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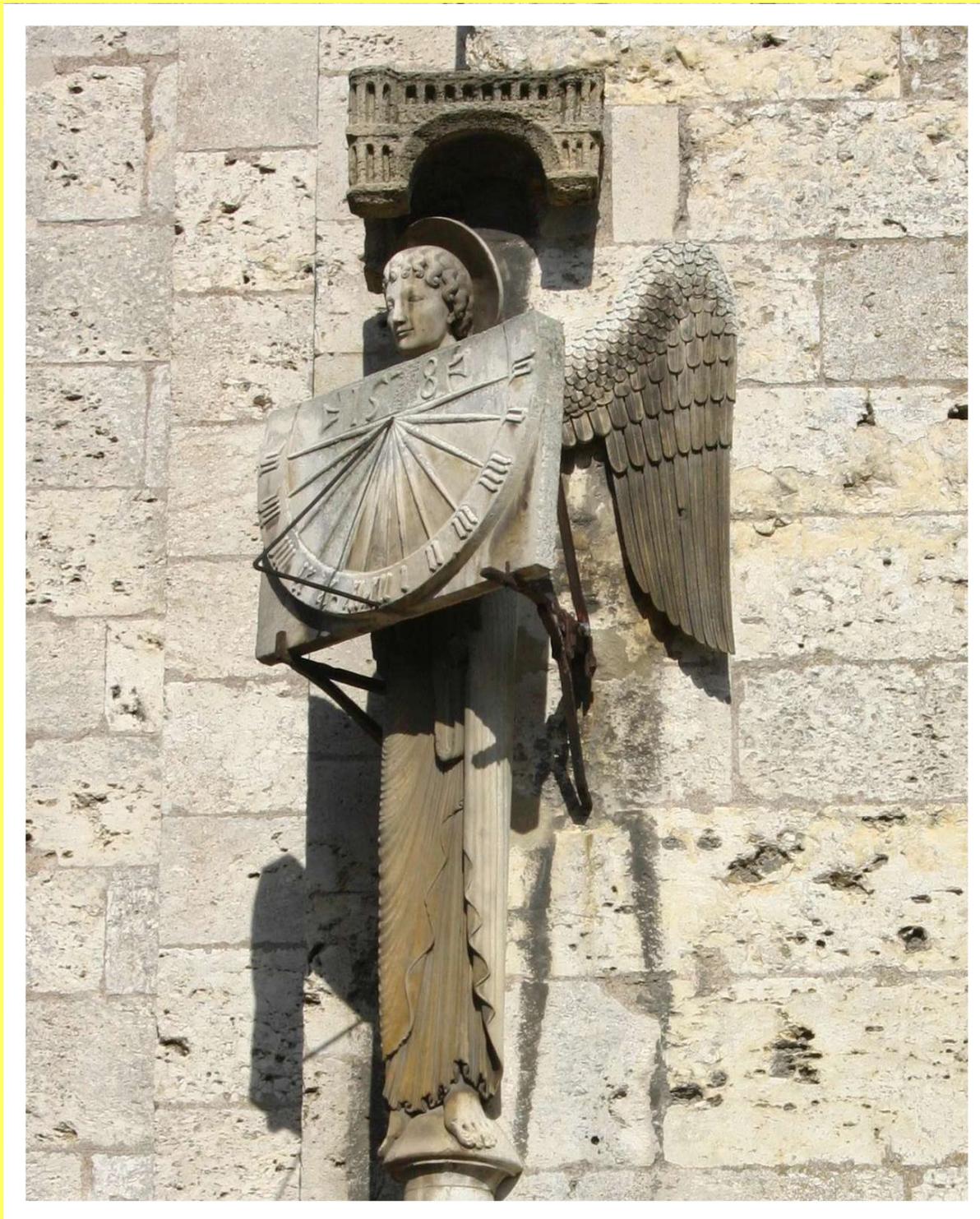
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Front cover: The famous Angel Dial on Chartres Cathedral, France, seen on the BSS Sundial Safari (see report on p.10). The dial (a replica—the original is in the crypt) is dated 1578 although the angel is considerably older. Although it has a polar-aligned gnomon and displays modern, equal hours, it is in the same style as earlier dials showing unequal hours with horizontal gnomons. Photo by Mike Cowham.

Back cover: Oh dear! The rather smart vertical declining dial (SRN 3604) above the porch of St Mary's Church, Pinchbeck, Lincs. The May 2007 painting is nicely done but what has gone wrong with the numbering? It looks as though the one-hour correction for BST has been applied in the wrong sense (the vertical noon line is labelled XI instead of I), the other lines are suspect too and the equinox line is missing. Photo by Mike Cowham.

BULLETIN
OF THE BRITISH SUNDIAL SOCIETY

## ISDN 0958-4315

VOLUME 23(iv) - December 2011

EDITORIAL

A bumper Christmas edition for you this time, courtesy of all our authors. The Treasurer has allowed a few extra pages so there is plenty of varied reading over this quiet period of the year for dialling, including some continued inputs from overseas writers. It is always interesting to see how different cultures interpret the artistic side of dialling, even if the astronomy remains universal. Also with this issue is our annual solar data card with the calculations courtesy of Fiona Vincent.

The Secretary tells me that responses to the membership survey are continuing to come in. He will feed back anything relevant to the *Bulletin* when he sums up and I will take notice so I do urge you to let him know how you think it could be improved. I don't, at the moment, have any plans for altering our presentation though I am aware that the overall layout hasn't changed for a number of years and might be looking a little tired. I do have some excellent material in line for next year so the content will not be affected.
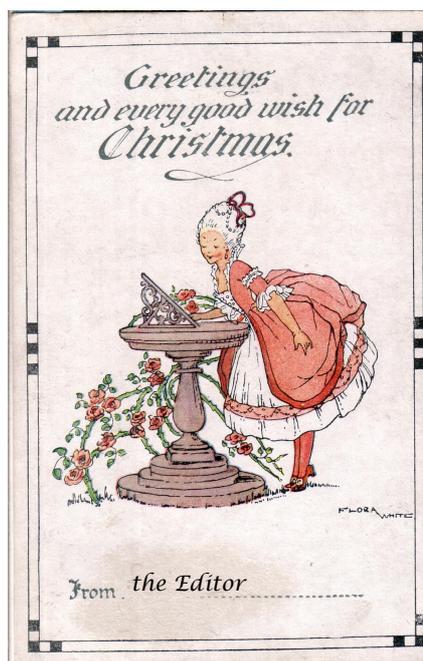
An appropriate greetings card, published c.1920s by J. Salmon with artwork from Flora White. Image courtesy of our Polish member Dariusz Oczki: see his website http:/gnomonika.pl for more examples. (Note that this web address was misspelled in the last issue.)

THE CANTERBURY PENDANT

Part 1: A New Insight from an Ancient Rule for Making Portable Altitude Dials

MARIO ARNALDI

This article summarises the attempt of the author to make, for the first time, a clear and correct edition of an ancient text, wrongly attributed to Bede, on the construction of an altitude dial. The findings give a new insight to the famous 'Canterbury pendant'. We will see that this little sundial was made more correctly than was previously believed.[1]

It is believed that the most ancient Latin document describing the construction of a cylinder dial was compiled in the 11th century by Hermann the Lame (*Hermannus Contractus*, 1013-1054), a Benedictine monk from the Abbey of Reichenau, Germany. He was also the author of an essay on the astrolabe (*De mensura astrolabii liber*) that is believed to have been translated from an Arabic treatise due to the frequent use of Arabic technical terms in its contents.[2] The text related to the construction of a cylindrical altitude dial is contained in the second book of the *De utilitatibus astrolabii*.[3] Hermann explains how to construct the instrument by a table of solar altitudes, data found with an astrolabe. He finds the shadow lengths for each hour by a simple but correct graphical procedure.[4] The Hermann text on the cylinder dial was very much dispersed and many other new Latin and European treatises were written after it.

The Arabs also knew a sundial similar to the cylinder dial. The principle was the same as the so-called 'locust's leg', a dial made with a flat rectangular board divided into columns for the zodiacal signs or sun's declinations. In each column or vertical day-line the hours of the day are marked. The gnomon can be fixed or movable, being inserted into a series of holes at the top of each column.

This dial could be mounted on a body with a circular section but usually was intended more as a cone dial than a cylinder: the name of both kinds was *Mukḥula*. We know that the oldest Arabic text about an altitude dial like this is probably from 9th century Baghdad.[5] Al-Bīrūnī mentions the *Mukḥula* but he does not explain the details of its construction. Al-Khwārizmī, in the late 10th century, names the *Mukḥula* as an horary instrument. We know also that in the 13th century an author named Ibn Yaḥyā al-Ṣiquillī wrote a treatise on the *Mukḥula*.[6] Also, al-Marrākushī wrote about it as did Najm al-Dīn al-Mīṣrī in the 14th century.[7]

At one time it was believed that Hermann was the inventor of the portable cylinder dial, since his text does not use any Arabic terms as are used in his essay on the astrolabe. Today, we know that neither Hermann the Lame nor the Arabs (who were subsequently believed to have been the originators) were the inventors of that dial, because a small portable cylinder dial made of bone (Fig. 1; height 62 mm, diameter 25 mm) was found at Este in the province of Padua, Italy, in the grave of a Roman doctor, and this has been dated back at least to the first century AD. This is the proof that the design was already known in Roman times.[8]

Additionally, the principle of the 'locust's leg' was also known by the Romans: an example is the well known 'Ham of Portici' found at Ercolano, near Naples.[9]
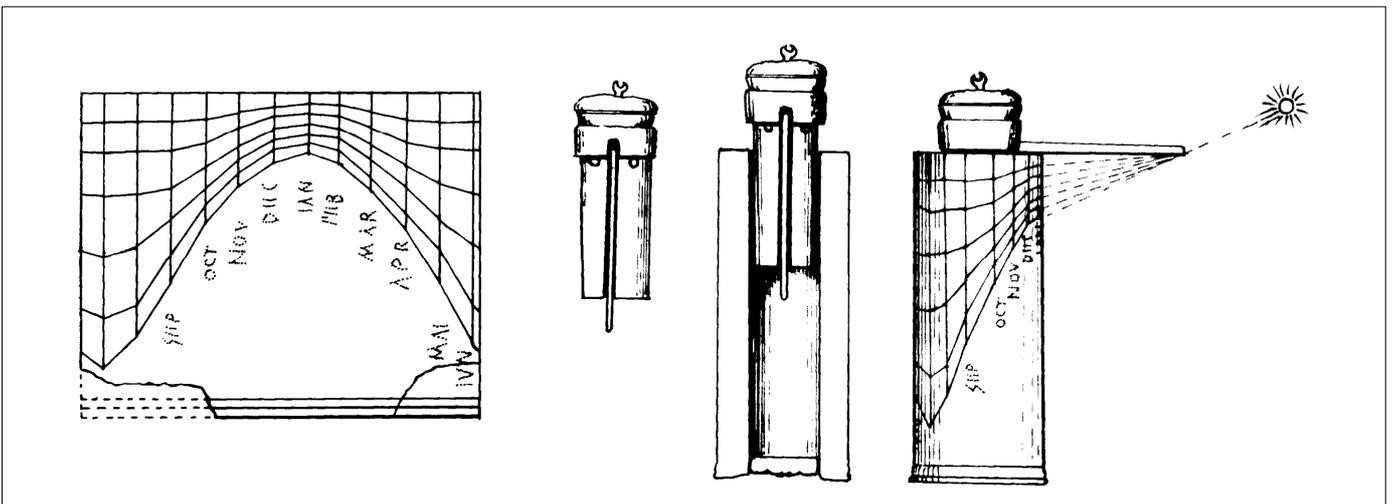

Fig. 1. Cylindrical sundial for travellers found at Este (Padua). (All the drawings are made by the author).

It is clear, therefore, that Hermann drew his information from some earlier scientific tradition but it is difficult for me to believe that Hermann looked at an Arabic manuscript, because in his text there is not one single Arabic word, and we do not know if some Arabic manuscript on the *Mukḥula* or on the 'locust's leg', older or even contemporary to him, has travelled in Europe into the 10th or 11th century. I believe that Hermann knew some old Latin-tradition text about it, and that he also had some Arabic knowledge or instrument that permitted him to write a new independent and corrected text.

An Older Manual for the Construction of Altitude Dials Like the Cylinder

Between the 10th and 11th centuries, the use of altitude dials in Christian Europe, working on the same principle as the cylinder for travellers, is proved by the presence of the so-called 'Canterbury Pendant'. This is a little portable sundial made of silver and gold found in 1938, during work on the floor of the cemetery inside the cloister of Canterbury Cathedral. This sundial shows only the third, the sixth and the ninth hours of the day[10] by a series of points along vertical columns assigned to the months of the year.

The presence of other altitude sundials of the same kind seems to be confirmed by the words used by Byrhtferth of Ramsey (c.970 – c.1020) in a passage of his *Manual*[11] and in the *Glossae* to the *De temporum ratione* of the Venerable Bede (627 – 735),[12] falsely attributed to the same monk.[13]

Then there is a text, older than the one written by Hermann, which until now has avoided the attention of the scholars. This text describes the construction of an altitude dial of this kind. It is inserted in a little treatise doubtfully attributed to Bede: the *Libellus de Mensura Horologii*.[14] This brief composition (for convenience hereafter simply *Libellus*) was published for the first time in 1563 in the first tome of the comprehensive work on Bede edited by Iohannes Hervagius (Johann Herwagen) from Basle[15] and reprinted in the second half of the 19th century in volume 90 of the well known series on patristic Latin texts edited by J.P. Migne.[16]

The *Libellus* is actually a collection of different texts (not all on gnomonics) gathered in seven chapters in this order:

1. The first one (the text of interest to us) does not seem to have a title and it starts with: "*Si quem delectat horologium componere*".[17]

2. The second one, *Ad meridiem inveniendum*, describes the method of finding the meridian line with the 'correspondent altitudes' of the Sun, also known as 'Hindu circles'.

3. The third one, *Horologium quod contra unumquemque mensem habet ad umbram humani corporis pede singularum horarum diei*, is the drawing of the 'shadow scheme' fan-shaped, falsely attributed to Bede. It is represented as a portable instrument.[18]

4. Then follows *Concordia XII mensium*, where the preceding 'shadow scheme' is reported in a textual way.[19]

5. The fifth one, *De Signis et horis XII mensium*, is the diagram of the length of the days, in equal hours, for every month and the corresponding zodiacal sign.[20]

6. Then, *De tribus diebus periculosis* lists the three dangerous days of the year, when one risks death.

7. The last one, *De Aegyptiacis diebus*, is a known text about the so called 'Egyptian Days, which lists all the 22 days of the year that are disadvantageous for human activities.[21]

The drawing in chapter 3 and the next text (no. 4) are found often together in a single *folio*,[22] while the text of chapter 2 is usually added to many medieval gnomonical works independently from the kind of sundial described.

The contiguity of chapters 2, 3 and 4 had always drawn the attention of researchers on 'shadow schemes' (shadow length measured in 'feet'), which were widespread in medieval times.[23] For this reason the first text of the *Libellus* has not been studied carefully and sometimes the entire compilation has even been dismissed as a disappointing gnomonic work.

We do not know the source consulted by Hervagius for his work, but whatever it was it seems now irreparably lost. We had only the Migne text. However, I can now add two further texts, but I think there might be more.[24] So at this point we know only three sources with the chapter 1 text.

A. The first text of the *Libellus*, published first by Hervagius and then by Migne. It has almost certainly the title *LIBELLUS DE MENSURA HOROLOGII*[25] that Hervagius gave wrongly to the full collection. It seems that the manuscript is definitely lost and we do not know its provenance.

B. A fragment of only six lines added in a narrow space at the bottom of folio 7v of the MS Vaticano Pal. 3101 (11th century), entitled *INVENTIO PENDENTIS OROLOGII*.[26]

C. A manuscript written between the 11th and 12th centuries and now kept in the Badische Landesbibliothek of Karlsruhe (MS. 504 Karlsruhe, fol. 58v); the text is preceded by the title *RATIO AD COMPONENDUM HOROLOGIUM*.[27]

The Text

I have used **A** as the basic text for the edition I made in an earlier article[28] because the evidence shows that this is surely the most complete and the closest to the original layout. Thus I have left the references to the columns as they are in the text of Migne (which is also easier to find than the Hervagius edition) but I have titled it as in **B**, because I think that this is most significant with respect to the rather generic titles in **A** and **C**; moreover I have corrected the text following the lessons of **B** and **C**.

The text in **B** lacks the first two parts (I and II in this edition) that, in contrast, are present in **A** and **C**; the incipit is *Prima linea quae ascribitur xii kalendis Iunii et iulii*.

All the texts, **A**, **B** and **C**, are the same other than some differences which are discussed in the Notes.

Beda Venerabilis (627-735) – *opera dubia* **Libellus de mensura horologii**	Pseudo-Bede **Manual for drawing a sundial**
INVENTIO PENDENTIS OROLOGII [29] I - (C: row 28) (A: col. 951) *Si quem delectat horologium componere, sive metallinum, sive ligneum, quod ad instar*[30] *perpendicularis videtur formari, praeter quod illud rotundum est, istud vero per sena latera, in quibus horarum ordo* (A: col. 952) *totius anni binis mensibus insignitur.*[31]	MAKING THE PENDANT SUNDIAL If anyone wishes to make a sundial, of metal or wood, similar to a perpendicular (sundial), not cylindrical but with six sides on which the hours are marked for the entire year in pairs of months.
II - *Longitudo namque quinque digitorum creditur sufficiens esse, plus minusve. Grossitudo quoque, si unumquodque latus sufficit ad gnomonem et inscriptionem Kaleda-* (A: col. 953) *–rum, satis videtur.*	The length (of the sundial) needs to be about five fingers; it needs to be thick enough so that each side can accommodate the gnomon and the names of the pairs of months.
III - (B: row 40) *Prima linea quae ascribitur XII Kal*[dis] *Iuni et iulii,*[32] *secundum placitum habeat initium: ipsum tamen spatium sex aequis spatiis dividatur, vel partibus, a primo puncto quod in una regione habetur, usque ad umbilicum. Secunda vero, quae xii Kalend. Augusti et Maii assignatur, a medio sextae horae spatio primi ordinis sortiatur terminum. Tertia, quae Aprilis et Septembris iisdem (ut supra titulatur) Kalendis, relicto dodrante penultimae secundi ordinis horae, quadrantem sumit exordium. Quarta penultimi spatii tertiae seriei, vindicat trientem. Quinta penultimi spatii quarti ordinis, quintam arripit partem. Sextae lineae terminus, quartae horae*[33] *confinio quinti ordinis coaequatur.*	The first line, assigned to the twelfth (day before the) Calends of June *(May 21)* and July *(June 20)*, has its length beginning where you like: its length is divided into six equal parts, starting from the first point in the section up to the gnomon.[34] The second line, assigned to the twelfth (day before the) Calends of August *(July 21)* and May *(April 20)*, begins at the point in the middle of the sixth hour space of the first section.[35] The third (line), assigned to the same calends as previously noted of April *(March 21)* and September *(August 21)* begins three-quarters of the way through the penultimate hour of the second section. The fourth (line) begins one third of the way through the penultimate hour of the third section. The fifth (line) begins one-fifth of the way through the penultimate hour of the fourth section. The end of the sixth line shares the boundary of the fourth hour of the fifth section.

The Instrument

The first paragraph (I) describes the shape and the type of the sundial. In our case it is a pendant altitude dial, apparently with a prismatic shape having an hexagonal section (*per sena latera*) working on the same principle as the cylinder dial (Fig. 2).[36]

The second paragraph (II) describes the instrument's dimensions. The suggested length for this object is approximately 5 fingers (about 9 cm) and its thickness (width or diameter) is enough so that every side can hold the gnomon and the writings related to the calendar.

The last part of the text (III) describes the construction of the month lines giving us the parameters for the relative lengths of the meridian shadows.

The Calendar

It is important to pay attention to the calendar suggested by the *Libellus*. Each day line, or monthly column, is assigned to two solar months with the same solar declinations.[37] This match was very common in Roman portable sundials, but in this special case the dates of the Sun's passage in the zodiacal signs (12 days before Calends) has a late-Roman origin.[38] In the calendar suggested by the *Libellus*, and reconstructed in Fig. 3, the data of the meridian shadow length in each column cannot be taken as the beginning of the solar month, that is the first day of the Sun's passage to the next zodiacal sign (about the 21st of every month). Instead, one must consider it as the middle point between two

zodiacal signs: in other words, with the solar declination near the fifth day of every calendar month.[39] The data for those days will be used in the second part of this article, when I analyze the horary scheme.

Construction of the Hour Points

Every monthly line, once that it is drawn with the correct length, is subdivided into six equal parts that represent the first six hours of the day (from sunrise to midday) and the
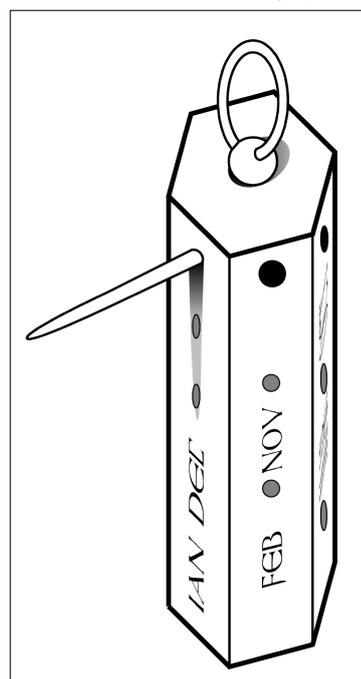

Fig. 2. Possible reconstruction of the portable sundial described in the Libellus de mensura horologii.
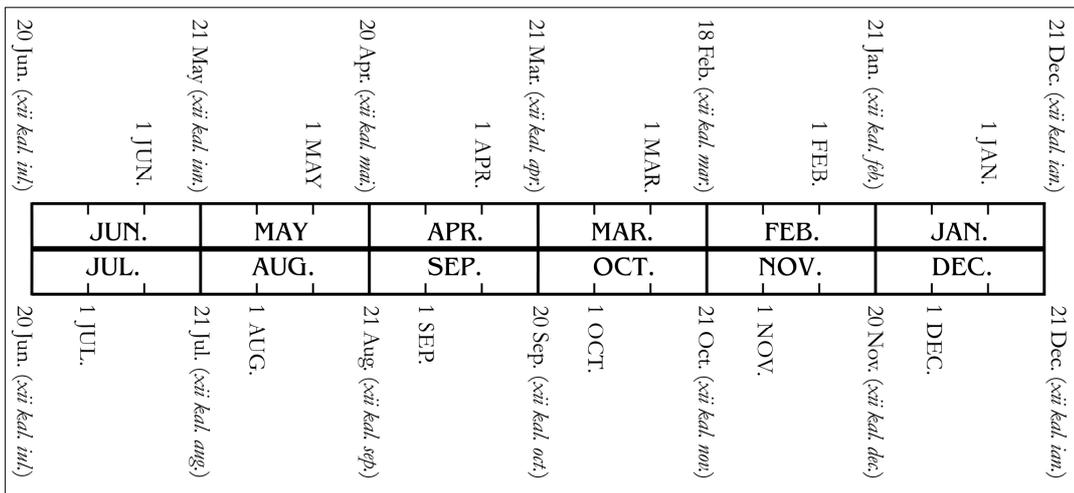
Fig. 3. The calendar suggested by the Libellus.

corresponding six hours after noon (from midday until sunset).[40] This division into equal parts appears obviously ingenuous but it is not alone in medieval literature: we can find it in chapter 21, titled *De inveniendis in dorso Astrolabii horis,* of the first book of the *De utilitatibus astrolabii*, where this division is given as correct for making *horologia* (sundials).[41]

Making the sundial described in the *Libellus* starts with the longest shadow line, which in our case is assigned to two periods that go from the 21 May to 20 June and from there back until 21 July (*xii Kalendis Iuni et iulii*). This line can be as long as one wants (obviously as long as possible). The extreme point of the second line that corresponds with the period from 21 July to 21 August and from 20 April until 21 May (*xii Kalend. Augusti et Maii*), matches against the mid point of the sixth space (that is the 6th and 7th hours) in the preceding months. The third line, dedicated to the 12th day before the calends of April and September (21 March and 21 August), starts from three-quarters of the penultimate space (5th and 8th hours) of the line for the preceding month. The fourth line starts from one-third of the penultimate space of the preceding month line. The fifth one, at one-fifth of the penultimate space of the preceding one and the sixth one ends at the limit of the fourth space (end of the 4th and beginning of the 9th hours) of the preceding column. The result is shown in Fig. 4

Possible Origin of the *Libellus*

Having so few sources, it is not easy to date the text of the *Libellus*. The most ancient manuscript among those listed at the beginning of this work is of the 11th century; nevertheless, from the evidence found during the study of the text, we can reasonably suppose that we are dealing with a more ancient tradition. If we consider that the compilation that has reached us by Hervagius is composed of elements known partly since antiquity (texts 2, 6 and 7) and partly dated back to the 8th century (3 and 4)[42] with others at least from the 8th century (5), we may date back the first text of the *Libellus* at least to the 10th century, if not earlier, i.e. to Carolingian times.

There are, actually, two clear references to traditions earlier than the 10th century. The first can be recognized in the use of the word *umbilicus* for identifying the gnomon (see Note 34), and the second one can be seen in the calendar limits (*XII kalendae*) that became conventional after the Council of Nicea (325 AD).

