AN EXCAVATED LEAD SUNDIAL

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Excavated sundials are an under-used resource in researching the development of horology.[1] They offer a different perspective on the development of everyday time-keeping to the carefully preserved sundials found in museums, on churches, and in aristocratic residences and gardens. A good example is the small lead sundial reported here.

The Find

The object shown in Figs 1 & 2 was found in July 2012 by the metal detectorist David Beaumont while searching for a lost wedding ring. It was located a few inches under the topsoil of a small uninhabited island in the middle of the River Avon as it passes through the village of Barford, just outside Warwick (see Fig. 3). After the find was shown to the local representative of the Portable Antiquities Scheme,[2] I was quickly able to identify it as a sundial.

The Sundial Details

The sundial is evidently made of lead and is 51.5 ± 0.5 mm in diameter (a nominal 2 inches) and 3.5 ± 0.2 mm (a nominal one-eighth inch) thick. With a weight of 76 g, it is quite robust. A scribed line around the perimeter, partly cut away, shows that it was marked out and cut from a sheet. The edge has a slight slope of a few degrees (smaller diameter at the top) which suggests that it was cut with shears rather than a chisel. A small hole penetrates the centre, slightly less than 1 mm in diameter though it is far from truly circular.

Fig. 1. Photograph of the Barford lead sundial.

The back of the dial is blank. On the front surface, there are two concentric circles and the 'hour-lines' indicated in the figures. Most of these lines terminate in a small pock on the inner circle which indicates how they have been set out, though one or two lines miss their pocks slightly. In the annulus between the circles, the lines are numbered 6, 7, 8, 9, 10, 11, 12, 1, 2, 3, 4, 5, 6 running *anticlockwise* and starting at the right in Figs 1 & 2. Due to corrosion and mechanical damage, not all of these numerals, which are orientated towards the inside of the circle, are clearly visible. It is apparent that the straight line elements of the numerals were engraved rather deeper than the curves.

The angles of the hour-lines, measured from the central diameter (the noon line) are shown in Table 1. Although they are not precisely symmetrical about noon and there is significant variation in the spacings, the strong impression

Time am (*hours*)	**Hour-line angle** (*degrees*)	**Hour-line angle** (*degrees*)	**Time pm** (*hours*)
6	–91	89	6
7	–76.5	75	5
8	–61.5	61	4
9	–47	46	3
10	–28	33	2
11	–14	18	1
	0		

Table 1. Measured hour-line angles, with respect to noon.

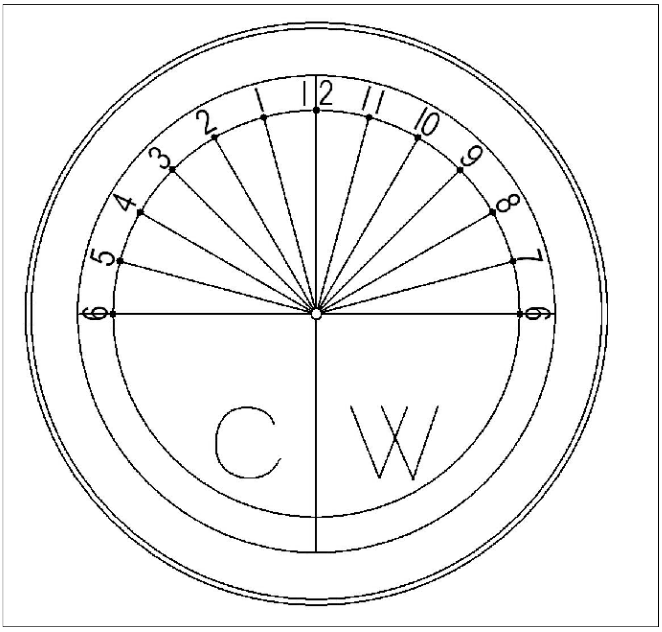

Fig. 2. Idealised drawing of the Barford sundial.

