Two precision clocks by William Nicholson

Jonathan Betts*

This article describes the two known clocks signed by natural philosopher and scientific journalist William Nicholson (1753–1815). For a short summary of the life and work of this significant figure of the Enlightenment, see the Notes from the Librarian in this issue.

Of the many technical subjects that interested William Nicholson, horology was very much at the forefront, Nicholson himself creating new types of escapement and temperature compensation for pendulum clocks, and publishing many horological articles by others, particularly on precision horology, in his *Journal of Natural Philosophy, Chemistry and the Arts*, or *Nicholson's Journal,* as it became known.

One of the very first articles he wrote himself for his *Journal*, a 12-page piece in May 1797, was 'On the methods of obviating the effects of heat and cold in time-pieces',[1] and a few months later he added 'On the Maintaining Power in Clocks and Watches', a 13-page dissertation on the energy sources used in clockwork (nothing to do with the later use of the term as a device for keeping a clock going whilst being wound) and including detailed discussion of escapements and their strengths and weaknesses.[2] He was also apparently a maker of both instruments and clocks; he certainly had good hand skills and carried out many practical experiments, though it is very unlikely he actually crafted these clocks with his own hands.

Fig. 1. Table regulator in satinwood veneered case signed by Nicholson and dated 1797. (British Museum)

Table regulator

In the British Museum's collection[3] is an unusual table regulator (Figs. 1, 2 and 3) in a high quality, satinwood veneered case (with

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1. William Nicholson, 'On the methods of obviating the effects of heat and cold in time-pieces', *Nicholson's Journal*, Series One, Vol.1, May 1797, 56–67.

2. William Nicholson, 'On the Maintaining Power in Clocks and Watches', *Nicholson's Journal*, Series One, Vol.1, December 1797, 429–430 and Vol. 2, May 1798, 49–60 plus engraving.

3. BM ref: 1958,1006.1925.

Fig. 2. The signature on the dial. (Jonathan Betts)

a finely made oak carcass), standing on four threaded brass bun feet for level adjustment. A swivelling shutter below the dial seals the winding hole from dust contamination when closed. The silvered brass dial, which has centre-seconds indication, is signed: 'Wm Nicholson f. 1797' (the 'f' standing for 'fecit' – made by).[4]

As far as is known, the design and combination of features in the movement of this clock are unique. In common with the other clock described in this article, the skeletonised inverted 'T' movement is evidently designed so that the technical features can be exposed and appreciated – very much in line with Nicholson's desire to disseminate technical information – and it is made to very high standard of construction and finish. The movement, which is seated on a substantial and well-finished cast-iron base, is of eight-day duration and fusee-driven. It has a five-wheel train with Harrison's maintaining power on the second wheel and high-numbered pinions of 10 and 12. This improves the efficiency of the meshing, as used in the best precision clocks of the period, but the train also employs quite high ratios and has an extra wheel in the train, which will reduce the efficiency to some extent.

The movement has Nicholson's escapement and Nicholson's form of temperature compensation on the pendulum suspension, both of which are described in the articles in his Journal, mentioned above. The half-seconds pendulum, which is suspended from Troughton's design of pendulum support, has a plain, lead-filled brass-cased lenticular bob and a steel rod with sliding brass weight for coarse regulation.

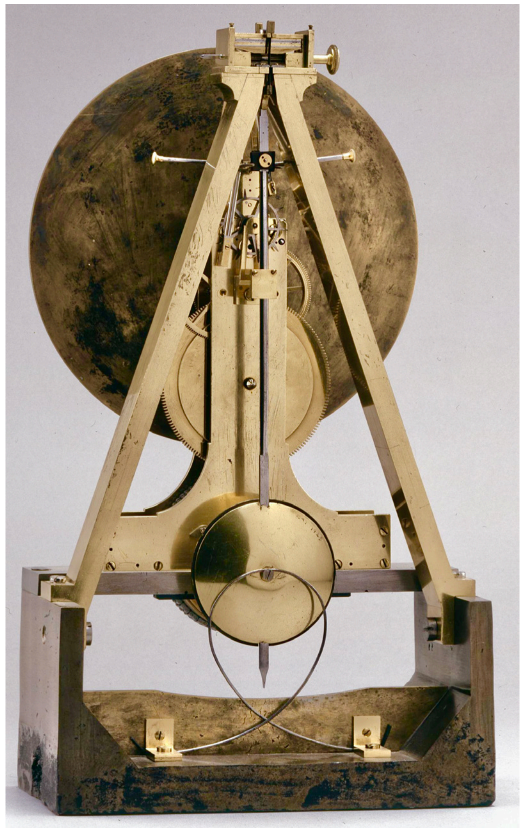

Fig. 3. The movement out of the case, showing the unusual wire loop pendulum securing device. (British Museum).