Apart from Pliny the Elder, the definition of the gnomon with the name *umbilicus* is also found in Bede's *De Natura Rerum*, which admittedly gets much from Pliny, while the same position of the dates in reference to the months is found in the description of a *Horologium* built according to special 'shadow schemes' in a manuscript of the year 850 (MS Cotton Tiberius A, III, *ff*. 178-179).[43]

We can find also that Hermann the Lame composed his *Demonstratio componendi cum convertibili sciothero horologeci viatorum instrumenti* looking at a text from the
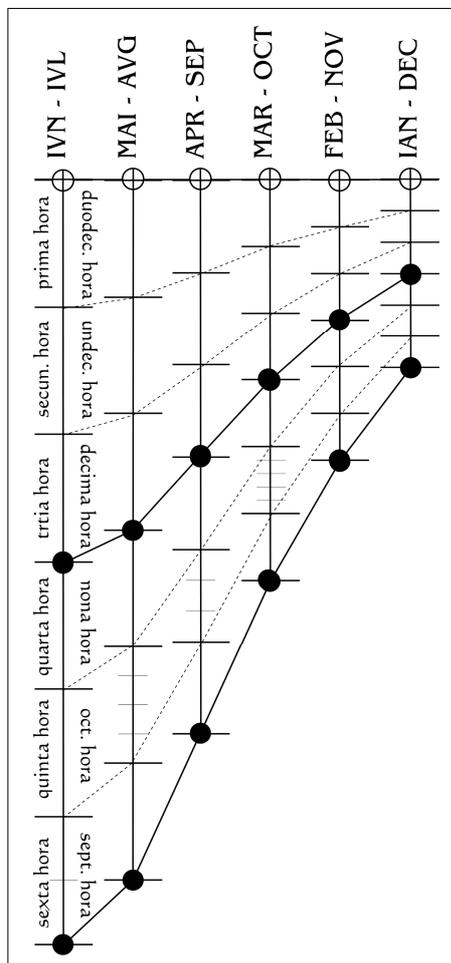

Fig. 4. Scale of the lines drawn by the manuscripts of the Libellus de mensura horologii. *In the present sketch the lines of the sixth and the third/ninth hours are shown with dots.*

same tradition (perhaps lost today) because he uses the Greek origin word *sciotherum* as gnomon. Before Hermann we can find that word only in the antique texts that came from between Roman and Carolingian periods.[44]

In conclusion, I believe that the text of the *Libellus*, as we know today, was probably composed during the 8th to 10th centuries but that it has a great affinity with the layout of the 'Cylinder of Este'. It is in reality the last witness of the Roman handbooks devoted to the construction of the portable sundials of which Vitruvius also speaks and it was still probably available up to the beginning of the Middle Ages.[45]

With this conclusion, we can imagine that Roman popular manuals on construction of portable sundials were probably composed by use of tables of midday shadow length calculated for different 'climates' (see discussion in Pt. 2).[46] The *Libellus* seems to be a surviving fragment related to England's 'climate', transcribed in Carolingian times, when it was perhaps taken to be a 'universal' scheme for portable sundials of that kind.

Now it remains to demonstrate in Part 2 that the graphic layout generated by the *Libellus* works correctly and has a strong relationship with the cylinder of Este and the Canterbury pendant.

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2. Hermannus Contractus: *De Mensura Astrolabii Liber* in P.L. Migne, vol. cxliii, coll. 379-90A.
3. Hermannus Contractus: *De Utilitatibus Astrolabii Libri duo, Liber secundus, caput primum, Demonstratio componendi cum convertibili sciothero horologeci viatoris instrumenti*, in P.L. Migne, vol. cxliii, coll. 405-8B.
4. He finds the shadow length by a quarter of a circle, divided in 90° on the border. The gnomon (*sciothere*) tip ends in the centre and from there rays reach the outer scale of degrees. At the end of the gnomon a vertical line crosses the degree rays giving the shadow length of that hour.
5. The text is preserved in the Ms. Istanbul, Aya Sofya 4830, fol. 129r-v; it describes a pillar dial construction by a table of vertical shadow lengths; Cf. King, *SATMI*, vol. i, part iv, ch. 7, par. 7.4, 585-6.
6. E. Wiedemann & J. Würschmidt: 'Über eine arabische kegelförmige Sonnenuhr', *Archiv für die Geschichte der Naturwissenschaften und der Technik* (1916), vii, 359-76. See also J. Livingston: 'The Mukhula, an Islamic conical sundial', *Centaurus*, 26, (1972), 299-313.
7. For a complete description see François Charette: *Mathematical Instrumentation in Fourteenth-Century Egypt and Syria. The Illustrated Treatise of Najm al-Dīn al-Mīṣrī* Leiden, 145-153 (2003).
8. The dial was found in 1901 but recognized as a pillar dial only in 1984 and studied in depth in: Mario Arnaldi & Karlheinz Schaldach: 'A Roman cylinder dial: witness to a forgotten tradition', *J. Hist. Astron.*, xxviii (1997), 107-117. Recently, a second sundial of this kind has been recognized in France by Christine Hoët-van Cauwenberghe and Éric Binet, with the participation of Annick Thuet: 'Cadran solaire sur os à Amiens (Samarobriva)', *Cahiers du Centre Gustave Glotz*, xix, (printed in 2010, but dated 2008), pp. 111-127, and in *Bulletin des Anti-*

quaires de France (to be published). This second dial is dated to the 3rd or 4th century.
9. G. Ferrari: 'Uno studio sull'orologio romano conosciuto come 'Prosciutto di Portici' ', *Gnomonica Italiana*, 15, 2-12 (June 2008).
10. These were temporary or seasonal hours that were used in the Middle Ages since the classical Greco-Roman epoch. The day was divided into twelve from sunrise to sunset, and similarly the night from sunset to sunrise. The hours were 12 every day and every night: the sixth hour was in the middle (midday), so noon was the sixth hour of the day. The length of the hours were different each day, shorter in Summer and longer in Winter.
11. "*seo sunne astihð pricmælum on þam dagmæle*" ("the Sun ascends point by point on the sundial"), and again "*Hawa, la cleric, hu seo sunne pricmælum stihð on þam dagmæle*" ("Observe, o clerk, how the Sun ascends point by point on the sundial"); S.J. Crawford: *Byrthfert's Manual (A.D. 1011)* 114-15, London (1929). See also Peter S. Baker & Michael Lapidge: *Byrhtferth's Enchiridion,* London (1995).
12. "*Puntus a pungendo est dictus, eo quod quibusdam punctionibus certae designationis in horologii designetur. Horologium, id est, series horarum de puncto scilicet in punctum.*" ("The Point (one of the fractions of one hour) is so called from the word '*pungendo*', and because of this they make some points on the sundials. The *Horologium* is a series of hours shown point after point"); Byrhtferth *Glossae et Scholia*, in Beda Venerabilis: *De Temporum Ratione*, P.L. curante J.P.Migne, xc, col. 304, Paris, (1862).
13. On the contradictory work of Herwagen (Hervagius) see Charles W. Jones: *Bedae Pseudoepigrapha: Scientific Writings Falsely Attributed to Bede,* 14-18, New York, (1939); reprinted in Charles W. Jones: *Bedae, the Schools and the Computus,* Aldershot (1994), in which the original numeration of the pages is respected. On the false attribution of the Glossae to Byrhtferth see Charles W. Jones: 'The Byrhtferth Glosses', *Medium Aevum*, vii, 81-97 (1938), and Jones, Bedae *Pseudoepigrapha* (ref. 3), p. 21– seq.
14. I was intrigued with this obscure text many years ago, soon after my beginning in the study of gnomonics in 1990. Not convinced of the criticism on it, I tried unsuccessfully a translation of it that makes some sense, so I waited until my knowledge was stronger and in 2008 I found the key. And finally the correct edition of that text has been published for the first time in M. Arnaldi: 'An ancient rule for making portable altitude sundials from an 'unedited' medieval text of the tenth century', *J. Hist. Astron.,* xlii, 141-160 (2011).
15. Herwagen, Johann (Beda Venerabilis): *Opera Bedae Venerabilis Presbitery, Anglosaxonis: Viri in divinis atque Humanis Literis exercitatissimi: omnia in octo tomos distincta…*, tome i, coll. 464-8, Basilea (1563).
16. Beda Venerabilis: *Libellus de Mensura Horologii*, P.L. Migne, vol. xc, coll. 951-6, Paris, (1862).
17. It is possible that Hervagius has incorrectly interpreted the text of the manuscript in his possession and that *Libellus de Mensura Horologii* is really the title of the first chapter.
18. The most ancient sketches of this type of *horologium* are from the 8th and 9th centuries; see Karlheinz Schaldach: 'Gli 'schemi delle ombre' nel Medio Evo latino', *Gnomonica Italiana*, 16, 9-16 (2008).
19. Also in this case the oldest text of the *Concordia duodecim mensium* dates back to the 8th century (see Carla Morini: 'Horologium e Daegmael nei manoscritti Anglosassoni di computo', *Aevum*, 73, 273-93, p. 286 (1999) and even earlier, Isidorus from Sevilla: *De Natura Rerum*, chap. 5, *De concordia mensium*), but we can recognize the roots of it in more ancient times.

20. This diagram usually appears together with other *rotae* in the manuscripts coming from Fleury. According to Jones, *op. cit.* (ref. 3), the most ancient scheme of this type is found in the MS Paris B.N., Lat. 5543 foll.134v-141r.

21. This text, together with (6), can be read in many manuscripts and works, with slight differences; (see Lynn Thorndike: *History of Magic and Experimental Science*, vol. i, chap. Xxix and app. ii, New York (1923). The oldest manuscript in which this text can be read seems to be MS Berlin Staadtbibliotek *Phill.* 1869, fol. 12r (9th cent.). See Jones, *op. cit.* (ref. 3), p. 88. Thorndike, *History of Magic*, (ref. 11) wrote that the most ancient is the 9th cent. ms. Paris, B.N. nouv. acq. 1616, fol. 12r. It is, however, a well known theme in antiquity and therefore not purely medieval.

22. See Schaldach, *op. cit.* (ref. 8).

23. About 'shadow schemes' see Schaldach, *op. cit.* (ref. 18).

24. However I have found no others although I did work hard to find them. Inside his collection of *Incipit*, Lynn Thorndike lists only **A** and **B**, but it does not recognize **B** as fragment of **A** (Lynn Thorndike & Pearl Kibre: *A Catalogue of Incipits of Mediaeval Scientific Writings in Latin,* London, Cambridge, Mass. (1963). I call attention here to **A**, **B** and **C** for the first time.

25. "Manual for drawing a sundial".

26. "Construction of the suspended sundial".

27. "Rule to make a sundial".

28. Arnaldi, *op. cit* (ref. 1).

29. **B**: "*INVENTIO PENDENTIS OROLOGII*" (the construction of the suspended sundial). The title of **B** is, as far as we know, only revealing the exact nature of the sundial described in the first text of the *Libellus*.

30. **C**: "*quod instar*".

31. **C** misses the reference to the cylindrical sundial and we read only: "*...videtur formari, per sena latera, in quibus ordo horarum totius anni...*".

32. I accept here the lesson of **B** ("*XII Kal^dis Iuni et iulii*") against that which is certainly wrong of **A** ("*xii Kal. Januarii atque Julii*"), perhaps is a bad interpretation by Hervagius of the written contraction for *Juni* as *Januarii*.

33. In **B** we read: "*...terminus, vel .v. horae confinium...*", this value gives a best result in the column related to the months of January-December, but I have left the version of **A** and **C** because at the moment it appears as a majority.

34. I have translated "*umbilicus*" as "gnomon" according to the teaching of Plinius the Elder ("*umbilicus, quem gnomonem vocant*") *Nat. Hist.* vi, 39, 2; this lesson was approved also by Bede ("*Umbilici quem gnomonem appellant*") in *De Natura Rerum*, cap. xlviii, P.L. Migne, xc, col. 274 A.; see also *De Temporum Ratione*, cap. xxxiii, P.L. Migne, xc, col. 450 A.

35. "first section", that is the order of the hours in the first line. It has to be understood for all the other remaining five 'sections'.

36. Sundials of this type were still in use in the 19th century, carved in the hilt of the trip stick of the Tibetan monks (an example can be seen in the Science Museum in London – see *www.sciencemuseum.org.uk/images/I059/10325654*.aspx (April 2010).

37. By 'solar month' I mean a month different from calendar month, it lasts the length as a zodiacal sign, but in ancient Latin times it gets the same name of the calendar month, so June, for example, means from the end of Leo up to the end of Gemini, and July means from the end of Gemini to the end of Cancer.

38. Derek J. De Solla Price: 'review of T.O. Cockayne, ed., *Leechdom, Wortcunning and Starcraft in Early England*' (London 1961), *J. Hist Medicine*, 202-3 (Jan. 1962). The 12 days before Calends of April (21 March) for the Equinox were established for the Equinox after the Council of Nicea

(325 AD), while the Julian calendar specifies 8 days before Calends of April (24 March).

39. So calculations considering the column 'June-July' as the date of the Summer solstice or column 'December-January' as the Winter solstice are wrong. A different calendar would require seven monthly lines, while the *Libellus* requires six.

40. We are speaking, obviously, of temporary hours.

41. "*Quando vis scire in dorso astrolapsus hora, in primis scias quantum sol debeat ascendere in ipsa die qua volueris horas probare, et ipsam ascensionem vel altitudinem solis a primo gradu ortus solis usque ad ultimum partire per vi partes ipsasque partes per signa, et, dum sol pervenerit ad ipsa signa in Alhidada, scias sic horas certas usque ad vi; post vi, retorna descendendo usque ad occasum. Sed tu, lector, si diligenter animadvertere quaeris, tu ipse per praedictam walzacoram, id est planant sphaeram diversa poteris fabricare horologia*", Hermannus Contractus (Gerbertus): *De utilitatibus Astrolabii libri duo*, *Liber primus, caput xxi, De Inveniendis in dorso Astrolabii horis*, P.L. Migne, vol. cxliii, col. 404D.

42. Schaldach, *op. cit.* (ref. 18) has well underlined the Hellenistic origin of the 'shadow schemes', even if the *terminus post quem* for the sketch to the text no. 3 can now be established to the 8th century.

43. R. Kellog & M. Sullivan, "The Tiberius Manuscript Horologium", *The Compendium*, vol. 4, no. 2, (June, 1997), 1-13.

44. See Vitruvius: *De Architectura*, I, 6.6; Hygunus Gromaticus: *Constitutio Limitum*, ch. 19; Plinius: *Nat. His.*, II, 76.

45. Although the grave of the Este physician has been dated to the 1st century, the sundial was probably of the first half the 1st century BC; see Arnaldi & Schaldach, *op. cit.* (ref. 8). The Roman handbooks of gnomonics covered a wide range (unfortunately little has survived) and attested by Vitruvius which in the chapter 8 of the ninth book of his *De Architectura* writes: "*Item ex his generibus viatoria pensilia uti fierent, plures scripta reliquerunt. Ex quorum libris, si qui velit, subiectiones invenire poterit, dummodo sciat analemmatos descriptiones*".

46. The measures of the shadow length of the other hours of the day seem to be found in simple manuals as it is the *Libellus*, using simple 'folk' methods.

Mario Arnaldi graduated from the Academy of Arts in Ravenna, Italy. He is the painter and maker of many artistic sundials. His main interest in gnomonics is research into the history of ancient Greco-Roman and medieval sundials: he has published many articles and several books on these subjects (*The Ancient Sundials of Ireland* and, most recently, *Tempus et Regula* vol. 1). He has been editor director of *Gnomonica Italiana* since 2006 and can be contacted at *marnaldi@libero.it*.

Chocolate Sundials

These chocolate sundials were made as a birthday present for diallist Malcolm Barnfield by his daughter-in-law Natalia Neophytou. Some are based on the Krugerrand coin and others have a rhino image. Presumably they all told temporary hours.

TIME FOR ANOTHER BEER?

JACKIE JONES

The idea for this glass originated about two years back at a 'how sundials work' session for a few friends. I had explained the principles of dialling and they had all made small working models. We then got onto other types including altitude dials. Steve Chapman, an organiser of a local beer festival, asked if one could be done on a beer glass. Although it was not something I had thought about before, it would be an interesting challenge.

Mike Cowham's monograph,[1] *A Study of Altitude Dials*, was a valuable guide in this field which was new to me. What I was planning was a transparent chalice dial, to be read from the outside, like a shepherd's dial.

The earliest known chalice dial dates from 1554, made in Aldersbach on the German-Austrian border; it is now in the British Museum.[2] It is about 14 cm high, made of silver-gilt and has hour and date lines on the inside with a central gnomon. Using it is simple: it is turned until the shadow of the gnomon falls on the time of year – in this chalice there are zodiac lines – and the tip of the shadow marks the time of day. Some later dials of this type did not have a central gnomon but used the lowest point of the shadow of the rim as an indicator. So the idea is not new; recently a small glass was produced by Hendrik Hollander in Amsterdam[3] which shows the time from 5pm and has six month columns.

Steve and I discussed the project further and arrived at our design targets. It had to be a 1 pint, lined glass. For those who are not British beer-drinkers, this means that a line indicates where a pint comes to, leaving space above for the head. It also gives an extra 12 mm of height; this extra height proved to be important. It also had to be very simple to use for those not familiar with sundials. Although there is a small group of beer and sundial enthusiasts, there are many who need educating about the other. So no fancy gimmicks or complex instructions, it must be obvious how it works.

We decided not to use the rim as the gnomon as it was too imprecise and difficult to establish the lowest point of the shadow. A dark circle with a transparent 2 mm centre would cast a beam of sunlight to the other side of the glass which would have equal-width columns for each month. Before doing anything too accurate, we did a rough mock-up of the idea (Fig. 1).

It was at this point that we had to find a firm to print them. Steve, being familiar with getting glasses printed, started contacting firms. Most said, when seeing our idea, "You mean you want to print all round the glass?" and claimed it was impossible. Eventually one firm found it interesting enough to be a challenge and sent us a sample glass so we could plan it accurately.

I first calculated the sun's altitude for each hour on the first of each month and the solstices using the formula given by Waugh[4] and Mike Cowham:

$$\sin a = \sin d \sin \Phi + \cos d \cos \Phi \cos h$$

where a = sun's altitude, d = declination, h = hour angle and Φ = the latitude, this being 51°.

I'm sure there are computer programmes which could do the layout, but as I am pretty useless with them and I was trained in producing accurate drawings, that is what I did. I started with measuring the glass – the outside width at the top and bottom and the height, plus a plan of the top with the light hole on one side with the months opposite. Then I drew on the sun's altitude for midsummer noon and realised that it went too near the bottom of the glass. At the top and bottom, the glass is thicker which would cause greater refraction; also the printing methods will not allow it. So the proposed layout was altered to have December in the centre, opposite the light hole. June was therefore at the side of the glass, the light had a shorter distance, so noon was higher up the glass. The extra 12 mm of a lined glass had allowed us to place the light-hole higher.
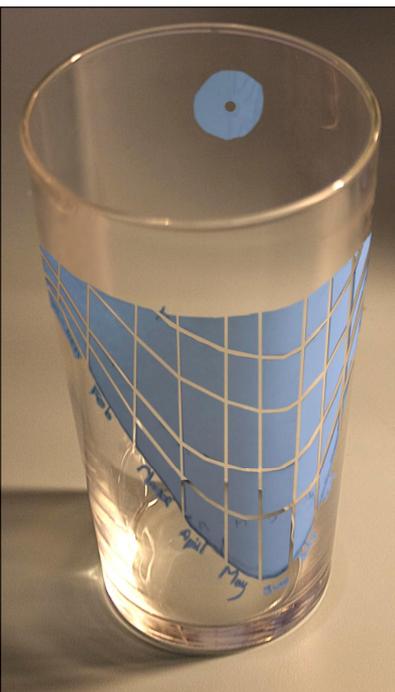
A layout of where the hour lines would fall on the side of the glass was done for each month and then transferred to a flat plan of the glass's surface. We did this on tracing

Fig. 1. Rough mock-up of the idea to show to the glass printers.
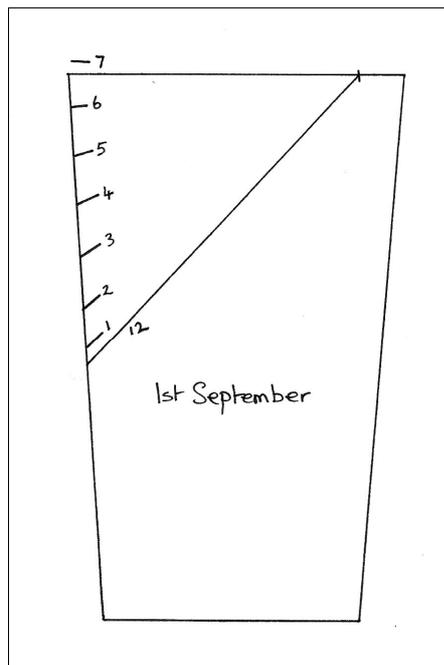
Fig. 2. Layout of where the hour lines for 1 September would fall on the side of the glass.
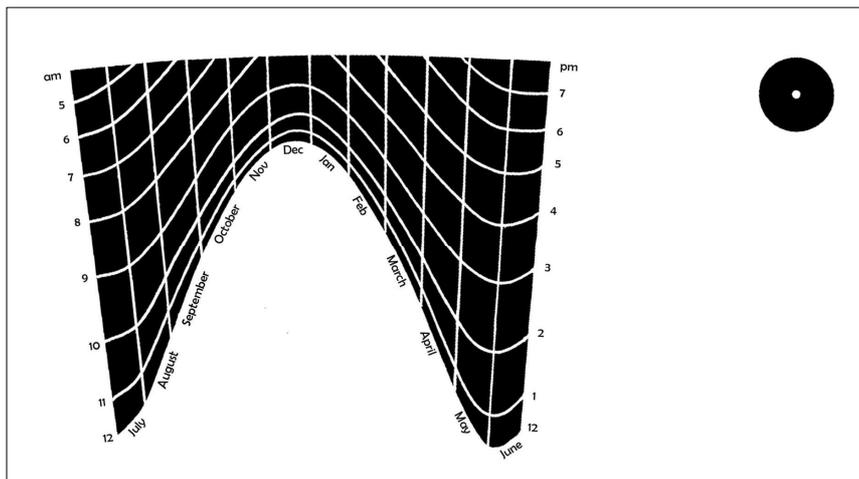
paper and tested it. It worked. Steve's son Joe then produced the final artwork, including the design containing the brief instructions for use and it was sent to the printers.

They then came back with an unexpected problem which delayed things. Due to the practicalities of printing directly onto glass, all lines which are vertical on the finished glass must be parallel on the layout. This would be impossible to produce in such a way that the hour lines would be continuous when printed. The only way to do it on a tapered glass would be to print the design on a transfer which would then be floated on. As it was so large and had to retain its shape, they decided to put two extra backing layers on the transfer. Eventually 96 glasses were printed, fired to fix the ink and delivered to us.

We then photographed it, wrote an instruction sheet, produced a simple website[5] and told the world about it. The response from those without knowledge of sundials was what we hoped for; they had no problem in understanding how to use it. The hours around noon are very close together and therefore not much use for timekeeping, but we felt it was important to include them both from a design aspect and educationally to show how shadows move throughout the day.

The dial also shows sunrise/sunset times and obviously works anywhere at 51° north. I have been asked if it is possible to design one for a lower latitude. Due to the higher mid-summer altitude of the sun at noon, a dial for 33° would have to be a beer glass 50 cm high – not practical, but it could be designed to work from 2pm.

ACKNOWLEDGEMENTS

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4. A.E.Waugh: *Sundials, their theory and construction*, Dover, New York, (1973).
5. *www.sundialglass.wordpress.com*

Jackie Jones studied jewellery at Hornsey College of Art. This led to making portable sundials in silver and then other dials such as painted, mosaic and the beer glass. As well as being membership secretary of the BSS, she is also involved in the Brighton Festival Open Houses and volunteers to help at a local beer festival. Jackie can be contacted at *Jackie@waitrose.com*

The BSS Sundial Safari to Le Mans, France

7-11 September 2011

The BSS Safari in 2011 visited the Sarthe and Perche regions of France and we were based in Le Mans. Why, you may ask, did we choose this area? It all started when we heard a talk at Newbury on this area which was given by Peter Ransom. He was most enthusiastic about the dials and so we thought that we would try to arrange a visit for our annual trip. We were lucky that a friend put us in touch with Michel Lalos and his wife Annick and they were able to make local arrangements and select some of the most interesting dials. Michel has a website on the dials of France, *michel.lalos.free.fr/cadrans_solaires/ index_cadrans_home.php.* His pages are ideal for those wishing to learn more about French dials.

This visit was not only to look at dials. The town of Le Mans is steeped in history and has many interesting Roman relics. Chateaux on the Loire offered a chance to look at how the rich lived in France. Chartres has much to offer the tourist, principally its cathedral with its fine stained glass. The Hotel Campanile in Le Mans also played a part as it tried to provide us with dishes of the region using local produce.

Probably the most important part of the Safari for me was the chance to meet up again with friends and to have the time to talk to them. We were also lucky this year as we had some newcomers and I hope that we will see them again. Finally, I would like to thank Jack Aubert for acting so perfectly as an interpreter. He enriched the trip for all of us.

Val Cowham

Amboise and Chenonceaux – Wed 7 Sep

White chateau of Amboise, high over the town with its wine bars and chichi shops. Slate roofs on the towers, yet this is only the remnant of a much bigger chateau, which would have been a township in itself. This was where Leonardo da Vinci was given shelter towards the end of his life by Francois I. In the ornate chapel of St Hubert, patron saint of hunting, is Leonardo's tomb (but possibly not his body).

