A MEDIEVAL EQUINOCTIAL DIAL EXCAVATED AT ST JAMES'S PRIORY, BRISTOL

JOHN DAVIS and CAI MASON

There is a distinct lack of medieval 'scientific' sundials in England (defined here as dials with polar-aligned gnomons delineated to indicate equal hours). However, recent archaeological investigations at St James's Priory in Bristol have uncovered a fragment of stone which has been identified as part of an equinoctial (or equatorial) dial for the local latitude and showing equal hours in the summer half of the year, labelled with Arabic numerals of medieval form.

St James's Priory

St James's Priory is located in what is now central Bristol, just south of the bus station.[1] It was founded in 1129 as a Benedictine cell of Tewkesbury Abbey. During the medieval period the nave was used as a parish church. The surviving west (parish) end of the church originally comprised a nave and two narrow aisles. The church retains many of its original Norman features; these include arcades in the nave with circular piers, and an un-restored wheel light and arcading on the west frontage. The cloisters (a small part of which survive towards the rear of 'Church House') and a southern extension to the south aisle (extant) were probably both built in the 14th century. A tower on the south side of the church was added in 1374.

When the priory was dissolved in 1540 during Henry VIII's dissolution of the monasteries, the nave was retained for use by the parish (now St James's Church, Grade I Listed), while some buildings of the priory complex, including Church House, were converted into dwellings. Further modifications were carried out in each of the following centuries, as is shown in Fig. 1 which colour-codes the different phases. The arrow on the top-left of the plan shows the direction of view in Fig. 3.

The south aisle was heavily modified in 1698. Millerd's map of 1673 (Fig. 2) shows a large porch on the south side of the church; this porch was demolished in 1802, to be replaced by the present structure. In 1864 a major renovation programme was undertaken. This work included demolishing some parts of Church House (the surviving part of the building is a Grade II* listed structure), and replacing the medieval north aisle with a new, wider aisle. The central arcade of the new aisle follows the line of the old north wall.

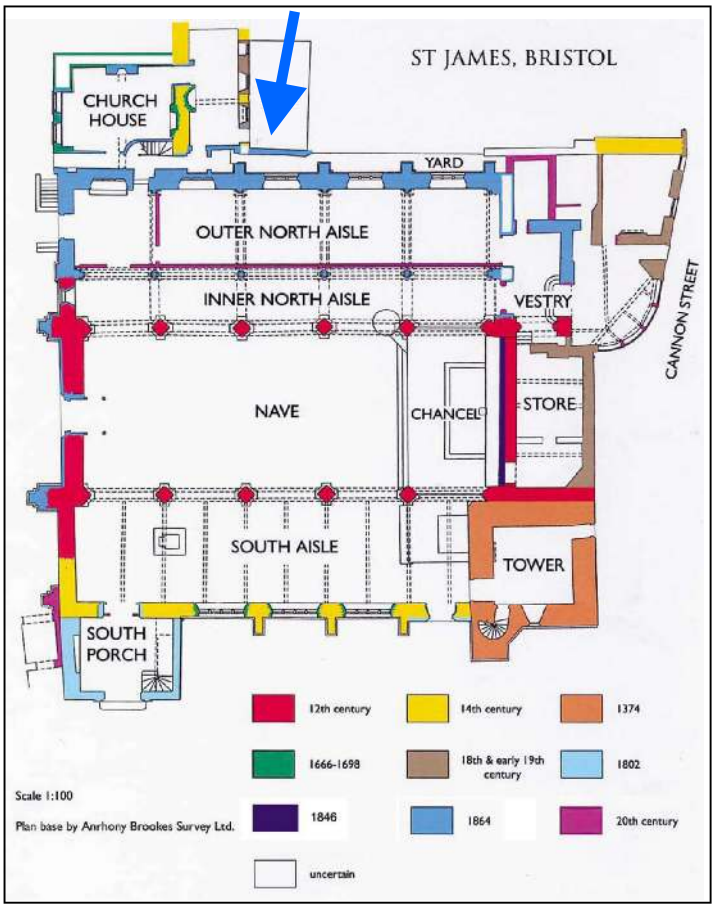

Fig. 1. Plan of St. James's Priory church showing various building phases (colour-coded). The blue arrow at top-left shows the direction of view in the photograph of Fig. 3. Drawing courtesy of St James Priory.

