Elliptical Clock

Circular Motion with an Elliptical Solution

Stuart Malin

As indicated by earlier jottings, I have been toying with the idea of an elliptical clock for some time.[1+2] I have now built Mark 1. It works, but there is still plenty of room for improvement, not least in the quality of the finish. I am also aware of several mechanical improvements that could be made but, for reasons that will emerge, there is never likely to be a Mark 2.

The idea is to have a clock with an elliptical dial, as has often been done before, but this time with hands whose ends also describe ellipses, so that they follow the dial rather than describing circles inside it.

The key to the whole thing is the Trammel of Archimedes, hereinafter abbreviated to 'trammel', of which I have given details elsewhere.[1+2] In brief, it comprises two shuttles that move in straight lines along mutually perpendicular tracks. The shuttles are attached with pivots to a bar so that their centres are always the same distance apart. The end of the bar, which extends beyond the shuttles, then describes an ellipse. A useful property, exploited here, is that the point on the bar mid-way between the shuttles describes a circle in the opposite direction to the end of the bar, thus permitting the conversion of anticlockwise circular motion into clockwise elliptical motion. I even went so far as to attach a hand to the trammel and drove it round a once-hourly elliptical path with a lead-off from a turret clock. I thought that the addition of an hour hand, to make it into a proper clock, would be simple, but it proved not to be.

The problem is that the central line, where a cannon pinion would normally go, is not available because the shuttles need to cross it. So how can one transmit the rotation through one trammel, through the motion-work and on to a second trammel? Then there is the question of how to support the various components while not interfering with the movement of the shuttles or the rotation of the bars and hands.

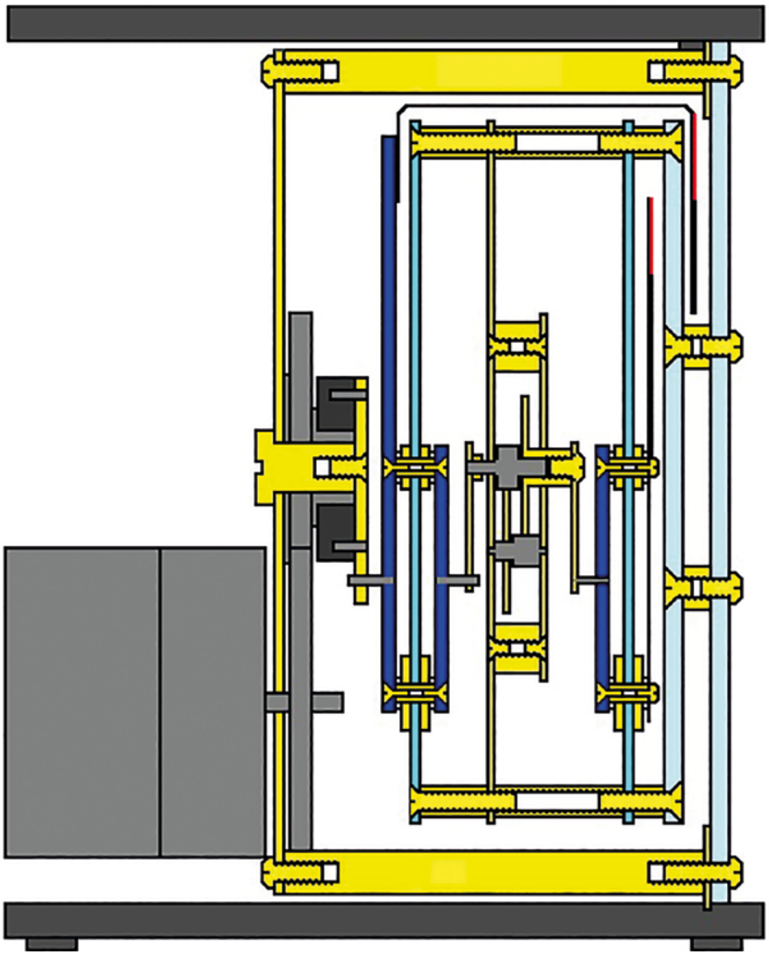

Figure 1. Side elevation of the clock with the dial to the right.