The escapement

Nicholson's escapement, fitted to this movement, is shown in the figure (Fig. 4), taken from the description published in his Journal, of which this actual clock appears to be the subject, though he states that the design was created in 1784.[5]

As drawn, the steel escape wheel rotates clockwise and interacts alternately with pallet D at the top of the wheel, and pallet E at the bottom.[6] The pallet arms are each attached to a horizontal arm with weight, B and A respectively; it is only the weight of these arms which prevent the escape wheel from running forwards. The horizontal arms sit on stops (I & K) and are both coaxially pivoted at the same centre as the pendulum's nominal

4. David Thompson, *Clocks* (British Museum, 2004), pp. 126–127. Ex-Ilbert collection, CAI-1925.

5. William Nicholson, 'On the methods of obviating the effects ..', 59–60.

6. Nicholson states that the pallets are in agate, but the current pallet surfaces themselves are in polished steel.

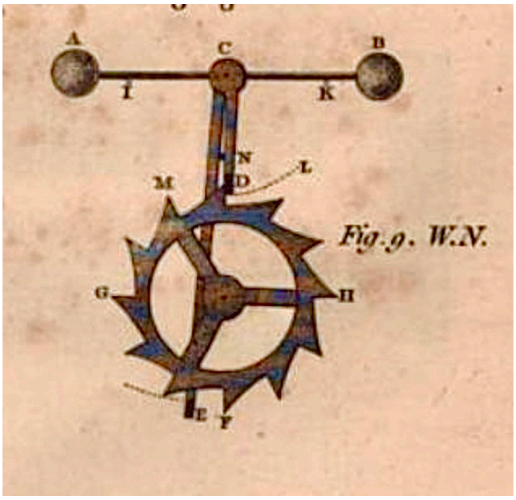

Fig. 4. Nicholson's escapement. While this employs gravity in delivering impulse it is not strictly a gravity escapement in the conventional sense (Jonathan Betts).

pivot point. A pin N projecting forward from the pendulum is positioned between the two pallet arms and lifts the arms alternately as it swings to and fro, two hardwood blocks mounted on the pendulum rod contacting the arms. As the pendulum swings, the escape wheel will advance, assisting the lift of the arm, until the escape wheel tooth parts company with the pallet and the pendulum continues, then returning under the full force of the weighted arm. The same action then occurs with the other arm on the opposite swing.

This escapement has been described as a form of gravity escapement. Superficially it is, but the term usually implies a form of constant force escapement in which gravity is used to repeatedly apply a given quantity of impulse. In this escapement the pendulum is obliged to fully lift the weighted arms on either side of its swing but with the lifting *assisted* by the escape wheel on the lift. So, it is the *difference* between the energy lost in lifting the arm on the upward swing, and the energy imparted on the downward swing which represents the impulse. This difference is of course directly related to the force delivered by the escape wheel in assisting the lift, so the net impulse to the pendulum is simply that delivered from the escape wheel, variable as it may be, and not gravity.

In fact, Nicholson himself does not claim it as a constant force gravity escapement. His description emphasises the fact that as the action of the pallets is close to the line of centres of wheel and pallet, sliding of tooth on pallet is minimised and the pallets are supposed to run without lubrication. In his description of the escapement in *Rees's Cyclopaedia*, c. 1820, William Pearson is also careful to avoid claiming this as a detached gravity escapement,[7] and in recent times Philip Woodward was clear about the escapement's limitations, referring to it as a 'pseudo-gravity escapement'.[8] Nevertheless, the BM's clock works well, with a running arc of around 11 degrees, and, without oil on the pallets, should have a longer service life than with an anchor or dead-beat escapement. Nicholson also notes that the escapement provides a dead-beat action to the centre seconds, aiding in precise time observations.

