10 pm - though reading 'moon time' from a sundial is no trivial matter, as Michael Lowne explained in BSS *Bulletin* 17 (i), March 2005.

Indeed, at major standstill, latitude 61.5°N - about 35 miles off the northern tip of Shetland - will become the moon's 'arctic circle'; from there northwards, there will be one day each month when it will technically be possible to see the moon circle the sky, without setting at all. A moon-dial would then need to show all the twenty-four hours.

The actual major standstill occurs in the middle of June 2006, but it changes only slowly: we will be able to enjoy this extreme behaviour of the moon for a couple of years. However, as the nodes continue to drift westwards, it will gradually return to 'normal'. The next minor standstill is in October 2015, and we won't see another major standstill until April 2025.

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## The John Rowley Moondial at Blenheim Palace

*This is one dial which will be affected by the major lunar standstill, in that its lunar chapter rings will be operational over a longer period than normal.*

*Will we see a queue of night-time visitors to view it?*

*Photos: J. Davis.*

Redacted

# THE 2005 BSS OPEN AWARD SCHEME

Fig. 1. Joanna Migdal with her winning Professional dial.



Fig. 3. Harriet James's dial in Jersey, highly commended in the Professional category.

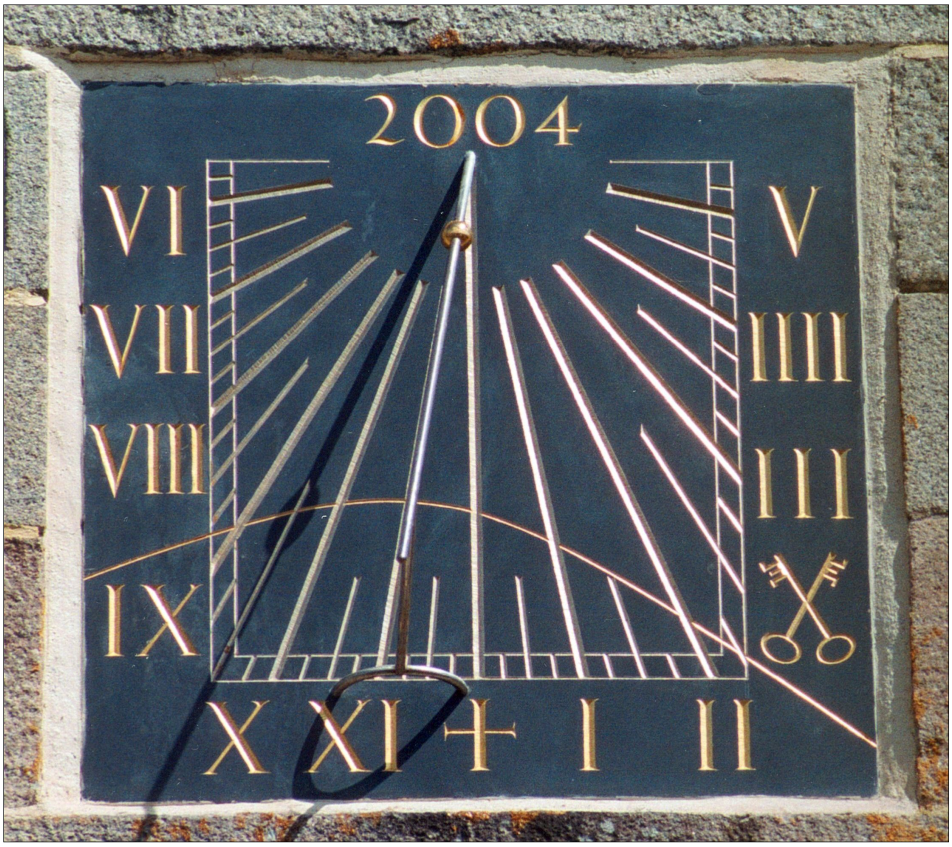

*Fig. 3. The highly commended Professional dial entered by Piers Nicholson.*


*Fig. 4. Heiner Thiessen's winning entry in the Amateur category.*

Fig. 5. Steve Daggitt's highly commended amateur design for Kidderminster School.

Fig. 7. Peter Scott's imposing multiple dial, highly commended in the Amateur category.

Fig. 8. The Melville slate dial entered by Michael Harley and winner of the Restoration category. Pictured as-found (right) and ready for re-installation (below).

*Fig. 6. The traditional vertical declining dial by Andrew James, highly commended in the Amateur category.*


*Fig. 9. The Millennium dial entered by B. Travers.*

*Fig. 10. The arboretum dial entered by D. Atkinson.*

*Fig. 11. The colourful dial entered by Ray Ashley and John Moir.*

# THE 2005 BSS OPEN AWARD SCHEME



## R A NICHOLLS



The aims of this Society include that of "promoting the science and art of gnomonics". To that aim the Society started the Open Awards Schemes in 1995. This (the third) Scheme produced 28 entries of dials made and erected in the previous 5 years throughout the British Isles. Both professional and amateur entries have always been encouraged. Also welcomed are entries of restored dials, and dials from pupils at schools and colleges. We were glad to receive restoration entries this time, but, sadly, none came from schools, despite very intensive lobbying of Local Government Education Departments and individual schools. The next Scheme could possibly consider earlier lobbying of schools, and getting help from individual members with children still in the education system.

The entries received are listed below. Most were from BSS members and all others had had advice from our members.

**PROFESSIONAL DESIGNERS (Totalling 13 entries)**

| Entry No. | Entrant | Type of Dial | Location |
|---|---|---|---|
| 1 | A Mills | Noon mark | Essex |
| 5 | H James | Vertical decliner | Channel I |
| 7 | A Smith | Vertical S | Lancs |
| 13 | J Jones | Portable polar | Sussex |
| 15 | S Hersh | Vertical decliner | Cambs |
| 16 | S Hersh | Vertical decliner | Devon |
| 19 | P Nicholson | Horizontal | London |
| 20 | P Nicholson | Polar | London |
| 21 | D Brown | Noon mark | Oxford |
| 22 | D Brown | Analemmatic | Somerset |
| 24 | Mackean & Russell | Horizontal & Equatorial | Sussex |
| 27 | Ashley & Moir | Vertical W decliner | London |
| 28 | J Migdal | Horizontal | Surrey |

**PRIZES FOR PROFESSIONAL DESIGNERS**

First Prize: J Migdal (Entry No. 28) Fig. 1.

Highly Commended: H James (Entry No. 5) Fig. 2

Highly Commended: P Nicholson (Entry No.20) Fig. 3

**AMATEUR DESIGNERS (Totalling 13 entries)**

| Entry No. | Entrant | Type of Dial | Location |
|---|---|---|---|
| 2 | S Daggitt | S recliner | Oxford |
| 3 | A Gardiner | Vertical S | Glos |
| 4 | M Thomas | Analemmatic | Cambs |
| 6 | P Walker | Horizontal | Salop |
| 9 | B Travers | Vertical decliner | Dorset |
| 10 | W May | Equatorial | Glos |
| 11 | H Thiessen | Equatorial | Hants |
| 12 | D Atkinson | Horizontal | Gloss |
| 14 | A Adams | Horizontal | Lincs |
| 18 | P Scott | Polyhedral | Lancs |
| 23 | A James | Vertical decliner | Devon |
| 25 | T P Walker | Vertical decliner | Somerset |
| 26 | E Everett | Analemmatic | Hants |

**PRIZES FOR AMATEUR DESIGNERS**

First Prize: H Thiessen (Entry No. 11) Fig. 4.

Highly Commended: S Daggitt (Entry No. 2) Fig. 5

Highly Commended: A James (Entry No. 23) Fig. 6

Highly Commended: P Scott (Entry No.18) Fig. 7

**RESTORATION DESIGNERS (Totalling 2 entries)**

| Entry No. | Entrant | Type of Dial | Location |
|---|---|---|---|
| 8 | H James | Horizontal | Dorset |
| 17 | M Harley | Horizontal | Ireland |

**PRIZE FOR RESTORATION DESIGNERS**

First Prize: M Harley (Entry No. 17) Fig. 8.

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One of the pleasures of the BSS Bulletin is the remarkably large range of dials described and discussed. This range was mirrored in the diversity of the entries to the Scheme, which numbered 50% more than the 2000 entry. The standard of workmanship and design necessary to make an accurate and pleasing dial is very high, and the dials entered were of high quality. The judges also appreciated the ex-
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cellence of the paperwork, photographs etc., in the entries. This itself required much extra work by the entrants, over and above work on the dial.

The choice of winners was difficult. Margins of success over failure were slim. The winners' entries are pictured in this article, with some comments on why they were thought worthy of the Society's Awards – such Awards now seemingly widely appreciated by dial designers and by clients commissioning dials.

**FIRST PRIZE WINNERS:**

**Professional Class: Joanna Migdal. Fig. 1**

With excellent metal work and engraving, the dial has a refreshing new perspective on the 'armillary' dial with an horizontal hour ring and an offset connection of the rings. The added sculptural chain and robust construction suit its position in a well-maintained, quiet public space. The nearby bench is engraved with instructions on the use of the EoT graph on the dial. The whole is a very pleasing group.

**Amateur Class: Heiner Thiessen. Fig. 4**

This dial resulted from much development work by the designer, and is simple to use and offers much more solar time information than usual from this dial type. The excellent workmanship and choice of materials has resulted in a visually attractive, accurate and very useful scientific instrument, which can also be easily moved from site to site.

**Restoration Class: Michael Harley. Fig 8.**

This is a restored Melville dial made firstly in 1834. The restored dial face shows the scars of its history but has clearly re-established the typical Melville style. This very successful restoration brings back useful life to an historic dial in its original position.

**HIGHLY COMMENDED AWARDS**

**Professional Class: Harriet James. Fig. 2**

The finely proportioned face, the engraving and gnomon (both in the local tradition), combine to give an excellent example of a new dial in the long tradition of vertical L.A.T. dials woven into British church history. The dial complements the impressive church and churchyard, with their examples of fine lettering. The dial is a pleasure to the visitor.

**Professional Class: Piers Nicholson. Fig. 3**

An impressive dial in an impressive setting. The workmanship of the brick pedestal is remarkable, and the polar dial metal-working is of equal high quality. Two unusual features which complement the dial as a whole are the vertical ends to the dial face and the light spot drilled through the gnomon. The EoT plaque is of equal quality.

**Amateur Class: Steven Daggitt. Fig. 5**

The school staff and children helped to choose the ideas built into this charming and practical dial, using donated materials – itself a constraint, but well overcome. The design of the face ties in with the school studies. The reclining angle helps to drain the face and the dial is also storable during the winter. The young lady on the extreme right of the picture is the daughter of the designer.

**Amateur Class: Andrew James. Fig 6**

This is another modern vertical fitting well into its (rural and farming) setting, and is also an accurate and useful instrument. The dial face is itself very satisfactory visually and the striking gnomon complements the farm machinery colours used on the farm. The workmanship of face and gnomon is very good – one gnomon edge is serrated to distinguish the correct shadow line.

