John Harrison: clockmaker and Copley Medalist. A public memorial at last

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The story of John Harrison, the clockmaker who effectively solved the ‘longitude problem’ in the eighteenth century, is a fascinating one. Here was a brilliant inventor who single-handedly took on the might of the astronomical fraternity and turned down Fellowship of the Royal Society, yet accepted its highest accolade—the Copley Medal—and had to enlist the help of King George III in pursuit of the final instalment of the Longitude Prize. This paper deals with the inventiveness of Harrison and the role of the Royal Society in the story and the very recent successful efforts to have his name remembered in perpetuity in Britain by a memorial in Westminster Abbey.

INTRODUCTION

Not for the first time, a forgotten genius has returned to the limelight through the actions of ‘the media’. In this case, it was the popular book Longitude, by the science writer Dava Sobel, followed by the TV film and the play, that were responsible for once more bringing John Harrison to the front of the stage.

The realization of the lack of recognition of this genius in any significant way in the UK led one of us (A.W.W.) to ask the Worshipful Company of Clockmakers to institute a Prize in his honor and to initiate a memorial in Westminster Abbey. A small exhibition in the Abbey organized by J.C.T., which included Harrison’s own personal wooden regulator clock, was followed by a major exhibition, ‘The Excitement of Time’, at the Royal Society, which focused on not only Harrison but the whole topic of horology and the Society right up to the present day.

This paper starts with a brief history of Harrison’s work and the brilliant inventiveness of the man. This is followed by an examination of the role of the Royal Society, including the Astronomers Royal of the period. Finally, some remarks are made about the current status of his recognition. Others might benefit from our experiences in their own efforts to ‘memorialize’ other British geniuses.

HARRISON THE INVENTOR

John Harrison was born in Foulby, Yorkshire, on 24 March 1693, and as a boy moved with his family to Barton upon Humber. As a young man he became a master craftsman in wood with an interest in church choirs and campanology. Just why he became a self-taught horologist is

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not clear, but perhaps the shortage of local clock-repairers provided the stimulus to this young man with a lively mind. Like many other inventors/scientists/craftsmen, both before and since, not having a local tutor caused him to ‘reinvent the wheel’, with highly significant consequences (figure 1).

Early wooden clocks

Dating from about 1713, Harrison’s first group of three surviving domestic clocks is conventional in principle, with the ubiquitous anchor escapement and seconds pendulum controlling a brass escapewheel. However, all other parts of these clocks are made from wood. Each has a solid cross tenoned oak frame with inserted oak movement plates and large oak gear wheels mounted on boxwood arbor shafts with integral cut small pinion gears. Steel pivot pins are inserted in the ends of the arbors and run in brass bushes inserted into the oak plates. No lubrication was used between the wooden gear teeth but the escapement and arbor bearings required lubricating exactly like a conventional metal clock, with all the problems of natural oils such as olive oil drying out in summer and becoming thick in the low temperatures of winter.

By 1720 Harrison was sufficiently well known as a clockmaker to receive the commission from Sir Charles Pelham to design and build a tower clock to be installed on the rebuilt stable block at Brocklesby Park. Harrison followed the design of his domestic clocks in this larger tower clock, with a strong oak cross tenoned frame and inserted plates. The oak wheels, with their inserted groups of teeth with the grain always running down the length of the teeth, were retained, as were the wooden arbors, but the boxwood pinions were largely replaced by brass ones. For the pinion on the escapewheel arbor he designed a new lantern roller pinion so that there was no sliding friction between the teeth. The rollers revolved on polished brass pins.
while rolling engaged along the parallel teeth of the large oak wheel: there was no sliding friction between the teeth.

Harrison changed the design of the pivots from steel to brass and inserted *lignum vitae* bushes in the oak plates as self-lubricating bearings. The conventional brass escapewheel was controlled by an anchor escapement, but it was inserted in a brass frame instead of forged iron pallets. The clock did not perform well and required many unpaid visits to keep it going. To overcome his problems, Harrison invented the ‘grasshopper’ escapement, a device of both complexity and beauty; this device led to a considerable advance in the stability of the clock when combined with isochronal cheeks on the pendulum.