The compensation

The temperature compensation is also of unique design, employing the Harrison bimetal principle to raise and lower the pendulum suspension through a close-fitting slit to correct for changing length in the pendulum rod. This too is described and illustrated in *Nicholson's Journal*, though he states there that he is unsure if the action of the bimetal would be consistent (perhaps this clock was partly a means of testing the principle). He also states that he is uncertain who first invented the bimetal, which is surprising, as by this date it was surely well known as Harrison's creation.[9] However, the present form of the compensation in the clock, although evidently once of the type shown in the Journal, is different and suggests

7. William Pearson, 'Escapement', in Abraham Rees, *The Cyclopaedia*… (London, 1819), Vol. 13. Also, *Rees's Clocks Watches and Chronometers*, David & Charles reprint, 1970, p. 210.

8. Philip Woodward, *My Own Right Time: An Exploration of Clockwork Design* (OUP, 1995), p. 26.

9. Nicholson was however clear about Harrison's contribution by 1809, when he published his *British Encyclopedia or Dictionary of Arts and Sciences…* where, under the heading 'Horology', he discusses Harrison's contribution and gives details of his compensation devices.

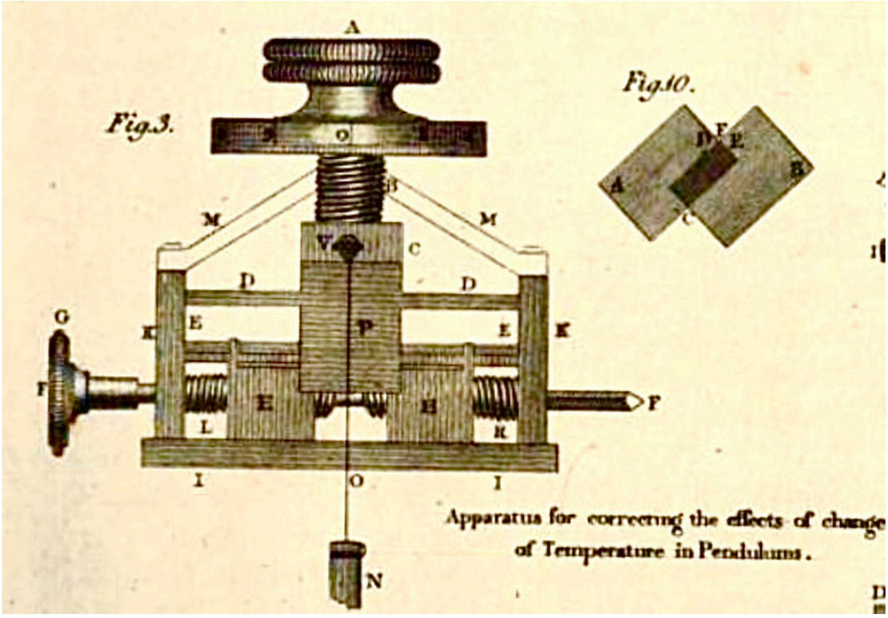

Fig. 5. Nicholson's compensation as published. The large knurled knob A at the top is for rate adjustment and the side screw G-F adjusts for quantity of compensation. E-E represents the bimetal bar (Jonathan Betts).

some interesting changes, probably during construction and testing.

As originally conceived (see Fig. 5) the pendulum suspension is fixed to a block P which can be raised and lowered by the large knurled knob A. The suspension spring runs through the slit at O and the suspension block sits on top of a single horizontal bimetallic bar E which has the brass element above and the steel below. When the temperature rises the bimetallic bar will bow upwards, becoming convex on its upper side, raising the suspension block up and drawing the suspension spring through the slit, shortening the effective length to compensate. The bimetal bar sits on two narrow 'rails' on the top of blocks H-H through which the horizontal screw G-F runs (the screw-thread reversed in the second block). When the knob G is adjusted the blocks move together or apart, and the distance between the 'rails' (the points from which the bimetal bar acts) changes. The further apart those points are positioned, the greater will be the vertical rising and falling of the suspension block when the temperature changes, so the amount of compensation is adjustable. What was extremely useful about this ingenious design was that both changing the rate of the clock and the amount of compensation can be achieved without stopping the clock.

