A SECOND DIY GARDEN HELIOCHRONOMETER

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Until the summer of 2016, I knew very little about sundials. In fact, dare I confess, I had never heard of the British Sundial Society. I thought, however, that it would be interesting to install a sundial in the garden, and I decided to try to construct it myself.

After researching the matter, I chose to build an equatorial heliochronometer. This subsequently provided the challenge of designing an instrument to take account of latitude, longitude, north–south orientation, the EoT, and the GMT/BST transitions. Remarkably, my heliochronometer (Fig. 1) worked reasonably well, and the outcome of that project was recorded in the September 2017 *Bulletin*.[1]

The construction of Mark I was great fun. In part that was due to my introduction to the fascinating world of sundials, and in part it was due to the interest in finding solutions to the many minor engineering challenges that Mark I presented.

Although appearing to be an impressive beast, Mark I, in practice, had design weaknesses. This is, of course, the nature of research and development – one never knows how something is going to work until it is tested. Most of the issues were a consequence of the weight of the cantilevered dial plate.

Fig. 1. Mark I.

Fig. 2. Mark II.

At the outset, I had never intended to make a second sundial. Experimentation with Mark I during 2017, however, and involvement with the BSS, helped me to visualise how I could construct a heliochronometer that would resolve all the weaknesses of my first instrument – and do so in far more elegant ways.

Mark II would have the same size of timescale as Mark I, but it would be a smaller and more portable instrument that, with a few simple plans, could be replicated by others. Thus Mark II came into being (Fig. 2). Full details of the design and construction of Mark II can be seen at my webpage *http://bit.ly/huhe02*.

I will describe in this article the successful elements of Mark I that were transferred to Mark II, the major differences between the two heliochronometers, and the way that Mark II, in particular, deals with the Equation of Time, and the GMT/BST transitions. I will conclude with thoughts of Mark III.

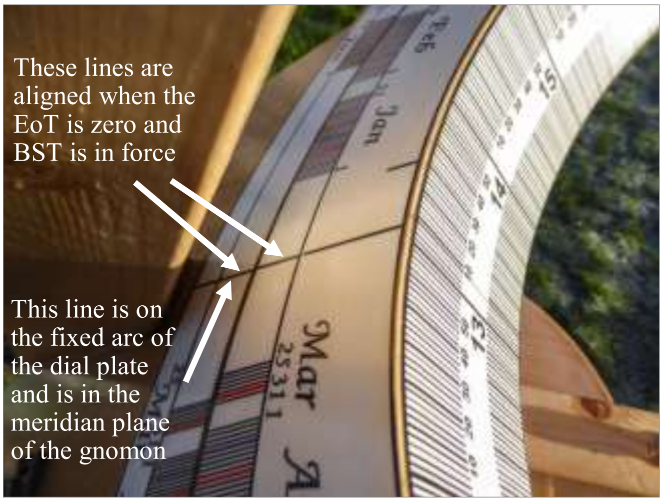

Fig. 3. The scales. Note that the upper element of the emphasised line-pair aligns with 13h 4.7m on the timescale.

Fig. 4. The timescale with the gnomon shadow at 13:07.

Successful Elements of Mark I Transferred to Mark II

I created all the scales from first principles, and they were commercially printed on self-adhesive vinyl for durability (Figs 3 and 4).

The gnomon is made from 0.8 mm stainless steel wire that is tensioned between its support points. This means that the gnomon can be both thin and totally straight (Fig. 5). A guitar machine head is used to tension the gnomon (Fig. 6).

Fig. 5. Attachment of the gnomon wire.

The timescale is positioned at right angles to the plane of the dial plate. This allows it to be easily read throughout the year.

Major Differences between the Two Heliochronometers

The equinoxes

The EoT correction graph for Mark I was mounted on the southern section of a complete dial plate annulus (Fig. 1). This required the timescale be oversized so that the protruding sections would not be in the shadow of the dial plate annulus during the periods of the equinoxes.

In Mark II, the dial plate does not continue over the section that would represent the period from 21:00 to 06:00. This allows the whole surface of the timescale to be read from 9:00 to 18:00 on days close to an equinox – when the sun is aligned with the plane of the instrument's dial plate.

Rotation of the timescale arc

Mark I used ball bearings to facilitate the rotation of a very heavy dial plate. Its dial plate was rotated by hand which, despite riding on the ball bearings, caused difficulty in exactly aligning the pointer with the EoT graph.

In Mark II, all moving surfaces that are in contact with other surfaces are covered with Teflon[2] to avoid any adhesion as shown in Fig. 7.