**Amateur Class: Peter Scott. Fig. 7**

Designed and built by "someone who had never before made a dial which could stand outside in wet weather" this is a tour-de-force. The finished dial is based upon existing (but larger) models, but is itself original in its use of modern materials, and newly devised delineation and assembly methods. The finished dial is a striking example of a modern approach to an old – and very difficult – dial design problem.

Other than prizewinners, there were other entries showing pleasing or interesting details. Three are detailed below:

**Gnomon Detail. Entry 9 – B Travers. Fig. 9**

This dial was one of those many designed with the Millennium celebrations in mind – few of which were entered to our Scheme however. This detail was original and very appropriate. It has not (yet!) been seen elsewhere.

**General View. Entry 12 – D Atkinson. Fig 10.**

This dial is erected in an arboretum, and as such is built, using materials appropriately taken from the woodland, by a group developing the arboretum for all, including those who are disabled, physically or visually. As such the dial could not get high marks for resolution of sun time, but did (possibly best of all entries) sit splendidly and appropriately in its surroundings.

**Dials as fashion. Entry 27 – Ashley/Moir. Fig. 11**

This colourful entry, situated in an equally colourful commercial area, has resulted in the shop décor being altered to fit the dial – photograph not available unfortunately.

Space prohibits more photographs here, but when certificates are presented at the next Conference, there will be a display showing the entries. The Society Archive will also contain details of all entries.

**A QUESTION OF SHADOWS**

It was a surprise that a significant number of entries were sited so that they were shadowed for considerable periods of the day – or even for months! It does seem necessary that sun dials (at least when new) should be useable for the maximum period of the limited sunlight in these latitudes. Some of the responsibility for this oddity may well lie with the commissioning brief, of course.

**CONCLUDING REMARKS**

Entrants are to be congratulated (and thanked – without them there is no scheme) on the high standard of their dials. As was the case in the two previous Awards Schemes, gaps and ambiguities in the Rules have been revealed, and will need attention for the next time.

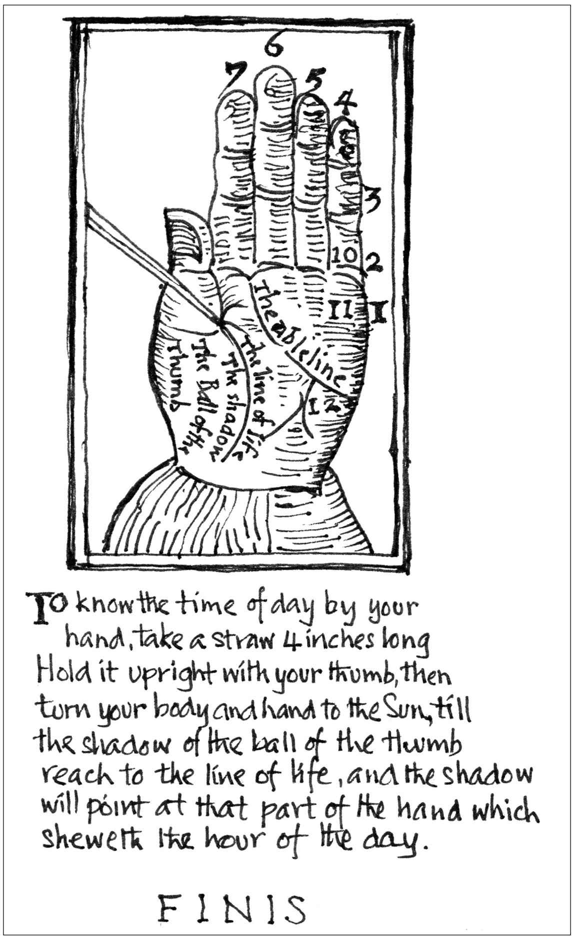
I thank also my fellow judges – a lot of thought (and talk, not to mention travelling) has gone into our judgements. The judges were Doug Bateman, John Davis, Margery Lovatt and Mike Shaw. We sought advice from Michael Lowne, Robert Sylvester and Ian Wootton on some specific problems.

This Awards Scheme, the entrants and the winners show British dialling is alive and well, and producing exciting and worthwhile dials to add to the heritage of our country.

**THANK YOU**

*The organisation of the Awards Scheme invariably has its problems, not least of which arise from the difficulty of viewing the different entries, scattered around the British Isles, during unpredictable weather and the differences of opinion of the empanelled judges. Nevertheless, undaunted by the prospects of disagreement and with singular determination, Nick Nicholls, a former Treasurer of the Society, took on the task with remarkable enthusiasm. There were 28 entries in all, an outstanding number compared with the number of entries submitted on previous occasions, reflecting on the fact that the awards are becoming recognised for the prestige that they confer on the winners. Thus, whilst the winners are to be congratulated on their achievement, so are the judges and the organisers of this event, particularly Nick Nicholls for all the energy and hard work that he put into this enterprise. The Council of the British Sundial Society much appreciates the credit that this event bestows on the Society and, on their behalf, it gives me great pleasure to thank Nick Nicholls and his team for making the Open Awards Scheme 2005 such a success.*

*Christopher St J. H. Daniel*
*Chairman*




## A 'Digit-al Sundial'

*Drawn by C M North after Goldsmith's Almanack for 1715. The original is in the York Archaeological Archives. Courtesy of Tony Wood.*

# THE INTRIGUING CASE OF THE BRAUNSCHWEIG 1334 SUNDIAL


## CURT ROSLUND

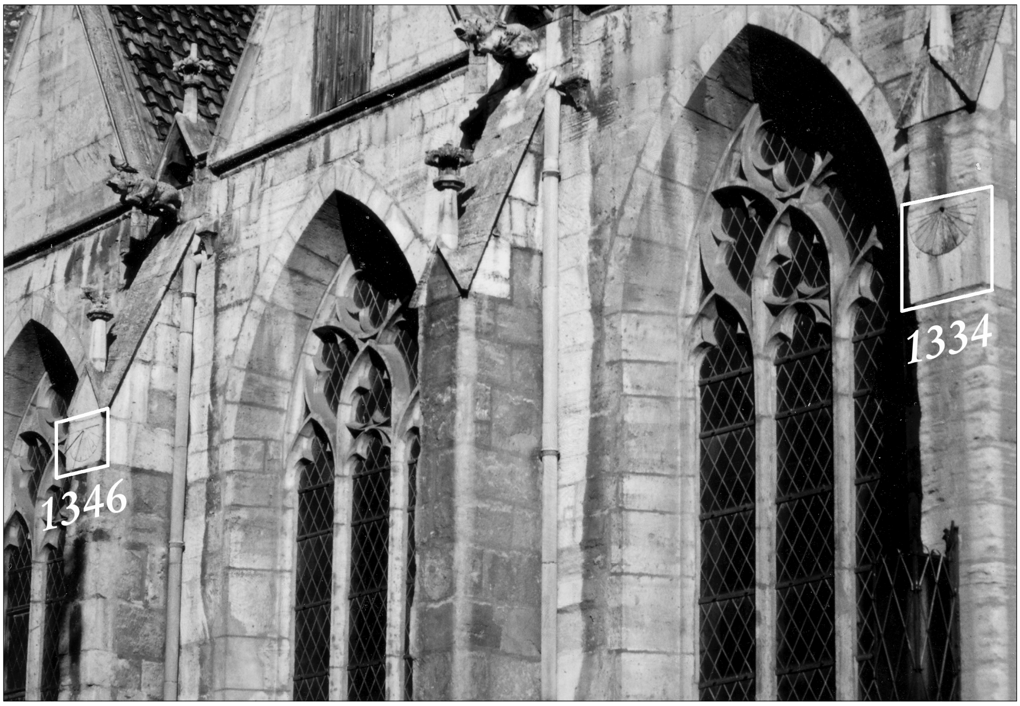




*Fig. 1. The locations of the 1334 and 1346 sundials on the south wall of the Braunschweig Cathedral.*

The Braunschweig Cathedral in Niedersachsen in Germany is known for its many sundials from different epochs. The two earliest sundials, from 1334 and 1346, are of special interest. They were set up at a time when mechanical clocks were coming into general use, showing a day of 24 hours of equal length throughout the year and challenging the old division of daylight hours differing in length depending on the season of the year. The performance of the first mechanical clocks was disappointingly unreliable and needed to be checked by frequent observations of the sun. A sundial was called for that showed time according to the new division of the day. The last mentioned sundial of 1346 might have been just the type of sundial one was looking for. The hour line pattern of this sundial is that of a conventional south-facing vertical sundial with a style parallel to the earth's axis. Although the line pattern of the 1334 sundial is of an unfamiliar sort, it is still possible that these two sundials on the Braunschweig Cathedral are among the first dials meant to complement the mechanical clocks.

Both sundials are on top of buttresses on the south wall of the cathedral about seven metres above the pavement. This wall is particularly well-suited for south-facing sundials as it deviates less than a degree from a line orientated due west and east. The earliest dial is located on the fourth buttress from the west end of the building and the later one on the second buttress.[1] On both dials, the hour line pattern forms a semicircle with a radius of about 26 cm. Both dials are still clearly visible, although slightly weathered. The original shadow pins, called styles, were lost long ago. The inclinations with respect to the vertical of the hour lines for the two sundials have been given by Zinner[1] but are here rounded off to the next higher whole degree.