However, this is not what is now present in Nicholson's clock (Fig. 6). Presumably Nicholson published his design before giving it a full trial in the clock, as it appears the compensation was insufficiently powerful and the arrangement had to be radically altered. To increase the power of the compensation, Nicholson substituted the single bimetal with a stack of three, arranged to compound the lifting effect, but no longer with any adjustment, the three bimetals all acting at their full lengths. With this arrangement, with a rise in temperature the lowest would become convex on top, the middle bimetal would become convex on the underside, and the top bimetal would become convex on top, all contributing to an upward lift. The brass/steel proportion of each bimetal was now what decided the necessary correction which would have to be determined by experiment. In order to create this arrangement, the original top rating nut was removed and the pendulum block was suspended on a plain brass bar sitting on the top bimetal. The lowest bimetal also now sits on a plain brass bar, but

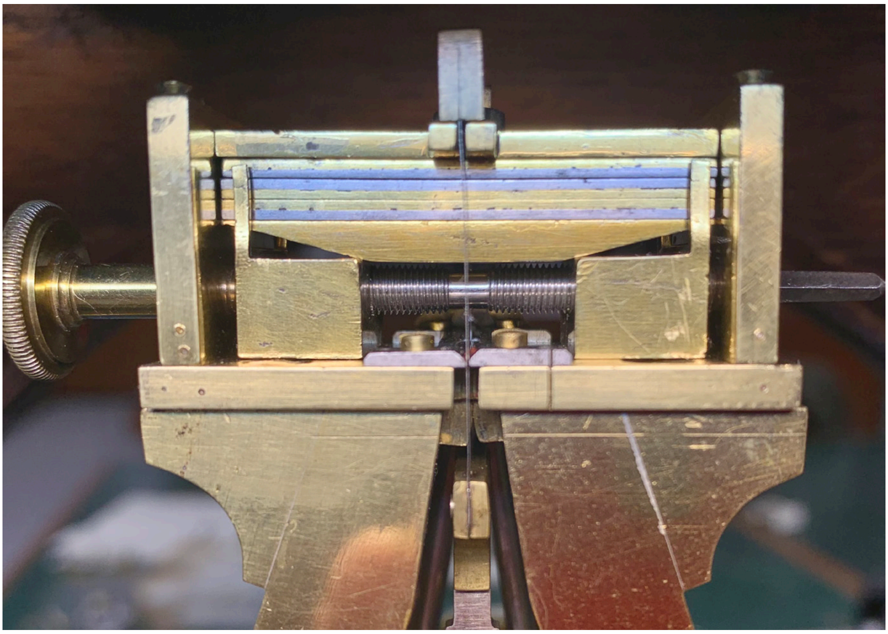

Fig. 6. The temperature compensation, radically altered from the published design and employing a stack of three bimetals (Jonathan Betts).

on the underside of that bar, the ends have angled ramps. These ramps sit on the edges of two brass blocks which are threaded to take the original horizontal double-screw, now repurposed as a rate adjuster. If the horizontal screw is adjusted, the blocks move together or apart and in doing so force the angled bar up or allow it to fall, taking the whole suspension / compensation assembly with it and providing rate adjustment. Nicholson refers to the clock as 'in his possession', but, assuming this is indeed the same clock, it is not known whether it performed well, or for how long he kept it.

Construction

It is also uncertain whether in fact he made the clock himself, as suggested by 'f' ('fecit') in the signature, but it seems highly likely he 'made' the design, but was not sufficiently skilled as a practical mechanician to actually craft this, or the other clock described here, with his own hands. His son, who wrote a biography of William, wrote of this period in his father's life that 'during this time he had always two or three mechanics employed on various machines of his own designing or invention', which supports this conclusion.[10]

Scratched on the back of the dial of this clock is the name: 'Harday / Copes Row', which seems likely to refer to William Hardy (d.1830), the noted chronometer and regulator maker of Coppice Row in Clerkenwell. Hardy was well known to Nicholson, who supported Hardy's applications for reward from the Society of Arts at various times. The graffiti probably post-dates the manufacture of the clock however, as Hardy is not known to have been at Coppice Row as early as 1797. Nevertheless, the clock's construction, both in case and movement, is of high quality, and it was probably made under Nicholson's direction by craftsmen of superior calibre.