High up on the side of the chateau is an incised dial, difficult to see the lines, and no gnomon.

Fresh breezy day that made the flags flutter over the riverside, yet not able to disturb the bobbly box trees, trimmed by invisible gardeners. The *Son et Lumiere* paraphernalia was around but of no interest during the day. Going round the interior of the chateau was not initially brilliantly interesting, but later rooms were a sequence showing furnishing and styles at various periods from late medieval to mid-19th century.

Leaving the chateau by a route that made its time as a prison credible, we went to Midi au Soleil, Jean Folshied's artisan shop displaying some of the dials he makes and sells. Many of Jean's dials have two sets of hour numbers, showing meridian hours and 'legal hours' (this area is very close to the Greenwich meridian). Jean also displays a dial made for Brittany, with a Breton motto.

Chenonceaux, built as a bridge over the river Cher, was much more of a crowd-pleaser, and its interior was devoted to the Five Queens (one was Catherine de Medici) but overlaid by the romance of Diane de Poitiers. The gardens were controlled and rigorously colour-themed, pink roses and silver leaved plants. Much work was ongoing to the three-storied chateau, and getting around was similar to a London mainline station, with many steps. Judging by the splendid fireplaces, the winters must be cold on the Loire. A guide informed visitors that kings were judged by their prowess with mistresses: well, none of the chatelaines had been

very interested in the one remaining sundial we could see, largely obsured by the shade of a tree.

The countryside was delightful, with wonderful trees. There were cows of all shades of brown, from splotches to toffee to cream. The 'autocar' sped by the many industrial zones and the scattered, well-kept houses.

Kate & David Hindle

Le Mans – Thur 8 Sept

At 09:00 precisely, the sundial group caught public transport outside the hotel for a walking tour of Le Mans causing enormous confusion to a bendy bus driver who had to use his iPhone to calculate the bus fare. The group descended from the bus in front of the magnificent Le Mans cathedral of Saint-Julien high above the river Sarthe surrounded by the old town.

The group strolled around to a garden in front of the cathedral to view an Ernest Bollée mean-time dial. We were met by Paul Deciron who gave a comprehensive description of the dial which was competently translated by Jack Aubert. The dial was given to the City of Le Mans on 8 May 1882 and later installed in the Garden of Jacobins in 1980 but was moved after restoration in 2000 to the Square R Triger. The advertisements at the time suggested that up to 50 may have been made but in reality only three are known to exist. The dial has a fixed correction for longitude and a daily correction for the Equation of Time (EoT). The rack and pinion arrangement was most ingenious with the month adjusted one side and the date on the other using a special handle. The local councils were probably not keen to employ someone

to make the daily adjustment. Smaller mean-time dials later became available and it is probable that the enormous cost of the dial prohibited sales.

The group then strolled to the Musee de Tesse passing some suggestive sculptures in the main entrance to see a small display of two slate dials and a gilt pillar dial. The pillar dial was signed FT BRU-NET dated 1637. Kevin Karney spotted a clock with two minute fingers with an unusual mechanical device for applying the EoT adjustment to the mean-time finger.

A lunchtime reception was then held at the Hotel de Ville where the group received a warm welcome by the Mayor. Michel Lalos made a fine speech in which he highlighted the many aspects of dialling including; mathematics, artistic, and philosophical. The mayor graciously responded and Val Cowham thanked the Mayor on behalf of the group for hosting the reception.

We were then free for lunch and many took the opportunity to stroll round the old town and visited the beautifully preserved Roman wall alongside the river Sarthe.

After lunch, and in the pouring rain, the group had special permission to visit the inner courtyard of the Prefecture to view the sundial on the Abbaye de La

Couture. The dial was originally painted in 1777, possibly on the recommendations of Dom François Bedos de Celles (1706-1779). This large vertical dial was restored in 1984 when it was refitted with the correct style but an over-enthusiastic builder filled in the engraved hours lines.

Next, we visited the Mediatheque Louis Aragon where a display of three armillary spheres (C16 to C18) and antique sundial books including Christophor Clavius's (1537-1612) *Gnomonices* were on display.

The group then walked to the Meridienne in the old town at 108 Grande Rue at the Hôtel Aubert de Clairaulnay. The Meridienne had a star nodus and displayed an analemma. There was much discussion about the significance of the number 69, or was it the zodiac cancer symbol, above the upper XII, and the number 172 below the lower XII on the dial.

After a tiring but fulfilling day the sundial group boarded another bendy bus and returned to their hotel.

Geoff Parsons

Le Perche – Fri 9 Sept

We travelled north from Le Mans, through the rolling countryside called Le Perche with Charolais cattle, standing maize and sown winter wheat. Le Perche is the home of the Percheron horse - cousin to our Shire horse. We arrived in the little rural village of St Mars-sous-Ballon. In the 11C/13C church, mounted

on an interior wall for protection, was a slate horizontal dial dated 1699. Finely incised and filled with red ochre by someone with a good knowledge of gnomonics, the dial had a central circular standard dial surrounded by four subsidiary dials showing Italian and various other hours. The dial celebrated the 52 years of service of the Benedictine priest Andreas Valiquet. The iron gnomon of the central dial was out of line, causing an intense gnomonical debate - culminating in the impressive conclusion that, during the 1945 placement in the wall, the gnomon had simply slipped - while moving from horizontal to vertical. Jack Aubert won runner-up status in the Safari's limerick competition with his musing about this dial…

> The Canon of St Mars sous Ballon
> Would have wept on his dial had he known
> 'Twould be twisted around
> And hung upside down
> In a place where the Sun never shone.

Before moving on, we had a short reception kindly hosted by the Mayor held in the ancient underground chamber, which was the village meeting hall.

Moving north on to Dangeul, we saw two mass dials on the church (our Secre-

tary conjured a third, but this was invisible to the rest of us - being perhaps a statistical aberration). The village also sported a modern (1996) painted galvanised-iron armillary sphere made interesting by naive rural engravings on the back of its bronze equatorial ring.

Moving north again to St-Jouin-de-Blavou, a short walk took us to the cemetery to see the most gnomonically interesting dial of the day, a pillar with two horizontal cylindrical dials under the scroll-work of the pillar.

We lunched in the attractive town of Mortagne-au-Perche, filled with faded houses of grandeur (the town has never been destroyed by war). We saw old slate horizontal dials in the museum. The museum's curator kindly showed us the crypt of an old church, destroyed in revolutionary times to provide stones for a new court-house and jail. Around the town we saw a number of vertical dials. The best of these was an analemma noon-mark with carved surround under the eaves of a grand town house set back from the road behind magisterial gates, in a very pleasant garden. Our gnomonists were intrigued by the double seasonal line marking the summer solstice, for which no obvious explanation could be offered.

Our final visit was south to the equally attractive town of Bellême to see more vertical dials around the town.

Kevin Karney

Alors c'est Samedi et c'est Chartres – Sat 10 Sept

Blue sky today and we are getting used to these early starts. Our first port of call is at the Lycée Marceau on the outskirts of the city where, as a special treat, the sun is shining on a large painted wall dial. The hours and half hours are delineated in blue and an analemma is drawn on the noon line. Closer inspection soon reveals several inaccuracies. The nodus shows 8:30 when clock time is 10am and the annalemma is not correct. Although the dial is attractive, expert opinion soon agrees that it is a fairly amateur restoration of an earlier dial. Above this on the same wall is another nodus supported on a tripod, probably used as a noon marker, but there is no noon line marked.

The coach having departed, we walked through the quiet, Saturday morning streets of the old town to find a dial in a pretty setting, high on the wall of a courtyard. This dial is now unreadable, we could discern only three hour lines but in this position the dial would have received limited amounts of sunlight.

As we came nearer to the cathedral, the streets and alleys began to bustle with Saturday morning shoppers, delicious French smells of cheese, coffee and charcuterie wafted around and then a flower market with tubs filled to overflowing with huge gladioli and monstrous dahlias.

The well known Angel Dial on the south west corner of the cathedral was, of course showing correct, local time. Dated 1578, the dial is marked from 6am to 6pm. A second dial – or possibly a noon mark – was spotted on the south face.

Inside, the cathedral's Gothic splendour, blackened by centuries of grime, is

dimly illuminated by the light from beautiful stained glass windows. A huge work of restoration is going on and we were able to glimpse the clean lines of soaring architecture where the stonework has been restored. The plan to complete the work by 2014 seems optimistic, but when finished it will be a magnificent sight and well worth another visit.

After dispersing for lunch – the sun encouraged eating at pavement cafés – we rejoined the coach and returned by A11 to Laferté Bernard where we found a dial painted on a buttress of the church. The gnomon was missing and the hour lines, which appeared to have been re-painted, showed 7am to 6pm. A second dial with a gnomon and seven hour lines was found, in poor condition, on the east face of the buttress and a third, scratch dial showed part of a gnomon and four hour lines.

A series of fountains in the town centre came on and off quite suddenly giving rise to some merriment and even 'skylarking' among more agile members of the group.

We were entertained to tea at the Tourist Office which had a shady garden with a bountiful walnut tree.

Our final visit was to Cherré where the church boasted two dials, both with bent gnomons. The south facing dial had lines and numbers restored, the west facing dial had six incised hour lines. As a distraction, a wedding party was leaving the church as we arrived. The guests drove twenty or more motor bikes on one of which the bride rode pillion.

Jane Walker

Le Mans villages - Sunday 11 Sept

Our last day dawned wet! The first stop was at Spay where a couple of vertical dials graced a building, one of which was unfortunately almost totally obscured by a tree. Our next port of call was the church at Parigné-l'Évêque with a high-up vertical and we had a frantic dash from the rain to a café. The bemused owner rallied well as a busload of safari-ists descended on her unannounced and she was given an ovation for the speedy response with which she served hot drinks all round. At Challes we saw a beautiful vertical dial and were granted entry to the lovely church. At Changé we saw an armillary sphere which members felt was in need of correct alignment. Our return to the hotel for lunch was along part of the Le Mans 24 Hour Race-track, speed being surely contrary to the practice of dialling. Our coach driver got up to all of 95kph!

The afternoon brightened considerably and straying only a little way from our hotel we visited the beautifully reno-vated Abbaye de l'Épau. It was founded in 1229 by Queen Berengaria of Navarre, widow of Richard the Lionheart and Dowager Countess of Maine. It is one of the last Cistercian establishments in France. Its imposing vertical dial was recently restored and we were told of the efforts put into its restoration. Highlight of the site though was a magnificent 17th century polyhedral sundial created by a Benedictine monk in 1635 on a lawn. Much time was devoted to scruti-

nising it and our hosts described its chequered history before it reached its present resting place. It was originally kept in the garden of the Château de la Groirie until it was restored and placed within the abbey precincts in 2004.

The evening's cabaret lived up to expectations. After yet another of our well and imaginatively presented dinners, Kevin Karney ran a limerick competition which was enthusiastically supported. It was won (see above) by Jack Aubert who was awarded a disc of *Almanac for Land Surveyors*. Other entertainments ranged from monologues to recitals and conjuring tricks. All in all, a most successful Safari thanks to the hard work of Mike and Val Cowham and also our French hosts whose efforts made it a truly memorable few days.

Robert Sylvester

SUNDIAL FESTIVAL AT THE GATCHINA PALACE, ST PETERSBURG

VALERY DMITRIEV

On 25 May 2011, Gatchina Palace celebrated two sundial events:

• the unveiling of the replica historical sundial on a parade ground of the Gatchina Palace.

• the opening of an exhibition 'Sundials of St Petersburg – History and the present'.

Fig. 1. The monument to the Russian Emperor Paul I with the empty pedestal.

Fig. 2. Detail of the replica dial.

Fig. 3 (below, right). The deep recesses in the top of the pedestal.

Fig. 4 (bottom right). Setting the new dial in place.

The Restored Sundial at the Gatchina Palace

Gatchina is a small city 45 km from St Petersburg. Historically, after the Northern War, the territory of Gatchina belonged to Peter I. The Empress Catherine II owned the palace and park, and the sundial was erected during the time of a favourite, Count Grigory Orlov. The dial was closer to the palace and later transferred to the garden, and in 1851 the dial was moved to its present position when the monument was installed on the parade ground (see V. Dmitriev: 'Sundials of St Petersburg', *BSS Bull.*, 21(i), 22-26, March 2009). Unfortunately, the dial itself was destroyed during the Second World War, see Fig. 1.

I became aware of the dial pedestal in 2008, and the keeper of archive of the State memorial museum Gatchina, Irina Ryzhenko, provided valuable assistance, such as an early 20th century photograph and other archival material, for the restoration of a sundial.

This information formed the basis of a close replica with a marble dial and a bronze gnomon closely following the historical photos. The gnomon and dial calculations are for the geographical co-ordinates of the Gatchina Palace 59° 33´ N and 30° 06´ E, and the dial indicates true solar time according to the 18th century standard. The detailed design is executed on the basis of a sundial in Petersburg, also of

the 18th century, such as the tradition of writing the numeral IIII instead of IV, as in Fig. 2.

Unfortunately, in the course of the reproduction it was not possible to resolve the 'riddle' in the top of the pedestal, as in Fig. 3. It was abundantly clear that orientation of the deep cross grooves in the pedestal defines the direction of the meridian and hence the orientation of the dial. The elaborate recesses are almost certainly connected with the mechanism of fastening of the dial to the pedestal.

It required more than two years to complete the coordination with the state and museum organisations, and at the beginning of 2011 manufacturing began. In April the dial was ready and with participation of employees from the Gatchina museum, was carefully set up on the original pedestal (Fig. 4).

Fig. 5. Unveiling the replacement dial by the Deputy Director of the estate.

Fig. 6. The completed monument with replica dial.

Figs. 7 and 8. The Armenia (top) and Butterfly dials

Fig. 9. The Dracula dial.

On 25 May 2011, there was a formal unveiling of the sundial (Fig 5). The Deputy Director of the memorial estate, Valery Arhipov, talked about the dial and the fact that it is one of the oldest monuments of the Gatchina Palace, which caused a great deal of interest to the public. It is satisfying that after almost 80 years the sundial on a parade-ground of the Gatchina Palace has returned on the historical place (Fig. 6).

Exhibition 'Sundials of St Petersburg – History and the present'

This was arranged to take place on an emperor's balcony of the Gatchina Palace to give details about the historical sundials of St Petersburg and the history of the dial of the Gatchina Palace. At the exhibition the author's sundials were also shown.

Readers of the *Bulletin* will know some of the author's dials – 'English garden' (20(ii)) 'Angel, playing a harp' (21(i)), 'The Lady with the dog' (21(iv)), 'Solar acorn' (22(i)), the Japanese garden dial and 'Dracula' (22(iv)), whilst Figs. 7 & 8 show the 'Armenia' and the 'Butterfly' dials. The author's work created considerable interest to visitors, and the exhibition ended with champagne under the vigilant protection of 'Dracula' (Fig. 9).

My thanks to Doug Bateman for help with the English.

THE SUNDIAL OF THE CERTOSA OF FLORENCE (TUSCANY, ITALY) RESTORED TO WORKING CONDITION

STEFANO BARBOLINI, GIOVANNI GAROFALO, GUIDO DRESTI & ROSARIO MOSELLO

Fig. 1. View of the Certosa of Florence.

The Certosa of Florence

The Certosa of Florence, also known as the Certosa del Galluzzo, was founded in 1341 on the hill of Monte Santo about six kilometres from the centre of the city. Its construction was ordered by the Florentine banker Niccolò Acciaiuoli during the Avignon Papacy, when the Carthusian Order was becoming established in Tuscany (Fig. 1).

Niccolò Acciaiuoli (1310-1365) was an aristocratic Florentine banker, Grand Seneschal of the Kingdom of Naples and Viceroy of Puglia. He was a cultivated man, enlightened and gifted, to the extent that his contemporary Petrarch described him as "*A man who would be rare in any time, and unique in ours*".

The Certosa was initially inhabited by Carthusian monks, who took possession of the building on 13 February 1342 and remained there, except for short absences, until 1958, when they were replaced by Cistercians. Carthusian tradition dictated that monasteries should be built in out-of-the-way places, but this Certosa was built close to a great city. This meant that the monks did not follow the usual rule of the order, which was based on a hermit's life of work, prayer and meditation conducted largely in solitude, but were open to contact with the local culture. The Certosa was accordingly frequented by artists, who embellished it with their work, turning it into a place of considerable artistic renown; works by Bronzino, Pontormo, Veneziano and the Della Robbia family give the monastery today the appearance of an art gallery.

Fig. 2. Angular sundial.

Fig. 3. Horizontal sundial.

Fig. 4. Quarter circle horizontal sundial.

The Carthusian monks of Galluzzo were also active in astronomical research, not only from a desire for knowledge but especially, as was the case in most monasteries of the time, from the necessity to determine the exact moment of the Spring equinox, which was used to calculate the date of Easter.[1] Evidence of the Carthusians' interest in astronomical science is provided by a number of sundials inside the Certosa. Prominent among them is a vertical corner dial with two plates (Fig. 2), bearing a coat of arms, taken from its original location and displayed in the entrance hall of the monastery. Two further sundials are to be seen in the great cloister, the first a circular, horizontal dial and the second in the shape of a quarter-circle (Figs 3 & 4).

But the most important astronomical clock in the monastery is located inside the building: this is a pinhole dial on the first floor above the Guest Quarters, in the rooms of the *Procureria*.[2] These rooms occupy the north side of the great courtyard in front of the Church of San Lorenzo, the *Corte d'Onore* (Fig. 5), bounded to north and south by two open arcades and to east and west by two false arcades, built between 1580 and 1600.[3]

Fig. 5. The Corte d'onore and the Church of San Lorenzo.

The Dial

We do not know if the construction of the dial dates from this period, or if it is the result of a subsequent intervention. The *Meridian line* comprises a 2.8 cm wide strip of grey *bardiglio* marble, set into a broader slab of white marble; into this are engraved the angular values (degrees) dividing the circle of the Zodiac, which contain the twelve constellations.

As the meridian line is located in a restricted space (a corridor) relative to the height of the gnomic hole, it does not have enough room to run horizontally for its entire length, as is usually the case, but had to be made up of two segments, one horizontal and the other vertical (Fig. 6). The vertical segment is outlined by a grey frame comprising an architectural motif in 18th century style. At the top of the architectural motif decorating the line is a hook and the outline of an oval object which was later removed, perhaps a portrait, a decoration or a plaque with an inscription.

Fig. 6. The pinhole dial.

White marble panels engraved with the signs of the Zodiac are placed at the sides and the ends of the meridian line. The slabs, and the panels, are set between two rows of red bricks, visibly older than the modern terracotta tiles with which the floor is now covered.

From the outset, the meridian line served as a calendar as well as marking true local noon. A brass star is attached to a small marble slab at the equinox point. At the sides of the equinox panel are set two smaller panels with the signs of Aries and Libra, outside which at both sides there are two narrow white marble slabs with the equinox line engraved on them (Fig. 7).
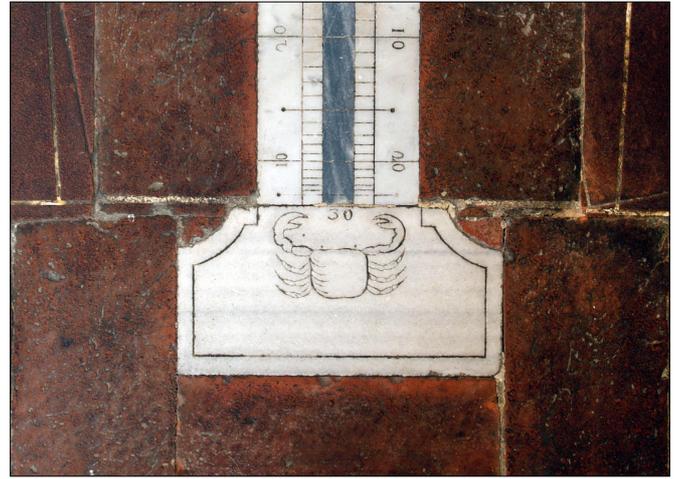
Fig. 7 (above left). The equinox panel.

Fig. 9 (above right). The summer solstice panel.

Fig. 8 (left). The horizontal segment of the dial.

Fig. 10 (right). The sealed-up gnomonic hole.

The gnomonic hole or *oculus*, made in a metal plate, has the shape of an eight-point star (Fig. 10). When the dial was first investigated in 2006, the hole was sealed with mortar. Father Sisto Giacomini recalls that in 1958, when the Carthusians were replaced by the Cistercians, the gnomonic hole was already closed and the dial was no longer functioning.

The most significant measurements of the instrument are (Fig. 11):

• gnomonic hole height at the Vertical Point (VP) 4240 mm;
• external diameter of gnomonic hole 15 mm;
• internal diameter of gnomonic hole 11 mm;
• distance from the summer solstice point to VP 1536 mm;
• distance from the equinox point to VP 4036 mm;
• height from the floor to the winter solstice point 2414 mm.

To the south, at the end of the horizontal segment (Fig. 8), at the summer solstice point, there is another panel, different in shape and size, on which is engraved the sign of Cancer (Fig. 9). At the top of the vertical segment, at the winter solstice point, is another, larger panel, bearing the sign of Capricorn.

The Vertical Point does not lie on the plane of the meridian line, which runs irregularly relative to the plane, but is lower by an average of 7 mm, arriving at 14 mm relative to the Equinox Point.

Dating the Instrument

Chiarelli & Leoncini[4] put forward the hypothesis that the sundial was constructed in 1763, perhaps in an interpretation of the final Roman numerals painted on the vertical segment of the dial (…CCLXII) and deducing the century from the style of the artefact. However, the vertical half-quadrant shows signs of an intervention which is

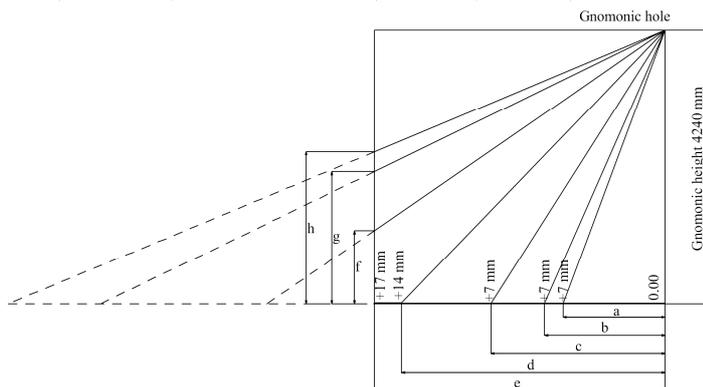| Zodiac Signs		Measured distances mm (2007)		Calculated distances mm (1773)		Difference mm
		Horizontal	Vertical	Horizontal	Vertical	
Cancer	a	1536.0		1562.2		-26.2
Gemini/Leo	b	1866.0		1844.9		+21.1
Taurus/Virgo	c	2781.0		2669.4		+111.6
Aries/Libra	d	4036.0		4040.9		-4.9
	e	4456.0				
Pisces/Scorpio	f		1025.0		1142.4	-117.4
Aquarius/Sagittarius	g		2030.0		2054.6	-24.6
Capricorn	h		2414.0		2363.4	+50.6

Fig. 11. Vertical section along the meridian plane. The numbers refer to differences in level between the meridian line and the floor.

Fig. 12. The winter solstice panel.

clearly later than the construction of the dial, comprising a very thin layer of white plaster bearing lines and inscriptions in black paint, in a style and characters different from the rest of the context. The drawing on the plaster is of part of the Mean Time analemma (*lemniscate*), around which the names of the months have been written. Also visible on the curve are small stylized arrows corresponding to the beginning of each month. The word DECEMBER in particular, painted on the marble panel, is clear evidence of a second intervention on a previous artefact. In fact, if the first author had intended to indicate December, he would certainly have engraved the word in the marble and not painted it on in this way (Fig. 12).

Almost certainly, the missing part of the mean time curve was originally also drawn on the floor, where the names of the other months were written and subsequently erased, as shown by the letters ZO (the last letters of MARZO, March), which are still legible to the left of the equinox point. These elements are tangible proof of an intervention on the dial carried out after the period of its construction. The upper part of the vertical segment bears a partly-obliterated inscription near the winter solstice panel; this reads "G.B.D. …CCLXIII", which might refer to the name of the author and the date of the intervention (Fig. 12). The letters and the partial date were obviously written at the same time; the letters suggest the name of Giovan Battista Donati who, between 1859 and 1872, was the director of the Astronomical Observatory of La Specola in Florence (later moved to the Arcetri Hill in 1871), while the incomplete date on the right-hand side, "…CCLXIII", would more plausibly refer to the year 1863. This interpretation would seem to be borne out by the covering coat of plaster and the drawing of the mean time curve (in use from the second half of the 19th century), and the lettering of the inscriptions, obviously later than the most likely date of the dial's construction.

Chiarelli & Leoncini[5] refer to work done to refurbish the guest quarters between 1769 and 1776, prior to the short stay of Pope Pius VI on his journey to France as the prisoner of Napoleon. The dial might have been constructed at that time, or even earlier, but this does not exclude that G.B. Donati may have overseen an extension of its function around 90 years later, at a particular moment in history.