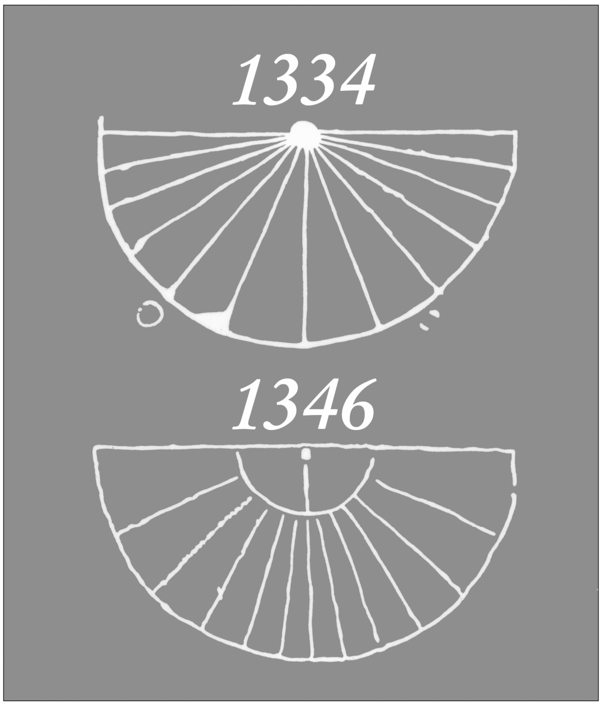



*Fig. 2. Charts of the dial plates for Braunschweig Cathedral's two earliest sundials from 1334 and 1346.*

| Post meridian sun times | 0:00 | 1:00 | 2:00 | 3:00 | 4:00 | 5:00 | 6:00 | pm |
|---|---|---|---|---|---|---|---|---|
| Hour lines according to Erfurt formula | 0.0 | 10 | 21 | 34 | 50 | 68 | 90 | deg |
| Computed hour lines | 0.0 | 10.30 | 21.38 | 34.14 | 49.59[1] | 68.44[2] | 90 | deg |

*Table 1. Computed angles between the meridian and lines showing hours of equal length for south-facing vertical sundials with a polar orientated style at a latitude of 47°18' N. [1] This angle falls below 49.5° for locations 9 minutes of arc north of the latitude above. [2] This angle exceeds 68.5° for locations 9 minutes of arc south of the latitude above.*

*Fig. 3. Braunschweig Cathedral's 1346 sundial with its new style.*

There is no evidence to suggest that sundials with a style orientated towards the celestial pole were known in classical antiquity.[2] They were either invented in or introduced to Europe in the early fourteenth century[3] for their unique ability to show hours of equal length throughout the year. As the hour lines for these sundials in most cases are not equally spaced, lists of numbers were drawn up, supposedly giving stonemasons the inclination of hour lines from the meridian for south-facing vertical sundials with a style pointing to the celestial pole. The earliest known list of such numbers was copied from an older document in 1346 by a student in Erfurt.[4] This list is found in at least seventeen medieval documents before 1530 and was much used in Germany where it was called *Horologium achas*, named after the sundial set up by king Ahaz of Judah about 750 BC (2 Kings 20:11; Isaiah 38:8). It is here referred to as the *Erfurt formula*. Regrettably, the Erfurt formula gave cause for misunderstanding as no details were given of how the sequence of numbers should be applied and for what sort of sundial it was meant.[5] There must have been alternatives to the lists of numbers. Enterprising masons could probably have obtained drawings of hour lines for particular parallels of latitude from other sources. Masons with elementary knowledge of geometry, may have been able to grasp the intricacies of a graphic method known since antiquity.[2]

By measuring the angles between the hour lines and the meridian, one can today determine the accuracy of the time shown by a sundial. Beginning with the Erfurt formula, one finds that its numbers give poor approximations for hour lines for south-facing vertical sundials with a polar orientated style at Braunschweig and even for those at Erfurt itself 150 km to the south. It can be shown that one has to go as far south as Zürich before computed inclinations of hour lines rounded off to the nearest whole number agree with those of the Erfurt formula (see Table 1). Strictly speaking, the formula is only valid in a narrow zone of 33 km between latitudes 47° 09' and 47° 27' N, where theoretically a properly adjusted sundial would give time correct to the minute.

By comparing the hour lines on the dial plate for the later sundial in Table 2 with those of the Erfurt formula and with computed or true hour lines for Braunschweig, one can surmise that the stonemason who cut the hour lines for this sundial knew how to make a more accurate sundial than one based on the Erfurt formula. It does run a few minutes fast in the afternoon and consequently a few minutes slow in the morning, but it is never more than eight minutes out of time, which would have been acceptable. The mean error of the time shown by this sundial is only five minutes compared to eight minutes for one based on the Erfurt formula.

The network of hour lines for the 1334 sundial is slightly but clearly different from the later one. One explanation might be that its style was set horizontally, as in older sundials. Zinner[4] was of the opinion that the later sundial also once had a horizontal style as the hole for it appears to be horizontal. However, it must have been easier for a stonemason to bore a hole perpendicularly to the surface of the

| **Post meridian sun times** | **0:00** | **1:00** | **2:00** | **3:00** | **4:00** | **5:00** | **6:00** | **pm** |
|---|---|---|---|---|---|---|---|---|
| Hour lines according to Erfurt formula | 0.0 | 10 | 21 | 34 | 50 | 68 | 90 | deg |
| True hour lines, polar style | 0 | 9.3 | 19.5 | 31.5 | 46.7 | 66.4 | 90 | deg |
| Hour lines for 1346 sundial | 0 | 8 | 18 | 31 | 46 | 66 | 90 | deg |
| 1346 sundial, post meridian times | *0:00* | *0:52* | *1:52* | *2:58* | *3:58* | *4:59* | *6:00* | *pm* |
| True hour lines, horizontal style at equinoxes | 0.0 | 23.6 | 43.3 | 58.5 | 70.5 | 80.7 | 90 | deg |
| Hour lines for 1334 sundial | 0.0 | 21 | 40 | 56 | 69 | 80 | 90 | deg |
| 1334 sundial, post meridian times | *0:00* | *0:53* | *1:49* | *2:49* | *3:52* | *4:56* | *6:00* | *pm* |
| **Pre meridian sun times** | **6:00** | **7:00** | **8:00** | **9:00** | **10:00** | **11:00** | **12:00** | **am** |
| Hour lines according to Erfurt formula | 0 | 10 | 21 | 34 | 50 | 68 | 90 | deg |
| Hour lines for 1334 sundial | 0.0 | 10 | 21 | 34 | 50 | 69 | 90 | deg |
| True hour lines, horizontal style at equinoxes | 0.0 | 9.3 | 19.5 | 31.5 | 46.7 | 66.4 | 90 | deg |
| 1334 sundial pre meridian times | 6:00 | 7:04 | 8:08 | 9:11 | 10:11 | 11:07 | 12:00 | am |

*Table 2. Angles measured from the meridian/the horizontal for lines showing hours of equal length for two south-facing vertical sundials at Braunschweig at the latitude of 52°16' N.*

stone and to bend the style to the correct delineation than to drill a hole at a given angle. The disadvantage of a horizontal style is that such a sundial can never show hours of equal length over an extended period of time. The precision of the time shown by the 1334 sundial with a horizontal style does not reach that of the later sundial, not even around the equinoctial days of March 21 and September 23 (see Table 2) and it deteriorates further when one goes outside the equinoxes. The 1334 sundial may be seen as an early attempt that failed to adapt the old type of sundial to the new system of time division. Another explanation might be that the stonemason misunderstood the Erfurt formula to begin at 6 am instead of at noon and cut the hour lines accordingly. In Table 2 one finds that the agreement between the formula and the carved lines is complete except for 11 am when there is a difference of one degree. No doubt, the mason who cut the hour lines knew as early as 1334 about the Erfurt formula but did not know how to apply it correctly. As the sundial must have been equipped with a horizontal style, it was only able to show hours of equal length near the equinoctial days. If so, the 1334 sundial was a false start for a new type of sundial.

In spite of the fact that the Erfurt formula was incapable of producing accurate hour lines for south-facing vertical sundials in northern and central Germany, one is surprised to find that the formula was also used for horizontal sundials with a polar style.[1] For such sundials the formula is strictly valid only for places near the parallel of latitude 42° 42' N which traverses central Italy!

In this light, the popularity of the Erfurt formula is remarkable. Its inadequacy could hardly have passed unnoticed. Adding errors introduced by poor adjustment and the effect of atmospheric refraction, sundials based on the Erfurt formula were hardly more reliable than the mechanical clocks they were supposed to oversee. Actually, the best test on the run of mechanical clocks would have been at noon as shown by a horizontal sundial with a vertical style. Was there an overriding motive for using the Erfurt formula instead of one better suited to show time in accordance with the new division of the day?

Could the numbers in the Erfurt formula for some reason have been chosen and arranged, not necessarily on astronomical grounds, in an orderly fashion called a mathematical progression? It can indeed be shown that the numbers in the Erfurt formula conform closely to the rules of a progression defined by a general term, $a \times n \times k^{n-1}$, where $n$ is the ordinal number of postmeridian true sun times of whole hours from 1 pm to 6 pm. By choosing the value 9.50 for the constant $a$ and 1.0957 for the constant $k$, the calculated terms after having been rounded off to the nearest whole number agree completely with those of the Erfurt formula: see Table 3. Strangely enough, it was found that the hour lines on the dial plate for the 1346 sundial follow a similar rule of progression as the Erfurt formula, this time with $a$ =7.90 and $k$ =1.1368. It should be noted that the general term $a \times n \times k^{n-1}$ in these mathematical progressions is the first derivative with respect to $k$ of the general term $a \times k^n$ in

| **Post meridian sun times, n** | **0:00** | **1:00** | **2:00** | **3:00** | **4:00** | **5:00** | **6:00** | **pm** |
|---|---|---|---|---|---|---|---|---|
| Erfurt formula | 0 | 10 | 21 | 34 | 50 | 68 | 90 | deg |
| Mathematical progression, $ank^{n-1}$ | 0 | 9.50 | 20.82 | 34.22 | 49.99 | 68.46 | 90 | deg |
| Hour lines 1346 Braunschweig dial | 0 | 8 | 18 | 31 | 46 | 66 | 90 | deg |
| Mathematical progression, $ank^{n-1}$ | 0 | 7.90 | 17.96 | 30.63 | 46.42 | 65.97 | 90 | deg |

*Table 3. Hour line formulas compared to mathematical progressions of numbers.*

a geometric progression with terms having a common ratio *k*.

The close agreement between the formulas for the inclinations of the hour lines and the mathematical progressions seem impressive and convincing but as long as an adequate astronomical explanation for the progressions is lacking, they could be unintentional coincidences if not corroborated by other evidence. On the other hand, no conclusive agreement with a mathematical progression could be established for the true hour lines for the Braunschweig dials.

The Braunschweig Cathedral's two earliest sundials, from 1334 and 1346, show the great efforts made to introduce the new time division of hours of equal length independent of the season of the year. The first attempt turned out as a failure but the next attempt twelve years later produced the earliest known sundial especially designed to show time according to the new system. In 1985, the later sundial from 1346 was equipped with a new style parallel to the earth's axis and is once again showing time.

**ACKNOWLEDGEMENT**

The author would like to express his gratitude for the assistance he obtained from the Evangelisches Dompfarramt in Braunschweig in allowing him to make measurements on charts of the dial plates for the cathedral's 1334 and 1346 sundials.

**REFERENCES**

1. E. Zinner: *Die ältesten Räderuhren und modernen Sonnenuhren*. Bamberg, (1939).
2. S. Gibbs: *Greek and Roman Sundials*, London, (1976).
3. R.R.J. Rohr: *Sundials*. Toronto, (1970).
4. E. Zinner: *Deutsche und niederländische astronomische Instrumente des 11. bis 18. Jahrhunderts*. München, (1956).
5. M. Neumann: *Sonnenuhren an alten Gebäuden in Braunschweig*. 2nd ed. Braunschweig, (1991).

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# SUNDIAL DELINEATION USING VECTOR METHODS Part 1

TONY WOOD

*EDITORIAL NOTE: The symbols used in this paper do not follow the approved BSS conventions, as shown in the BSS Glossary. Readers are therefore warned that they do not have their standard meanings (as they do in other Bulletin papers) and hence care must be taken in interpreting the equations.*

Vectors, together with axis transformations, are used to derive the equations used in sundial delineation. The approach is believed to be new and results in simple equations for direct plotting of hour and declination lines.