The subsequent whereabouts of the clock following Nicholson's ownership are also uncertain. The clock bears two other scratched names: 'Thos. Thompson' on the front plate, and on the back of the dial: 'C H Hobson, MAR 1938', indicating the clock was worked on by the noted clock restorer Charles Hobson at that time. It is known that one descendant, Guy B. Nicholson (1871–1963), sold a number

10. Sue Durrell (ed.), *The Life of William Nicholson 1753–1815* (London: Peter Owen, 2018), p. 62.

Fig. 7. Signed by William Nicholson, the little skeletonised clock was intended to be mounted in gimbals and to be portable. The tiny square on the front of the base unlocks the glass cover (Jonathan Betts).

Fig. 8. The rear view of the clock, showing the later pendulum and open mainspring barrel (Jonathan Betts).

of family artefacts in April 1936, and the clock might have left family ownership then. What is sure is that the clock was acquired by the celebrated collector Courtenay Ilbert (1888–1956) from the London firm of Clowes and Jauncey (later Frodsham's) for £20 in 1938. Hobson was their principal restorer and it is likely they had the clock restored before sale to Ilbert. The majority of Ilbert's collection was acquired for the British Museum in 1958 and the clock has remained in the BM's collection since.

Miniature gimballed regulator

The second clock (Figs 7 and 8) is altogether a smaller, more elegant timepiece. Dating from the early ninteenth century, it is quite different in appearance and its movement is even more exposed and 'on show'.

The movement is skeletonised in form, having only a brass base and a close-fitting brass-bound glass cover forming its case. The glass cover is locked onto the base by a key inserted in the front of the base which causes a sliding frame underneath with four bolts, to engage with four slots in the bottom of the cover. The large opening in the front glass of the cover would originally have contained a rotating brass winding shutter to ensure the case was dust sealed when not being wound. The finely made fusee-driven movement has inverted 'T' form plates in gilt brass, fixed securely to the brass base plate. The lower part of the front plate is finely engraved: 'W Nicholson London' (Fig. 9), though this signature is largely obscured by a fixed brass spirit level mounted along the front of the clock.

The bottom edge of the back plate is scratched: 'Barrett Nov 10 1805' and the fine, tapered blued steel mainspring is signed: 'RS 1806' (Fig. 10), both probably contemporary with the clock's manufacture.[11] As with the other clock described here, it seems very likely Nicholson oversaw the clock's construction to his specification, but would have had very little 'hands-on' involvement.

Fig. 9. The engraved signature on the movement. (Jonathan Betts)

Fig. 10. The high-quality, tapered mainspring is signed: 'RS 1806' and is probably contemporary with the clock's creation. (Jonathan Betts)

The fusee has Harrison's maintaining power and drives a six-wheel train terminating in a dead-beat escapement. The simple steel-rod pendulum, which is probably not the original, is suspended from a silk suspension which also appears of fairly crude construction and is probably later; spare holes on the edge of the rear plate suggest some attachment associated with an earlier suspension. The pendulum bob is scratched: 'H Hill / 11 8 74' and 1874 may be the date of this change (Fig. 11).

The elegant dial is in the form of two narrow white-enamel rings with gilt brass bezels, one large for arabic hours with a minutes circle and having blued steel hands, and a smaller white-enamel seconds ring with arabic ten-seconds marks and a counter balanced seconds hand.

With its dead-beat escapement and a good train, the clock is evidently intended for precision timekeeping, but its original purpose is not known and it does not appear to be mentioned anywhere in Nicholson's Journal. In common with the earlier clock, this timepiece has high numbered pinions, but has lower ratios and is a better overall train from an efficiency point of view, though it does require six wheels owing to the very short (high frequency) pendulum (just over 1/3 seconds in period).

The particularly interesting feature of the clock is that it was designed to be fitted into gimbals, almost certainly mounted on a tripod, and was thus intended to be used in a 'portable' environment. That is to say either in use when subject to motion or, more likely, in use when being constantly moved from one place to another, when careful levelling each time would not be necessary owing to the gimbals. An example might be when in use in surveying or for astronomical use on voyages of exploration similar to those used by Captain Cook in the 1760s and 70s and by Nicholson's friend J. H. de Magellan in his clocks made for the 'Iberian Contract'.[12]

On the underside of the clock base (Fig.12) is a threaded socket for the attachment of a weighted rod acting as a counter-weight.[13] A conjectural arrangement for how the clock might have been used is shown in Figs 13 and 14.