The 1714 Act announcing the ‘Longitude Prize’ of the unbelievably large sum (for those days) of £20 000 led to much work by the astronomers of the day—led by successive Astronomers Royal. After all, the Royal Greenwich Observatory had been set up by King Charles II in 1675 essentially to provide the information to solve the longitude problem. The planned method was to use the motion of the Moon through the heavens (or, later, to use Jupiter’s satellites) to give the ‘absolute’ time at a point on the Earth’s surface that could be compared with the ‘local’ time and thereby give the required longitude.

Harrison, however, felt that he could make a clock of sufficient accuracy to carry ‘absolute’ time with it even with the temperature changes and violent motion on board ship. It seems that few, if any, other clockmakers had similar confidence. Before he could start on a sea clock he needed a land clock (figures 2 and 3) several times more accurate than the best London clocks of the period against which to check his new concept. A clock was the natural starting place because watches of the period were status symbols rather than accurate timekeepers. Thus Harrison’s first sea clock (figure 4) was a large-scale conception. Even though it met the requirements for the award of the prize, Harrison felt that he could improve on the concept. He made a further two large sea clocks but he was not satisfied with their performance and they were never tested at sea. Harrison was by now turning his inventive mind to a fast-beating high-energy watch (figure 5) that met even his high standards. In the trial voyage to and from Jamaica the watch lost only 1 minute 54.5 seconds in 147 days—half the error permitted over twice the distance required under the Longitude Act!

**Harrison’s major inventions**

It is not clear just when John Harrison heard of the Longitude Prize but presumably it was in the early 1720s. The incentive was enormous (shades of the Nobel Prizes today—for those in the lucky disciplines!). Various inventions were made and these, with others, were honed up over the years, including the following:

- self-lubricating bearings;
- roller bearings and later caged roller bearing;
- a temperature-compensated pendulum, offsetting the downward expansion of iron rods against the upward expansion of brass rods;
- the grasshopper escapement with no sliding friction between the wooden pallets and the escapewheel, thus requiring no lubrication;
- the isochronal suspension, whereby the support had curved cheeks for the pendulum support spring, which resulted in the period’s being independent of its amplitude;
- the spring-controlled cross-linked oscillating double balance giving the first practical sea clock;
bimetal of brass and steel whereby the temperature compensation of his later sea clocks was improved by reducing the thermal capacity and increasing the surface area over a gridiron as well as increasing the actual movement at the point where the compensation on the balance spring took place;

- the fast-beating high-energy spring balance together with diamond pallets and multiple jewel bearings.

The early result of these innovations led to the construction of a long case ‘regulator’. This clock was to be his standard, ground-based instrument for many years, against which he could calibrate his sea clocks. He checked the accuracy by timing the occultation of a star against his neighbour’s chimney and claimed it was accurate to 1 second a month. It was this actual clock that was shown in the Abbey and as the centrepiece of the larger exhibition in the Royal Society.

By about 1730 Harrison, by then 37 years of age, took his plans to London to seek support for a frontal attack on the longitude problem. The Royal Society then came upon the scene.
Insofar as the Astronomers Royal were all Fellows of the Royal Society and these office-holders were all in favour of the ‘lunar method’, it might have been expected that the Society would be anti-Harrison. However, this was not the case. Even the astronomers soon came to realize that they were dealing with a brilliant man, albeit one who could be argumentative and self-opinionated (nothing changes!).

The interaction started when Edmund Halley, the second Astronomer Royal, was approached by Harrison on his visit to London with a request for advice. Halley, a distinguished scientist with many successes to his credit, not least the characteristics of lunar motion, referred the rough man with unusual ideas to George Graham, a leading light in the Society, Britain’s premier instrument maker and a distinguished horologist himself. Graham was won over, not least by Harrison’s demonstration that his gridiron pendulum with its lower thermal mass was superior to Graham’s own with its large thermal capacity mercury weight and that his clock was more precise than Graham’s best. Graham made an interest-free loan to Harrison to enable him to live and start the fabrication of his first sea clock and essentially set him off on his ultimately successful mission.
That the dice were loaded in favour of the ‘lunar method’ followed from the presence of Newton and Halley in the initial group who set up the Longitude Commission, which was to adjudicate on the award of the Prize. The Commission always contained the Astronomer Royal and had other professional, academic astronomers as members.