Since a sundial works essentially by shadow planes and lines intersecting a (usually plane) surface, vector methods are simple and suitable. The equations of the lines and points of intersection are easily obtained. Likewise, for Cartesian axes the transformation from one set to another comprises a simple equation for each co-ordinate when a rotation about an axis is made. No more than three such (Euler) rotations suffice for all cases. A self-consistent sign convention is employed and the equations define lines which are drawn on a complete (i.e. all four quadrants) Cartesian plane. Some dials appear drawn with entirely negative y values.

Current texts[1-5] describe geometric constructions, but only Rohr[4] additionally gives a mathematical derivation. The relevant equations are quoted in the BSS Glossary.[6] Since the results here are somewhat simpler than those quoted in the Glossary and are essentially based on elementary mathematics, a break with conventional notations and their frequently differing sign conventions has been made and a new set of symbols adopted to emphasise the move from astronomical derivation.

Belk has produced a very similar approach in his derivation of the relevant equations.[7] Use has been made of direction cosines throughout and the associated methods for finding the intersection of lines and planes, but the follow through to direct plotting via simple equations has not been made.

The object is to enable lines to be plotted on Cartesian Ox, Oy axes. To this end all the results are in the form y = f($x$) or x = f($y$). Where this is not possible the parametric form $x$ = f($t$), y = g($t$), is provided. In order to make clear the methods involved it is necessary to explain both vector notation and the process of axis transformation. Neither is particularly difficult but the resulting equations, although elementary, contain many terms since a dial may require three angles to define its orientation. Additionally the position of the sun requires two more angles and so up to five angles can be involved in a single equation.

The notation adopted is intended to help keep track of the both the angles involved and the dial types considered. For working angles Greek letters are used, as follows:

- *a* is the 'shadow angle' derived from the time of day in '24 hour clock' notation.
- *l* is the latitude, taken to be north throughout.
- *d* is the declination angle of a vertical dial.
- *g* is the inclination angle of a dial inclined from vertical.
- *e* is the sun's declination angle derived from the day of the year with 365 days.

Other angles are defined as derived. The sign conventions are defined as the angles are introduced later.

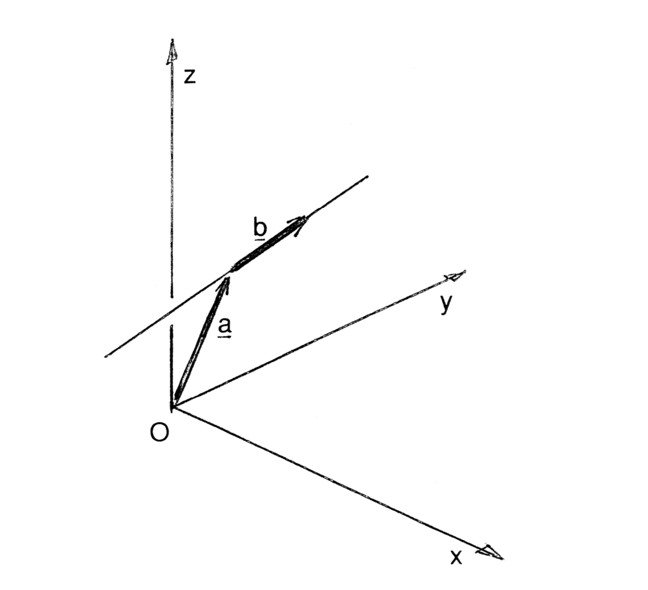


*Fig. 1. Vector equation of a line.*

**Dial types**

For clarity, suffixes are adopted for the vector components, as follows:

- H horizontal
- V vertical, direct south
- D vertical, declining

R inclining (R since reclining rather than proclining dials are considered in the worked examples)

E vertical, direct east

W vertical, direct west

P polar

Q equatorial

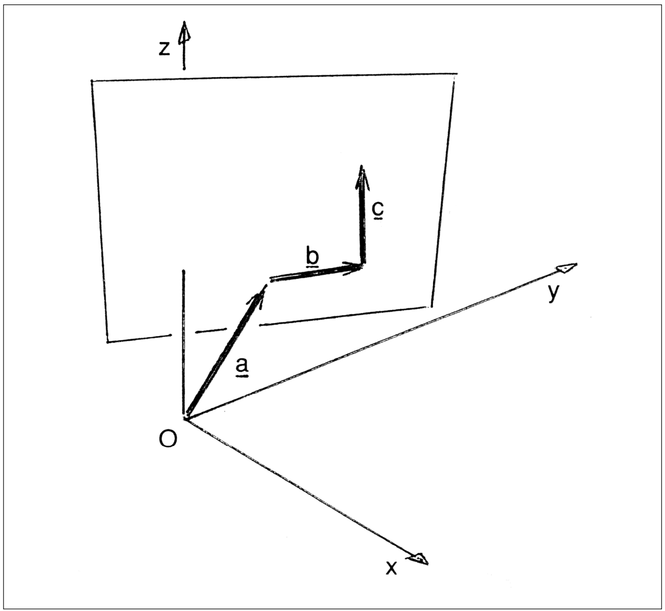


*Fig. 2. Vector equation of a plane.*

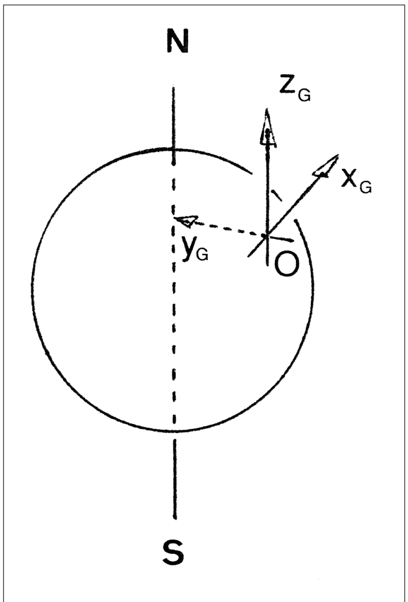


*Fig. 3. Gnomon axes.*

**Vectors**

A vector (in bold type, underlined in the figures) consists of size and direction and is conveniently written in the form

$x\mathbf{i} + y\mathbf{j} + z\mathbf{k}$

Where **i**, **j** and **k** are read 'in the Ox direction, Oy direction and Oz direction' respectively and the quantities *x, y* and *z* tell you how far in each of these directions. Referring to Fig. 1 we see Oxyz Cartesian axes (right-handed throughout) and a line which may be written:

$\mathbf{r} = \mathbf{a} + p\mathbf{b}$

and

$\mathbf{r} = x\mathbf{i} + y\mathbf{j} + z\mathbf{k}$

are the general co-ordinates, being found from **a**, which is the jump from the origin onto the line, and *p*, a parameter used to slide up and down the line, whose direction is defined by vector **b.** It is convenient to make **b** a unit vector.

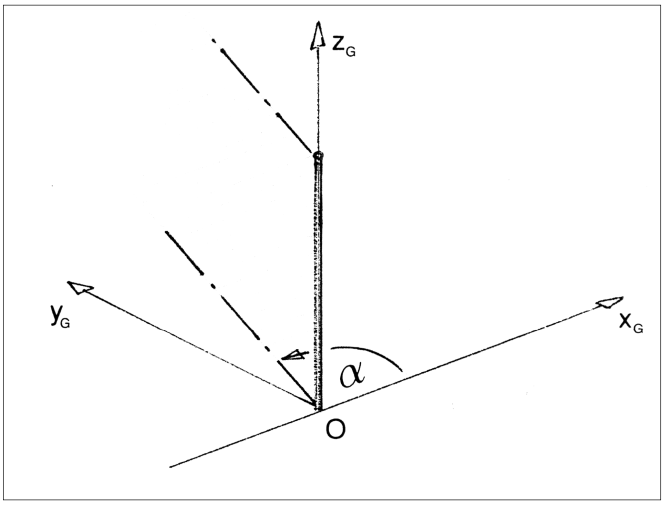


*Fig 4. Shadow in gnomon axes.*

Note that this is not a unique equation to the line, other values for **a** are possible and consequently *p* would take different values to define a particular point. Similarly, a plane appears (see Fig. 2) as

$\mathbf{r} = \mathbf{a} + p\mathbf{b} + q\mathbf{c}$

Again, **a** jumps you onto the plane, with **b** and **c** being any two vectors in the plane, which must not be collinear. Choosing *p* and *q* enables any point in the plane to be specified. Again the equation is not unique.

**Axis transformations**

All the axis systems used are right-handed, thus defining the sign conventions i.e. rotations are positive for Ox g Oy about Oz, Oy g Oz about Ox and Oz g Ox about Oy. (These rotations are called Euler angles when applied successively.) Our starting axis system (gnomon axes) is as shown in Fig. 3 with the gnomon parallel to the earth's axis along $Oz_G$, $Ox_G$ off to the east and $Oy_G$ inwards, towards (and perpendicular to) the earth's axis.

The shadow of the gnomon (Fig. 4) is a plane streaming downlight behind the gnomon like a stiff flag, with $Oz_G$ as

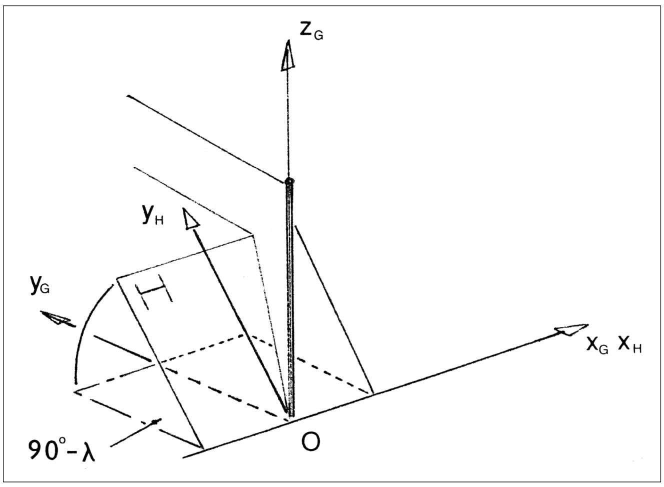


*Fig. 5. Shadow and horizontal dial plate in gnomon axes.*

flagpole. The hour lines will then be found from the intersection of this shadow plane with the dial plate. The intersection will of course be a straight line, initially regarded as in gnomon axes (Fig. 5) but it will also be in the dial plate plane. The dial plate is where we wish to draw our sundial and therefore *we work in dial plate axes* (Fig. 6) as the intersection line lies entirely in its Oxy plane.