In addition, a belt and pulley mechanism allows very easy and precise adjustment of the timescale arc of Mark II (Figs 8 and 9).

Fig. 6. Guitar machine head used to tension the gnomon.

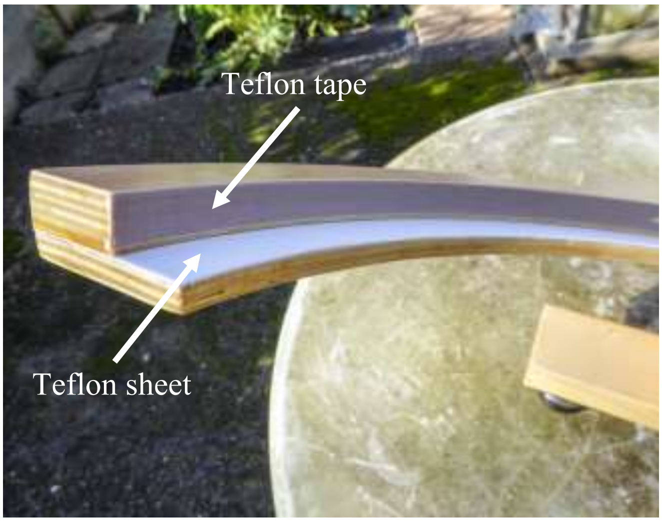

Fig. 7. Teflon tape and sheet covering moving surfaces.


Fig. 8. Mechanism that rotates the timescale arc.


Fig. 9. Setting the EoT correction for the day.

The positioning of the gnomon

The locating and checking of the gnomon position for Mark II is assisted by a gnomon adjustment tool: a wooden channel, shown in Fig. 10, provides alignment for the gnomon wire. The gnomon supports on Mark II also allow a wider range of adjustment for the ends of the gnomon wire than was the case on the earlier instrument.

The EoT correction

The EoT correction employed by Mark I used a pointer that was attached to the rotating section of the dial plate. This pointer was aligned with a graph of the EoT in order to effect the required rotation of the timescale (Fig. 11). As mentioned above, this was difficult to set with precision.

The method used by Mark II is derived from that used by the Pilkington Sol Horometer (Fig. 12). The Sol Horometer correction for the EoT, on a given day, is effected by the alignment of a pair of lines that are specific to that day. One line of the pair is located on the static section of the Sol Horometer dial plate, and one is located on the section that rotates. When the appropriate line-pair is aligned, the rotating section of the dial plate will be set for the day.

Fig. 13 shows, in close up, the graduations on the EoT scale of a Pilkington Sol Horometer. The EoT correction for 5 June would be effected by aligning the graduations indicated by the white arrows.

Fig. 10. The gnomon adjustment tool.

Fig. 11. The EoT correction mechanism of Mark I.

Fig. 12. A Pilkington Sol Horometer (photo: Steve Shaw).

Fig. 13. EoT scale on a Pilkington Sol Horometer (photo: Steve Shaw).

In transferring this idea to Mark II, I visualised a single line-pair, for a single day of the year, being attached to the dial plate. One would first set the instrument so that it was properly adjusted to read solar time (or solar time with a longitude correction). The line-pair would then be attached such that the two lines were at their correct angular displacement for that day's EoT correction – one line would be fixed to the static section of the dial plate and the other fixed to the rotating timescale arc. As in relation to the Sol Horometer, alignment of the line-pair would then cause the timescale arc to rotate by the angle required to effect that day's EoT correction. Fig.14 shows the Mark II scale set for 10 December.

I noted that in completing the above process of attaching a line-pair, it would not matter where on the circumference of the dial plate that line-pair was fixed. The EoT correction is

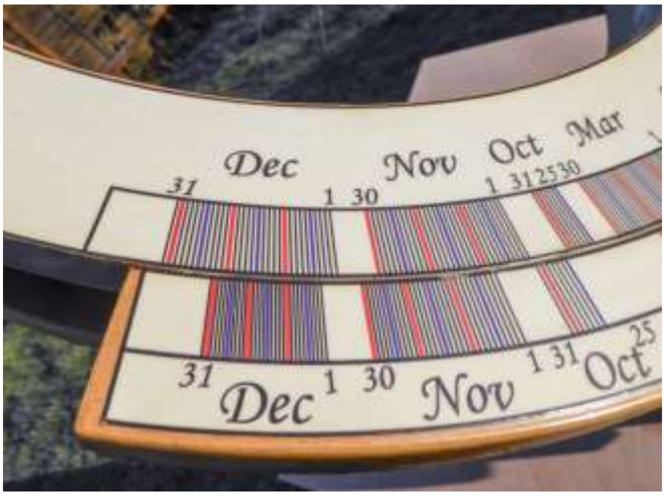

Fig. 14. The scale set for 10 December. Blue lines represent dates divisible by 5, and red lines are dates divisible by 10. The first and last dates of each month are numbered.