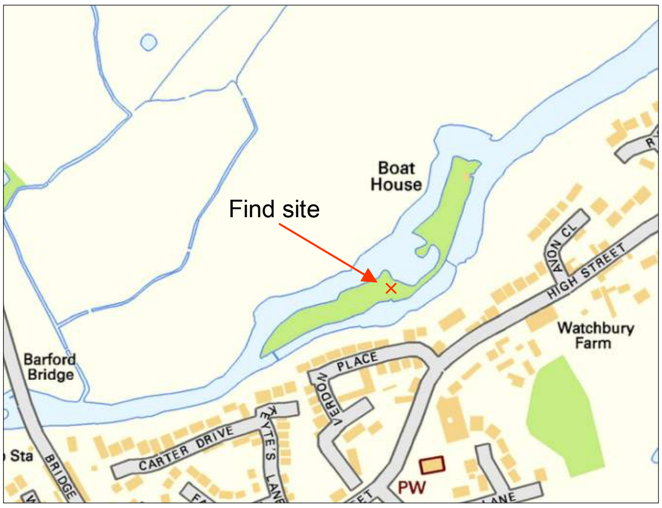

Fig. 3. Map of the find location on the R. Avon at Barford.

which is gained is that the maker was attempting to space the lines at regular 15° intervals, *i.e.* it is an equi-angular dial, not a 'scientific' one.

To the bottom (as shown in Fig 1 & 2) of the dial, large but shallow engravings give initials thought to be "C W", presumed to be for the maker.

History

There was a watermill in Barford, associated with the island, since at least 1086 – it was valued in Domesday at 2 shillings and 3 sticks of eels.[3] By the 13th century the mill, known as "La Lee", had been granted to the priory of Thelsford. After the dissolution of the monasteries the mill, and another at Barford, were granted to John Dudley, Earl of Warwick and Duke of Northumberland. For much of the 17th century it was in the hands of several generations of the Ward family. In 1692, a Charles Ward of that family 'quitclaimed' (renounced) the mill to a William Price. The fact that Charles Ward's initials match those on the dial could be purely coincidental and any connection would be very difficult to prove but it provides for some interesting speculations.

In more recent times, the island where the dial was found continued to have a mill for grinding corn until the end of the 19th century. It was then not used regularly until 1914 when an electric generator was installed.

Discussion

The overall appearance of the sundial initially tempts one to describe it as a 'portable mass dial', even though such things are not reported in the literature. It does, though, need rather more careful consideration.

The choice of lead as a material for the dial suggests that it was not made by a professional mathematical instrument maker or perhaps even a full-time metalworker. Lead has been available as a roofing material for a very long period, it is easy to both cut and engrave, and it is resilient against weathering or light wear. It would thus be an obvious choice for a provincial artisan wanting to produce a dial cheaply for his own use.

Delineating the dial would require just a pair of compasses (which masons, blacksmiths or carpenters would have had access to), a straightedge and a simple scriber. Angles may be bisected exactly with compasses alone (*e.g.* to form the right angle and 45° lines) and although there is no exact construction to trisect one – to form the 15° lines – it is a trivial task to achieve this by trial-and-error, stepping-out an estimated spacing. Any practical workman could have achieved this.

The anticlockwise numbering of the hour-lines indicates that this would be a vertical, rather than horizontal, dial. This is discarding as highly improbable any thoughts of a southern hemisphere dial. The small central hole could only have held a very thin rod gnomon prependicular to the dial surface (*i.e.* horizontal, like a mass dial) unless it was bent downwards (something which is unlikely and for which there is very little evidence). Combined with the equi-angular hour-lines, these would mean that the dial could not show modern equal-hours with any accuracy.

Vertical equi-angular dials were also sometimes used to try to show unequal (temporary) hours though again the accuracy is rather poor.[4] Even in the medieval period, rules for spacing the lines non-uniformly to achieve a passable approximation to unequal hours existed (the 'Erfurt formula') and the hours were counted from sunrise, putting noon as 6 hours, not 12 as engraved on the dial.