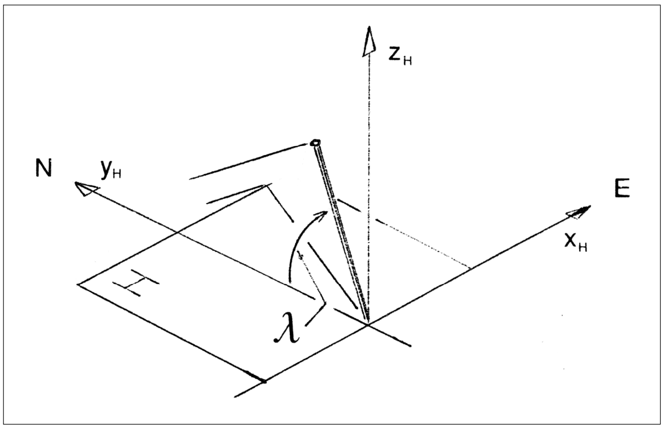


*Fig. 6. Shadow and horizontal dial plate in dial plate axes.*

The next step is to transform the equation of the shadow plane into dial plate axes; and then find its intersection with the dial plate plane. The equation of the dial plate plane in its own axes is $z = 0$ in co-ordinate geometry or, in vectors:

$$\mathbf{r} = \mathbf{0} + s\mathbf{i} + t\mathbf{j} + 0\mathbf{k}$$

or, more conveniently

$$\mathbf{r} = x\mathbf{i} + y\mathbf{j}$$

This involves substituting new values for $x_G$, $y_G$ and $z_G$ in the vector equation for the shadow plane according to the angles required to rotate the dial plate axes into position from their original alignment with gnomon axes. This sounds mathematically taxing but in fact, providing the rotations required are dealt with one at a time, the steps are routine. In general, if $x_O$, $y_O$ and $z_O$ are the vector components in 'old' axes, and we rotate the axes $f$ about $Oz_O$, the values $x_N$, $y_N$ and $z_N$ in the 'new' axes will be given by:

$$x_N = x_O \cos f + y_N \sin f$$

$$y_N = y_O \cos f - x_O \sin f$$

$$z_N = z_O$$

for a rotation of $f$ about the $Oz_O$ axis (see Fig. 7). $f$ is positive Ox g Oy

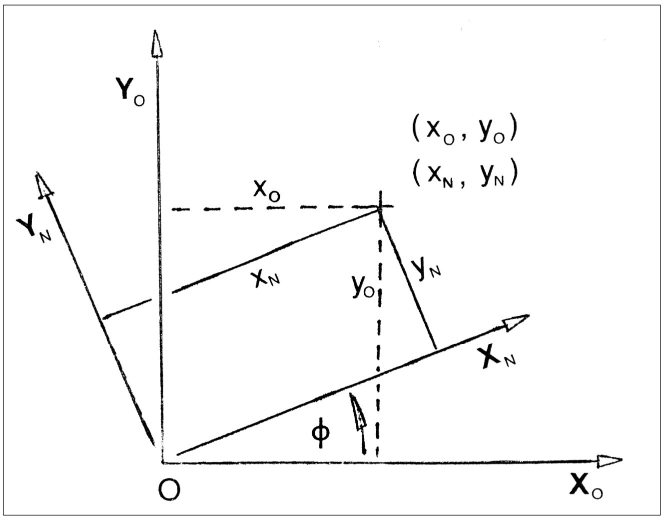


*Fig. 7. Coordinates in axes transformed by rotation about Oz.*

Similarly for rotations about Oy and Oz axes, due account being taken of the signs of the angles.

Referring now to Fig. 3 and the gnomon axes as defined above - *the dial plate starts off aligned with the gnomon axes,* so for a horizontal dial it is necessary to rotate it through (90° - latitude) about the gnomon axis $Ox_G$ to be in the required position. (Note - for a direct south vertical dial we need to keep going and rotate the dial plate through (180° - latitude); and the gnomon is now along the *negative* $Oz_G$ axis - see Fig. 8.)

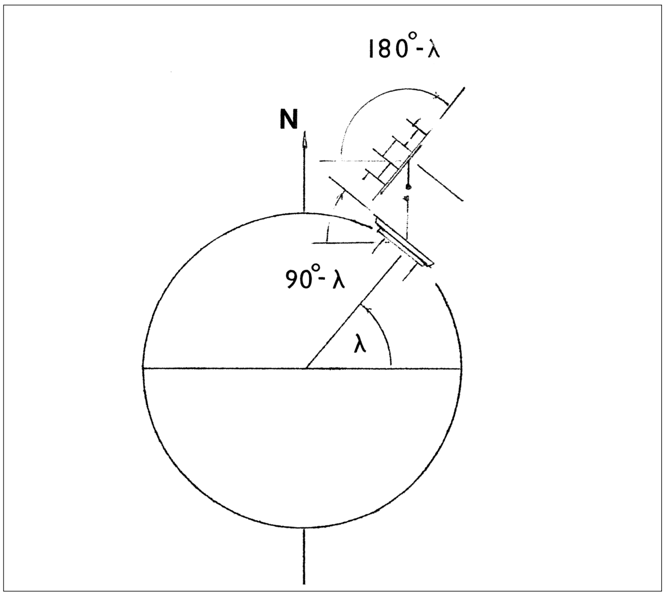


*Fig. 8. Direct south vertical dial – rotation required from gnomon axes.*

Taking the horizontal dial as our example we have therefore the transformations for the vector components:

$$x_H = x_G$$

$$y_H = y_G \cos(90° - l) + z_G \sin(90° - l)$$

$$z_H = z_G \cos(90° - l) - y_G \sin(90° - l)$$

giving us the vector components $(x, y, z)_H$ in horizontal dial plate axes derived from the components in gnomon axes $(x, y, z)_G$.

So much for background theory, it is now time to start looking at the practicalities of the earth-sun system. We note that the equation of time provides us with a correction for the tilt of the earth's axis, so we can take it to be zero for our geometry. Likewise, until we consider declination lines, the sun's declination (taken as zero at the equinoxes) can be ignored (see Fig. 9).

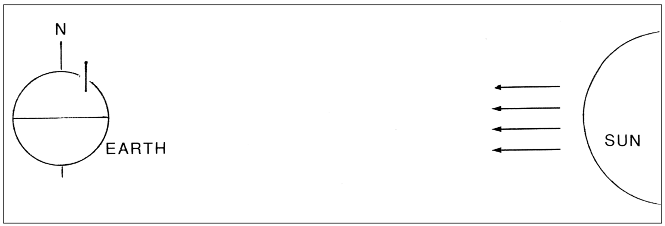


*Fig. 9. Sun-Earth geometry for sun's declination of zero.*

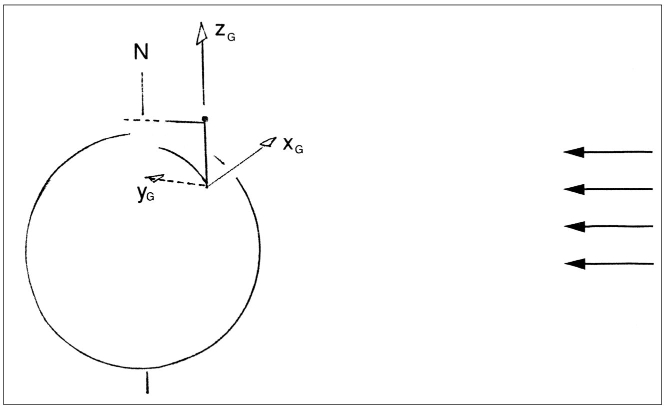


*Fig. 10. Close-up of Earth for geometry of Fig. 9.*

We now have an upright earth with a sun going round in the equatorial plane causing the gnomon shadow to nip round at about 15°/hour as shown in close-up in Fig.10. It remains only to write down the vector components $x_G$, $y_G$ and $z_G$ of the shadow *plane*, transform them into dial plate axes $(Oxyz)_H$ and find the line of intersection, now conveniently helped by knowing $z_H = 0$ i.e. the line of intersection lies in the dial plate plane.

Since the approach here is mathematical rather than astronomical, and to avoid confusion with previous notations and their associated conventions we adopt:

1) Shadow hour angles ($a$) rather than sun position hour angles i.e. 180° difference at any $T_{24}$ (Time from midnight in 24-hour clock, local apparent time).

2) The angle notation specified in the introduction.

3) We note two derived angles: the sub-style angle $h$, measured from $Ox_H$ and the style angle to the dial plate $z$ (formerly known as the 'style height'). These will be shown in fig. 22 for a vertical declining dial.

Off we go! Applying the forgoing preamble to the particular case of a horizontal dial at latitude $l$ north, we have:

S is the shadow plane and we have gnomon axes (Fig. 3):

$Oz_G$ parallel to the earth's axis, positive northwards
$Ox_G$ positive to the east and
$Oy_G$ positive towards and perpendicular to, the earth's axis.

$a$ is the 'hour angle' of the shadow, given by:

$$a = (270 - 15\times T_{24})°$$

where $T_{24}$ is the time in hours by the 24-hour clock, local apparent time. We note: $a$ varies linearly from 180° at 6 a.m. through 90° at noon to 0° at 6 p.m (see Fig. 4).

The equation of S is:

$$\mathbf{r} = \mathbf{0} + p(\cos a\ \mathbf{i} + \sin a\ \mathbf{j} + 0\mathbf{k}) + q(0\mathbf{i} + 0\mathbf{j} + 1\mathbf{k})$$

($\mathbf{0}$ is the null vector as the plane passes through the origin.)

As we are in 'gnomon axes' we can re-write the above for $(S)_G$ as:

$$\mathbf{r} = p(\cos a\ \mathbf{i} + \sin a\ \mathbf{j}) + q(\mathbf{k})$$

with

$$\mathbf{r} = x_G\mathbf{i} + y_G\mathbf{j} + z_G\mathbf{k}$$

Subsequently we will present only the vector components rather than the full equations as written above.

The vector components of the shadow plane, in gnomon axes are then:

$$x_G = p\cos a\ ,\quad y_G = p\sin a\ ,\ \text{and}\ \ z_G = q$$

## HORIZONTAL DIAL

For a horizontal dial the relevant angles for the dial plate referred to gnomon axes are given from Fig. 8 where $l$ is the latitude and therefore the dial plate is at an angle $l$ to the gnomon. It is convenient to set up dial plate axes $(Oxyz)_H$ so that $Ox_H$ coincides with $Ox_G$ of the gnomon axes (to the east), $Oy_H$ along a line of longitude and pointing north, $Oz_H$ is then vertically up (see Figs. 5 and 6). By now rotating our axis system about the $Ox_G$ axis by (90° - $l$) to that of the horizontal plane (H), the intersection lines are entirely within the new $(Oxy)_H$ plane.

The transformations are:

$$x_H = x_G$$

$$y_H = y_G\cos(90° - l) + z_G\sin(90° - l)$$

$$z_H = z_G\cos(90° - l) - y_G\sin(90° - l)$$

and so the components of the shadow plane in horizontal dial plate axes are:

$$x_H = p\cos a$$

$$y_H = p\sin a\ \cos(90° - l) + q\sin(90° - l)$$

$z_H = q\cos(90° - l) - p\sin\alpha\,\sin(90° - l)$

with parameters $p$ and $q$ to be determined.