A Probable Intervention by an Astronomer, Expert in Gnomonics

G.B. Donati's intervention in 1863 also seems likely because, in that period, shortly after the foundation of the Kingdom of Italy (1861), the time system to be used in the country was under discussion; the debate culminated in the adoption of *national time* (1866), also called 'the time of the meridian of Monte Mario', and later (1893) the Central Europe Time. In fact, the inadequacy of local time was plain, and the need for a common time over increasingly large geographical areas was seen as imperative. As early as the beginning of the 19th century this was a perceived necessity, and all the European states had started to take appropriate measures.[6]

Florence, about to become the capital of the new Kingdom, was especially animated by a spirit of renewal and change which affected all fields of activity between 1861 and 1865, the year when the capital of Italy found its location in the city on the river Arno. The face of Florence underwent a radical transformation, and its culture also prepared to take up the new challenge that history had presented it with.

The innovatory fervour of the time, then, may have persuaded the Carthusian monks too to adapt to the new situation, and they may have asked Giovan Battista Donati to take on the task of overhauling their sundial. To date, no documentary evidence of his appointment has come to light – it was very likely informal – but it is possible that in 1863 the astronomer added an equation of time curve and calendar elements to the original sundial.

Though there is no documentary evidence of this hypothesis, it can be supported by Donati's undoubted interest in sundials, at exactly the time in question. He had already worked on the dial in what is now Piazza della Signoria, then called Piazza del Granduca, which was used to check and adjust ('temperare') the mechanical clock built on the tower of Palazzo Vecchio. This innovation was a reflection of the technological development of Tuscany, which as early as 1844 had one of the first railway networks in Italy.

The dial in the square was not working well, however, due to damage to the gnomon, so that the authorities governing 'Water, Roads and the Civil Fabric of the State' wrote on 8 January 1858 to the Director of the Imperial and Royal Museum of Physics and Natural History to request the intervention of an expert to repair the dial. In reply, Giovan Battista Amici,[7] then the director of the Astronomical Observatory, wrote that he had appointed the astronomer Dr Donati to undertake the repair. Dr Donati's[8] appointment was confirmed, and in the course of his intervention he found that not only had the gnomon been moved for unknown reasons[9] but there was also an unspecified "error of the quadrant", which might result in people reading the wrong time.[10]

It is hard to say what error this might have been, but it is possible that this was when the equation of Mean Time – not previously envisaged – was added, as in the correspondence there is no mention of substitution, but of correction of the slab. This took place five years before the date painted on the Certosa dial.

A second episode in which Donati is known to have been involved with a problem of gnomonics occurred in 1864, or just a year after the probable date of the intervention on the Certosa dial. Donati had in the meantime become the new Director of the Specola Observatory in Florence, and now asked to make observations at the great gnomon devised by Toscanelli in the church of Santa Maria del Fiore.[11] His investigation revealed that the bronze plate with the gnomonic hole was missing: it had been removed for restoration and never put back into place. The disappearance was recorded in a strongly critical article in the newspaper *La Nazione*, raising an outcry in public opinion.[12]

Donati is mentioned a third time in connection with gnomonics in 1865, when the owner of the building in Piazza della Signoria on which the sundial is placed asked for the dial to be moved, as he had to do some restoration work on the façade. Moving the dial presented some difficulties, as "*the shadow of the Tower of the Palazzo della Signoria at midday covered almost the whole façade of the building*", which Donati had already pointed out during his previous intervention on this dial, in 1858. This time, however, after perusing the new request and the attached drawing, Donati pronounced in favour of the move in a document written in his hand on 21 February 1865.

It should be noted that the document of 17 February 1865 confirms the previous intervention by Donati (1858) as the "*reduction to mean time of the recorded Sundial*". By an odd coincidence, the Certosa dial underwent the same kind of intervention, presumably in 1863.

To sum up, while exercising his main profession of astronomer, G.B. Donati also took an active and not merely casual interest in sundials, to the extent that he was regarded as an expert consultant by the authorities of his time.

In particular:

• in 1858 he oversaw the restoration of the dial in Piazza del Granduca;
• in 1864 he asked permission to make observations at the famous Gnomon in Santa Maria del Fiore;
• lastly, in 1865 he was asked to give a technical opinion on the dial in Piazza del Granduca, which meanwhile had become Piazza della Signoria.

His interest, and his expertise, in the subject were thus beyond dispute. And his interest may not have been restricted to these two dials, but may have extended to adjusting the Certosa Dial (in 1863?), just a year before his investigation of the Gnomon of the cathedral.

No technical documents have been found, perhaps because these tasks did not come under Donati's official professional remit but were part of a private commission, probably conferred by word of mouth and performed free of charge, in so far as they were for a religious institution; this being the case, it is likely that no documents of any kind were drawn up. It is however certain that without the administrative correspondence we would not have known either about his intervention on the Piazza della Signoria dial, and without the outcry over the missing plate with the gnomic hole we would never have known of Donati's interest in the Cathedral Gnomon, because neither of these cases are referred to in specific technical-scientific publications.[13]

The Dial Restored to Working Condition

Between 2006 and 2007, two of the authors (SB & GG) became interested in the case of the Certosa dial, and tried to reconstruct its origins and its history. They studied its architectural appearance and its dimensions, and expressed their dismay about the gnomonic hole being sealed up, which meant that the working of the dial could not be checked experimentally. The architect Dr V. Tesi of the Monuments and Fine Arts Office was informed, and promised to resolve the problem when planned work on the maintenance of the roof of the old Guest Quarters was to be carried out. Access to the part of the roof where the gnomonic hole is located would require the erection of scaffolding and safety measures, the cost of which could not be justified merely by the restoration of the hole.

The planned work was performed in 2009-2010. The roof was completely renovated and the plate with the star-shaped hole temporarily removed during the building operation, but replaced when the work was completed. Repositioning the plate required careful calculation to find its exact position again. These calculations had of necessity to take their starting point from the characteristic points of the dial line – solstice and equinox points and the points where the sun entered the different signs of the Zodiac – which remained unaltered during the work. Furthermore, the calculations had to take account of the angles of the sun's height at the latitude of the Certosa, at the presumed time of the dial's construction, and on the dates corresponding to the characteristic points (see above), given concrete form along the line by the corresponding panels engraved with the signs of the Zodiac.

This process revealed something we did not anticipate: the calculations made at different dates in the year to determine the original position of the gnomonic hole, the results of which ought to have confirmed each another, in fact gave different results which did not correspond to one single position, and with variable differences between them, sometimes actually giving the opposite sign. The obvious stability of the line and the building in which it is housed ruled out inaccurate calculations or some slight subsidence in the floor in which the line is set as reasons for these differences (Fig. 11). The meridian line provides the moment of the sun's passage on the local meridian, determining true

local noon, but does not perform correctly its function as a calendar for which it would appear to have been constructed.

After this surprise, a more careful appraisal of the situation revealed an important fact – the equinox point appeared to be fairly consistent with the position of the gnomonic hole. This highlighted two points, one technical, the other historical-cultural. The technical question concerns the centrality of the equinox point compared with the meridian line. This centrality had been maintained. The historical-cultural question concerns the placing of the dial in a religious institution, and the function it must have had in the life of the Certosa. The importance for the liturgy of the Roman Catholic Church of the exact establishment of the date of Easter is well-known, as is the importance of the astronomical calculation used in determining this date, which takes as its starting point the spring equinox. In such a symbolic place for this tradition, therefore, it is inconceivable that a sundial would not be able to correctly determine the date of the spring equinox. Nor is it possible that the builder, with an eye to his client, would not have taken great care at least over this aspect. Accordingly, this essential function was built into the instrument.

One further important historical-cultural point, related to the place where the dial is located, is that in the Florentine tradition the calendar began with the spring equinox, when the sun entered Aries, but more precisely on the 25 March, the feast of the Annunciation (*ab incarnatione*). This tradition was kept up until 1 January 1750 when, with a law passed on 20 November 1749, the Grand-Duke Francis II of Lorraine ordained the adoption of the 1st of January as the beginning of the year.[14]

The other points of the line corresponding to the different signs of the Zodiac unfortunately show more or less marked differences compared with the calculated values (Fig. 11), which cannot be corrected uniformly and consistently by moving the gnomonic hole. So the bronze plate was replaced in its original position, and the inconsistencies revealed during the examination of the instrument were accepted as irreparable.

The bronze plate before removal had been firmly fixed to a triangular slab of 'pietra serena' (a grey sandstone) into which three anchor holes had been drilled. This small artefact was restored at the beginning of October 2010. The

Fig. 13. The gnomonic hole restored to use.

Fig. 14. 8 October 2010: the midday sun once again passes on the meridian line.

slab with the plate was set into the new roof and the bronze covered with a protective sheet of glass (Fig. 13). At true local noon on 8 October 2010, the sun once again shone through the reactivated gnomonic hole onto the meridian line, restoring it to life (Fig. 14), to the great satisfaction of students of gnomonics and amateur enthusiasts.

Today, accustomed as we are to measuring time with instruments and technology of the highest precision, its measurement by a sundial has lost much of its scientific meaning; nevertheless, this ancient instrument keeps intact its fascination and its historical and educational value.

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7. G.B. Amici *(1786-1863).* Astronomer, optician, engineer, professor of mathematics in Modena (1815-25), in 1831 he was summoned by the Grand Duke Leopoldo to be director of La Specola Observatory in Florence.

8. G.B. Donati *(1826-1873).* Astronomer, director of the Specola Observatory in 1859, succeeding Amici. In 1872 he moved the Observatory to the Arcetri Hill.

9. Correspondence between the Direzione Generale delle Acque, Strade e Fabbriche Civili dello Stato e l'I. and R. Museo di Fisica e Scienze Naturali, 1858, Museo Galileo, Firenze: "*restore the deflected gnomon to its previous position".*

10. Idem: "*the solar clock must be corrected so that the public is not led into error".*

11. Saalman Howard, *Filippo Brunelleschi: The cupola of Santa Maria del Fiore,* Desmond Zwemmer, London, 1980; doc. 382: from the Archivio dell'Opera del Duomo, Quaderni di cassa, Series VIII, 1, 61, c.2.
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12. *La Nazione,* Tuesday 23 August 1864, Anno sesto, N. 236: Lo Gnomone di S. Maria del Fiore: "*... And when the gnomon cannot or will not be repaired, I propose (and I think this is right) that at the bottom of the inscription on the monument displayed in our Cathedral, by the Regency, to perpetuate the memory of the work of the XV and XVIII centuries, that it be noted that the renowned work was destroyed, in that year, with the names of those who conducted the works of the basilica over the centuries and of the architect who superintended the work".*

13. S. Barbolini & G. Garofalo: *La meridiane storiche fiorentine*, Ed. Polistampa, Firenze, pp.104-5 (2011).

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Stefano Barbolini was born in Florence in 1952. An astronomy enthusiast and a member of the Italian Amateur Astronomers' Association, he has carried out a census of the sundials in the provinces of Florence and Grosseto. He also restored Giuseppe Slop's dial in the 'Stork Room' of the Specola Museum in Florence (2005, *Bull. BSS*, 19(i): 33-39), the gnomonic hole in the church of Santa Maria Novella (2006),
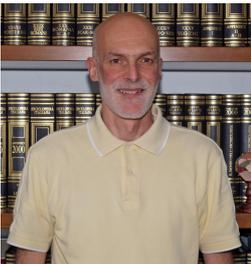
the Palazzo Pitti Sundial, created by Vincenzo Viviani (2007, *Bull. BSS*, 20(i): 3-10) and the dial in the Certosa del Galluzzo (2010, this issue). Mail: *barbolini@inwind.it*

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⊎

A Stump-work Dial

In the Crimson Bedroom at Montacute House in Somerset is a mirror framed by stump-work (a type of three-dimensional embroidery) and at the lower edge is the image of what appears to be a sundial. It seems to be a declining west dial and could possibly be a representation of the dial which is to be found on the house itself (SRN 2984) which also declines west. The mirror dates from about 1650 but little else is known about it.

John Lester

NEW DIALS

Ferrycarrig, C. Wexford, Ireland

The 35 acre Irish National Heritage Park is located at Ferrycarrig in the south east of Ireland, approximately 3 km west of Wexford Town on the Dublin to Rosslare N11 road (52° 21' N; 6° 31' W). It has sixteen archaeological and historical reconstructions covering 9000 years of Ireland's history and one of them, the Early Christian monastery, consists of a stone church with a corbelled roof, a monk's cell, a scriptorium, a refectory, a herb garden, a Celtic High Cross and, recently added, a sundial.

Made from an 'as found' granite slab and weighing over 2 tonne, the 180 cm high sundial was erected in February 2011. Modelled on those used in the Early Irish Christian monasteries, it was carved under supervision of consultant archaeologist Dr Ronan O'Flaherty of Crane Bag Consulting, by Wexford stonemasons Sean and Pat Hickey.

Only twelve of the ancient monastic sundials, some over a 1000 years old and in various states of repair, have survived and three others, although documented, have been 'lost' in recent times. The temporal lines on these sundials were designed not to measure the passing hours but to mark the times when canonical prayers should be said. To emphasis the times of the principal prayers *viz* morning prayer (Lauds), mid-morning (Terce), mid-day (Sext), mid-afternoon (None) and evening (Vespers), the lines on the dial were sometimes terminated in enclosing semi-circles in a trident like effect.

Underneath the dial face there is a cross carved in relief within an incised circle.

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ROBERT STIKFORD'S 'DE UMBRIS VERSIS ET EXTENSIS'

JOHN DAVIS

The manner by which 'scientific' sundials, designed for the local latitude and indicating time in equal-hours, were introduced into Europe in the early 15th century is a continued subject of debate. These dials gradually replaced the earlier Saxon and mass dials with their horizontal gnomons which showed unequal (temporary) hours but took no account of latitude.

The oldest extant scientific dial in the world with a polar-aligned gnomon is the one by Ibn al Shatir in Damascus, made in 1371.[1] Islamic dials showing equal hours date to well before this time, although they normally used a point nodus rather than a polar-aligned gnomon. King[2] states that the earliest explicit reference to a pole-style gnomon is by the Mamluk author Sibt al-Maridini who flourished in Cairo c.1460. The material in this treatise was not original and clearly the invention must have been earlier, though perhaps not by such a long time period as might be suggested by centuries of dial history in the Islamic world.

In Europe, these 'scientific' dials – termed 'modern' by Zinner[3] because they are the type still common – were reasonably well known in manuscripts of the mid-fifteenth century, as well as by a handful of extant examples.[4] But although it seems reasonable to suppose that the knowledge of how to design a scientific dial reached Europe by diffusion from the Islamic world, there is remarkably little evidence of this and it is still possible that the method was re-invented in Europe. The majority of the European manuscripts of the period describing how to design a dial – either horizontal or vertical – are very similar and quite short, using a geometrical method for producing the layout. This is in contrast to a typical Islamic text which is much more involved and uses detailed tabulated values to draw up their complex dials. The European manuscripts are clearly related to each other as scribes in the scriptoria of monasteries across Europe copied and recopied basic texts. This raises the questions: where did the original texts come from and what were they based on?

John Whethamstede

John Whethamstede (c.1392–1465) was abbot of the monastery of St Albans for two spells, 1420–40 and 1451–65.[5] This is the post which had earlier been occupied by Richard of Wallingford (?1292-?1336), builder of the famous St Albans astronomical clock, inventor of the *Albion* and perhaps the most accomplished English astronomer and instrument maker of the Middle Ages.[6] Both Whethamstede and Richard Wallingford had strong connections with Oxford, only 35 miles away and home of the 'Merton Calculators' at Merton College, responsible for the leading astronomical and calendrical research of the 14th century.[7] Whethamstede was not himself an astronomer but his writings indicate that he was interested in the subject and in the work of his illustrious forebears at the Abbey. His major legacy to history is a codex called the *Granarium* (a play on his name) originally written c.1430 and which was a compendium or encyclopedia of the knowledge of the time, drawing on the information in the extensive library at St Albans.[8] Various partial copies of this manuscript still exist, e.g. British Library MS Cotton Nero C VI part 1. Part of its contents is devoted to listing the inventors of a very wide range of items, including libraries, making fire and trousers (!) as well as various technologies such as the plough. In the key section on astronomy and astronomical instruments, Whethamstede draws on his own knowledge as well as that from the St Albans library when he writes on sundials:

> *Figuram in plano pariete, que docet per umbras horas diei certitudinaliter agnoscere, adinvenit primitus, quo ad horas inequales, Albategni secundum aliquos, Arzachel vero secundum alios; quo ad horas vero equales, adinvenit illam primitus monachus monasterii Albanensis, qui apud suos Robertus Stikford fuerat nuncupatus*

> [It was originally Albategni, according to some, or according to others, Arzachel, who invented the figure on the vertical wall which showed how to recognise accurately from the shadows the unequal hours of the day. With regard to the true equal hours, the first inventor was a monk of the monastery of St Alban, known amongst his colleagues as Robert Stikford.]

Thus, having attributed the design of sundials showing the old unequal hours to either Albategni (c.858-929), the famous Islamic astronomer better known as Al-Battani, or to Azarchel (1029-1087), the leading instrument-maker from Muslem Spain, he says that the dial for equal hours was invented by a monk from his own abbey, Robert Stikford. This is a very bold claim which must be treated cautiously as there are no other sources to support it and it could well be that this Stikford, not previously known to the world of science history – he appears only as a footnote in North's work on Richard of Wallingford – merely copied the information from an earlier source. Nevertheless, it is extremely important as it shows that there was knowledge of equal hour sundials in England before 1430. Whethamstede was clearly aware of Arab astronomy yet did not know of their pole-style dials.
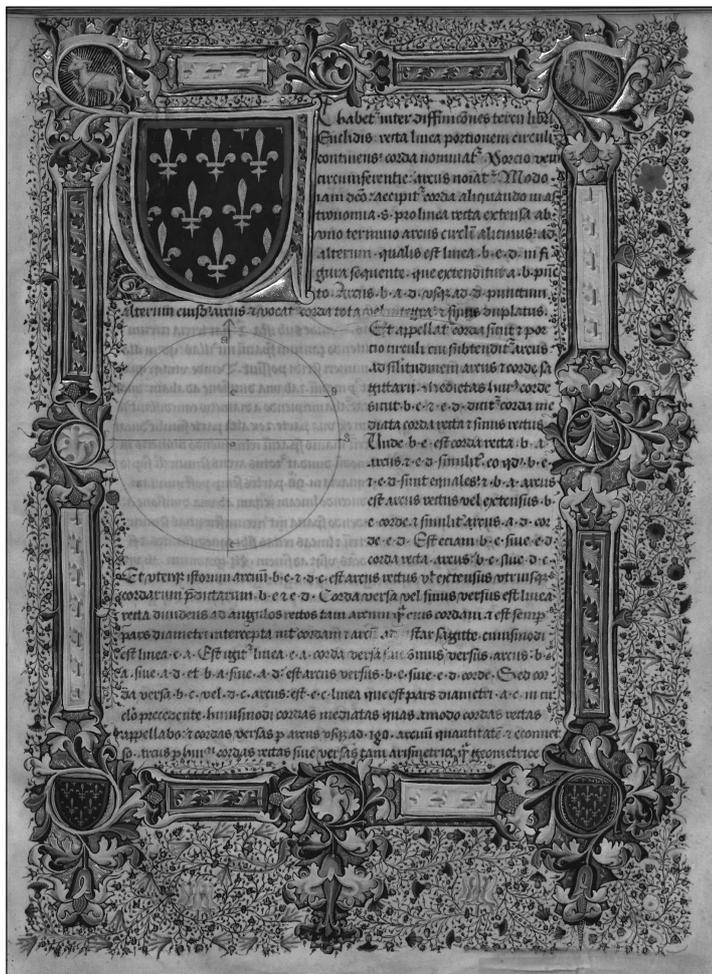
Fig. 1. The beautifully-illuminated first page of the Biblioteca Ambrosiana copy of Stikford's 'De Umbris...'. Ambr. & 201 bis sup, f.80r.

Robert Stikford

Robert[us] Stikford[e] is mentioned four times in the roughly contemporary *Gesta Abbatum*[9] for St Albans over the period 1396–1401 where he is described as the *tertius prior* in lists amongst many other monks. This relatively senior position in an establishment of around a hundred monks suggests that he was not a young man at that time.[10] His origins are unknown though it is noted that there is a village of Stickford near Boston in Lincolnshire with a 13th century church.

His work was unknown to history until quite recently (2005) when a previously-overlooked manuscript in the Biblioteca Ambosiana in Milan was discovered. The manuscript,[11] which is described in general outline by Anna Bellettini,[12] includes a treatise called *De Umbris Versis et Extensis* (roughly 'On the motion of shadows', and shortened to *De Umbris* in this article) by Robert Stikford. It seems to be a copy of a large astronomical codex which was given by Whethamstede to the Duke of Bedford around 1430. John, Duke of Bedford (1389-1435) was the third son of King Henry IV and brother of Henry V. He was Regent of France (Governor of Normandy 1422-32) under his nephew, Henry VI, and an important commisioner of illustrated manuscripts. He is known to have

visited St Albans in June 1426 and thus Whethamstede, as an abbot seeking political favours for his establishment, promised to have a copy of an astronomical codex prepared for him and it seems this included Stikford's *De Umbris*.[13] Whethamstede later regretted the high cost of the book.

The manuscript is not an autograph one so we do not know when Stikford's original, which is presumed lost, was written. The best guess must be in the period 1396–1401 for which we have evidence of his existence but clearly it must be before 1426 and thus earlier than the simple dialling manuscripts described above. Thus Stikford is exactly contemporary with Geoffrey Chaucer whose *Treatise on the Astrolabe* was written in the early 1390s. Whereas Chaucer wrote in English, Stikford used the standard Latin of the academic and monastic world.

In contrast to the rather short (one or two folios only) dialling manuscripts of the mid-fifteenth century which are relatively common, Stikford's treatise is quite extensive at 28 double-sided folios. The Ambrosiana copy is a high-quality production, with illuminated capitals and wonderfully controlled calligraphy, again in contrast to the scrawling run-of-the-mill dialling manuscripts half a century later.

A key passage of the *De Umbris* (f. 86r) reads:

> *Nos autem ad presens principaliter intendimus scribere quod nos cum labore, Deo - cui gratias - inquisicionem nostram ad propositi nostri methodum dirigente, per racionem invenimus, videlicet qualiter superficiebus planis perpendiculariter super circulum emisperii elevatis et immobiliter situatis ad latitudinem 51 graduum et 50 minutorum, que dicitur esse ville Oxonie latitudo, hore equales a meridie vel media nocte possint cognosci per umbras.*

> ['However, we now in the first place intend to write what with difficulty we (God, to whom thanks, directing our enquiry into our proposed method) have found by reasoning, that is to say just as a flat surface raised perpendicularly above the circumference of the hemisphere and immovably placed at latitude 51 degrees and 50 minutes, which is said to be the latitude of the city of Oxford,[14] so the hours from midday or from midnight can be seen to be equal by their shadows']

This clearly shows that Stikford himself thinks that the method is novel and also that he is designing a dial for the latitude of Oxford.

De Umbris Versis et Extensis

A full transcription, translation and interpretation of Stikford's masterwork is currently being produced.[15] Some key features have already emerged and will be discussed here.

The opening page, shown in Fig. 1, begins with the basics, giving the key elements of geometry from Euclid which are required for dialling. Stikford fills twelve folios with text and diagrams showing the geometric constructions needed to construct the various non-linear (trigonometric) scales for projecting the position of a shadow.

The values are given in two vertical blocks, for the beginning of Cancer (the summer solstice) and for the beginning of Capicorn (the winter solstice). No values are given for the equinoxes. The table is then divided into three horizontal blocks, for different types of hour. The first, labelled on the left for the *hora Naturales*, run 4-12-8 and are clearly the equal or modern hours. The second block is for the *hora Artificiales*, running [0]-6-[12] and which are thus the unequal or temporary hours, counted from sunrise to sunset. Finally, the *hora Vulgares*, (common hours) run [0]-4-[8] are best described as the octaval system normally seen on Saxon dials and some mass dials. Each of these hour systems is well-known to diallists, though not necessarily with these names. The common terms are *æquales* or *æquinoctales* for the equal hours and *horæ inequales* or *temporales* for unequal hours.[16] But the use of the terms 'artificial' and 'vulgar' hours can be found in the calendars of Nicholas of Lynn (*fl.* 1386–1411).[17] What is surprising, though, is that clearly the three systems are coexisting at the end of the 14th century. The general understanding has been that equal hours gradually took over from unequal hours during the 15th century but here we see that the old Saxon system is still hanging on as well, probably used more outside the environs of the monastery and university. It must have been most confusing.

The calculations used for the values in the table can be run backwards to derive the value of the obliquity of the ecliptic that Stikford has used. A value of 23° 33′ is obtained, suggesting that Stikford has consulted a version of the Alfonsine tables as earlier works of Al Battani (Albategni) and Al Farghani (Alfaginus, mid-9th century), both of whom he quotes elsewhere in *De Umbris*, are associated with a value of 23° 35′.[18] The calculations of the sun's altitude to individual minutes parallels the calendars of Nicholas of Lynn who produced values for each equal hour of every day of the year.[19] Whereas Nicholas also calculated the horizontal shadow length (in feet and sixtieths) for a man 6-feet tall, Stikford has the vertical distance of the shadow from a horizontal gnomon. It seems possible, even likely, that there was contact between Nicholas and Stikford given the closeness of their dates and that the former was at Oxford at exactly that time.