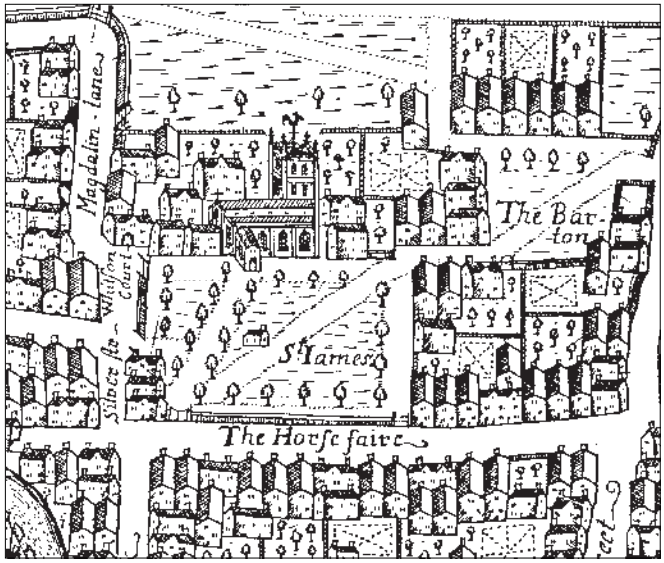

Fig. 2. Section of Millerd's map of 1673 showing the Priory from the south.

Fig. 3. The opening on the Victorian N wall in which the dial was found as rubble infill. The arcades on the right side of the picture are the remains of the medieval cloister (incorporated into the later Church House).

Worship at St James's Church ceased in 1984 and it has been open for quiet contemplation since the 1990s. The St James Priory Project has recently renovated the church.

The Excavation of the Dial

As part of the St James Priory Project, Bristol and Region Archaeological Servics (BaRAS) undertook an archaeological watching brief of the site over the period 2008–11 on behalf of the Project and its architects, as required by the planning consent for a major redevelopment.[2] One aspect of the work was to open a set of three apertures underneath windows in the 1864 north wall of the outer north aisle (see the plan of Fig. 1 and the photograph of Fig. 3). This revealed that the interior of the wall incorporated several re-used fragments of worked stone which probably originated from demolished parts of the priory. All of the fragments were carved in Bath stone (oolitic limestone) which is distinct from the largely sandstone Victorian wall, and included window mullions, other mouldings and a fragment which was later identified as part of a sundial. Considerably less than 5% of the interior of the wall was exposed so the finding of the dial was extremely lucky.

The Dial

The fragment of the sundial can be seen in Figs 4, 5 and 6. It is quite small, approximately 160 × 115 × 90 mm, and in the form of part of a rough cube with the face chamfered-off at an angle of around 38°.

With only part of the dial extant, some thought is needed to be able to visualise its original appearance. To be used as

Fig. 4. Photographs of the sundial fragment. Top: front view. Bottom: side view with fragment resting on the worked bottom face and a with cardboard template.

an equinoctial (equatorial) dial, the angled block needs to be set on a horizontal surface such that the angled face is at the co-latitude for the location. Bristol is at 51° 27.5′ N so that the face of an equinoctial dial is at 38.5° to the horizontal. With the block oriented like this, the '6' line lies horizontally and represents 6pm.

A speculative reconstruction of what the complete dial may have looked like is shown in Fig. 7. In this picture, the flat, worked surfaces of the fragment, other than the circular face, are located at the base, the top, the left-hand side and the rear; all other surfaces are broken.