The vector components of the dial plate plane in dial plate axes are simply:

$x_H = s\,,\quad y_H = t\,,\quad z_H = 0$

so the parameters $s$ and $t$ are conveniently $x_H$ and $y_H$ directly.

Equating the two sets of vector components, we can eliminate the parameters $p$ and $q$, (helped by the condition $z_H$ = 0), and find $y_H$ as a function of $x_H$, yielding:

$y_H = (\tan a/\sin l)\times x_H$

It is convenient to continue with the other delineations on a horizontal dial by way of example, the other dial orientations and types being treated more cursorily and their derivations not detailed.

**Declination Lines**

By marking some fixed point on the gnomon style (the nodus) its shadow is seen to trace a line across the dial face during the course of a day. The different lines for different days are used to decorate the dial plate and provide interesting 'furniture'. The principal days chosen are the days of the solstices and equinoxes.

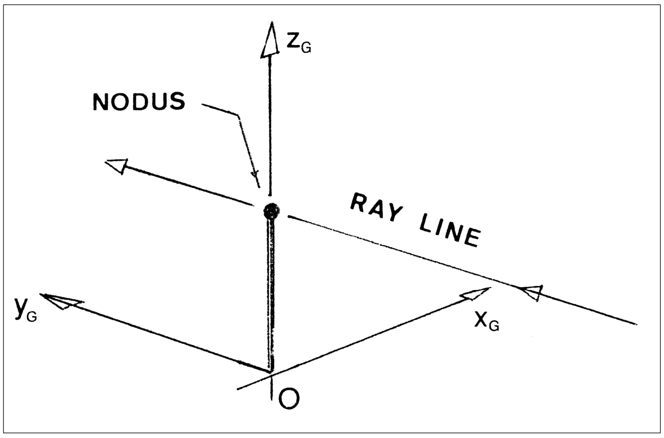


*Fig. 11. Ray line in gnomon axes for zero declination of the sun.*

It is now necessary to introduce the concept of the 'ray line', i.e. a line from the sun passing through the nodus and striking the dial plate. Figure 11 illustrates the ray line from the sun (still with declination zero from our previous simplifications) for a nodus placed at $z_G = n$ in gnomon axes. The vector components of the ray line then would then be:

$x_G = p\cos\alpha\,,\quad y_G = p\sin\alpha\,,\quad z_G = n$

Now, however, it is necessary to take account of the tilt of the earth's axis, which, *from earth*, results in the sun trotting round the earth lower down or higher up as in Fig. 12,

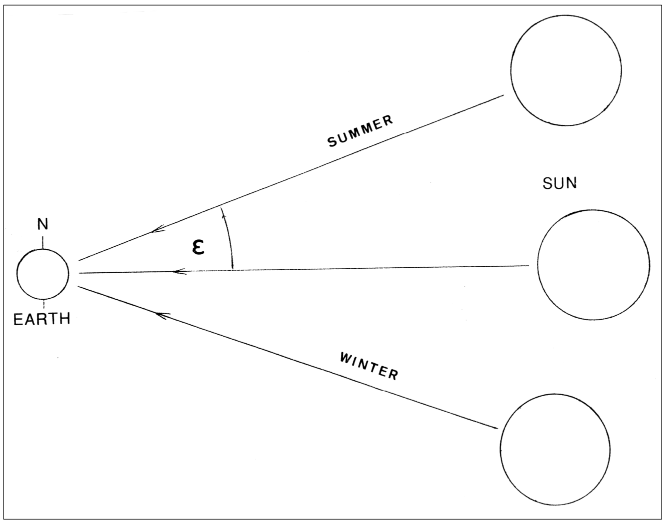


*Fig. 12. Sun-Earth geometry with sun declination e.*

the angular limits being ±23½°, the earth's tilt. Taking the 'sun's declination angle' therefore as $e$, the value for any day is given by:

$e = 23.5°\times\sin\{(D_n - 80)\times(360/365)°\}$

Where 80 is $D_{80}$, the spring (vernal) equinox and $D_n$ is the day of the year such that:

$D_1$ = January 1st = 1

$D_{365}$ = December 31st = 365

The ray line alters up and down accordingly and its vector components (in gnomon axes) become:

$x_G = p\cos e\,\cos a\,,\quad y_G = p\cos e\,\sin a\,,\quad z_G = n - p\sin e$

As before, we transform these components into dial plate axes by a rotation of (90° - $l$) about $Ox_G$ i.e.

$x_H = p\cos e\,\cos a$

$y_H = p\cos e\,\sin a\,\sin l + (n - p\sin e)\times\cos l$

$z_H = (n - p\sin e)\times\sin l - p\cos e\,\sin a\,\cos l$

and equate to the now familiar:

$x_H = s\,,\quad y_H = t\,,\quad z_H = 0$

Eliminating $p$, then $a$, we have:

$$x_H^2 = \frac{(n - y_H\cos l)^2 - y_H^2\sin^2 l\,\tan^2 e}{\tan^2 e}$$

Which is at least explicit, and yields two values of $x_H$ for each value of $y_H$ selected. The curve in general is a hyperbola, which collapses to a straight line:

$y_H = n/\cos l$

for the equinoxes, when $e = 0$.

The substyle angles $h$ and $z$ are derived simply by transformation of the style line from gnomon axes into the appropriate dial plate axes. The vector components of the style being:

$x_G = 0$ , $y_G = 0$ , $z_G = n$

and the co-ordinates of the nodus being likewise $(0, 0, n)_G$ by selecting a value for $n$.

Transformation of the style line vector components and nodus co-ordinates into the appropriate dial plate co-ordinates using the same transformations as for the delineations gives the sub-style angles and nodus results.

For a horizontal dial, the sub-style line angle ($h_H$) is trivially along the $Oy_H$ axis at noon. $h_H = 90°$

The angle of the style to the dial plate ($z_H$) is similarly at once equal to the latitude:

$z_H = l$

The sub-nodus co-ordinates $(x_n, y_n)_H$ are $(0, n\cos l)$

The nodus height above the dial plate $(z_n)_H$ is $n\sin l$

**Dial Illumination**

The illumination of the dial plate by the sun is subject to two limiting conditions:

1) The horizon, below which the sun cannot shine horizontal rays (the horizon limit $L_H$) and

2) The sun's position relative to the dial plate; illumination commencing or ceasing when the ray line is parallel to the dial plate (the sun position limit $L_S$).

For a horizontal dial the horizon limit $L_H$ is when the ray line is parallel to the dial plate i.e. its $z_H$ component, is equal to the height of the nodus above the dial plate, giving:

$z_H = (n - p \sin e)\times\sin l - p \cos l \cos e \sin a_{LH} = n \sin l$

and so

$a_{LH} = \arcsin(-\tan l \tan e)_{PV,1}$

the angle being expressed in degrees and the subscript PV,1 meaning 'principal value and first non-principal value'.

The corresponding times, $L_H$ , are then:

$T_{24} = 18 - (1/15) \times \arcsin(-\tan l \tan e)_{PV,1}$

The horizon limit is of course dependent only on the dial's location and the time of year and applies to all dials, not just horizontal ones.

For a horizontal dial the plate is illuminated whenever the sun is above the horizon and the sun position limit, $L_S$ , does not apply. It is considered in the treatment of vertical dials and subsequently.

**VERTICAL DIAL, DIRECT SOUTH**

For a vertical direct south dial we repeat the above but the plane of the dial plate is now rotated $(180° - l)$ about the $Ox_G$ axis (see Fig. 8) and the dial plate's axis system is as shown in figure 13.

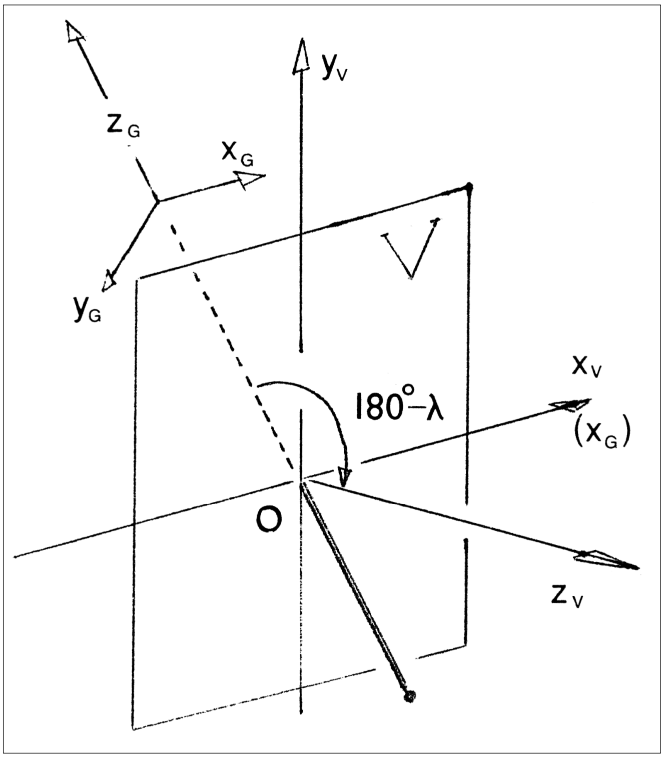


*Fig. 13. Direct south vertical dial as seen. Axis system related to gnomon axes.*

The shadow plane components in vertical dial plate axes are now:

$x_V = p\cos a$ , $y_V = -p\sin a \cos l + q\sin l$ , and

$z_V = -q\cos l - p\sin a \sin l$

Again, equating to $(x, y, z)_V = (s, t, 0)_V$ for the dial plate axes and eliminating $p$ and $q$ we have:

$y_V = (-\tan a/\cos l) \times x_V$

giving lines to draw in the lower two (negative $y_V$) quadrants of the Cartesian axes on the dial plate.

The declination lines are given by a similar result to that for the horizontal dial:

$$x_V^2 = \frac{(n - y_V \sin l)^2 - y_V^2 \cos^2 l \tan^2 e}{\tan^2 e}$$

the equinox ($e$ = 0) straight line being $y_V = n/\sin l$. Note:

1) for a vertical dial $n$ is taken with a negative value ($n$ = -100 in the examples).

2) negative values of $y_V$ are chosen to obtain the two values of $x_V$.

The substyle angle is now $h_V$ = -90° corresponding to noon.

The angle of the gnomon to the dial plate is:

$z_V = l$ - 90° (appears as a negative value)

The sub-nodus co-ordinates are $(x_n, y_n)_V = (0, n\sin l)$

The nodus height above the dial plate is

$(z_n)_V = n\cos(180° - l)$ or $-n\cos l$

(remembering that $n$ is negative).

**Illumination Times**

The horizon limit, $L_H$ is dealt with in the section on horizontal dials and applies to all dials.

The sun position limit, $L_S$, is again found from the condition that the ray line is parallel to the dial plate. For non-horizontal dials this may override the horizon limit i.e. the dial plate is not illuminated although the sun is above the horizon.