11. There are several possibilities for the identity of 'Barrett' as a working clockmaker in London at the time, but no contemporary mainspring maker with the initials RS is shown in Jeremy Evans, 'Mainspring Makers of London and Liverpool – Some Observations and Lists', *Antiquarian Horology* Vol. 27, No.1 (September 2002), 63–89.

12. Jonathan Betts, 'John Hyacinth de Magellan (1722–1790) Part 3: The Later Clocks and Watches', *Antiquarian Horology* Vol. 30, No.1 (March 2007), p. 26.

13. This counterweight and rod was extant until relatively recent times, as described by a descendant who recalls them when he was younger. Sadly, they were lost in a house move.

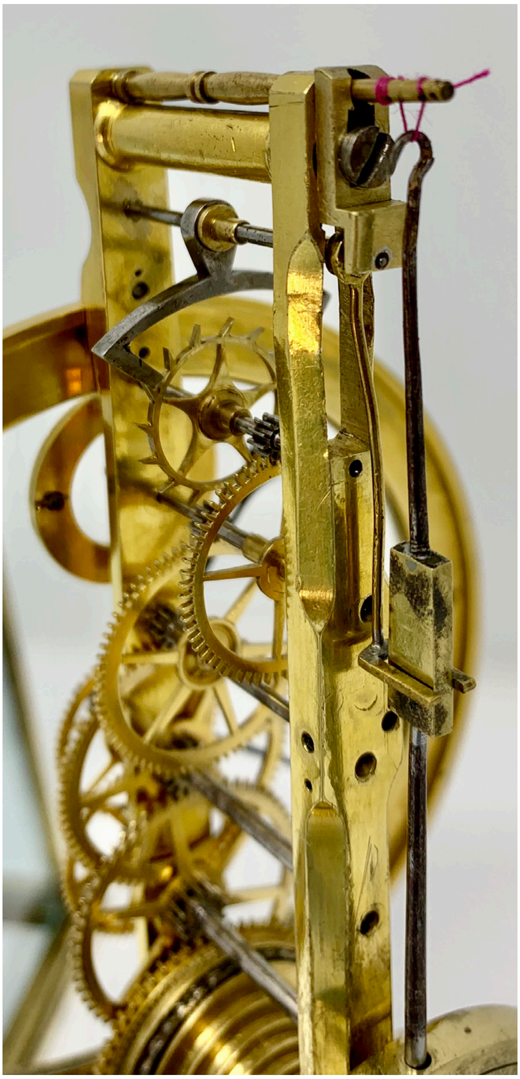

Fig. 11. The rather crude pendulum arrangement and unused holes on the rear plate suggest there was an earlier arrangement, perhaps with pendulum compensation of some kind. (Jonathan Betts)

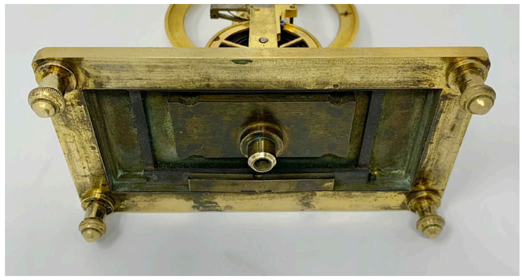

Fig. 12. The base has a threaded socket for fitting a weighted rod to keep the clock horizontal when in its gimbal mounting. (Jonathan Betts)

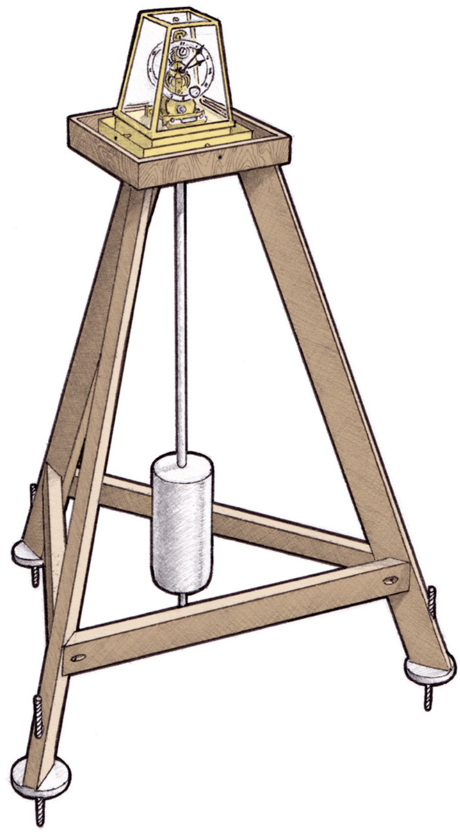

Fig. 13. An 'artists impression' of how the clock might originally have been used, on a portable wooden tripod, similar to those used in contemporary voyages of exploration. (Lee Yuen-Rapati)