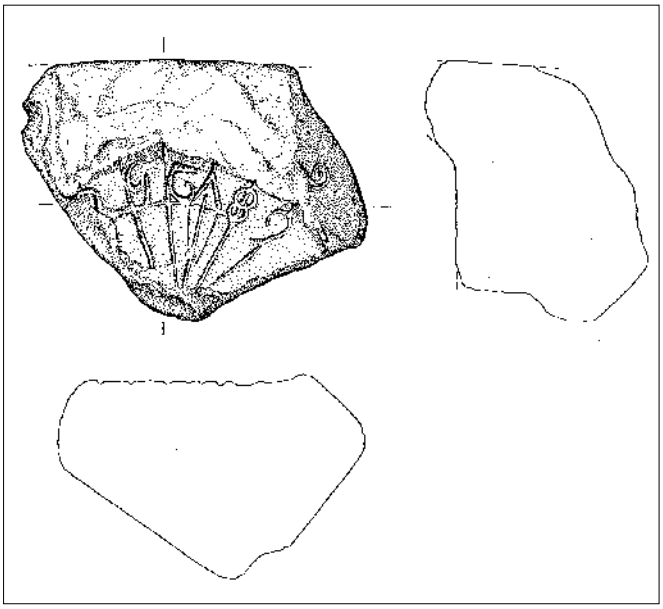

Fig. 5. Drawing of the sundial fragment. © BaRAS, drawn by Ann Linge.

A circular area of about 150 mm diameter has been slightly recessed in the chamfered plane and forms the dial face. This area shows traces of a reddish colouration. A set of radial lines is clearly engraved in the face and these are equi-spaced at 15° intervals as is shown by Fig. 6, taken with a transparent template over the dial. The centre of the circle is unfortunately missing but its approximate position can be estimated from the template and the accuracy of the delineation seen. The lines are numbered clockwise 4, 5, 6, 7, 8 and 9 although part of the figure '4' is missing. Note that there is no line for '10' although Fig. 5a shows that at least part of the numeral '10' would have been visible on the fragment if it had been part of the original design. The form of the numerals is medieval and is discussed further below. Additional engraving takes the form of a small circle with a central dot on the upper worked face adjacent to the '9', and two almost-radial lines lightly cut approximately midway between the 6 & 7 and the 7 & 8.

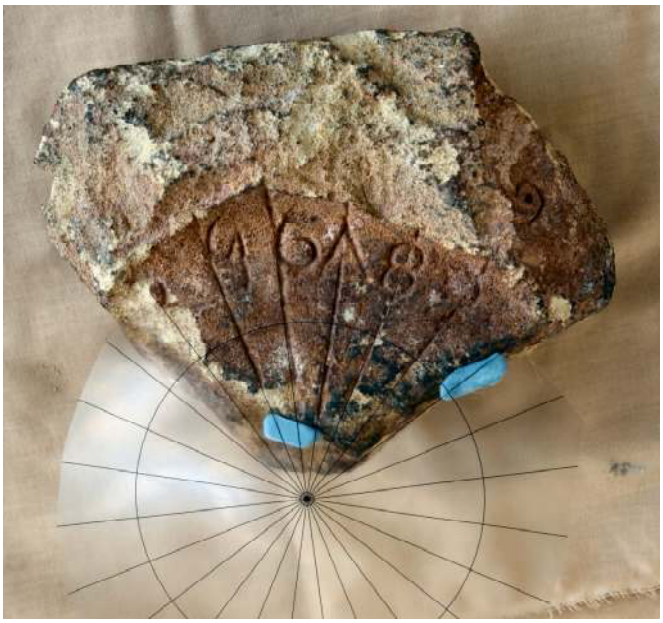

Fig. 6. Photo of dial face with a transparent equi-angular template attached.

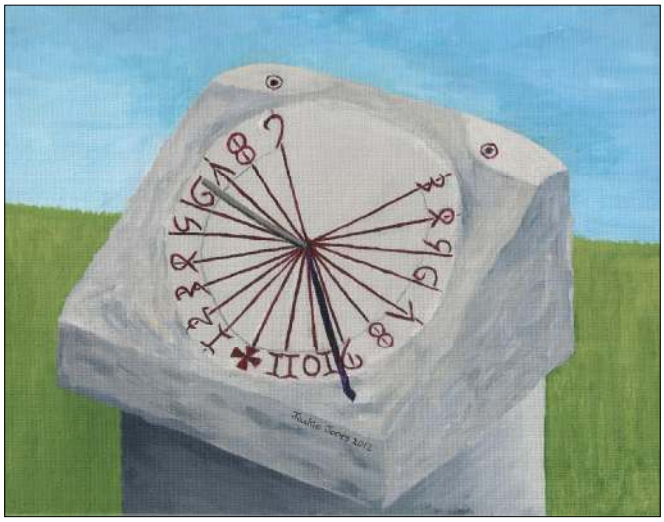

Fig. 7. Artist's impression (by Jackie Jones) of what the dial may originally have looked like.