For a vertical direct south dial, we have (by putting the ray line $z_V$ component equal to the nodus height above the dial plate):

$\cos l = -(n - p\sin e)\times\cos l - p\cos e \sin a \sin l$

and so the hour angle for the sun position limit ($a_{LS}$) is given by:

$a_{LS} = \arcsin(\tan e/\tan l)_{PV,1}$

with the time of $L_S$ being:

$T_{24} = 18 - (1/15)\times\arcsin(\tan e/\tan l)_{PV,1}$

**To be continued**

**REFERENCES**


1. A.E. Waugh: *Sundials - Their Theory and Construction*, Dover Publications, New York, 1973
2. R.N. Mayall and M.W. Mayall: *Sundials - Their Construction and Use*, Dover Publications, New York, 1994
3. P.I. Drinkwater: *The Art of Sundial Construction*, Drinkwater, Shipston-on- Stour, 1985
4. R.R.J. Rohr: *Sundials - History, Theory and Practice*, Dover Publications, New York, 1996
5. A.P. Herbert: *Sundials Old and New*, Methuen, London, 1967
6. J.R. Davis: *BSS Glossary*, British Sundial Society, 2004
7. J.A. Belk: *Tired of Trigonometry? Substitute some Algebra*, Paper presented at B.S.S. Annual Conference 2005, Royal Holloway College, London.



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# DOM ETHELBERT HORNE
## Founding Father of Mass Dial Studies

**TONY WOOD**

The Museums Survey currently in hand by the Society has turned up a few surprises, amongst which was the discovery that Ethelbert Horne's manuscripts and photographs were held in a complete archive in Taunton at the Somerset Studies Library.

*Fig. 1. The Rt. Rev. Abbot Ethelbert Horne (1858-1952). Line drawing from Ref. 3.*

Known to the sundial world as Dom Ethelbert Horne, the title he held when he wrote 'Scratch Dials';[1, 2] in fact he held several senior positions in the Roman Catholic Church and in archaeology through membership of the Somerset Archaeological and Natural History Society. At the time of his death in 1952 he was: The Right Reverend Abbot Ethelbert Horne O.S.B. and also F.S.A. (Fig. 1).

Born in 1858, he joined the Order of St Benedict in 1879 and subsequently in 1891 was appointed the parish priest at St Benedict's, Stratton on the Foss in Somerset. After appointment as Prior of Downside Abbey (Somerset) from 1929 to 1934 he became, well into retirement, titular Abbott of Glastonbury.[3, 4] His range of interests was remarkable, centred round his membership of the Somerset Archaeological and Natural History Society, becoming its Chairman, President, Editor of the *Proceedings* and finally Vice President. In addition to archaeological excavation he was a frequent contributor to the *Proceedings*, published articles in the journals of other Societies and wrote half a dozen books. In addition to mass dials, his interests included dovecotes, holy wells, medieval embroideries, church glass, including the early glass of Wells Cathedral, and considerable archaeological work including the excavations at Glastonbury Abbey in the 1930s.

Dom Ethelbert was an accomplished photographer and was effectively the first to make a collection of mass dial photographs, recognising the fact that they were in fact early sundials. This was still a subject of debate with alternative explanations being offered.[5] His book encompassed a variety of mass dial forms and consequently other correspondents informed him of their local dials and were inspired to write their own summaries and surveys of these mysterious markings. Arthur Green in Hampshire[6] and T W Cole in Suffolk produced commentaries and listings; Cole in 1935 producing a nationwide survey of dial locations which is still in print.[7]

The extent to which Dom Ethelbert was a pioneer is shown by the fact that his first edition of 'Scratch Dials' appeared in 1917 following several years' patient photography; by way of comparison the first German records did not appear until 1965[8] and other continental countries have only recently started to maintain records of their mass dials.

'Scratch Dials' usually appears as 'ref. 1' in any British publication these days. Following several papers in the *Proceedings* from 1913 onwards which covered regions of Somerset, the book appeared in 1917 with a second edition in 1929. The earlier edition contained the complete Somerset listing and descriptions in addition to photographs and a classification system. The Somerset listing is a *tour de* *force* comprising 224 dials, all fully described.[9] The original photographs are in two large bound volumes in the Taunton archive and a selection was used to illustrate his books.

In addition to his early recognition of them as medieval dials he also recognised 'Saxon Dials' as a separate class, something later authors did not always do. He included them in 'Scratch Dials' however; today we would regard the two ages as distinct, indeed there seems to be a sharp dial divide at the Norman Conquest.

Such was the effect of Dom Ethelbert's unique early study of mass dials that they came to be regarded as peculiarly British, even English, and at least one author has suggested that their origin was here in the West Country.[10] Today the jury is still out as more and more dials are being noted and recorded in continental Europe. In the preface to the second edition he advances the view that they came from Normandy, which accords well with current thinking. Only now do we have the ability to bring all the records together and assess the distribution and history of these dials. His conclusions are today accepted as explanations for various puzzling aspects of scratch dials: their occasional multiplicity, varied wall locations and upper half delineation. Debate over the use of a 'bent gnomon' still lingers; a reference now available supports his view that the gnomon was substantially perpendicular to the wall.[11] The sole point of doubt is his assertion that the gnomon was sometimes made of latten, a form of brass. He offers no direct evidence and such few metal remains as have been found are of iron, which is much more likely given the 'amateur' nature of their dials' construction – as he himself points out.

The archive of Dom Ethelbert's manuscripts and photographs is held in the Somerset Studies Library at Taunton and is a considerable pile of documents and packets. Thanks to Librarian David Bromwich I was able to examine it and obtain copies of the complete Somerset photographs. In addition there was a large volume of letters and photographs of other mass dials, some in envelopes unopened since their deposit in the 1950s. There are also photographs and documents covering his other interests as mentioned above.

The extent of his work is remarkable; it is to be hoped that his legacy can be continued and the archive fully explored one day and incorporated into the national records. This article is also written in the hope that our continental colleagues can fill in the history of their mass dial discoveries and so continue the trail started by Dom Ethelbert and his recognition of the scratch dial as part of sundial history.

**ACKNOWLEDGEMENT**

Special thanks to David Bromwich for help with the archive in the Somerset Studies Library at Taunton.

**REFERENCES**

1. E. Horne: *Primitive Sundials or Scratch Dials*, Barnicott & Pearce, The Wessex Press, Taunton, (1917).
2. E. Horne: *Scratch Dials, their Description and History*, Simpkin Marshall Ltd., London, (1929).
3. H. St.G. G.: 'Ethelbert Horne: Obituary', *Proceedings of The Somerset Archaeological and Natural History Society*, XCVII, pp. 193-194 (1952).
4. R. Dunning: *Fifty Somerset Churches*, Somerset Books, Tiverton, (1996 ).
5. E. Horne: 'Scratch Dials', *Birmingham Archaeological Society Transactions and Proceedings*, LI, 1-9, (1925/1926).
6. A. R. Green: *Sundials – Incised Dials or Mass-Clocks*, SPCK, London, (1926 and 1978).
7. T.W. Cole: *Origin and Use of Church Scratch-Dials*, Hill Bookshop, Wimbledon, 1935. Reprinted by Pierhead Publications Ltd., Herne Bay, (2001).
8. H. Melka & P. Starsy eds: *Maria Koubenec 1899 – 1995*, Regionalbibliothek Neubrandenburg, Germany, (2000).
9. The Ethelbert Horne Archive, Somerset Studies Library, Taunton, Somerset
10. P.R. Hamilton-Leggett: 'Mass Dials', Webpage: www.argonet.co.uk/users/hamleg/dint.html (1997).
11. J. Hovendon: *Practica Chilindri*, c. 1270.

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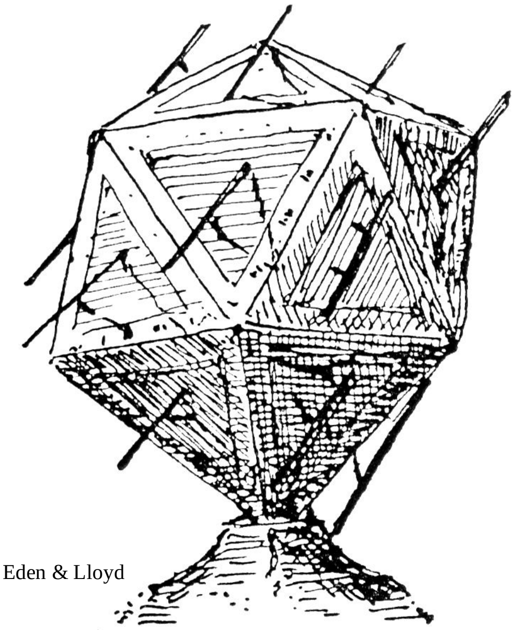


Eden & Lloyd

*A facet-headed dial at Walton Hall, made in 1813 by the mason George Boulby. It is in the form of an icosahedron, with 20 equilateral triangles. It was bought by the naturalist Mr. Waterton for the Hall, near Wakefield. Compare the dial to that of the BSS Award prizewinner Peter Scott on page 111.*

# TICKLESS TIME

## ROGER BOWLING

Surprising though it may seem, there is a one act play in which the plot and the action revolve around a sundial. It is a garden horizontal dial and on the plinth, large enough for the audience to see and understand is an equation of time graph, constructed for a longitude correction of nineteen minutes and twenty seconds. The play is titled 'Tickless Time'.

The story in brief. Ian has made a sundial, and as he demonstrates that it is accurate, he is very pleased with himself and shows it to his wife, Eloise. He announces that henceforth they will live an honest life, away with untruthful ticking clocks, sun time will now rule their lives. Eloise thinks Ian is wonderful although she does not quite understand his reasoning, she agrees that true time is better than the lies of mechanical clocks.

When Ian begins to collect all the clocks, from the house, the alarm clock, the cuckoo clock and the kitchen clock, and to bury them in a grave by the sundial, she thinks he is going too far, and she also finds a few difficulties. How is she to catch the train to go shopping for a new hat, and besides she likes the ticking of a clock?

Their friends Eddy and Alice arrive for dinner. Eddy understands what Ian is trying to do but makes fun of him. Alice's only concern is that the cuckoo clock was their wedding present to Ian and Eloise, and please, could she have it back? Mrs Stubbs, a neighbour and a beacon of common sense arrives to look at the new sundial, and enquires if it is running yet. Her clock has stopped and her husband who works at the fish freezing factory will soon be home. She is not bothered whether it is tick time or sun time she is given, but Mr Stubbs always has his supper at half past six. Annie the cook shows the strongest objection to the lack of the kitchen clock, how can she fry onions in butter for three minutes? She threatens to seek employment elsewhere, but is pacified by the exhumation of the kitchen clock.