Overall, the clock is very nicely designed, but it does have a significant failing in the proportions of the dead-beat escapement. This has an escaping arc of four degrees but the escape wheel teeth are relatively short and there is very little allowance for supplementary arc. Just one degree on either side over the escaping arc sees the pallet nibs bottoming in the escape wheel (Fig. 15) and the clock requires a very constant power supply to avoid either stopping (if too low) or bottoming (if too great). Being out of beat would also soon cause bottoming, but at least the gimbal arrangement is likely to prevent this.

While it is known the clock has remained in the family's possession all its life, details of its earlier use are sadly unknown. Sue Durrell has pointed out that 1806 was when Nicholson

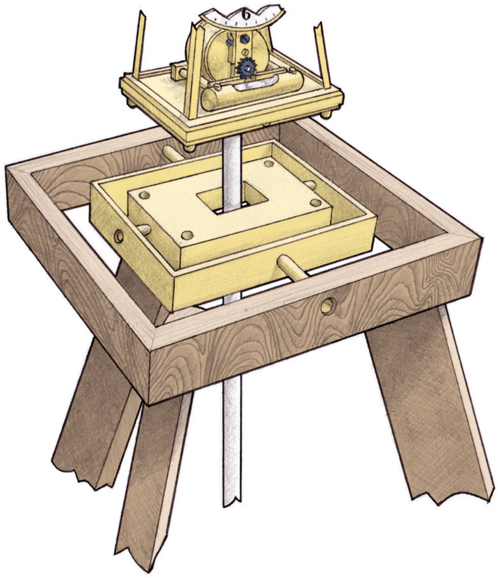

Fig. 14. The conjectured arrangement for gimbal support for the clock. (Lee Yuen-Rapati)

started surveying work for the West Middlesex Waterworks, and it is possible the clock was intended for his own use during this work. One additional piece of graffiti gives a clue to its whereabouts a few years later. On the bottom edge of the front plate is scratched: 'Richardson Whitby Dec 11 1814', and Nicholson's son (also William) was working for Lord Middleton in Malton in Yorkshire just 30 miles away at the time, so it's possible the clock was in his hands by 1814, just one year before his father died.

Acknowledgments

I would like to acknowledge the kind help given in this research by family members Sue Durrell and Nick Nicholson; Oli Cooke at the BM kindly provided access to their clock and related information, and Lee Yuen-Rapati was responsible for the fine drawings forming the 'artist's impressions'.

Appendix: Data on the two clocks

Table regulator
Height: 60cm (incl.finial); Width: 31cm; Depth: 17.5cm
Main Train
Fusee: 6 turns

Fig. 15. The constrained design of the dead-beat escapement allows only for a small supplementary arc before bottoming. The exit pallet (left) has just received the escape wheel tooth but has very little further to go before reaching the root of the wheel teeth. (Jonathan Betts)

Gt wheel: 180
2nd wheel: 144/12
3rd wheel: 144/12
4th wheel: 60/12
Escape wheel: 10/10
Pendulum Frequency: 0.5 secs per hr.
Motion work
2nd wheel pinion: 24 (driving)
Min wheel pinion: 48 (driven)
Minute wheel: 120/32
Hour wheel: 80
Cannon pinion: 25

Miniature gimballed regulator
Height: 18.5cm; Width: 13cm; Depth: 7cm
Main Train
Fusee: 8.5 turns (ratchet: 54; chain: 46cm / 117 links and set-up ratchet: 24)
Great wheel: 60
Maintaining wheel: 96
Intermediate: 60/12
Centre: 80/12
Fourth: 75/10
Fifth: 64/10
Escape: 15/10
Pendulum frequency: 0.3125 secs per hr
Pallets embrace 4 ½ teeth.
Motion work
Hour wheel: 60
Minute wheel: 64/20
Cannon pinion: 16