The solution proposed here is illustrated in **Figure 1**. At least one example of each type of pillar is included in the figure, but some of the pillars have been omitted to avoid confusing the picture. Moving from left to right, i.e. from the back of the clock towards the front, we first encounter the motive force: a one-cycle-per-hour, clockwise, 240V AC, Cruzet motor (grey). Two similar wheels, just inside the back plate, convert the motion to anticlockwise. Onward transmission of power is via a hard rubber clutch (dark grey) that permits the setting of the hands by rotating the slotted brass knob at the back. Though not shown, there is a screw for adjusting the clutch pressure. An anticlockwise rotating arm attached to the clutch has a pin near its end that fits loosely into a hole in the dark-blue bar of the first trammel at a point half way between the two shuttles that slide in slots in the light-blue plate. The end of this bar carries the minute hand (black, with a red end), which wends its way to the dial, thus cutting off the possibility of any support for the rest of the works except from the front of the dial, inside the locus of the end of the hand.

On the other side of the shuttle-plate

Figure 2. The elliptical clock indicating 4:51.

Patek Philippe Inventory S-116 'The Telescopic Hands' Pocket Watch

Figure 3. 'Lazy tongs' watch from the Patek Phillippe Antique Collection. Made for the Chinese market, 89mm high. London, c. 1795.

a short bar (dark blue) connects the two shuttles. It has a hole in its centre that describes an anticlockwise circle once an hour, thus de-convoluting what the trammel has done. This circular motion is picked up by a pin attached to a rod and is fed through standard motion work, from which it emerges as a 12-hour-period, anticlockwise, circular motion. A second trammel, similar to the first, drives the hour hand (black with red end, on the right-hand side of the light-blue shuttle plate) around an ellipse. The right hand side of the shuttle plate is the dial. On the far right of the figure is a sheet of Perspex (light blue).

That gets over the problem of having no cannon pinion, but there is still the matter of construction. This time I will go from right to left on **Figure 1** and it might also be helpful to refer to **Figure 2**. A rectangular brass plate with a large elliptical hole in it is hard up against a sheet of Perspex. This Perspex/brass sandwich supports the whole of the rest of the clock. Behind the front sheet of Perspex and bolted to it, but leaving a gap for the minute hand, is another Perspex sheet. The second sheet is an ellipse, slightly larger than that in the brass in front of it and slightly smaller than the ellipse traced out by the outer end of the minute hand, to avoid one touching the other. The bolts uniting the two Perspex sheets are those seen towards the centre of the dial in **Figure 2** in the directions of 12, 3, 6 and 9. They need to be near the centre to avoid fouling the inner end of the minute hand, which passes between the two sheets.

A second set of four countersunk screw-heads can be seen in **Figure 2** on the dial between 1 and 2, 4 and 5, 7 and 8, and 10 and 11. These are in the second Perspex sheet and are at the ends of columns which support the two shuttle-plates and, between these, the motion-work plate. They are positioned to avoid encroaching on the ellipse swept out by the hour hand. The final, outermost set of four screw-heads, in the brass front-plate, head columns that support the motor, clutch etc., in fact, everything behind the back trammel. The additional four holes in the front plate are of historical interest only. They were possibly used for ritual purposes. The lower edge of the brass front-plate extends slightly below the Perspex and fits into a slot in the lacquered case; gravity keeps the top end of the front-plate against stops at the top of the case, which stands 18cm high.

So why no Mark 2? The clock may not be pretty, but it works well enough. One problem is the sliding friction, μ, of the brass shuttles in their brass plate. This is exacerbated by pushing the shuttles from the mid-point of the line joining them, with the force applied to the shuttles at an angle, θ, of up to 45 degrees to their direction of travel, thus decreasing the effective force by a factor of $\cos\theta$, and by the sliding friction of $\mu \sin\theta$. That is why it requires the small, but powerful, Cruzet motor, which is commonly used to drive small turret clocks, rather than a clockwork drive. The real crunch came when I visited the Patek Philippe *Watch Art* Grand Exhibition at the Saatchi Gallery, London, in 2015. The exhibition included a beautiful elliptical watch made c. 1710 in London, **Figure 3**, whose hands were 'lazy tongs' that expanded and contracted so that their ends followed ellipses, presumably controlled by cams.

In the light of this simple and elegant solution to the elliptical problem, I came home, kicked the clock and screwed up my notes. There the matter rested until a visitor from the BHI, perhaps misguidedly, suggested that I should write it up for the *HJ*. Hence this.

ENDNOTES

1. S. Malin, 'Wooden Thing With A Handle', *The Horological Journal*, 156 (2014) 390.
2. S. Malin, 'The Trammel of Archimedes', *The Horological Journal*, 156 (2014) 534–535.