Against this onslaught upon the truth as perceived by Ian, he is beaten, the clocks are returned to the house, and Ian buries the sundial. Mrs. Stubbs thinks this is wrong and lectures Ian, "after you've made a thing that's right you oughtn't to bury it, even if there is nobody to want it", and she restores it to its pedestal. The party then argues whether it is twenty past six or twenty to seven. Annie from the kitchen has the final word, and announces the only time that really matters, 'Its dinner time'. *Exeunt omnes.*

TICKLESS TIME

A COMEDY IN ONE ACT

BY SUSAN GLASPELL AND GEORGE CRAM COOK

CHARACTERS

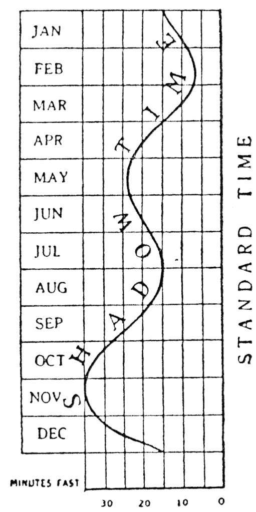
IAN JOYCE, *Who Has Made a Sundial.*
ELOISE JOYCE, *Wedded to the Sundial.*
MRS. STUBBS, *a Native.*
EDDY KNIGHT, *a Standardized Mind.*
ALICE KNIGHT, *a Standardized Wife.*
ANNIE, *Who Cooks by the Joyces' Clock.*

The play was first performed by the Provincetown Players in New York, on December 20, 1918, with the following cast:

| | |
|---|---|
| IAN JOYCE . . . . | James Light. |
| ELOISE JOYCE . . . . | Norma Millay. |
| MRS. STUBBS . . . . | Jean Robb. |
| EDDY KNIGHT . . . . | Hutchinson Collins. |
| ALICE KNIGHT . . . . | Alice MacDougal. |
| ANNIE . . . . . | Edna St. Vincent Millay. |

TICKLESS TIME

SCENE.—*A garden in Provincetown. On the spectator's right a two-story house runs back from the proscenium—a door towards the front, a second-story window towards the back. Across the back runs a thick-set row of sunflowers nearly concealing a fence or wall. Back of this are trees and sky. There is a gate at the left rear corner of the garden. People entering it come straight toward the front, down the left side and, to reach the house door, pass across the front of the stage. A fence with sunflowers like that at the back closes off the left wing of the stage—a tree behind this left fence.*




*The sundial stands on a broad step or pedestal which partly masks the digging which takes place behind it. The position of the sundial is to the left of the centre of the stage, midway between front and back.*

*From behind the tree on the left the late afternoon sun throws a well-defined beam of light upon the horizontal plate of the sundial and upon the shaft which supports it. On this shaft is the accompanying diagram: two feet high and clearly visible.*

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*The title and first pages of the published version of 'Tickless Time'.*

The play was written in 1918, and first performed in New York on December 20th of that year, by the Provincetown Players. One critic writes, "the ironic pull of reality undercutting grand gestures of moral and metaphysical indulgence. In other words [it was] to some degree an in-joke, gentle deflations of their own pretensions, a mockery of their own overseriousness. But as [a play] it is nothing of real interest beyond an unusual stance of self consciousness". Well that is the sort of thing critics write, I would call it a curious comedy, but nevertheless this play has a most excellent pedigree.

The authors were Susan Glaspell, 1882-1948, a prolific writer of plays and novels, and George Cram Cook,1873-1924, poet, playwright, teacher and critic. They married in1913 and were founders and luminaries of the Provincetown Players of Provincetown, Mass. USA, right on the tip of Cape Cod. The group were leaders of the small theatre movement. Founded in 1915, their first theatre was a converted fish warehouse, The Wharf Theatre; later they took over the Greenwich Village Theatre and other New York theatres. Eugene O'Neill and Susan Glaspell were the major writers for the players. Later, O'Neill won the Nobel prize for literature in1936, and Susan Glaspell likewise went on to greater things, winning the Pulitzer prize for drama in 1930, though not of course for Tickless Time. In addition to Tickless Time being the only play to feature a sundial and the EoT so prominently, it has another claim to our attention. George made a garden sundial for Susan soon after they were married, at their home in Provincetown. It has been suggested that this was the inspiration for the play. Can our American friends tell us if it still exists? Surely these facts make this literary jewel unique, and that sundial a literary icon?

I find it hard to understand what the audience of 1918 would make of the play; would they understand the EoT. graph? But I'm sure they would have a better grasp of it than a present day audience. Judging by the popularity of Susan Glaspell in America, I think this play will have had many more presentations, but I do believe it is due for a revival before an appreciative and fully comprehending audience in this country. I suggest the Newbury Little Theatre, or maybe elsewhere at the AGM. In the notes to the play, it states that it could easily be adapted for an English audience, and suggests Falmouth for Provincetown, just about the same time difference of 20 mins. Required are two gentlemen and four ladies, acting experience is not desirable, just the ability to read the lines, with feeling.

**ACKNOWLEDGEMENT**

My thanks to Tony Wood for bringing this literary masterpiece to my notice and for lending me the book of one act plays that contains it.

**BIBLIOGRAPHY**

C.W.E. Bigsby: *A Critical Introduction to Twentieth Century American Drama. Vol.1 1900-40.* CUP, Cambridge, (1982).

S. Glaspell: *Trifles, and six other short plays.* Ernest Benn Ltd. London, (1926).

J. Hampden (Ed.): *Ten Modern Plays.* Ernest Benn Ltd. London, (1926).

J.D. Hart: *The Oxford Companion to American Literature. 5th Ed.* OUP. Oxford, (1983).

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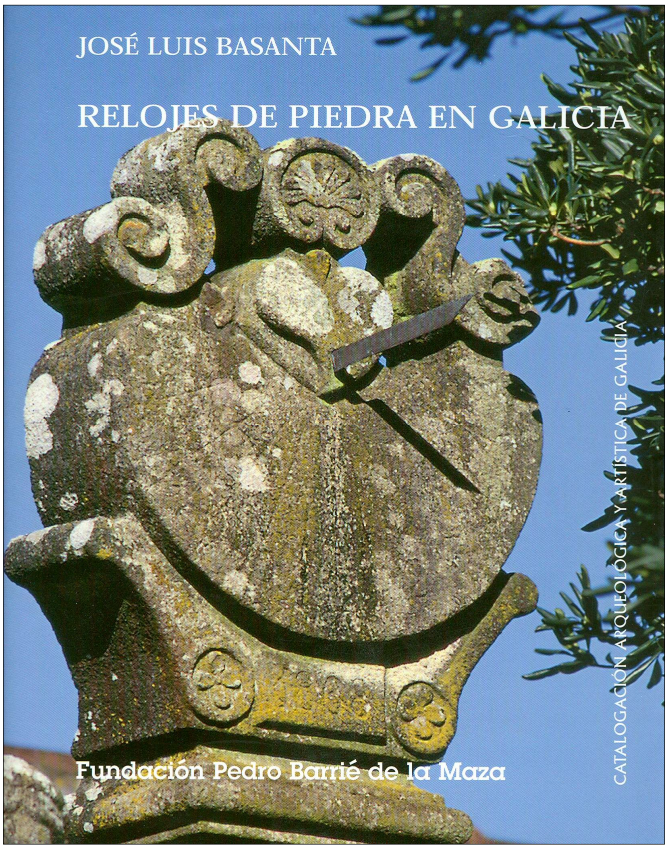
*This BSS logo was presented to the BSS during the Italy Tour 2004 by Mario Arnaldi on behalf of the* Coordinamento Gnomonico Italiano *(the Italian sundial society). It was made by the noted Italian artist Marco Bravura with the mosaic in blue and gilded glass and fitted neatly into a gilded wooden case.*

# BOOK REVIEW

**Relojes de Piedra en Galicia (Stone Sundials of Galicia) by José Luis Basanta, Fundación Pedro Barrié de la Maza, A Coruña, Spain, 2003.** *Softback with dust cover, 280mm ´ 220mm, 372 pp, 819 colour illustrations.*

*ISBN 84 95892 16 2.* €36.54




This beautifully produced book is a feast of delights for anyone interested in sundials. It is beautifully illustrated throughout its 372 large pages. It contains useful sections on the historical development of sundials, on references to them in Spanish literature, and on representations of sundials in paintings, cartoons, bank notes, and stamps.

The author has identified 379 sundials in Galicia, which is the northwest region of Spain. 241 of these are in the province of Lugo. Only around a third of the total are on churches, a quarter are on houses, and a fifth on "horreos", the traditional Galician grain stores which are now falling out of use and into neglect.

The middle section of the book consists of 110 pages of photographs, many in full colour, of some 250 Galician sundials, divided according to their situation. A further 102 pages are devoted to sundials outside Galicia, and are again copiously illustrated. There are 150 sundials identified in other regions of Spain, and nearly 100 in other countries of the world (mainly in Portugal, Italy or Great Britain). The book concludes with a description of the methods of construction of sundials, a bibliography of articles and books, mainly in Spanish, a glossary of technical terms, and an epilogue by René Rohr (in both French and Spanish)

This book developed out of an exhibition of photographs in the Museum of Pontevedra. The Fundación Pedro Barrié de la Maza agreed to publish this second edition as part of their series entitled 'Catalogación Arqueologica y Artistica de Galicia'. This second edition closely follows the text of the first, but with the addition of the excellent photographs, which add so much to the interest of the book and the understanding of the subject.

*Piers Nicholson*

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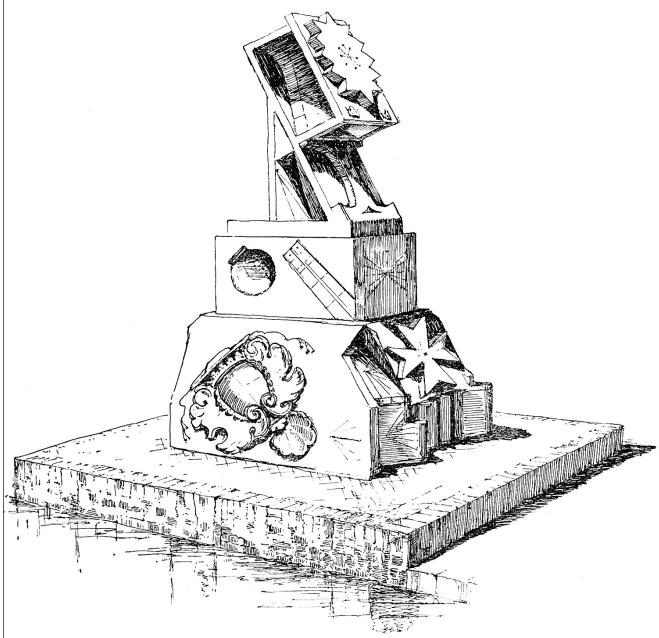
## A SPANISH DIAL



*A lectern dial of the type usually found in Scotland. This example is illustrated in Eden & Lloyd and was at Buen Retiro, Churriana near Malaga. Is it still there? Made of white marble, it is said to have 150 dial faces. It features the royal arms of Spain and two castles and a lion for Castille and Leon. It also has a ducal coronet and a cardinal's hat. One of the scaphe dials on the second tier is in the shape of a scallop shell, the symbol of pilgrims.*

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