On the grounds of symmetry, the drawing of Fig. 7 has speculated that there was a second dot-and-circle in line with the 3am mark. These dots are not features known on other dials but would have been aligned in the E-W direction and thus may have been related to the direction of the equinoctial sunrise and sunset directions.

The red colouration of the dial face and some other surfaces is most likely to be the result of long exposure to weathering, though it is just possible that the dial face was painted. Broken surfaces of the fragment, presumed to have been broken just before being encapsulated in the wall, have a rather lighter off-white colour.

The dial depicted in Fig. 7 would only have operated in the summer half of the year when the sun's declination is positive. Presumably, a second 'winter' dial would also have been required but there is no evidence to allow a speculative design – it could have been a separate structure or somehow built into the same stone, as on the much later Scottish sundials. In fact, the dial would have operated for rather less than half the year as the recessed dial face would have made it difficult to see the gnomon shadow on the actual face until the declination was several degrees above the equator. Note, though, that the hour-lines seem to continue up the inside rim of the face to minimise this limitation.

The dial is imagined in Fig. 7 as standing on some form of pedestal with the chamfered surface facing north. It is possible, though unlikely, that the dial was attached to a south-facing wall but if this were the case the wall itself would have restricted the period when the dial could operate to times when the sun's azimuth was within 90° of South. Another possible location would have been on a south-facing buttress.

Dating the St James Dial

The dial fragment is not explicitly dated and so its age can only be estimated from other clues, particularly the context of its discovery and the style of the engraving. The rubble in which it was found is clearly of a medieval nature and so its identification as coming from demolished parts of the Priory date it securely to before the dissolution, i.e. pre-1540. But it is the form of the numerals which provides more detailed evidence. The use of Arabic numerals in Europe only became widespread after Leonard of Pisa ('Fibonacci', c.1170–c.1250) wrote *Liber Abaci* in 1202 (re-published in 1228) and even then their use tended to be restricted to technical writings. The individual numeral forms evolved dramatically over the following centuries and did not take on a fully 'modern' appearance until the early 16th century.[3] The numerals which persisted for the longest with non-modern forms were 4, 5 and 7. In addition, the shapes of the '6' and '9', which tended to have a generally recognisable modern form, were stylistically different in that they originally had sweeping horizontal tails.

The numerals 4, 5 & 7 on the St James dial have forms which compare quite closely with those found on the 'Norfolk horologium' described recently[4] and also to be found in the manuscript of Robert Stikford[5] and the Kalendarum of Nicholas of Lynn,[6] the latter being dated to 1386. These particular forms remained in use for over a century and so the St James dial is most likely to date from the late-14th or the 15th century.

The choice of Arabic rather than Roman numerals for the dial is in itself significant. It took a long time for the Arabic system to become standard in England – merchants in the Elizabethan period often still compiled their accounts (with some difficulty!) using Roman numerals. The use of Arabic numerals in the medieval period implies an educationally-advanced, and probably scientific, designer. Church sundials from the 16th century, designed for use by the common populace, normally used Roman numerals. So it appears that the St James dial was made for, or by, someone familiar with the latest manuscripts on mathematics and astronomy and was intended to be read by similarly-educated people.