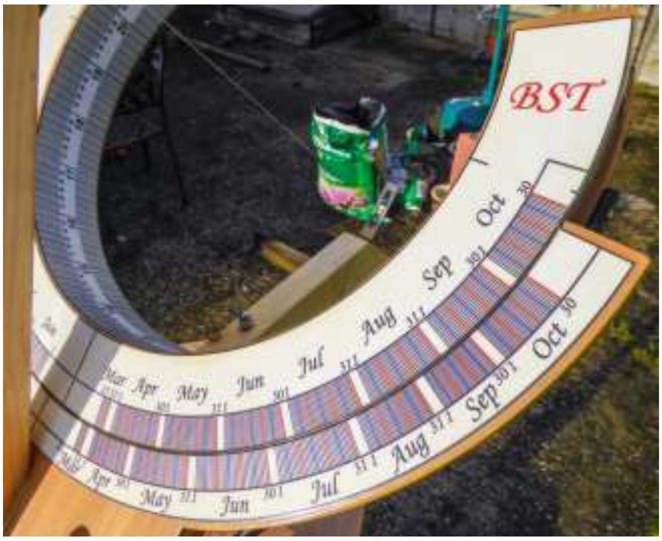

Fig. 15. The BST section of the EoT scale.

Fig. 16. The GMT section of the EoT scale.

effected by the angle of rotation required to align a line-pair. It is thus the relative positions of the two related lines that is important, not where the line-pair, as a unit, is placed.

The location of one line-pair in relation to any other line-pair is also irrelevant as long as the final configuration does not make the scale hard to read.

These facts allowed me to place line-pairs for each day of the year in the configuration shown in Figs 15 and 16.

The transitions between GMT and BST

In relation to Mark I, the transitions between GMT and BST were achieved by having two separate EoT graphs that were set 15 degrees, or one hour, apart.

These transitions on Mark II employ a similar idea, but utilise the independence of each line-pair on the EoT scale, as described above.

Months marked on the scale of the Sol Horometer are contiguous (Figs 12 and 13) and, taken together, occupy the entire circumference of the circle on which the outer and inner scales meet. As previously mentioned, this arrangement is not a logical necessity because the location of one line-pair has no bearing, other than aesthetically, on the location of any other. This fact allowed me to group all GMT dates on the east side of the sundial's longitudinal axis, and all BST dates on the west side. The graduations simply occupied as much of the remaining dial plate annulus as was available.

For purely aesthetic reasons, the sequence of GMT dates runs clockwise and the sequence of BST dates runs anticlockwise.

Each pair of EoT correction lines for GMT dates is displaced by 15 degrees, or one hour, relative to the BST dates to reflect the one hour difference between BST and GMT. This grouping is slightly complicated by the fact that the transitions between GMT and BST do not occur on the same dates each year. GMT changes to BST on the last Sunday in March, and BST changes to GMT on the last Sunday in October. This means that dates between 25 March and 30 March inclusive, and also dates between 25 and 30 October inclusive, might, depending on the year, fall within either the period of BST or the period of GMT. These dates, therefore, appear both on the BST and on the GMT sections of the scale.

There is no line-pair for 31 October on the BST section of the scale as 31 October must always fall within GMT. Similarly, there is no line-pair for 31 March on the GMT section of the scale as 31 March must always fall within BST.

Might there be a Mark III?

At the time of writing, I am observing how Mark II functions and, in particular, how it copes with the weather. I believe, however, that the basic design is sound. When I am certain of this, it may be the time to consider an instrument that can be used at other latitudes and longitudes and that includes a scale for determining the time of year.

REFERENCE and NOTE

1. B. Huggett: 'A DIY garden heliochonometer', *BSS Bulletin* 29(iii), 36–40 (September 2017). Further details are described at *http://bit.ly/huhe01*.
2. Teflon is a registered trademark of the Chemours company (formerly DuPont). The material is generically known as PTFE or polytetrafluoroethylene.

For a portrait and CV of the author, see *Bulletin* 29(iii), September 2017. He can be contacted at *brian.huggett@gmail.com*