The Royal Society had the task of inspecting equipment produced by claimants, and Harrison’s first sea-going clock, H1, was duly presented to them in 1735. A very satisfactory impression was made and a certificate signed by five Fellows stated ‘it highly deserves public encouragement in order to [enable] a thorough trial’. The Fellows were Edmond Halley, George Graham, Robert Smith (Professor of Astronomy in Cambridge), James Bradley (Professor of Astronomy in Oxford, later to follow Halley as Astronomer Royal) and John Machin, Professor of Astronomy at Gresham College, London.

After a sea trial and further improvements by 1740 Harrison was still not satisfied, his finances were in a parlous state and another letter of support was sent. Inspection of the letter (January 1741) shows that of the 12 Fellows signing the letter, 9 had astronomical connections. All were members of the Longitude Commission: the letter did the trick and Harrison was awarded further funds.

In 1749 Harrison’s prestige in the Royal Society was so high that he was awarded the prestigious Copley Medal—the Society’s premier award. The citation read by the President, Martin Folkes, contained the famous words ‘...on account of those very curious instruments invented and made by him for the exact measurement of time’. A good lawyer would surely
have got Harrison the Prize there and then because of the Society’s statement with regard to ‘the exact mensuration of time’!

John Harrison had been offered the Fellowship but, remarkably, declined. He asked that it be given instead to his son, William, at that time his assistant. This was not possible, of course, but William was later elected in his own right, as will be described. (Concerning Harrison’s declining of the Fellowship, one of us (A.W.W.) is fascinated by the fact that one of his forebears, Robert Peel, declined the Presidency in 1848. He did, though, found the modern Conservative Party. Fortunately, lack of space precludes speculation on the possible interrelation of these activities.)

By the late 1760s, Harrison (figure 6) realized that his large slow-beating clock-sized movements had fundamental problems that were more likely to be overcome by using a more rapidly oscillating balance wheel with more relative rotary energy. A London watchmaker, John Jefferys, made a watch with bimetallic temperature compensation to Harrison’s design that showed such promise by its accuracy that he developed his horological designs to construct a large watch, H4, which satisfied the requirements of the original Act. But the elusive Prize was not yet to be and here we have to turn to the activities of the fifth Astronomer Royal, Nevil Maskelyne, a distinguished Fellow but a man who has had a bad press.

**NEVIL MASKELYNE AND THE HARRISON SAGA**

It has been claimed by many (for example Dava Sobel¹) that Maskelyne impeded Harrison’s pursuit of the Prize. He was certainly after the Prize himself (by definition—as Head of the Royal Greenwich Observatory) and it is true that he was a member of the
Commission and charged by them with testing Harrison’s watch. What are the facts? Was he honourable?

For a start, Maskelyne supported Harrison’s son William by signing his ‘Certificate of Nomination’ in 1765; there was no sign of animosity there. For a start, Maskelyne supported Harrison’s son William by signing his ‘Certificate of Nomination’ in 1765; there was no sign of animosity there. 5

The main problem came in 1767 when Maskelyne published, by order of the Commissioners of Longitude, ‘An account of the Going of Mr John Harrison’s watch (H4) at the Royal Observatory from 6 May 1766 to 4 March 1767’. 6 The background was that, after a very successful test of H4 in going from Portsmouth to Jamaica and back, where the watch had lost only 1 minute 54.5 seconds, the Board of Longitude had required Maskelyne to make further tests on the watch. The Board had met on 9 February 1765, some 6 months after the successful sea trial, and had awarded half the Prize (£10 000, less the money already advanced). However, they drew attention to the Act’s requirement that the method should be ‘found Practicable and Useful at Sea’. Remarkably, they interpreted this as requiring the construction of more watches and, after more meetings, culminating in one on 26 April 1766, they instructed Maskelyne to test H4. For disputed reasons, Maskelyne’s test showed a poor performance of H4 at the Observatory over the period of the test: 6 May 1766 to 4 March 1767.