Early Scientific Dials in England

The earliest reliably-datable 'scientific' dial in Britain is the stone polyhedral originally made by Nicholas Kratzer for Iron Acton. This dial is coincidentally also now in Bristol and was made quite soon after Kratzer first came to England in 1518.[7] It features Arabic numerals although it is wrongly delineated. Kratzer brought his knowledge of dial-making, derived from 'old manuscripts' he copied in a Bavarian monastery, with him. It is sometimes thought that scientific dials were unknown in England before Kratzer but, whilst he can be credited with popularising dials here, they were definitely known before this – both manuscripts[8] and excavated instruments provide the evidence.[9]

The Introduction of Equinoctial Dials to Europe

Small brass equinoctial dials exist as part of pocket compendia found both in England and continental Europe throughout the 15th century. The basic components of these compendia (a magnetic compass, a folding equatorial ring held at the co-latitude by an extended gnomon and a lid featuring a primitive nocturnal) are unchanging but variations in the sophistication of construction and size, together with their metallurgy, points to their having been made by numerous centres.[10] This is quite different from the concentration of manufacture of the later ivory diptych dials in Nuremburg. However, monumental stone examples of this class of sundial from medieval Europe were unknown until the St James Priory find.

According to the eminent astronomer and historian of astronomy Ernst Zinner (1886–1970),[11] the first explicit mention of an equatorial dial in Europe is due to the astronomer Nicholaus de Heybech, writing in Erfurt in 1431.[12] Zinner refers to this in one of his early notebooks[13] where he derives his information from a manuscript MS 683 at the working monastery of Klosterneuburg, near Vienna. The reference to equinoctial dials appears at the end of a fairly standard description of an equal-hour wall sundial and so is not the first definition of a polar-pointing style. A full analysis of the manuscript, which is not explicitly dated nor signed by Heybech, is ongoing.[14]

Equinoctial dials are thought to have been known in classical antiquity but were very rare. Schaldach has described a two-sided marble equatorial dial, originally from Amphiareion near Athens, which he dates to between 350 and 320 BC.[15] Another possible example is the dial depicted in the Roman mosaic of the villa at Brading, Isle of Wight, though it is also possible that this rather unclear image actually shows some form of hemicyclium.[16] It never became popular, though, and appears to have been unknown in the early medieval period in Europe.

In Britain, there is a small corpus (less than 10) of unattached slate or stone dials which have 15° markings, sometimes with Roman numerals, which are usually interpreted as either horizontal mass dials with vertical rod gnomons or the more common vertical mass dial.[17] The best-known examples are from Crowan, Cornwall, and Nendrum, Ireland. Although these could perhaps represent equatorial dials, the fact that they are single sided (despite being on relatively thin slabs) and have hour lines for a full 360° makes it unlikely that they were ever intended to have been placed at the co-latitude angle with polar-aligned gnomons and thus the interpretation as sophisticated mass dials remains the most likely.

It is perhaps significant that St James Priory followed the Benedictine order. The 'Rule of St Benedict' meant that timekeeping was particularly important to their establishments. St Alban's Abbey, home of the late 14th century monk Robert Stikford who wrote on advanced equal hour sundials without using a polar gnomon, was also Benedictine.[18]

Conclusions

The St James's Priory sundial is a major find and means that Bristol now has the two oldest 'scientific' dials in Britain. Its survival and discovery were remarkably fortuitous. Although it is not possible to date it exactly, it reinforces the growing awareness that equinoctial dials were a key early step in the development of scientific dials in early 15th century Europe. It is frustrating to wonder what other potential finds remain as infill rubble in the priory walls!

ACKNOWLEDGEMENTS

We are grateful to BaRAS for permission to quote extensively from their report (ref. 2) and to Ann Linge for preparing Figs 2 and 5. Jackie Jones kindly made the artist's impression of Fig. 7. Susan Jotcham (St James Priory) is thanked for Fig. 1. Tony Wood and Graham Aldred (BSS) helped in identifying the fragment as a dial.