One other noteworthy feature of the table is the use of a sexagesimal system for lengths as well as for angles, and of the use of a basic length of 12 units (representing a foot of 12 inches?). This was standard practice for the time and results in a higher level of precision than is strictly necessary for a sundial.
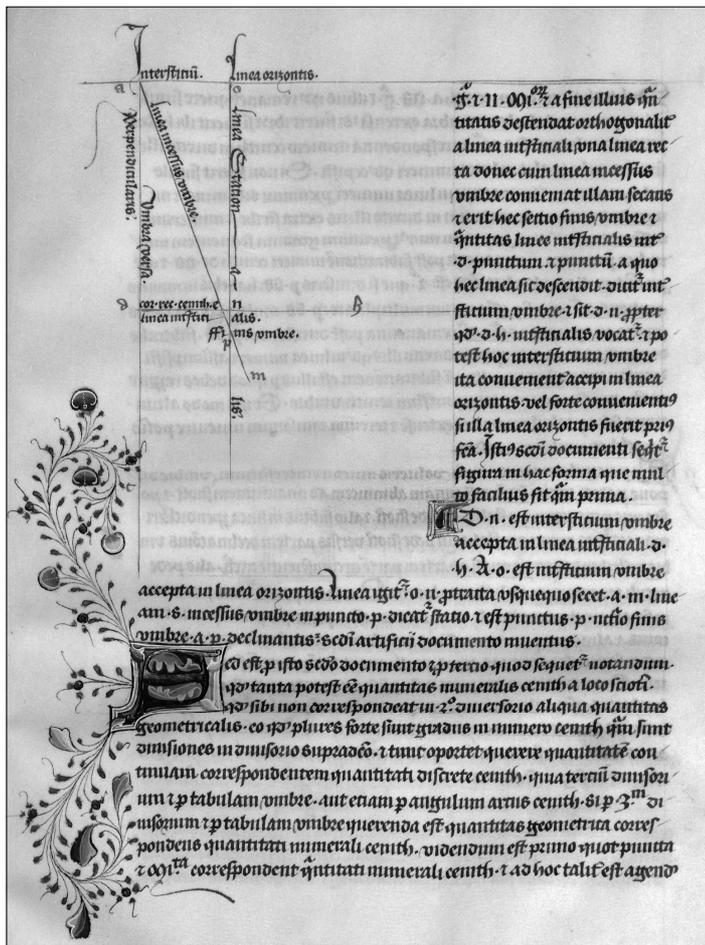
It is interesting that Stikford uses the word '*sciotherum*' (originally from ancient Greek) to mean gnomon, although it becomes clear later that this is a horizontal gnomon in which it is only the tip which casts the time-indicating shadow. As is common to many medieval treatises, the length of the gnomon is reckoned as 12 units.

After the folios of basic geometry, Stikford sets about calculating the directions of the sun and a shadow at various times of the day and for different occasions during the year. The result is a table (Fig. 2), headed *iam tabule numerales ad meridiem Oxonie subsequantur* [A table of solar values for the latitude of Oxford follow]. The table gives values of three parameters:

• *altitudo* : the Sun's altitude in degrees and arcminutes.
• *cenith* : the Sun's azimuth in degrees and minutes but measured from the E or W points. The word 'cenith' (Chaucer uses *cenyth*) might suggest a translation to 'zenith' but it actually derives from the Arabic for 'direction'.
• *umbre* : the vertical position of the shadow cast by the tip of a horizontal gnomon, of length 12 units, in units and 1/60th unit. Whilst the word *umbre* clearly means 'shadow', its use with this specific technical meaning of distance is unusual.

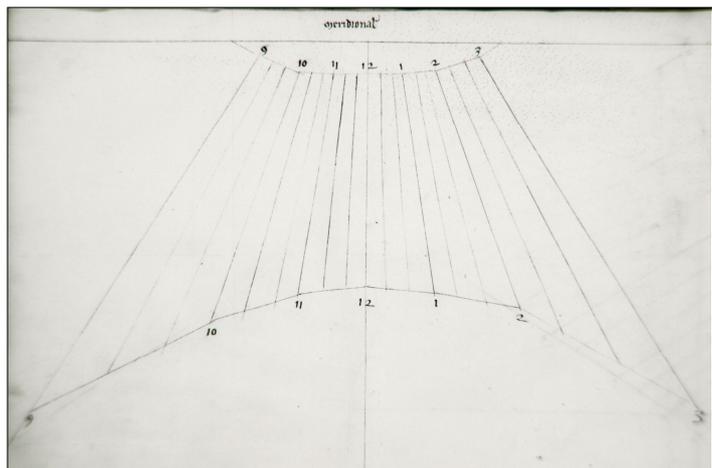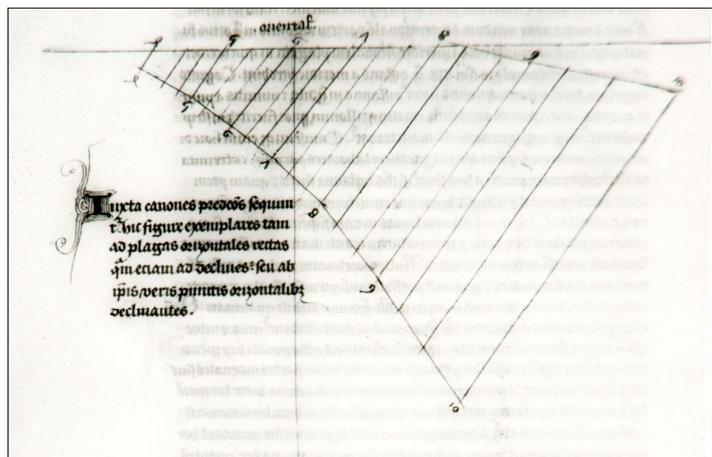*Fig. 3. A typical page of Stikford's calculations from 'De Umbris...', Ambr. & 201 bis sup, f.93r.*

Stikford then sets about using these solar values to calculate the lines of vertical sundials. A typical folio is shown in Fig. 3. After many folios, his results are displayed by five example designs; direct east and west, together with declining dials and, finally, a direct south dial (Fig. 4). The first drawing is introduced with the text:

> *Iuxta canones predictos sequuntur hic figure exemplares tam ad plagas orizontales rectas quam eciam ad declives seu ab ipsis veris punctis orizontalibus declinantes*

The production quality of these drawings is significantly poorer than the geometric diagrams earlier in the text, probably indicating that they were drawn by another hand – perhaps a mathematician rather than a full-time scribe. Nevertheless, the dials are fascinating as they may well be the earliest scientifically-delineated equal-hour dials in Europe. The two declining dials appear to be for SW and SE walls although this is not specifically stated. What is significant though is that at this very early date in European scientific dials the relatively difficult calculations for a declining dial have been attempted at all: the vast majority of surviving early dials are all direct S.

The method by which the dials have been drawn is clearly discernable. The position of the shadow of the tip of the

gnomon has been plotted, for each equal hour, at the summer and winter solstices and these have been joined by straight hour-lines. Declination lines for the two solstices have been drawn, piecewise linear, from the ends of the hour-lines. Each hour has been divided into three parts by intermediate hour-lines, probably by trial-and-error with the dividers. These lines thus represent 20 minute periods, also known as a mile-way in this Chaucerian period.[20] The division of the hour into thirds seems to have been quite common at this time.

The position of the gnomon and its length are surprisingly not shown on the drawings and must be found by the user. It is clear that this is a theoretical study and not an instruction manual for making a real dial. The realization that extending the hourlines backwards to a common origin, and then stretching a string from this point to the tip of the gnomon seems to have been missed, though it was tantalizingly close.

Conclusion

Stikford's treatise strongly indicates that the earliest scientific dials in Europe were not very simple ones with polar-aligned gnomons and on vertical south walls, as would be suggested by the extant mid-fifteenth-century examples found on a few church walls in continental Europe. Instead, rather more sophisticated designs were available in England around half a century earlier. We do not know how far this knowledge spread from St Albans and how many actual dials were made but, given the tightly-connected monastic

Fig. 4. The final dial designs at the end of De Umbris,
(a) a direct E dial at f. 103v and
(b) a direct S dial at f.104r. Ambr. & 201 bis sup.

links of the time, it is likely that the information became known within a few decades. The belief that simple always predates complex in the world of technology is a common fallacy: in the clock world, complicated astronomical clocks were around for some time before the one-handed church clock became common.

The step in Europe from the equal-hour scientific dial with a nodus and declination lines to one with a polar-aligned gnomon passing through the nodus point still eludes us. It might be that, once a Stikford-design was seen in action, the possibility of a polar-pointing rod gnomon became obvious. Certainly, it happened within a few decades, if not more quickly.

The degree to which Stickford's work is novel, and the debt which he owed to earlier Islamic work, is not completely clear. The only two Arab mathematicians that he quotes (Alfaganus and Albategni) lived several centuries before him and, although Alfaganus is believed to have written on sundials, he did so in a period well before the development of the polar-aligned gnomon: although his *Elements of astronomy on the celestial motions* was translated into Latin in the 12th century his work on sundials seems to be lost. Thus it seems that Stikford worked out the theory for himself, perhaps by extending the shadow-length tables of Nicholas of Lynn.

ACKNOWLEDGEMENTS

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19. See North, *op.cit.* (ref 16) pp. 89 & 106 for samples of Nicholas Lynn's tables.

20. See North, *op. cit.* (ref 16) p.47 for a discussion on Chaucer's use of the mileway.

For a CV of the author, see *Bulletin* 23(ii) p.13.

MEDIEVAL CATHOLIC ENGLISH MASS DIALS OF THE 14TH & 15TH CENTURIES

CHRIS H.K. WILLIAMS

Hitherto we have analysed the surviving appearance of scratch dials and their broad religious context. Medieval Catholic dials were very different from Reformational/Protestant dials.[1] Although clearly discernable from surviving appearance alone, their original appearance would have differed even more dramatically. This can be confidently inferred from Catholicism's and Protestantism's markedly different religious iconographies – a difference from which dials would not have been immune. This, and the next, article will consider the original appearance of these dials.

The most authentic impression of medieval Catholic iconography can be seen in church wall paintings. Sufficient have survived – preserved under plaster or lime wash – to reveal how utterly ubiquitous they once were. Unsurprisingly, the pantheon of saints provided endless inspiration, as did messages of a moral nature, both often portrayed in rather secular circumstances.[2] Fig. 1 indicates the range of paintings to be found in English parish churches.[3]

How should we interpret such paintings? Their quality is vernacular, rather than fine, art. But that is to apply our modern conventions. Medieval art was not experienced aesthetically, but viscerally. In an illiterate age it was the way to convey messages. Therein lay an endless supply; a supply that not only covered all interior walls, but recovered them – over-painting was endemic. Medieval vernacular art is akin to modern popular print – its content and symbolism was read; and new editions replaced the old!
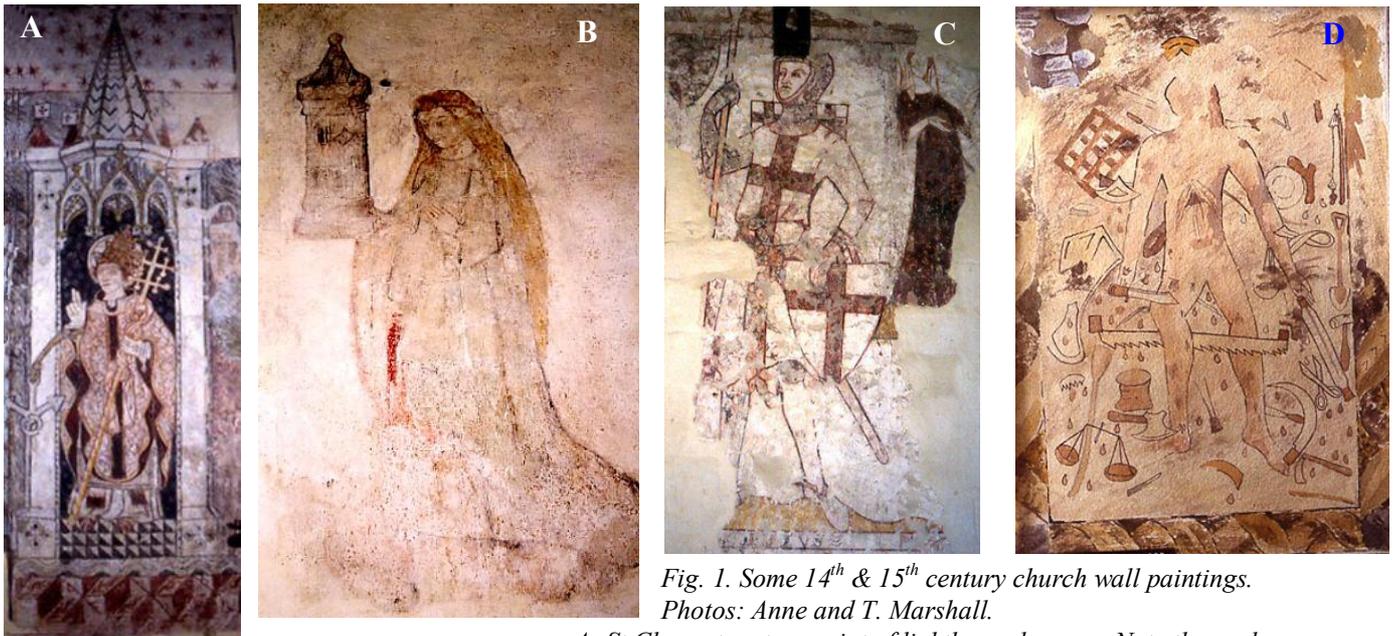

Fig. 1. Some 14th & 15th century church wall paintings. Photos: Anne and T. Marshall.

A: St Clement, patron saint of lighthouse keepers. Note the anchor symbol. (St James the Great, South Leigh, Oxfordshire).

B: St Barbara, patron saint of childbirth. Note the tower, symbol of her imprisonment, to protect her from lustful suitors. Note also the tower's cylinder dial – the chilindre – profile, symbolising her imprisonment's duration. (St Ethelbert's, Hessett, Suffolk).

C: St George with the rescued princess. Note the red cross. He became England's patron saint after appearing at Agincourt. (All Saints, Little Kimble, Buckinghamshire).

D: A warning to Sabbath breakers. Christ's wounded body recalls his Passion. The tools, if used on the Sabbath, symbolise Christ is further wounded. (St Winwaloe, Poundstock, Cornwall).

E: A warning against idle gossip. The two women are gossiping, not praying as suggested by their rosaries. Traces of the devil are just discernable – Gossip is the devil's work. (All Saints, Little Melton, Norfolk).

Note: See main note (3).

Colour decoration was not confined to medieval interiors but, for obvious reasons, exterior evidence is very rare. Cathedral fronts, with all their carving and statues, were a riot of colour. Conservators examining the west front of Exeter have analysed hundreds of paint samples, establishing it was repainted eight times before the Reformation.[4] Were the exteriors of parish churches colour decorated? Given their adoption of interior painting, stained glass, coloured floor tiles, and all manner of other trappings, it would be remarkable if they were not - another example that the absence of evidence cannot be taken as evidence of absence. Perhaps surviving statue niches on some parish churches are the remaining vestigial evidence?

What are the implications of our appreciation of Catholic religion and iconography for the original appearance of mass dials? There are two overriding considerations. Firstly, medieval churches were awash with an explosion of colour. It is inconceivable mass dials were not also colourfully decorated whilst in use. To presume (in the absence of proof positive) they were not flies against the conventions of the time. Secondly, symbolism was rampant. It is inconceivable mass dials did not embody symbolic meaning, thereby validating their upper halves, completely redundant in purely time indicating terms. Again, to presume otherwise flies against the conventions of the time. Medieval 360° dials are only fully explicable in terms of symbolic as well as functional terms.

Given the ravages of time on dials' scratched remnants, any trace of original painted decoration has long been lost. Any 'entombed' archaeological example preserving original decoration would be miraculous. No such evidence has yet been found. Perhaps the best to be hoped for, and again yet to be seen by diallists, is a manuscript illumination of a mass dial. The only contemporaneous analogue we can
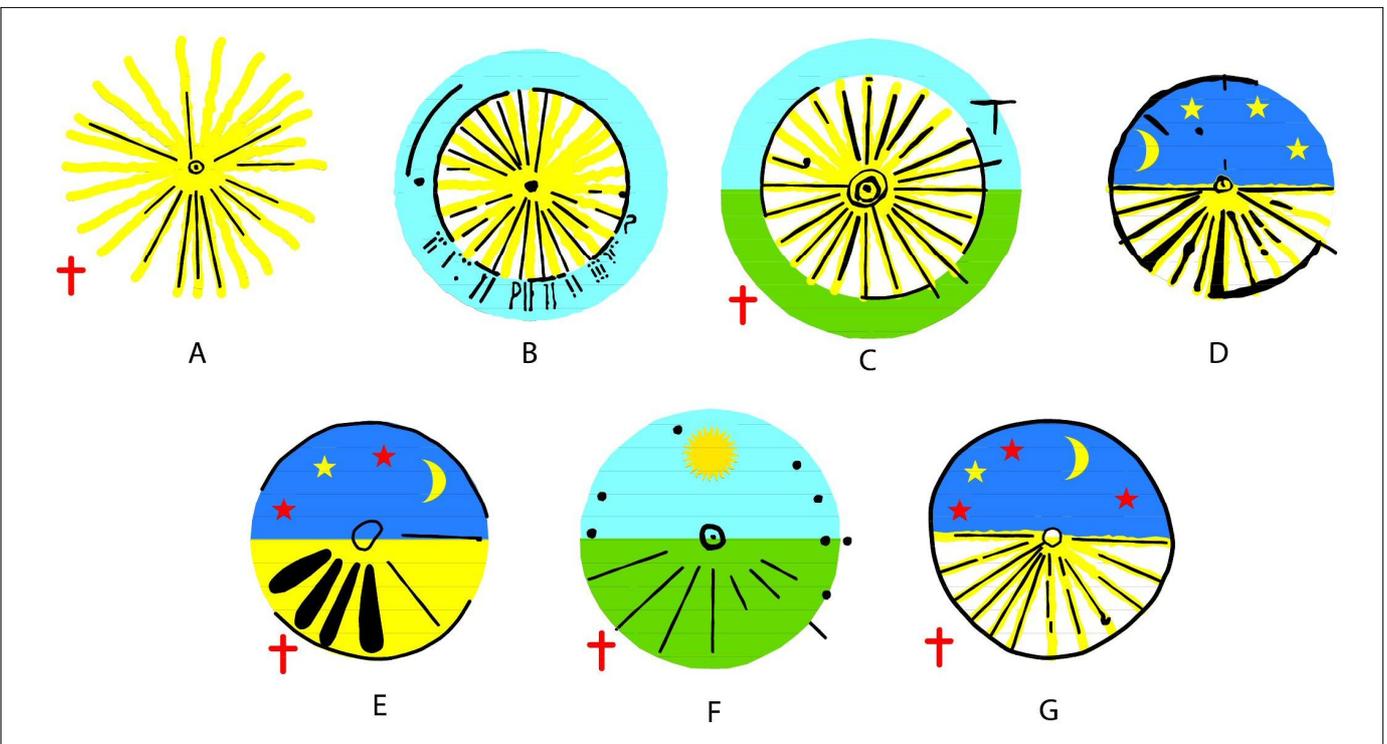
currently deploy are mechanical clock dials (Fig. 2). Sun (burst or ray) clock dials also occur in illuminated manuscripts.[5] We can only speculate on the sun motif's derivation. Surely the inspiration for such clock dials is far more likely to be secondary, flowing from an established earlier sundial decorative tradition, than primary and original to mechanical clocks themselves?

The sun is the most obvious decorative motif for a sundial. As well as representing the ultimate and most intimate physical association with a sundial, the sun is also deeply endowed with rich religious symbolism. Such symbolism is multi-layered. Firstly, the sun symbolises the light of the world – God's eternal light. Secondly, it symbolises creation and life – especially the Creation. Thirdly, its daily rise symbolises Resurrection. Although this listing is by no means complete, it is sufficient to appreciate that there is no better single symbol of God's omniscience and omnipresence than the sun!

Another interpretation of 360º dials is that they represent day and night. Again the symbolism is rich and multi-layered: life versus death, living and departed souls, heaven versus earth and by implication the twilight zone - Purgatory. Each, and all, of these would have resonated with medieval Christians in ways virtually unimaginable to us today. In a very real sense medieval Catholicism was a single community embracing both the living and the dead. Life was but preparation for one's own death, the next world and the day of judgement; one assisted, through prayer and masses, departed souls in the agony of purgatory; and, one lived and died in the firm expectation one's own purgatorial agonies would be alleviated by the prayers of the earthly living.

In the absence of extant evidence, and the virtual certainty that no material evidence will come to light in the future, we can only conjecture as to mass dials' original in-use appearance. Figure 3 is an attempt to do so: it is intended to be indicative not definitive. Almost infinite variation in execution can, as with any artistic endeavour, be imagined. Undoubtedly there were different styles – some ornate, others less so – and an evolution therein. Despite all that texture being beyond retrieval, Fig. 3, for all its stylised limitations, forces us to confront and recognise a stark reality – surviving mass dials are, of themselves, but a ghostly and glaringly inadequate guide to both their original appearance and meaning.

That dials were painted and decorated cautions against over-interpreting a dial's scratchings. Not all of a dial's detail need originally have been scratched – only sufficient to aid reinstatement. It cannot be assumed all hour or event lines were scratched – as opposed to only painted. It is improbable all, or any, of their inscribed annotation was scratched. Inscription need not have been limited to indicating times or services. Some dials' annotation might have been personalised to the priest who used it or, given the importance of masses for the dead, the departed souls for whom masses were being offered. It is conceivable a dial's decoration and annotation changed whilst it was in use.

Symbolism has been considered from a purely visual perspective. Although the most directly relevant iconographic context, there was also a long literary tradition, which can

be traced back to the 5th century, utilising the horologium – sundials and clocks – and time itself as a religious or theological metaphor.[6] Whilst a full intellectual appreciation was confined to a small educated literate elite, the literary tradition would have influenced, again in ways no longer obvious or meaningful to us today, both the original perception and appearance of mass dials. For example: general perception would have been affected by the common use of 'Horologium' in the title of theological works; and, the frequent use of twenty-four chapters therein may have helped inspire mass dials with lines dividing day and night into twenty-four hours.

Hopefully all are persuaded that the traditional approach of former mass dial students, by focussing on dials' surviving appearance independent of their iconographic context, was unduly conservative and restrictive. We have a deep and detailed appreciation of their iconographic context. By reuniting mass dials with their contemporaneous Catholic iconography, their remains can be reinvigorated. Although the exact original details of an individual dial are beyond retrieval, mass dials can be collectively repatriated with their generic character. (Fig. 3). The time has come for diallists to look beyond skeletal monochrome remains. Catholic mass dials were colourful, with an extensive symbolic oeuvre. Appearance wise, symbolism trumped time indicating functionality. It is even probable symbolic message was more important than time indication. This visual rehabilitation is of course additional to our previously established understanding of their true original numerical incidence.[7] All churches once had mass dials: most several. It is likely, given itinerant chantry priests and the importance of masses for the dead, that more than the one dial was in concurrent use. Hopefully all are also persuaded Catholic mass dials deserve and warrant far greater appreciation and recognition amongst diallists.

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2. We have, in addition, already considered crucifixion and judgement paintings. *Ibid.*

3. Readers wishing to explore the full glory of church wall paintings should consult Anne Marshall's website: *http://www.paintedchurch.org/index.htm*

4. See Andrew Graham-Dixon: *A History of British Art,* BBC Books, (1996).

5. Two c.1450 examples of such illuminations: Sapientia surrounded by clocks and other time related instruments in a copy of Henricus Suso's *Horologium aeternae sapientiae,* Bibliothèque Royale, Brussels, MS IV, iii, f.13v; and Temperantia adjusting a clock in a copy of Christine de Pisan's *L'Epître d'Othéa,* Bodleian Library, Oxford, MS Laud misc. 570, fol. 28.

6. See Otto Mayr: *Authority, Liberty, and Automatic Machinery in Early Modern Europe,* The John Hopkins University Press, Baltimore & London, (1986).

7. See Chris H.K. Williams: 'English Scratch (Mass) Dials: The Ravages of Time Revisited' & 'The English Scratch & Mass Dial Era: The Evidential Period c.1250 to c.1650', *Bull. BSS,* 23(i) & 21(iv), 36-8 & 18-9, (2011) & (2009).

For a CV and portrait of the author, see *Bulletin* 23(i).

THE MARGARET STANIER MEMORIAL SUNDIAL:
AN UNEQUAL-HOURS DIAL FOR NEWNHAM COLLEGE

Part 2. Evolution of the Design

ANNIKA E. LARSSON

In Part 1, which was published in the September issue,[1] Frank King gave an account of the gnomonic details of the gnomon-driven unequal-hours dial that was made as a memorial to Margaret Stanier in 2010. Here, in Part 2, Annika Larsson describes how she developed the design into the finished sundial.

The Story So Far

In Part 1, it was shown that by carefully choosing the orientation of the gnomon, it is possible to make a gnomon-driven sundial that indicates unequal-hours to acceptable precision. The gnomon must be in the meridian plane and, in the latitude of Cambridge, should dip downwards towards the south by an angle of about 8.9°.

With this angle of dip the variability in the direction of the shadow at the ends of hours III and IX is minimal. The variability at the end of hour VI is zero and at the ends of most of the other hours it is acceptably small.
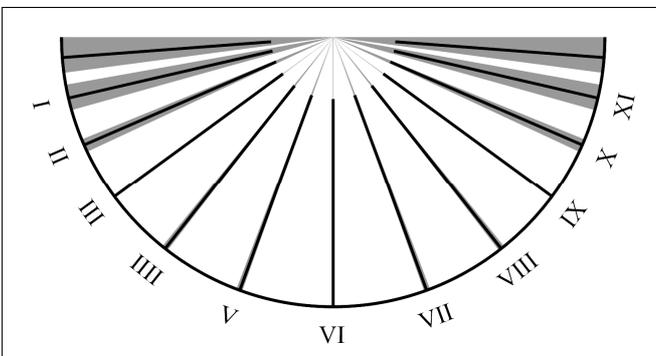

Fig. 1. Embryonic design.