Harrison’s reaction can be imagined: an intemperate booklet was published in which Harrison accused Maskelyne of many irregularities in the manner in which the trial was carried out and proceeded to blast the lunar method. Most importantly, and regrettably, he impugned Maskelyne’s honesty.
What is the truth? Two centuries later, Quill made an exhaustive study of the situation and concluded that Maskelyne’s summing up was fair and reasonable, but ‘he made no allowances in Harrison’s favour’. Maskelyne himself became sensitive to the criticism and in later life he wrote (in about 1800) that

‘...he [Maskelyne] always allowed Mr Harrison’s great merit, as a genius of the first rate. ... He made no opposite [opposition] to Parliament granting him the remainder of the reward of £20,000; but only to the Board of Longitude doing it; as he had not submit[ted] to trials, and those sufficient to enable the Board to give it to him according to the terms of the Act’.

To revert to Harrison’s pursuit of the Prize, he continued to fulminate and eventually, through the intercession of King George III, achieved his goal in 1773 when Parliament voted the residual prize money. This is not to say that Harrison received the Prize itself. No one did! Maskelyne had been right in Harrison’s not having satisfied the terms of the Act (a successor of the original Act, with more stringent requirements) but Parliament realized the injustice that Harrison had suffered. He, Harrison, had certainly solved the longitude problem and sea clocks eventually became the method of choice of determining longitude at sea for some 200 years.

What, then, of Maskelyne’s role? That he was honourable seems to be true. That, as a Government-funded scientist, he obeyed the rule-book is also true. It was this latter, uncommon among scholars, which led to the problems and the popular myth that he was the villain in the Harrison saga.

HARRISON’S MEMORIAL

Harrison’s true memorial is his contribution to accurate navigation and thus the status of Britain as a maritime power in the nineteenth century; there can be few—military or otherwise—whose work was as effective.

As mentioned in the introduction, there is now a Harrison Medal awarded by the Worshipful Company of Clockmakers for work leading to the better appreciation of the history of horology. Jonathan Betts of the National Maritime Museum was the first prizewinner, and Dava Sobel was the second.

The creation of a memorial for John Harrison in Westminster Abbey (figure 7) was not a trivial matter. Understandably, various criteria had to be satisfied, including the guarantee that it was, indeed, Harrison who made the unique timekeepers and that he would not have been upset had he known that he would have been memorialized. The Worshipful Company of Clockmakers (through its Clerk, Mr Joe Buxton) took over the non-Abbey side of the administration, once permission had been given. Fund-raising was a major component, with arrangements made that excess funds over those needed would be used for training new clockmakers. The unveiling of the memorial by the Duke of Edinburgh (himself a Fellow of the Royal Society) on 24 March 2006, was followed by lectures in the Institution of Civic Engineers. The lectures, by John C. Taylor, Dava Sobel and Jonathan Betts, related to Harrison’s life and work and were a brilliant climax to a memorable occasion.

Again, as remarked earlier, the small exhibition in the Abbey spawned a much bigger one at the Royal Society from July to September 2006, ending with its being shown in Buckingham Palace for the Reception of 500 eminent scientists on 24 October 2006. Harrison, we think, would have been pleased.
Postscript. It is perhaps appropriate that rewards for the ‘pursuit of time’ should take a long time: 47 years elapsed between Harrison’s learning of the Prize and securing his award, and the period between his death and the unveiling of a memorial was 230 years! We hope that Harrison is content with the outcome of Prince Philip’s continuing where King George III left off.

NOTES

7 H. Quill, John Harrison, the man who found longitude (Humanities Press Inc., New York, 1966).
8 The European Magazine, June, p. 408 (1805).