REFERENCES & NOTES

1. The site of St James Priory is in central Bristol (BS1 2LU, NGR ST 58895 73470), and is bounded by St James Parade to the south, Cannon Street to the east, Whitson Street to the west and Bristol Bus Station to the north.
2. For a full report of all the excavations on the site, see Cai Mason: *Archaeological Watching Brief & Building Recording during alterations at St James Church, Bristol for St James Priory Project*. BaRAS Report No. 2112/2011, BHER No. 24820 (Sept 2011).
3. For a range of numeral shapes found in manuscripts from the 12th to the 16th centuries, see for example Adriano Cappelli: *Lexicon Abbrieviaturarum...*, Hoelpli, Milan (1899) pp. 380-385. Also available as a modern facsimile.
4. J. Davis: 'A Portable Horologium', *BSS Bull.,* 24(i), 18-22 (Mar 2012).
5. J. Davis: 'Robert Stikford's De Umbris Versis et Extensis', *BSS Bull.,* 23(iv), 24-28 (Dec 2011).
6. S. Eisner (Ed.): *The Kalendarium of Nicholas of Lynn,* Scolar Press, London (1980). An illuminated page of the *Kalendarium* is on the British Library website.
7. For Kratzer, see J.D. North: 'Nicolaus Kratzer - The King's Astronomer', in E. Hilfstein et al. (eds), *Science and History. Studies in Honour of Edward Rosen*, Studia Copernicana, 16 (1978), 205-34. The Iron Acton dial is currently on display in the Bristol Museum & Art Gallery.
8. J. Davis: 'A Very Early Description of a Horizontal Dial in English', *BSS Bull.,* 24(ii), 24-28 (June 2012).
9. One possible scientific vertical dial in the form of a ceramic tile is from St Augustine's Priory, Canterbury, SRN 5891.
10. An example is shown in an illustrated manuscript c. 1450 (a French translation of Henry Suso's *Horologium Sapientae*, now in the Bibliothéque Royale de Belgique, MS. Bruxelles, B.R.IV, f. 13v). Another illustration is the famous etching by Urs Graf, c. 1507, 'Man with a sundial'. A discussion of the various known examples in England and Europe was presented by J. Davis, 'Excavated Sundials', presented at the 2012 BSS Conference, Cheltenham (t.b.p.).
11. E. Zinner: *Deutsche und Niederländische astronomische instrumente des 11-18 jahrhunderts*, Beck'sche Verlagbuchhandlung, Munich, (1956).
12. For an early description of Nicholaus Heybech (there are many variant spellings) see Lynn Thorndike: 'Nicholaus de Heybech of Erfurt', *Isis*, 39, pp.59-60 (1948). There is some online information on him at *http://naa.net/ain/personen/show.asp?ID=79.*
13. Ernst Zinner: *Verzeichnis der astronomichen Handschriften des deutschen Kulturgebietes*, C.H. Beck, Munich, (1925).
14. We are extremely grateful to Ronald Salzer, University of Vienna, for obtaining images of MS Klosterneuburg 683. The reference to an "*annulus*" is on f. 96r, lines 27-32.
15. K. Schaldach: 'The arachne of Amphaireion and the origin of gnomonics in Greece', *J. Hist. Astron*., xxxv, 435-445 (2004).
16. For a picture of the Brading mosaic dial, see J. Bonnin: 'Symbolic Meanings of Sundials in Antiquity: Introduced by an explanation of ancient timekeepers', *BSS Bull*., 23(i), 6-10 (Mar 2012).
17. A.O. Wood & F. O'Carroll: 'A Celtic quartet', *BSS Bull*., 20(ii), 84-87 (Jun 2008).
18. See ref. 5.

Cai Mason is a professional archaeologist with 10 years experience. He is currently employed by Bristol and Region Archaeological Services and can be contacted at *Cai.Mason@bristol.gov.uk.*

For a biography and portrait of **John Davis**, see *BSS Bull.* 23(ii).

Holbein's Cylinder Dial

There are many depictions of cylinder (or shepherd's) dials from the Roman period onward. What makes this one special is that it was drawn by Hans Holbein the Younger, between 1532 and 1543. Holbein was Henry VIII's court painter and a friend and countryman of the king's horologist Nicholas Kratzer, so it is possible, even probable, that the image is of a real dial which Kratzer had made or was planning to make. The image is from Holbein's *Jewellery Book.* (Other examples of Holbein/Kratzer collaborations are the famous painting *The Ambassadors* and the Sir Anthony Denny clocksalt (see *BSS Bull.*, 21(iii) p. 45.)

Curiously, this image has been cut out around the dial's outline, as though it was destined to be used as part of a larger composite drawing. Another interesting feature is that the months Se, Oc, No at the bottom of the cylinder are written right-to-left, to show the direction the scale is running.

Image courtesy of the Trustees of the British Museum. Reg no. SL,5308.148

JD