Fig. 1, reproduced from Part 1, shows, for a direct south-facing dial, the positions of the 13 hour-lines from sunrise to sunset inclusive. Associated with each hour-line is a grey region whose margins indicate the range of directions of the shadow at the unequal-hour indicated. Each hour-line is in the mean direction.

The greatest variability is at sunrise and sunset and, in the mean positions, the (unlabelled) sunrise and sunset hour-lines slope noticeably downwards. These sloping lines prompted considerable design thought.

The procedure for determining the directions of the hour-lines also holds for declining and reclining dials. The Newnham College dial is vertical but declines about 3° west.

Early Thoughts

Having worked as a designer and stone-cutter on a number of Frank King sundial projects I was not too surprised when he got in touch with me just a few days after Newnham College suggested that a sundial might be an appropriate memorial to Margaret Stanier.

I gathered that an unequal-hours dial was a possibility but this was long before the gnomonic details were settled. Fig. 1 was some way into the future.

Fig. 2. The intended site.

The principal early problem was persuading the Cambridge Planning Office to allow a sundial to be put up in the position that the College had chosen. The intended site is shown in Fig. 2.

There is a panel of limestone blocks roughly 2m square set into a recess in the wall of a college building. The panel is ornamented by a faux balcony and the balcony rail is supported at its centre by a horizontal bracket which is perpendicular to the stonework. The bracket cannot be seen but its shadow shows up as a short diagonal element running downwards to the right. This bracket could almost serve as a gnomon for a traditional design of unequal-hours dial.

The panel is close to direct south-facing and the space above the rail seemed a good site for a sundial. This space invites a rectangular dial but, to go some way towards echoing the circular shape of most mass dials, it was decided to round off the corners and design an elliptical dial. The proposed material was slate and the dial furniture would be cut and gilded.

The local planners argued for a dial cut directly into the stonework. This would have required a protracted period with scaffolding against the wall and associated security implications. It would also have greatly increased the cost. The College and I both thought it would be better to make the dial in a workshop.

Living in Sweden, I was happy to keep my distance during the long-drawn-out discussions with the planners and the first design which was sketched by Frank King. This was requested by the College so they could have something to discuss. The design is shown in Fig. 3 and it gives a hint of what dial furniture can look like when cut in slate and gilded. It also incorporates a possible inscription. The sun is plagiarised from the dial at Queens' College.
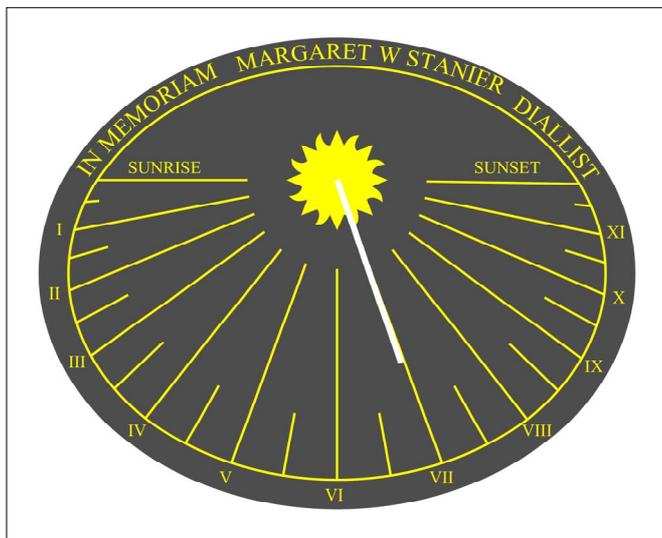

Fig. 3. The first design.

The sunrise and sunset hour-lines are almost horizontal but this is the result of a gnomonic fudge. Instead of placing the hour-lines in the mean directions, each is placed in the position appropriate for a solar declination of −2°!

With a direct south-facing dial, the shadows at sunrise and sunset will be horizontal at an equinox whatever the orientation of the gnomon. The dial actually declines about 3° west and there would be no sunrise shadow at an equinox. Using a solar declination of −2° just happens to result in both the sunrise and sunset hour-lines being approximately horizontal.

Drawing these hour-lines horizontal is misleading since this direction marks one extreme of the range of directions, as indicated by the upper margins of the sunrise and sunset grey regions in Fig. 1. At this stage, the variability had not been calculated.

The design includes half-hour lines. Their directions are determined in the same way as those of the hour-lines. Given that this is a declining dial, the hour-lines and half-hour lines are not quite symmetrically arranged about hour-line VI, but the asymmetries are barely noticeable.

The gnomon is white simply to ensure that it stands out against the background. It is shown in elevation lying along

the sub-style. The direction of the sub-style indicates that the dial declines to the west but the sub-style angle is much greater than it would be with a polar-oriented gnomon. Given that the gnomon is only a few degrees off being perpendicular to the dial, the figure is implying that the gnomon is extraordinarily long!

The design has clear limitations both aesthetic and gnomonic and it was later modified to the form seen in Fig. 4. The Queens' dial sun has been replaced by a circle which represents the intended gnomon support seen in elevation. This is at the centre of a more flamboyant sun which has alternating wavy rays and spiky rays. These two forms of ray are sometimes said to represent heat and light respectively.
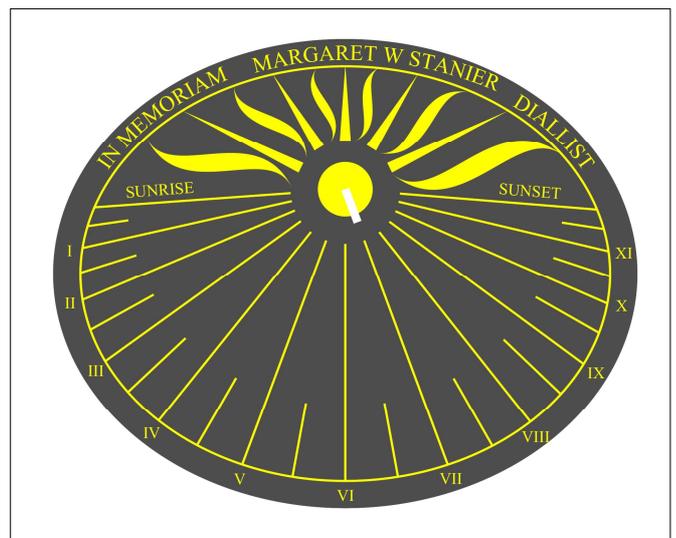

Fig. 4. A refinement.

There are 11 sun-rays which, with the 13 hour-lines, makes a total of 24 radial elements. This total alludes to those mass dials that have 24 hour-lines at roughly 15° intervals.

The gnomon seen in elevation is much shorter than in Fig. 3 and this corresponds to a more realistic length.

The principal gnomonic improvement in Fig. 4 is that the hour-lines and half-hour lines are now aligned with the mean directions of the shadows at the relevant times. The hour-lines more closely correspond to the directions in Fig. 1.

The sunrise and sunset hour-lines are sloping and although this is gnomonically honest it is rather unsettling. Even experienced diallists are unaccustomed to seeing sloping lines for sunrise and sunset.

Frank King discussed this matter with me and he asked whether I could think of an elegant way of indicating the grey regions for sunrise and sunset. Although the planning problems were still unresolved, I was unable to resist the temptation to produce a design of my own any longer.

My First Design
Fig. 5 shows my first attempt. It differs markedly from Figs 3 and 4. The two long wavy rays of the sun snake

Fig. 5. A fresh start.

between the (implicit) margins of the sunrise and sunset grey regions and take the place of the hour-lines for those times. I removed the half-hour marks for half an hour after sunrise and half an hour before sunset. The other half-hour marks have been replaced by stylised flowers which grow in the morning and shrink in the afternoon.

Most of the rays of the sun have been turned into lettering which spells out SCIENTIST and DIALLIST with these words being separated by the two wavy rays for sunrise and sunset. The wavy rays are unlabelled but at their outer ends there are a cock's head and an owl which serve as metaphors for sunrise and sunset respectively.

Fig. 6. Details of two suns.

The lettering that forms the sun is not wholly fanciful. Fig. 6 shows, on the left, detail of the limb of the sun taken from space with solar prominences appearing as a spike and as a loop. On the right of Fig. 6 there is detail of the letters LLI from DIALLIST as they appear when cut in slate and gilded.

I chose to have a gilded chapter ring which doubles as an inscription band and I proposed to have ungilded raised lettering within it. The band includes the inscription MARGARET STANIER and the cock's head and the owl as well as the hour labels. I changed IV to IIII to balance the VIII on the afternoon side of the dial.

Given the normal viewpoint of the finished dial, the lettering in Figs 3 and 4 is much too small and it is significantly larger in Fig. 5.

While this proposal was being developed, the College was also giving thought to the design. The version in Fig. 5 was

submitted for consideration but was not taken up. The College preferred the more conventional sun of Fig. 4 and they also asked to have the inscription at the bottom of the slate rather than at the top. This presented something of a challenge. The hour labels clearly couldn't be moved to the top of the dial so, if there were to be any hour labels at all, they and the inscription would both have to be below the hour-lines.

The Starbucks Inspiration

At this time I was planning a brief visit to Cambridge and I was invited to lunch in Newnham College to discuss progress. On the day of this lunch, as a pre-meeting meeting, Frank King treated me to coffee at a Cambridge Starbucks and I had to report a total lack of progress. We pored over numerous sketches and we doodled on several table napkins but nothing really appealed to either of us.

Just as the deadline for leaving approached I had an idea. We hadn't exploited the fact that mass dials are very often inscribed in circles. I asked for a blank sheet of paper and a printout which showed the elliptical outline and the orientation of the hour-lines. I then walked over to the front window of Starbucks and used it as a tracing table. Five minutes later I came up with Fig. 7.
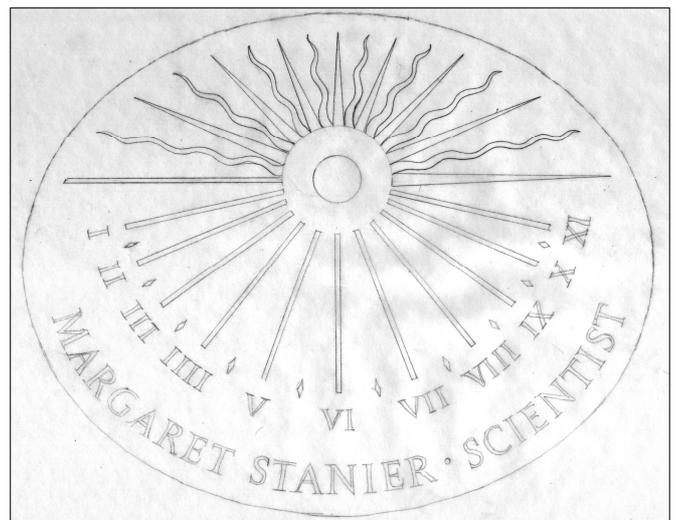

Fig. 7. The Starbucks sketch

This needed a good deal of refining but it would serve as something to show to the College. Stopping only to pause at a photo-copier, I rushed off to Newnham and enjoyed my lunch. The College liked the design and there was relief all round!

The Working Drawing

The planners still hadn't given their approval but there had been sufficient progress for me to feel confident that this sundial would see the light of day. On return to Sweden I prepared a long list of measurements which would be used to prepare a working drawing. This would be used for setting out the design on slate. The working drawing is shown in Fig. 8.
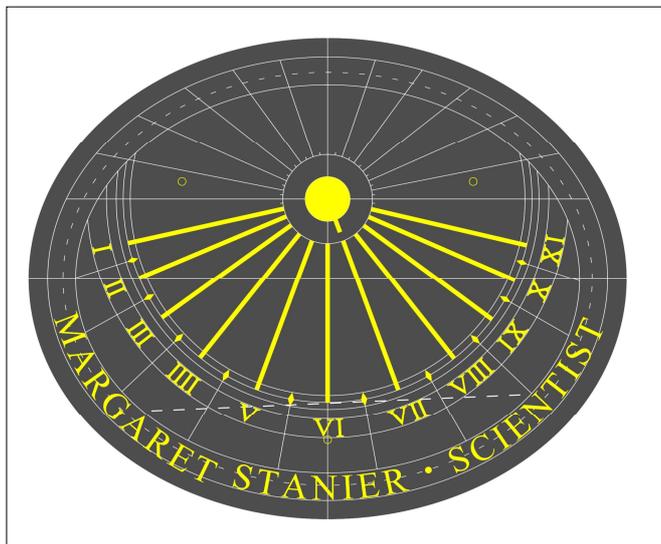
Fig. 8. Guidelines to be transferred to the slate.

All the white lines are construction lines or guidelines. These are used for setting-out but do not feature in the finished dial. Two crucial reference lines are the major and minor axes; those who work on elliptical plaques call this pair of lines the Big Cross. Other guidelines include the top and bottom lines of the lettering for the inscription and for the hour labels.

The only true ellipse in the drawing is shown by the broken line which runs roughly along the centre-line of the inscription band. The top and bottom lines of the inscription and the rim of the slate itself are closed curves parallel to this ellipse so these curves are not quite ellipses.

There are numerous arcs of circles, all centred on the root of the gnomon. These include the bounding circles for the inner and outer ends of the hour-lines and the top and bottom lines of the hour labels.

There are 13 straight construction lines radiating from the root of the gnomon. These and the 11 hour-lines mean that there are 24 radiating lines altogether. The 13 radiating white lines mark the centre-lines of the rays of the sun which will be drawn on the slate.

There are rather fewer rays than on the Starbucks sketch and the two horizontal rays will be wavy rather than straight. These two rays will stand in place of the sunrise and sunset hour-lines and their wavy appearance reflects the rather wayward behaviour of the sundial at sunrise and sunset!

The 13 radiating lines have quadratic spacing. Starting with the upward vertical, the spacings are 18.75°, 17.25°, 15.75°, 14.25°, 12.75° and 11.25°. These values total 90° and adjacent values differ by a constant 1.5°. The purpose of this progression is to ensure that the spaces between adjacent rays have approximately the same area.

The sloping broken line is the path traced by the shadow of the tip of the gnomon at an equinox. This line is clearly not at right-angles to the sub-style. The equinoctial line has the expected slope. It is the sub-style angle which is unusual.

There are some contrived details in this design which even the most assiduous diallist would probably miss. For example, the equinoctial line is tangential to the circle that bounds the outer ends of the hour-lines and the sub-style passes through the dot that separates STANIER from SCIENTIST.

Also, the half-hour diamonds vary in size. They grow slightly in the morning and then shrink in the afternoon, an echo of the ancient idea of the sun being born afresh each day and fading in the afternoon, a metaphor for life itself. This is a memorial sundial.

There are three mysterious yellow circles in the drawing, one almost hidden by the VI. These show the positions of the holes in the other side of the slate where metal dowels will eventually be glued for the purposes of attaching the dial to the wall.

Setting-out

The go-ahead finally came and, back in Cambridge, I was at last able to start work on the slate itself. This had been ordered from Ivett & Reed,[2] a local supplier of stone. As delivered, the slate was 1067 mm × 868 mm and it was 35 mm thick. This was blue-grey Welsh slate, honed on one side with a light bevel round the rim. The slate was of memorial quality and almost completely free from iron pyrites (fool's gold) which goes a rusty colour when exposed to the elements.

My first task was to draw the Big Cross on the slate, which was not supplied with the major and minor axes neatly marked out. This is surprisingly difficult because conventional geometrical procedures are not as useful as theory would suggest. The standard practice is to draw an outline of the slate on tracing paper and then fold the paper in half both ways so that the two creases form a cross. This cross is transferred to the slate.

I then transferred the other construction lines in the working drawing to the slate before marking out the hour-lines, the rays of the sun, the lettering and other details of the design. Three representatives from Newnham College came round to check everything before I started cutting. Each letter was called out one at a time and checked.

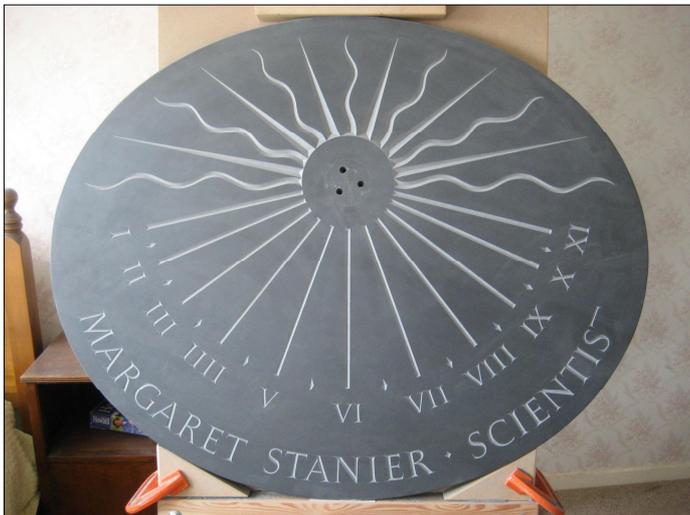*Fig. 9. Cutting the rays of the sun.*

Fig. 10. Cutting almost complete

Fig. 11. Gilding complete.

Cutting

I decided to cut the rays of the sun first and Fig. 9 shows my working arrangements, using an easel set up in Frank King's spare bedroom.

Fig. 10 shows the cutting almost complete. There is just a final letter T outstanding. Notice that the sunrise wavy ray ends with an upward flick. It is time to get up. The sunset wavy ray ends with a downward flick. Notice also the three holes through the slate. The gnomon support is secured via three bolts whose heads run through a base-plate on the hidden side of the slate.

Lettering, and especially hand-cut lettering in stone, is a much-studied subject. The spacing of letters is of great importance and a seminal work on this topic was written by David Kindersley.[3]

Lettering on sundials is particularly challenging. It makes sense to arrange the hour-line labels so that they are centred on the extensions of their hour-lines. Unfortunately, the quirks of Roman numerals and the irregular spacing of hour-lines can lead to strange effects. For example, there are large, but different-sized, gaps either side of the V and there are small gaps either side of the VIII.

Also, when first drawn out, the half-hour diamonds either side of the VIII appeared almost as quotation marks and subtle adjustments were made to correct this impression.

One strange effect caused me some concern. Clearly, the M of MARGARET and the final T of SCIENTIST should appear to be on the same horizontal level but the letters M and T have different weights. To compensate for it being the lighter letter, the T was drawn slightly higher than the M but it still *appeared* to be significantly lower.

It took a little while to understand this illusion. My eye was relating the M to the I that labels the first hour-line but was relating the T to the I of XI, the last hour label. The extra width of the XI compared with the I was causing the deception.

Gilding

Prior to gilding, the slate was transferred to a table where it was carefully washed to ensure that there was no slate dust or other dust in the V-cuts. This is a messy job which explains the plastic sheeting covering the carpet in Fig. 11.

When the slate was dry and as free as possible from dust, gold-size was painted into the V-cuts. Slate is almost impervious so the V-cuts can be flood-gilded. This means that the size can be applied beyond the edges of the V-cuts; the surplus is rubbed off later.

The size needs to be left 12 to 18 hours to set and reach the right degree of tackiness before the gold leaf is applied. During the time that the size was setting, the room was left undisturbed with the door shut and the central-heating turned up a little.

I was helped with the gilding by a Japanese colleague, Emi Sato, another stone-cutter with previous experience of sundial work. Gilding requires draught-free conditions and is best carried out in a hermetically sealed room. The applied gold leaf needs to be left for a minimum of three days and preferably a week before the surface of the slate is rubbed.

Fig. 11 shows the gilding complete and the gold clearly extends beyond the confines of the V-cuts. The gnomon has been placed on the slate to enhance the photograph. Margaret Stanier was an enthusiastic bellringer so the gnomon support is in the form of a little bell. The gnomon and its support were fabricated in stainless steel by Teversham Engineering[4] and the gold plating was undertaken by Modern Metal Finishes.[5]

Fig. 12. Blemishes in the gilding.

The flat surface of the slate was rubbed down using wet and dry paper. This removed the surplus gold and size, and left only the gold in the V-cuts. This job required copious quantities of water so the slate was taken outdoors. The gold was then burnished with a firm but soft brush under running water.

Rubbing down offers rewards and disappointment in equal measure. The surplus gold is rubbed off quite quickly but any problems with the gilding show up quickly too. Fig. 12 shows a typical gilding problem. Part of the outer end of the upper right-hand arm of the X of XI seems to have been missed. This can be caused by residual dust acting as a barrier to the size, or this patch may have been missed when either the size or the gold was applied. The slate was carried back indoors and every minute detail of every feature on the dial was inspected and blemishes such as that in Fig. 12 were attended to.

Fig. 12 also shows the characteristic chatter marks of hand-cut letters. Sand-blasted lettering and other machine-cut lettering do not show this feature. The photograph illustrates another illusion. The lettering is lit from below and this lighting tricks the eye into thinking that the V-cuts stand out from the slate whereas they are actually cut into it.

Fixing

The final task before the sundial was taken to Newnham College was to glue three 14 mm fixing-dowels into the holes in the back of the slate. The finished dial was now ready to be fixed to the wall. Two strong men from Ivett & Reed did the heavy lifting and the fixing.

Fig. 13 shows the sundial a few minutes after the scaffolding was removed. Emi Sato and I are admiring the new dial and lamenting the absence of sun!

We had been given explicit instructions about where to place the dial relative to the faux balcony. Unfortunately, in the specified position, the holes for the upper fixing-dowels would have been drilled into one of the joints in the stonework so the dial is perhaps 50 mm lower than agreed with the planners!

Fig. 13. With Emi Sato enjoying the new sundial.

Fig. 14. Half-way through the eighth hour.

Given the camera angle used in Fig. 13, the dial does perhaps look a little low but when the sun came out, it was clear that the chosen position was preferable. Fig. 14 shows the dial half-way through the eighth hour and even at this time, early in the afternoon, long shadows are being cast by the greenery above the stone panel. This is despite the fairly aggressive cutting-back which is clear in Fig. 13.

With the planning problems now receding into history, I am better placed to look back on the many enjoyable aspects of this project. I wonder whether casual passers-by see this as just another sundial. How many notice VI where there is usually XII? How many spot anything unusual about the orientation of the gnomon? Will Newnham College remember to cut back the greenery? Will there be an upsurge in demand for unequal-hours sundials?

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5. Modern Metal Finishes Ltd, *www.mmfgold.co.uk*

Annika Larsson is proprietor of *Inscriptorum*, a Swedish design workshop. She has a background in lettering and stone-cutting and

examples of her work abound in the UK and Sweden and elsewhere in mainland Europe. She has worked with Frank King on a number of sundial projects, most notably the large noon mark on the Stock Exchange in Paternoster Square in London. She may be contacted via *www.inscriptorum.com*

THE NEWSTEAD SUNDIALS

DENNIS COWAN

Newstead is a small village of around 200 inhabitants, reputed to be the oldest inhabited village in Scotland. It is in the Scottish Borders just outside the town of Melrose which itself is famous for its beautiful ruined abbey, one of several in this part of Scotland. The stonemasons and architects and other tradesmen who built Melrose Abbey were all lodged in Newstead and it was possibly this link that caused Newstead to be the site of the first Masonic Lodge in Scotland.

The Lodge was set up by the masons, mainly to control the level of training and craftsmanship of the apprentices, before becoming journeymen. However, the building fell into disrepair after the Lodge moved its premises into Melrose in 1742 and only a marker stone and plaque now remain.

But my interest is in sundials and, in the *Castellated and Domestic Architecture of Scotland*, Thomas Ross states that "there are numerous dials in this village, a fact which is accounted for from the circumstance of Newstead having been the home of many first-class working masons, who had the taste to set up dials on their own houses."[1] Ross went on to describe and sketch six of these dials.

Ever since I first read Ross's account I have wanted to see these sundials. I have been to Newstead several times in attempts to find them but, despite my efforts, I have only been able to locate one of them. I was beginning to think that all of the others had been lost in the intervening 120 years or so.

But that changed in August 2011 when I had yet another attempt. I surfed the internet once more and eventually found an organisation, the 'Trimontium Heritage Trust',[2] who organise walks during the summer months from Melrose through Newstead and on to Trimontium, the site of an old Roman fort. On their website, describing the walks, it said that whilst passing through Newstead that amongst other things, they would see some sundials.

This was what I needed. Unfortunately, their walks were held on Tuesdays and Thursdays and I was unable to attend any of them. There was a contact e-mail address on their website and so I contacted Donald Gordon, their Secretary, to ask if he could tell me where the sundials were. He replied that better than that, he would give me a personal guided tour.

I should say at this point that I do not have a copy of the *BSS Register*, as part of my enjoyment is the research that goes into tracking down Scottish sundials. Rightly or wrongly, having a copy of the *Register* would perhaps take some of that enjoyment away, so I don't know if any or all of these dials have been recorded by the BSS. But I'm still in a quandary. Should I get a copy of the *Register* or not? Does anyone have any thoughts on this?

We made our arrangements and one Sunday a few weeks later we met up in Newstead, unfortunately on a very wet day. I soon realised that it was unlikely that I could ever have found any more sundials on my own. The first sundial (Fig. 1), a cube surmounted by a ball, could be seen from a public lane, but it was so out of the way that it was no wonder that I hadn't seen it before.