It might be suggested that the dial could operate as an equinoctial one showing equal hours for the winter half of the year by positioning it at an angle to the horizontal equal to the co-latitude, with the face downwards, and with a polar-aligned gnomon. The fact that the back of the dial, which would need to be engraved to form the face for the summer half of the year, is blank is one strong reason why this arrangement is rejected as improbable. A small corpus of stand-alone stone sundials with equi-spaced hour-lines does exist though these too have an uncertain basis to their time-keeping principles.[5]

There are, though, difficulties with the suggested vertical arrangement. The first of these is that it would place the numbers, and the 'CW' inscription, upside down. Perhaps the maker did not realize this until too late.

A second difficulty for a portable mass dial is that it would need to be aligned facing true south. There is absolutely no evidence that the dial was associated with a magnetic compass so one possible solution is that it was held, or fixed, to a south-facing wall, either on a church or another building. This might have been a permanent set-up with a nail through the centre both fixing the dial and acting as the gnomon. The small size of the central hole would only have allowed a pin, rather than a nail, to have been used. Microscopic examination of the hole shows it to have an approximate elliptical shape with a sharp 90° corner at one end. This suggests that it was formed by the tip of a cut-nail, rather than a round pin.

Dating the Dial

The dial could have been lost on the island at almost any date in the second millennium. There are very few clues in its appearance as to when it was made. The form of the numerals does not look to be medieval in style (though unfortunately the most characteristic numerals of 4, 5 and 7 are no longer visible) which would place the dial as later than about 1500. Perhaps the strongest clue, other than the form of timekeeping, is the 'W' of the 'CW' inscription, which is engraved as two overlapping Vs (*i.e.*, a double-u). In printed books and also on some dials this form is at its most common from the second half of the 16th century to the end of the 17th. Considering that this is a provincial piece and not one made in the workshop of a London mathematical instrument maker, this period could even be extended and it would certainly be within the ownership of the mill by Charles Ward.

By the end of the 17th century, the only form of timekeeping in common use would have been modern equal hours. Together with the 6–12–6 numbering, this suggests that the dialmaker was attempting to make an equal-hour dial but lacked the knowledge to design one scientifically, drawing instead on experience with mass dials on churches. Its very existence does show the interest in practical timekeeping at that period.

Acknowledgements

It is a pleasure to thank Matthew MacFadyen and Kirsty Healy, the landowners and owners of the dial, for allowing me to examine it in detail and to report it here. David Beaumont is to be congratulated for finding the dial and I am also grateful to Angie Bolton, PAS Representative for Warks. & Worcs., for alerting me to the find.

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WINDOW REFLECTIONS

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In *Bulletin* 24(i) of March 2012 (p.48), John Moir mentions the possibility of using the reflection of the sun from a window as a sundial and draws attention to the shape of reflections from double-glazed windows. These have the form of crosses with bright diagonal arms and concentrations of light in the centre. Fig. 1 is the reflection on a brick wall from a 400 mm square window at a distance of about five metres.

Fig. 1. Reflection from a square double-glazed window.

An optical investigation shows that both panes of a double-glazing unit are concave as seen from their exteriors and that the reflected pattern can be explained by the departure of a surface from a plane. Radial slope profiles of the glass were derived and two examples are shown in Fig. 2, one for a radius from the centre perpendicular to an edge and the other for a diagonal. That of the perpendicular is almost a straight line, indicating that the section conforms quite closely to a parabola, the theoretical shape for a surface subjected to a uniform pressure. The diagonal profile shows an increase of the slope to a maximum at about 150 mm

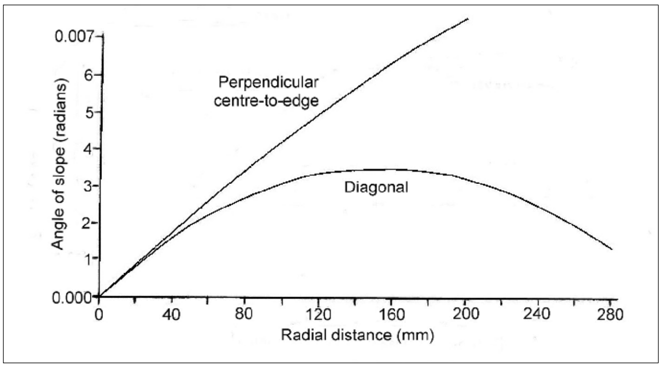

Fig. 2. Radial slope angles.