Fig. 1. The dial on the stone arch.

It was on top of a stone arch leading to the garden of the house just where the arch joined on to the building, and from the lane it was half hidden by the arch itself. Only two faces could be seen, one of which has the initials "JB" for J. Bunyan, an old mason's name in Newstead. The date of 1754, which was on the right hand face according to Ross, is now missing, as that part of the face has since flaked away.

The next dial (Fig. 2) was locked up in a hut in a private garden! There was no chance that I could have found that one on my own. Donald had kindly arranged for access to the hut and we took the dial outside in order to photograph it. Ross reported that this dial "is dated 1683, and has the initials W.M. and L.M., standing for the surname of Mein…. another old mason name in Newstead." The initials M. and L.M. (or is it I.M.?) can still be seen but the date which was on the right hand face is now missing, as that part of the dial has gone. The Arabic numerals and ini-

Fig. 2. The dial locked in a hut.

tials have been cut very deeply into the stone and are extraordinarily clear for such an old dial. Stubs of the two gnomons remain in place.

The third dial (Fig. 3) was in the same garden but it was now mounted on a two-pieced rectangular shaft, rather than on a corbel on a building as Ross had described it. It is unusual in that it has a semi-cylindrical dial, similar to those on some Scottish lectern sundials, on its west face. The other two dial faces had had their solid gnomons replaced at some point, quite possibly when the dial stone was mounted on its new shaft, which apparently took place at the beginning of the 20th century. The shaft has the motto "Sunshine and shade by turns but love always" apparently scripted by the wife for her deceased husband.

Next, Donald took me into another private garden where a single-faced stone dial dated 1659, not mentioned by Ross, was mounted above the back door of the house (Fig. 4). A

Fig. 3. The semi-cylindrical dial.

Fig. 4. The back door dial.

porch has since been built around the doorway and the dial, so it spends its life in the shadows. The motto on the dial is "Ut umbra sic [vita]" translated as *Life is like a shadow*. How apt for this dial now. It also has a motto in Hebrew and the dial itself is surmounted by a much-worn head.

Fig. 5. The date-stone dial.

We then moved on to another single-faced dial, again not mentioned by Ross, on the north facing wall of a house known as 'the Auld Hoose'. This dial was rectangular and measured only about 8″ by 5″ (200 × 125 mm). Despite the fact that it was on the main street, I had not noticed it on my previous visits even though, in retrospect, it stands out like a sore thumb, as the whole wall is covered in white painted harling apart from the sundial itself (Fig. 5). My excuse is that I was looking for dials like the ones sketched by Ross and not for a small single face dial like this. However, not even the Royal Commission on the Ancient and Historical Monuments of Scotland (RCAHMS) have recognised it as a sundial. They say it is "a small exposed date-estone now too indistinct to read". [3] But even though the lower half has flaked, it most clearly is a sundial as the hour lines, the remaining numerals of 4 and 5 and the gnomon hole testify.

Fig. 6. The corbel dial.

Fig. 9. The dial fragment.

The only sundial that I had been able to find previously (Fig. 6) is mounted on a corbel on the corner of a house in the main street and can't really be missed. It is dated 1777 and its central south face has Arabic numerals from 6am to 6pm whilst its west face has Arabic numerals from 1pm to 8pm and the east face also has Arabic numerals, this time from 4am to 10am. All three of the gnomons are complete.

So at last I have seen six Newstead dials, although only four of them were those described and sketched by Ross. I can only assume that the other two have unfortunately been lost. The first missing dial (Fig. 7) is dated 1751 whilst the second dial (Fig. 8) appears to be identical in design to the dial on the archway in Fig. 1.

However, there are many instances of various carved stones being re-used in the walls and buildings in Newstead. Why indeed should a mason throw away good stone? A possible fragment of a sundial (Fig. 9) has been found re-used as a
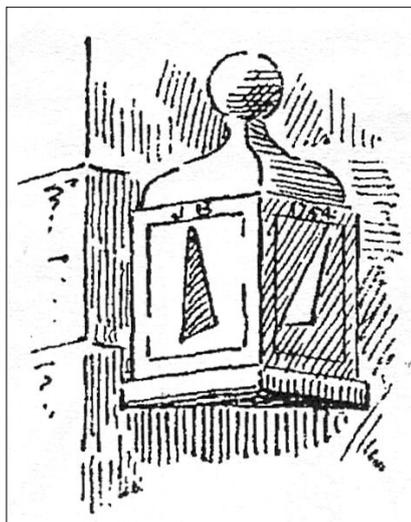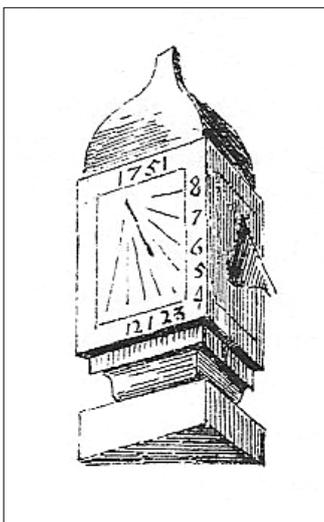
stone in a building just off the main street in the village and its filled-in gnomon hole, if that's what it is, can be easily seen. If there is one, then there are possibly others, so I expect that I will still have to visit Newstead again and again, this time looking very closely at all of the walls and buildings in the village. Maybe parts of the two missing dials will eventually turn up.

So the quest continues.

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Dennis Cowan is married with two apparently grown up daughters and two grandchildren. He lives in Fife in Scotland and works as a Contracts Manager for Babcock International Group. He has only been interested in sundials for a few years, since he first saw the wonderful obelisk sundial by John Mylne at Drummond Castle Gardens near Crieff. His main sundial interest is in tracking down ancient sundials especially those identified by Thomas Ross. He can be contacted on *dennis@sundialsofscotland.co.uk* and has a website *www.sundialsofscotland.co.uk*.

His other main interest is in climbing all of Scotland's Munros (mountains over 3,000 feet). He is a member of the Cioch Mountaineering Club in Dunfermline and he has now climbed 231 of the 283 Munros. He was Treasurer and Webmaster of the Club for many years before standing down early in 2011 to give more time for his other pursuits.

Fig. 7 (left). The first missing dial. After MacGibbon & Ross.[1]
Fig. 8 (right). The second missing dial. After MacGibbon & Ross.[1]
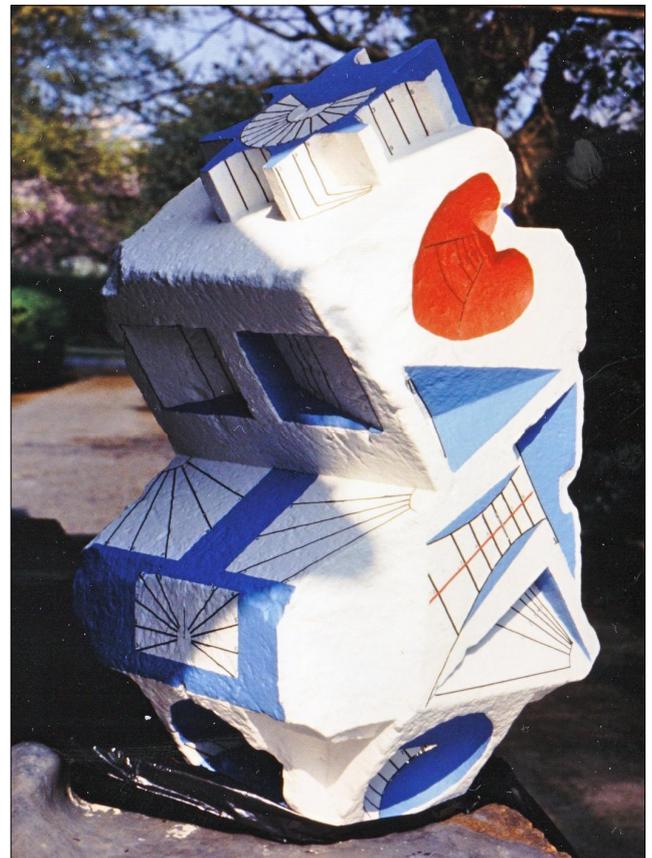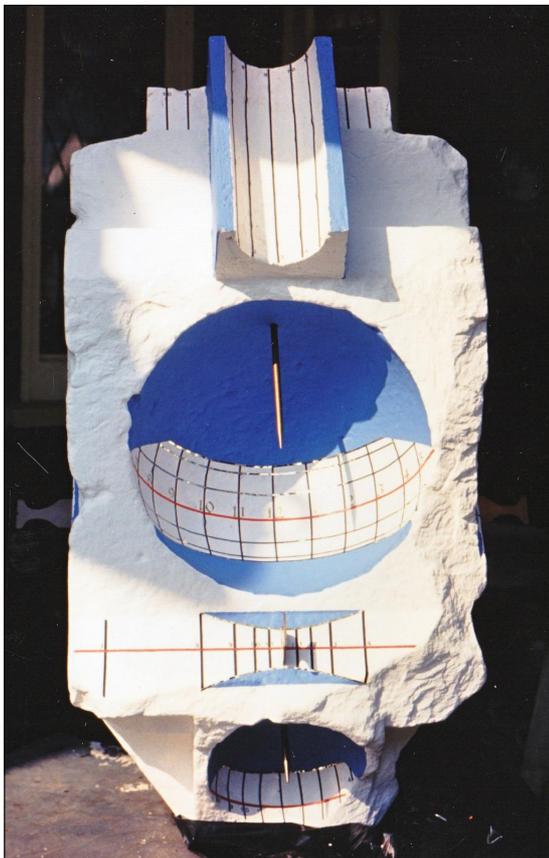
A PAINTED POLYHEDRAL DIAL

JOHN FOAD

Loudoun Castle in Ayrshire was the ancestral home of the Campbells of Loudoun, whose origins can be traced back to the 11th century. It is said that the treaty of Union between England and Scotland was signed under a tree in the castle grounds. After a troubled recent history, the castle was destroyed by fire in 1941 and it remains in ruins to this day. In 1985, a fine fully-featured polyhedral dial from the estate was given to Andrew Somerville for restoration, and eventually, after his death, found its way to Anne Somerville's home in Higher Poynton, Cheshire. Those of you who were at the Wyboston Conference may know it as the 'puzzle dial' that I showed on the back page of the *Recorder*; and I give my thanks to Robert Sylvester and others who alerted me to its identity (Fig. 1). I have since found that in 1990, Mrs Sheena Williams

Fig. 1. The Loudoun dial (SRN 1502) stripped of its paint.

from the Loudoun Estate restored the dial 'in 17th century colours' (see Figs 2 and 3). Some dials in the past were indeed painted. One of John Smith's books [see p.49, Ed.] gives details of colours and painting, and of course we have the Pelican dial in Oxford. Many church verticals were delineated in paint, and quite possibly some early mass dials. However, no other painted Scottish polyhedrals appear to be known, and someone seems to have had second thoughts on the propriety of the new restoration of the Loudoun dial. In 1992, George Higgs removed all the paint and re-engraved the lines, leaving the dial as I trust it is today. I say "I trust", as the dial was donated to the new Arboretum at Jodrell Bank Observatory around 1999, and currently the managers appear to have lost track of it. I hope it will be found. In Anne Somerville's report of the dial in 1995, she wrote "To be returned to Loudoun Castle if and when it is ever re-built".

Figs 2 & 3. The dial in all its painted glory, c. 1990.

MIND THE GAP – SUNDIALS AND LEAP YEARS

FRANK H. KING

Calendars are quite commonly found on sundials but they almost invariably ignore leap years. With a leap year about to begin, this article suggests how to accommodate 29 February. More controversially, it is noted that while 29 February may be the extra date *in a leap year it is not really the extra* day.

Introduction

Calendars on sundials are most often found alongside some representation of the equation of time but they can be associated with any astronomical observable that varies periodically with a period of one year; solar declination and solar longitude are two other examples. The representation of the astronomical observable may be in a variety of forms such as a graph, a table or a ruler-like scale.

There are three major design difficulties when trying to show how an astronomical observable varies with the time of year:

• Uncertainties about the calendar itself.
• Long-term changes in the relationship between an astronomical observable and the time of year.
• Short-term consequences related to the leap-year cycle.

Uncertainties about the calendar include how the very slow drift of the Gregorian calendar might one day be corrected. The abandonment of the leap second would introduce a new slow drift. The introduction of permanent summer time would be equivalent to shifting the calendar by one twenty-fourth of a day.

Fortunately, uncertainties about the calendar can safely be ignored. Sundial makers can reasonably assure their clients that the effects are very small and, if cumulative, won't show up during their lifetimes. The long-term changes to astronomical observables cannot be ignored quite so readily and some comments are offered below.

The leap-year cycle can be ignored only on low-precision representations of the calendar. On a calendar where each day of the year is indicated, one can sometimes read to a fraction of a day and more thought is required. The heart of the problem is that:

The period of the astronomical observables of interest is the tropical year whereas the calendar runs to civil years of 365 or 366 days.

The most common solution is to set out a calendar year of 365 days and somehow compress the tropical year to fit. Omitting 29 February is both inelegant and unnecessary.

Illustration I: The Equation of Time

Fig. 1 shows an equation of time scale that runs for the first half of the year and is set out as a quadrant. The figure is adapted from a reproduction of an early 19th-century sundial by Whitehurst of Derby. The reproduction was made by John Davis.[1]
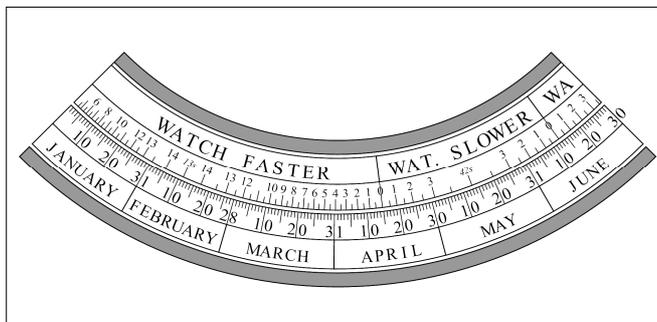

Fig. 1. Equation of Time scale (after Davis and Whitehurst[1]).

It is instructive to consider how this design might be set out using equation of time values which are appropriate for today. The task falls naturally into three stages:

1. Set out the date scale from January to June.
2. Set out the equation of time scale.
3. Align the first scale against the second.

The date scale

The date scale can be copied without modification but even this exercise offers a few surprises. Taking 28 days for February, there are 181 days in the period January to June but there are only 180 spaces in the date scale. There are though 181 tick marks delimiting these spaces.

The only reasonable interpretation is that each tick mark represents the middle of a day. This is consistent with the '30' of 30 June straddling the final tick mark. The second half of 30 June is off the end of the scale.

A pedant might ask whether the middle of the day means midnight or noon (recall that the GMT day[2] ran from noon to noon until 1925). It is assumed that each tick mark refers to noon and the centre of each space is implicitly midnight. Accordingly, the left-hand half of each space is the afternoon of one day and the right-hand half of each space is the morning of the next day.

Having 180 spaces is convenient because the tick marks are at exact 0.5° intervals and so can easily be set out using a large protractor.

The equation of time scale

The equation of time scale presents different difficulties. It is convenient to start with the mid-April zero as a reference datum ignoring, for the moment, the precise date to associate with this datum.

Using published tables or, these days, the Internet, the designer can set up a spreadsheet to show how many days (and fractions of days) there are from the reference datum to any value of the equation of time which is an integral number of half minutes.

The plan is to set out a sequence of tick marks at offsets either side of the reference datum. Each offset can be expressed in degrees simply by multiplying the offset in days by 0.5°. A long tick mark is placed at each offset that relates to a whole number of minutes and a short tick mark is placed at each half-minute sub-division.

There are additional tick marks for the extrema. In the figure, the mid-May extremum is shown as *42s*, indicating (from its context) 3m 42s.

The designer might usefully take stock when noting the offset of the mid-June zero from the reference mid-April zero. Using tables published for 2012,[3] the offset is about 58.5 days or 29.25°. In 2100, the offset will reduce to about 57.5 days and it will reduce to less than 56.5 days in 2200.

Users of the scale can certainly read offsets to a fraction of a day so a shrinkage of over one day per century is eventually going to be noticed. The long term doesn't seem quite so long. What should the designer do?

The simplest solution is to set out the scale so that it is correct when new and accept that it gradually goes out of date. If one can decide on a design life then the scale can be set out to be correct at the half-life point. Maybe the life-expectancy of the commissioning client can be discreetly estimated.

In the special case of a painted dial which needs major maintenance every 20 years or so there can be an upgrade with each repainting. The designer might leave instructions about what to do!

Alignment

The goal is to set out and align the two scales so that, at any stage in the leap-year cycle, the user can read corresponding values as accurately as one can relate inches to centimetres on a steel tape that shows both units side by side. This requires a little understanding of the effects of the leap-year cycle.

It is convenient to start by assuming that the tropical year is exactly 365¼ days. This simplified model will be refined later. The following table shows the approximate times of the mid-April zero from 2008 to 2012:

2008-04-15 05h
2009-04-15 11h
2010-04-15 17h
2011-04-15 23h
2012-04-15 05h

In each case, the zero falls on 15 April. In 2008, a leap year, the time was 5h and for each of the next three years the time slips six hours later. This accords with the assumption that the tropical year is six hours longer than a common year. In 2012, the extra day in February converts the six-hour slip into an 18-hour advance and the time returns to 5h.

The date scale in Fig. 1 has deliberately been drawn so that it can be used rather as the sliding-bar of a slide rule. With this fantasy design, the date scale could, in 2008, be set so that 5h on 15 April aligns with the zero. The bar could then be slid one-quarter of a day left in each of the next three years. In 2012 it would have to be slid three-quarters of a day right and would thereby return to where it started.

The February–March hiatus

All the tick marks on the sliding-bar slide together. This is appropriate for the tick marks from 1 March to 30 June but, in leap years, is inappropriate for the tick marks from 1 January to 28 February. The January and February tick marks are not affected by the extra day in February until the year following a leap year.

Accordingly, in leap years, the January and February tick marks should be slid one-quarter of a day left whereas the March to June tick marks should be slid three-quarters of a day right. The sliding-bar has to be cut so that, in a leap year, a gap of exactly one day opens up as shown in Fig. 2.
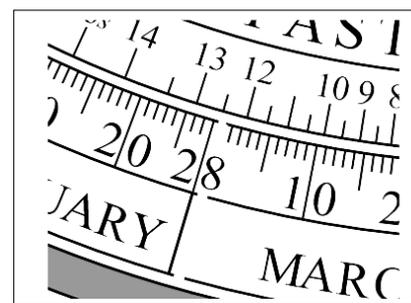

Fig. 2. One-day gap in the date scale.

Coming back to the reality of a fixed scale, the designer could resort to two lots of averaging. First, it is only in leap years that there is a gap; in common years there is no gap. On average, the gap is one-quarter of a day and the designer could therefore introduce a fixed gap of one-quarter of a day. With the introduced gap and with the scale for July to December appended too, the total length of the calendar will exactly match the (currently assumed) length of the tropical year.

Secondly, noting that over the years 2008 to 2011 the average time of the mid-April zero is 14h on 15 April, the designer should simply align that time permanently with the relevant zero on the equation of time scale.

Over the four-year cycle, this alignment would never be more than nine hours in error but with a little care it is easy to correct the error at any time of the cycle.

Reading to high-accuracy

One imagines an offset-arrow whose tail end is placed at a precise point on the date scale and whose head end indicates where the user should really be looking. The offset-arrow may point left or right but it will never be more than nine hours long.

At 11h on 2009-04-15 the offset-arrow would be three hours long and point right. The user would align the tail of the arrow with 11h and note that the head indicated 14h. The equation of time would then be read as zero which is the correct value at 11h on 2009-04-15.

The offset-arrow stays three hours long and pointing right from midnight at the beginning of 1 March 2009 to midnight at the end of 28 February 2010. The behaviour of the offset-arrow throughout a leap-year cycle is shown diagrammatically in Fig. 3. The figure shows a greatly enlarged and somewhat distorted view of two elements of the date scale: the half-days either side of 12h on 28 February and the half-days either side of 12h on 1 March. The inserted quarter-day gap separates these elements. There are two additional scales in the figure which show individual hours on 28 February and 1 March as well as the six hours in the gap.
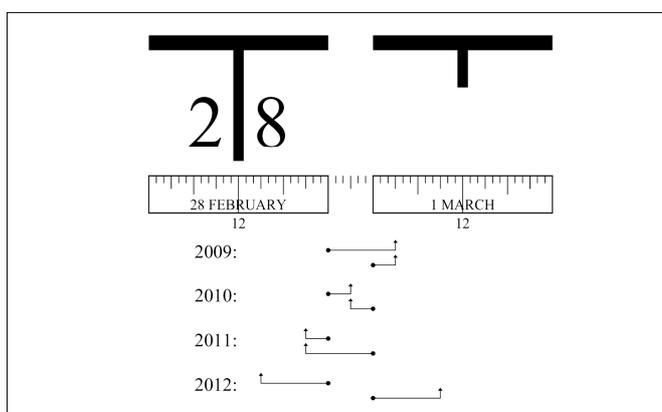

Fig. 3. Quarter-day gap in the date scale.

There are numerous arrows below the scales. The lower of the two 2009 arrows is the one just noted. It is three hours long and points right. Its tail is set to midnight at the beginning of 1 March 2009. This arrow holds good for exactly 365 days and is shown again as the upper of the two 2010 arrows where its tail is set to midnight at the end of 28 February.

Note that the head of the offset-arrow now points to the middle of the gap. This doesn't correspond to any date in 2010 but the corresponding (though unshown) value on the equation of time scale *is* valid in 2010.

The arrow then flips. It stays three hours long but points left. This is the lower of the two 2010 arrows. Its tail is set to midnight at the beginning of 1 March and its head still points to the middle of the gap. The two midnights coincide so the indicated equation of time should be the same. This arrow holds good until midnight at the end of 28 February 2011 where it is shown as the upper of the two 2011 arrows.

The arrow then becomes nine hours long and still points left. It is shown as the lower of the two 2011 arrows. This arrow holds good until midnight at the end of 28 February 2012 where it is shown as the upper of the two 2012 arrows where the tail is set to midnight at the end of 28 February.

The behaviour so far is easily understood. The head of the arrow has been smoothly cycling round while the tail of the arrow has jumped across the inserted gap on each occasion that it encounters the gap. Each jump has been from one representation of midnight to another representation of the same midnight and results in the arrow pointing six hours further to the left.

The two arrows in 2012 relate to two midnights which are separated by the whole of 29 February. By inspection, the tails of the two arrows are 24 hours apart. For these special 24 hours, the offset-arrow can be ignored. The centre of the inserted gap corresponds to 12h on 29 February and the 12 hours either side of the centre account for the whole day. During these 24 hours the equation of time can be read without any offset.

Midnight at the beginning of 1 March 2012 marks the start of another four-year cycle when the offset-arrow points nine hours right. This offset is 18 hours further to the right than it was 24 hours previously. The result is shown as the lower of the two 2012 arrows and holds good until midnight at the end of 28 February 2013 when its position is exactly as the upper of the two 2009 arrows.

Refining the Model

The tropical year is shorter than 365¼ days by a small amount and the inserted quarter-day gap should be shortened by exactly the same amount.

The quarter-day gap was justified by the argument that this was the average width of the gap over the four-year cycle. Over the full Gregorian leap-year cycle there are 97 leap years in 400 years so the average length of the gap is 97/400 days which is very close to the required value.

Within the precision that one may hope to read the scales, the simple model will hold good for a number of years but it will steadily become less satisfactory. The only simple remedy is to be more careful about choosing which time and date to align with the mid-April zero. Instead of using 14h on 15 April, the average time over the four-year cycle 2008 to 2011, the designer might consider using the average time over a four-year cycle around the expected mid-life of the instrument.

The behaviour of the offset-arrow is only a little different from the description given above but the differences are cumulative. The head of the arrow continues to cycle smoothly round but each common-year jump now results in the tail of the arrow pointing slightly less than six hours further to the left. In each leap year, at midnight at the beginning of 1 March, the offset of the arrow is advanced slightly more than 18 hours further to the right.

Readers are invited to consider what happens in the year 2100 which is not a leap year.

This steady drift is not easy to keep track of in one's head but the shape of the equation of time curve is itself changing and, by comparison, the vagaries of the Gregorian calendar are hardly of major concern.
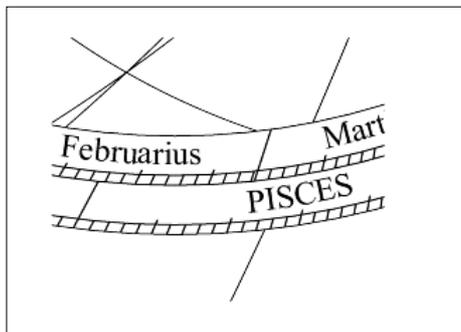
Fig. 4. Detail of the ecliptic ring of an astrolabe.

Illustration II: Solar Longitude

Fig. 4 shows a close-up view of part of the ecliptic ring of an astrolabe. There are again two scales with the inner scale being the calendar and the outer scale indicating solar longitude. The first 20° of Pisces are shown, corresponding to solar longitude running from 330° to 350°.

Solar longitude is another astronomical observable which has a period of one year. The sun travels the 360° of the ecliptic in just under 365¼ days, averaging slightly less than 1° per day.

The calendar in this example has days running from midnight to midnight and the fragment shown includes the last half of *Februarius* which concludes with a just-under-quarter day for 29 February. This short day serves exactly the same purpose as the inserted gap in the equation of time example.

Illustration III: Solar Declination

In the case of the equation of time and solar longitude, there is an implicit assumption that the user knows the date and wishes to read off the value that applies to that date.

A third astronomical observable which has a period of one year is solar declination and, since sundials can show solar declination directly, it is more common to use the declination to determine the date rather than the other way round. This invites a more imaginative way of depicting the calendar.
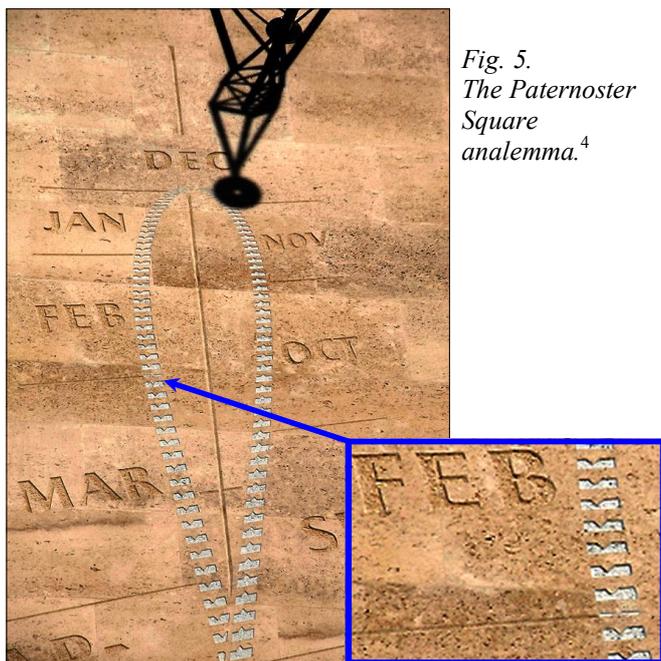

Fig. 5. The Paternoster Square analemma.[4]

Fig. 5 shows part of the large analemma on the Stock Exchange noon mark in Paternoster Square. The analemma itself is arranged as a calendar with a short strip for each day of the year. There is a specially narrow strip, just visible in the photograph, for 29 February.

The margins of the strips were carefully set out starting with the top of the 1 March strip. The solar declination at noon on 1 March 2003 was taken as a reference value and the top margin corresponds to this reference declination. The top margin of the 2 March strip corresponds to the declination 24 hours later and this margin marks the bottom margin of the 1 March strip.

The top margin of the 29 February strip corresponds to the solar declination at noon on 29 February 2004, exactly 365 days later, and therefore just under a quarter of a day before the declination returns to the reference value. Accordingly, the 29 February strip is much thinner than its neighbours.

For about 36 years (not far short of the design life of the building) the declination at noon on a particular date will correspond to a line drawn somewhere through the strip for that date. The 29 February strip is visited only in leap years.

When is Leap-Year Day?

Sometime after the Paternoster Square noon mark was completed, I received an unexpected e-mail[5] suggesting that 29 February was the wrong date to choose for the thin strip and that the correct date of the intercalary day is 24 February. To quote from the message:

> As far as I know nobody, at least in this country, has formally moved it from day 55 in the year (starting January 1st). In any case, who would have authority to do so?

This message could not be lightly dismissed. It was from John Chambers, former Head of the UK Time Service at the National Physical Laboratory, whose responsibilities included overseeing the broadcast of the Greenwich Time Signal. Some explanation is necessary!

The general arrangement of our calendar has been inherited from Roman times. The names of the months differ very slightly from the Latin equivalents and the lengths of the months are unchanged. The principal difference is the way a particular date is identified. Fig. 6 illustrates some terminology.

Feb.	22		
	23	VII	Terminalia
	24	VI	ante diem sextum kalendas martii
	25	V	ante diem quintum kalendas martii
	26	IV	ante diem quartum kalendas martii
	27	III	ante diem tertium kalendas martii
	28	II	pridie kalendas martii
Mar.	1	I	kalendis martii
	2		

Fig. 6. Part of the Roman calendar.

The main column of numbers shows the last week of February and the first two days of March as they might appear in a modern calendar. The Latin on the right shows how the Romans would have identified the dates from 23 February to 1 March.

The Romans counted dates backwards, rather as we talk of so many days before Christmas. Likewise, the display on the countdown clock currently in Trafalgar Square indicates how many days there are to go before the start of the 2012 Olympic Games.

The first day of each month was a major reference and, for the last few days of February, the Romans counted backwards from the first day of March. In Fig. 6 this scheme is indicated by Roman numerals and note that 1 March counts as I. There was no zero and the VI alongside 24 February indicates six days *up to and including* 1 March.

The Latin is now fairly easy to follow. The reference day *kalendis martii* translates as 'on the first day of March'. Pedants may note that *kalendis* is ablative plural. Rather as the English word 'scissors', the Latin for 'the first day of' is always plural. It is ablative to indicate 'on some point of time'. The word *martii* is, strictly, an adjective qualifying a hidden *mensis*. Together, this pair of words means 'of the martial month'.

Most of the dates shown begin with *ante*, a preposition which takes the accusative, so the ending of *kalendis* changes and *ante kalendas martii* means 'before the first day of the martial month'.

Following *ante*, there is an indication of how many days there are to go. Thus *ante diem sextum* means 'on the sixth day before'. Interestingly, *diem sextum* is accusative when it should strictly be ablative, *die sexto*, to indicate 'on some point of time' as with *kalendis*.

In pre-classical Latin *ante die sexto* was indeed written but, to Roman ears, the ablative after *ante* did not sound right and by classical times the case had changed, an early example of sloppy use of language!

The anomalous *pridie* simply means 'on the day before'. This leaves only *Terminalia* unexplained. Terminus was the god of boundaries or endings and 23 February each year was marked by a festival in his honour called *Terminalia*. When the Julian calendar was introduced, the day following *Terminalia* was deemed the appropriate place to insert the extra 24 hours required in leap years.

Instead of adding an extra day, the Romans deemed 24 February, in leap years, to be a single day 48 hours in length. This day was called *ante diem bis sextum kalendas martii*, with *bis* meaning twice.

It is this nomenclature which gives rise to the term 'bisextile year' found in the Book of Common Prayer. The curious 48-hour day was eventually recognised as two separate days but, importantly, it was the first of the two that was considered to be the intercalary day. A modern pedant might therefore write the dates of the last week of February in a leap year as:

23, 24', 24, 25, 26, 27, 28

Modern practice might be considered merely a relabelling:

23, 24, 25, 26, 27, 28, 29

This relabelling does not change the fact that 24 February is strictly the extra day if not the extra date.

It seems unlikely that many people are greatly troubled by the above analysis but in the late 1990s both Sweden and Finland formally enacted legislation to change the intercalary day from 24 February to 29 February.

One of the few manifestations of this change relates to the Saint's day for St Matthias. Finnish almanacs for 1996 show his Saint's day transferred from the usual 24 February to 25 February on account of the leap year but almanacs for 2000 show his Saint's day retained at 24 February. The Roman Catholic Church ducked this problem by moving the Saint's day to 14 May but that was to avoid occasionally having to celebrate St Matthias's Day in Lent!

Summary

Designers of sundials who wish to include calendars on their instruments should consider inserting a special short day to extend the year to match the length of the tropical year.

While most designers would consider that the right place to insert this short day is between 28 February and 1 March, super pedants should insert this short day between 23 February and 24 February.

REFERENCES & NOTES

1. Replica of the John Whitehurst dial, SRN 0612, stolen from Clumber Park (NT). It was made by John Davis (*Flowton Dials*) and exhibited at the 2010 BSS Conference before installation on the original pedestal. The EoT scale on the replica is actually based on a slightly later dial by Whitehurst & Son, now in Derby Museum.
2. *en.wikipedia.org/wiki/Greenwich_Mean_Time*
3. The equation of time values in this article were determined using the solar calculator provided by NOAA, the US National Oceanic & Atmospheric Administration, at: *www.esrl.noaa.gov/gmd/grad/solcalc*
4. Photograph by David Isaacs.
5. John Chambers: E-mail sent as a private communication on 23 August 2008.

For a portrait and CV of the author, see *Bulletin* 23(iii), Sept 2011.

☟

READERS' LETTERS

Drinkwater's challenge

In *Bulletin* 23(ii), June 2011, Peter Drinkwater asks for a formula to calculate the length of the horizontal shadow. I'm not sure this is what he is looking for, but it may help. Admittedly it doesn't look very graceful, but it gives (I hope) the right answer! Should anyone want an explanation of how I arrived at this formula please let me know.

For a given declination (δ) and latitude (φ) then the following formula gives the hour angle (h) at which the shadow of a gnomon on a scratch dial falls at 45°. Having found h, one can then calculate the altitude (a) and horizontal shadow length (L) in accordance with Peter's article.

$$\cos h = \frac{\sin 2\varphi \tan \delta + 2\sqrt{1 + \cos^2 \varphi - \sin^2 \varphi \tan^2 \delta}}{2(1 + \cos^2 \varphi)}$$

The results below can be compared with those in Table 2 on page 39 in the above-mentioned article (for $\varphi = 52°$).

Date	h	a	L
21 December	14.7	13.5	25.0
20 March	31.6	31.6	9.7
21 June	48.5	43.4	6.3

The general case, for a shadow at an angle G to the meridian, gives:

$$\cos h = \frac{\sin 2\varphi \tan \delta \tan^2 G + 2\sqrt{1 + \cos^2 \varphi \tan^2 G - \sin^2 \varphi \tan^2 \delta \tan^2 G}}{2(1 + \cos^2 \varphi \tan^2 G)}$$

Sue Manston
smanston@hotmail.co.uk

Peter Drinkwater counter-responds

I find the responses of Mr Lowne [in the June issue] and Ms Manston extremely invigorating: people exist who actually understand what I am on about – a new experience! But my 'challenge' – if such it was – was to 'translate' my 'solution' from the 'language' of plane geometry to the 'language' of abstract calculation.

Mr Lowne expertly analyses the problem, explains how it may be solved, and verifies the correctness of my drawing; but it stops short of providing an equation which would 'translate' it. Ms Manston equally expertly solves the problem without recourse to my drawing at all.

Both solutions are, of course, correct, and both agree with my own results; exactly what one would expect in the field of geometry "which is the only science that hath pleased God hitherto to bestow on mankind" (Hobbes). But the language difference remains. My own original solution was different again: a large-scale orthographic lemma with a plotted elliptical 45° curve drawn freehand. That such a crude method of working should yield such 'good' results is a marvel in itself.

It seems almost fortuitous that the base latitude (52°) should turn out to be that of Shipston. Perhaps the original observer was a monk at Evesham Abbey (itself an Anglo-Saxon foundation). If this was the case then it is surely of minor significance that one of the words used in the original manuscript is "forneah" (farnear), a word still current in our local dialect and often rationalized as 'so near and yet so far'.

Perhaps the whole business lies much closer to home than I first envisaged.

The Senior Sundial

I would like to know which is the oldest sundial in the British Isles which is still in its original place. 'Sundial' in this context would be scientific, excluding Saxon, mass, Roman, transitional and portable devices. As for place – sundials can be moved from their original position because of re-building, changes to a garden or estate, so providing the dial is at its original premises, that should be acceptable. As for repair or restoration, again, that would be good enough, but a replacement would not. I daresay various rules could be discussed further but I suggest we keep it straightforward.

The standard might be set by the Pelican dial at Corpus Christi College, Oxford, SRN 0989, positively dated to 1581. Unfortunately, the Fingask Castle dial, SRN 1566, Rait, Tayside, has a doubtful date of 1563 and may not be at its original place.[1] The BSS Register lists several good candidates, for example, in Suffolk, vertical south dials at Sternfield, SRN 3825, 15xx; Stutton Hall, SRN 4490, 158x; Thorington, SRN 1276, 15xx; Thorndon, SRN 3333, 157x; and in Warwickshire, vertical south dials at Ilmington (two), SRNs 1430 and 6514, both 15xx; and Shilton, SRN 4612, 15xx. In Wiltshire, I don't think there are any comparable with these – Stonehenge doesn't count!

Why would I like to know? Firstly, any facts we can find out about sundials are interesting, especially well-researched facts, together with the story of the background, the people and the environment of the dial. Secondly, the Register, an amazing knowledge bank, provides us with huge potential.

Perhaps members, especially Recorders, however modest, might like to give us the benefit of their direct face-on experience, through the Editor, thus generating further knowledge about sundials.

John Ingram, Wiltshire

1. A.R. Somerville: *The Ancient Sundials of Scotland*, London, pp.D2-43 (1994).

Sundial Crests

I notice that some families feature a sundial in their crests. Hart, a Scottish family, for instance, are said to have 'a sundial *or*, on a pedestal *gules*', while the family of Asklaby have 'a sundial on a pedestal', and Cuppage have 'a sundial *arg*'. I have been unable to track down an illustration of these crests, and I wonder if one of your readers can help, or indeed find other such armorial references?

John Foad

James Fairbairn, T C and E C Jack: *Fairbairn's Book of Crests of the Families of Great Britain and Ireland*, London (1905)
www.archive.org/details/fairbairnsbookof01fair

Organisational Changes

The *Newsletter* of September 2011 contains interesting reports by our new Chairman and new Secretary. Both clearly feel that numerous large changes are required in the way this Society is organised. The Secretary refers to a review already completed by him on possible changes. He has already shared this review with some members, and I hope that all members may soon read it - possibly an article in the Bulletin?

Changes in the existing methods can of course only be authorised by the members. This has previously been obtained by votes at the AGM at the annual conference. This conference normally attracts – at most – one fifth of members, many of whom leave before the AGM. The large changes forecast seem to need improved voting methods, such as postal and proxy voting.

The changes suggested will need approval by the Charity Commissioners. I was the Council member who negotiated and agreed our present Constitution with the Commissioners. One thing was always paramount in their thoughts – to be a charity, all BSS activities, knowledge and expertise should not be confined to the Society. All the Society's activities should be open to the whole community. However, this outreach did not have to be without charge to users.

The main activities of the Society now (*Bulletins*, publications, *Register*, conferences, dial safaris, Newbury meetings) have increased enormously the quality of their content and their organisation in the last decade. This has been possible with our present constitution and members.

The actual nature of the necessary changes have not yet been discussed and settled, and to talk of outside sources and their consequent costs (unknown) would seem imprudent in the light of the apparent financial difficulties. Furthermore, it could well turn out that the necessary skills required are already present in the membership.

Nick Nicholls, Dorset

Frank King responds:

I am happy to reassure members that no organisational changes or changes to the Constitution or, indeed, any changes that will need approval by the Charity Commissioners are being suggested. The purpose of the survey is to determine the views of the membership. These will be fed back and discussed at the next conference.

More on Dial Transmission

Like Chris Williams, I was delighted to see Peter Drinkwater's percipient and stimulating article on 'scratch dials' in *BSS Bull* 23(ii), 36-43, and the comments in the following issue (*BSS Bull* 23(iii), 37 & 44). The question of transmission evoked in both is a thorny one for while the transmission of the semi-circular dial with right-angle gnomon (what Sharon Gibbs calls 'protractor-dials') from secular Late Antiquity to early Christianity is clear, with good evidence for their existence, in the Christian Near East up to, and perhaps beyond, the 8th century, evidence for their survival in Chris-

tian North West Europe is much weaker and fails entirely between the mid-6th and the mid-8th centuries. This prompts the question of how such dials reappeared, particularly in Britain, from the late 8th century onwards. Some possibilities are suggested in my article 'A Use for the Sun in the early Middle Ages: the Sun-dial as symbol and Instrument', *Micrologus; Nature, Sciences and Medieval Societies*, xii 2004, 27-42, but like Peter Drinkwater I have failed to find any evidence that either Pope Gregory the Great or his successor Sabinianus (604-6) (usually the latter is designated), issued a decree ordering the use of bells and dials in churches in 606. Certainly no such decree appears in Philip Jaffé's *Regesta pontificum romanorum…*, 2nd edition, 2 vols, Leipzig 1885-88. If Coleman's reference cited by Drinkwater to 'John Stow' refers to the 16th-century antiquary then perhaps the origins of the legend are to be found in his works.

Chris Williams describes the water-clock as "inherently equal hour" as the mechanical escapement, while Peter Drinkwater considers it primarily a timer rather than a timekeeper. Neither is really the case. Although both water-clocks and weight-driven clocks more easily show equal hours, both can be adapted to show unequal hours as were weight-driven clocks in Japan from the late 17th/early 18th century onwards, as were the monumental water-clocks erected in Antiquity at Oropus and Athens, and as described by Vitruvius. Such water-clocks were definitely timekeepers being fitted with both aural and visual time-displays. Others, used in the law-courts, were however simply time measurers. Which of them was used for timing astronomical observations is uncertain.

Concerning the point about the variability of the clergy; a factor in the decline of scratch dials in the 17th century, alongside the linked development of more accurate clocks, watches and dials, may have been the rise in the intellectual and educational level of the clergy which occurred during this period. On Peter Drinkwater's final point that a classical dial showing equal hours is not known, there is one possible candidate. This is a spherical dial at Hever Castle in Kent, now mounted on a 1st century AD Roman altar with which it has no relation. It is drawn for latitude 37°, which corresponds well with Sorrento in Sicily whence it is supposed to derive. In their description of it F.A.B. Ward & D. Vaughan ('Sundials at Hever castle', *Antiquarian Horology*, xii, 307-12 1980) ascribe it to the 1st century AD and argue that it shows equal hours. If so it a unique, extraordinarily important, document in the history of dialling. However it is alone among 300 dials. It seems urgent that it be carefully re-examined.
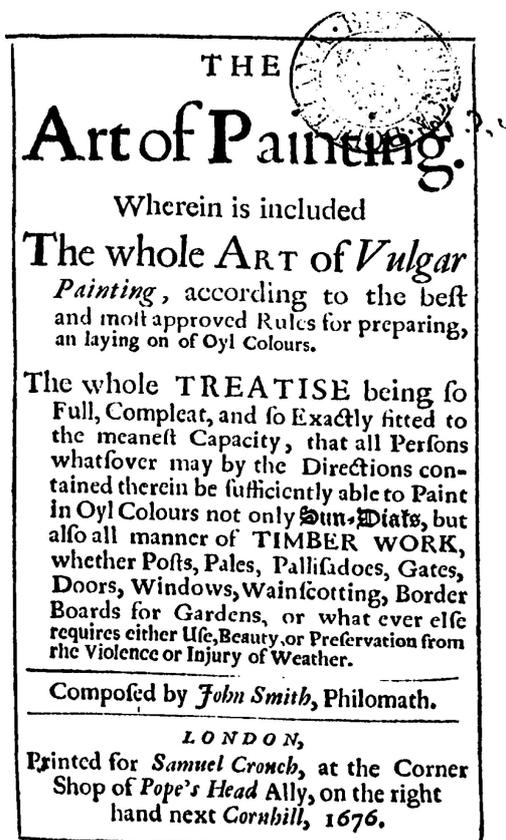
Anthony Turner, Paris

[An article on the Hever dial is due for publication in the next issue. Ed]

THE ART OF PAINTING SUNDIALS

Painted sundials are discussed in two articles in this issue, dealing with both mass dials and the Scottish polyhedral variety. Of course, painted wooden dials are quite common but the details of stone dials are rather unclear.

A book entitled *The Art of Painting*, published in 1676 by John Smith (philomath) throws some light on the subject. An enlarged edition, called *The Art of Painting in Oyl* was published in 1687. Although it tries to cover all sorts of painting, it is clear that the author really has sundials in mind but has tried to maximise his readership. Much of the book is concerned with the preparation of the paints, burning and grinding various pigments before mixing them with linseed oil. Methods for preparing wooden boards and plastered brick walls are also described. For stone dials, Smith advises "If you are to work on a Stone, the best way is to drench the Stone with Linseed-Oyl till 'twill drink in no more, then shall whatever you paint on it, be better prepared against the ruins of time."

The colours which are suggested are:

* Lamp black – for the figures if not "guilded"
* Spanish brown – for priming the surface
* Red lead
* White lead – for the top surface of the background
* Willow charcoal or sea-coal
* Vermillion (scarlet) used for hour-lines
* Lake – a crimson colour

* Smalt ("blew") used for dial margins if the numbers are "guilt"
* Blew Bice – a pale blue for backgrounds
* Blew Verditer – to make a green when mixed with yellow
* Judico – a very dark blue
* Umber – a pale background when mixed with white, or burnt in a "crusipple" to give a shadow for gold
* Verdigrease – green or blue-green
* Yellow Oaker
* Pink Yellow "inclining to a green"

Smith gives much practical advice for laying out the dial (including offsetting the origin of a declining dial from the centre of the plane), painting and gilding. For repainting dials, he recommends stripping the surface and laying out the dial afresh after remeasuring the wall declination. Whilst this is quite good advice – often ignored – his reasoning shows a major misconception. He says: "... so that a Plain that stood full South 30, 40 or 60 years ago shall now decline some degrees either to the East or West, according to the nature of the Earths motion"! Whether this is due to an incorrect understanding of magnetic variation or just the inaccuracies of earlier dialmakers is unclear.

JD
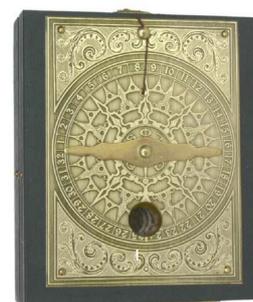
BSS Newbury Meeting – 24 September 2011

Frank Coe

A new location this year — Sutton Village Hall, Stockcross, near Newbury, but as usual, expertly organised by David Pawley and his helpers. About 34 members and visitors attended on a fine day, but with intermittent sunshine which didn't always help members exhibits set up in the garden outside. As usual Peter Ransom acted as MC and introduced the programme for the day.

The first talk was by John Davis who described "A Norfolk Horologium" found by metal detection in a field. (Apparently Norfolk is one of the best areas in the country for such finds.) About the size of a £2 coin, it has an engraved front with what could be a gnomon hole in the centre, a 16pt compass rose with perimeter lettering. The question of whether it was a horizontal or equinoctial dial and whether it dates from before 1400 will possibly be clarified by planned chemical analysis of the metal (see next issue).

On his first visit to a Newbury meeting, Woody Sullivan from Seattle described "Ceiling Reflection Dials", often illustrated in books but now only existing in a few examples: Palazzo Spada and Trinita dei Monti—both in Rome—and the Lycee Stendahl in Grenoble. From these Woody had been inspired to create his own dial on the angled ceiling of his workshop/study. With the help of an artist friend he showed through many illustrations how this was done to record, not only the expected astronomical lines and points, but also many other commemorative points of a family nature.

Martin Birdseye then described the forming of a large ceramic pot with an internal gnomon, various jigs for scribing the declination lines in the wet clay. This was destined for the Canadian Clock Museum at Deep River but he was unprepared for the Museum request for it to be demountable from its metal supporting pillar and also vandal-proof. This was eventually accomplished and, in answer to a question, Martin confessed to being a fan of stainless steel crinkle washers to avoid cracking when clamping ceramic to metal.

A plea for "A sense of fun on a serious subject" was the title of Michael Maltin's description of a scheme to illustrate the scale and size of the solar system for school children and the general public. He showed that something the size of a cricket ball and a plane the size of a football pitch would do the trick but even then many of the planets would only be pinheads – nicely revealing that most of the solar system is empty space. Several members were provoked to recall similar models on public display to achieve the same purpose.

After lunch, Frank King entertained us with "Mind the Gap - Sundials and leap years". He reminded members of the difficulties of devising calendars and setting out analemma diagrams on stonework. It all seems to boil down to where the extra day in a leap year is inserted. Is it the 29th of February as most of us believe, or should it be after the 24th of February? The arguments are quite involved but fortunately Frank's paper is on page 42 of this issue where we can study them at leisure.

In "Repairing Mrs Gatty", Peter Ransom had taken a bookbinding repair course to learn how to rescue his disintegrating copy of the famous sundial book. He took us through the various steps and showed the completed repair. I for one felt that, "Yes, I could probably learn to do that".

"Lifting a sundial into place" is probably something most of us have done at one time, but as Mike Groom reminded

us, it can be a serious matter when the stone is too heavy to lift. In his case, a transom, pulley blocks, lots of carpeting and a magic monofilament called Spectra as a replacement for stainless steel eventually did the trick without injury.

Plans to collect details of War Memorial dials were described by Tony Wood. The Imperial War Museum list will be used but it is thought not to be exhaustive.

The final talk of the day was given by Geoff Parsons on the subject of heliochronometers. The original Pilkington and Gibbs instrument was manufactured from about 1906 until 1920. As a result of a dispute between the two men, production stopped but then Pilkington

introduced the 'Sol Horometer' which Gibbs regarded as "ugly" but was easier to operate in low light conditions.

After the talks, conversations begun over lunch were concluded and the exhibits examined. Elspeth Hill had brought along

the normal bookstall and a number of interesting items were on display, including a (very heavy!) cross dial brought by David Pawley and an ingenious 'analogue computer' for the equation of time by John Foad which featured an elastic band as the cursor. This neatly showed the combination of the two components, tilt and ellipsicity. Chris Lusby-Taylor had a pair of scaphe dials and schemes for mounting mirrors at precise angles. Some of these items can be seen in the pictures.

Chris Williams, Sue Manston, Geoff Parsons, Mike Isaacs and John Moir inspect a pair of shiney heliochronometers. (The candle is part of the outdoor décor, not a candle-clock!)

Left to right: Margery Lovatt, Pat Sedgwick, Doug Bateman, Tony Belk and Ian Wootton.

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