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SCIENCE LOST AND LONGITUDE FOUND: THE TERCENTENARY OF JOHN HARRISON

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As the three-hundredth birthday of John Harrison is celebrated with symposia at the Royal Society and at Harvard University, what is happening in Harrison studies? The production and reception of the Harrison chronometers must be a subject with enormous potential for the historian of science. First the biographical setting is extraordinary — a humble carpenter from an utterly obscure provincial village wins, against all informed expectation, the fabulous prize for finding the longitude. The story of how he managed what was widely believed to be impossible is gratifyingly protracted and tortured: Harrison's struggles with machines and men lasted for the most of a long lifetime. Little wonder that we are inclined towards a romantic tale of a little man triumphing over vested interest and official bureaucracy to wrest his just reward from an unwilling establishment; only slightly more wonder that his case for recognition is still being fought today.

Second, Harrison, as an unpredictable outsider, ignorant of the rules and conventions and unimpressed by those he encountered, stepped on almost everyone's toes and challenged all manner of tacit boundaries — between mathematical and mechanical skill, public and private intellectual property, gentlemen and players. The Harrison question, which dominated the business of the Board of Longitude for some 35 years, forced them to consider vexed issues of public sponsorship and the disbursement of public funds on technical ventures, guided only by the force of inadequate and outdated legislation. Harrison was not one to accept the competence of public men. Thankfully he was no respecter of anyone — an infuriating man to deal with, he seemed never to be grateful, never to know when he had as much as his position could command or expect. It was Harrison's impossible traits that made life so difficult for the Astronomer Royal and the Commissioners for Longitude, but which probed and challenged the assumptions of that tiny arm of eighteenth-century British government that related directly to science, and so has opened these assumptions to the scrutiny of historians.

Almost all the prominent features of the Harrison romance need significant qualification. Although his origins were humble, his character was not. Nor was he "little", if that connotes naïvety, innocence, or a lack of manipulative skill: he was as good at political operating as mechanical. So far as is known, he was the first longitude pretender to effect, in 1737, a meeting of the 23-year-old Board of Longitude, he dominated their agenda for decades, and persuaded them to speculate large sums on his unlikely ambitions. He used the propaganda techniques of printed broadsheets and ghost-written pamphlets to embarrass the Board and further his cause. Through Parlia-

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mentary petitions and letters to the King and to government ministers, he very effectively appealed above the Board's authority. Indeed, the most implausible feature of the Harrison tale — the relationship he and his son established with George III — has reasonable documentation. The second general qualification is that, as Gould has shown, Harrison did not solve the longitude in any realistic or effective sense, even though he met the conditions of the Longitude Act.[1] He demonstrated that mechanical ingenuity could deliver the required accuracy, but his horological techniques did not become part of practical chronometry — that was pioneered by Pierre Le Roy and rationalized and applied by John Arnold and Thomas Earnshaw. Finally, Quill has shown that, strictly speaking, Harrison did not win the £20,000 longitude prize.[2] Rather, the Commissioners allowed him an intermediate reward of £10,000 and Parliament subsequently granted him a separate £8,750, independent of the Board's authority. Taken together with £4,000 awarded over the years as grants from the Board, Harrison's total receipt of public money was £22,750. Characteristically Harrison and his son William maintained they had been "stung out of" £1,250.

There have been two book-length accounts of Harrison, to add to Gould's pioneering monograph on *The marine chronometer*. Humphrey Quill's fine biography, *John Harrison, the man who found longitude* was published in 1966 and has stood the test of time; it is from this work that the above details of Harrison's career have been taken. In 1976 W. S. Laycock's *The lost science of John "Longitude" Harrison* gave a novel imperative to Harrison studies. Laycock set out unashamedly to right past wrongs, which for him meant to recover and demonstrate Harrison's "science" and indeed his use of "scientific method". Speculative recreations of Harrison's methods and intentions, only tenuously secured in Harrison's notoriously obscure prose, are elaborated through sophisticated mechanical analysis. The adulation of Harrison is not tempered by the historian's customary scepticism. At one point, in discussing a discrepancy between Harrison's performance claims and his own theoretical predictions, Laycock abandons any vestige of critical methodology by saying that "... it is surely much more likely that I myself, who am still as it were groping around in but a glimmer of light, am yet lacking a full comprehension of his approach, than that the master himself either was misled or has misled us in this one matter ...".[3]

So uncritical an approach might be thought fatally to compromise Laycock's work, but the analysis is challenging and technically, if not historiographically, sophisticated. Laycock aimed at uncovering Harrison's principles, and so he held that reconstructions should use modern techniques, "provided we do not vitiate any of his basic principles themselves". Harrison's achievement, apparently, was not grounded in the technology and materials of his own time: "such shortcomings as have been discussed in the examination of Harrison's work arise from the limitations of practice in the eighteenth century."[4] There is an irony here, for it might well be imagined that for Harrison his spectacular success as a mechanic stood out triumphantly, in its own terms, as a vindication of an understanding wrought

in the workshop — a mechanical empathy that could not be codified by the techniques of those he called "the Priests and Philosophers". But in the end, proper recognition, according to this historiography, depends on the codification of "the University men", the "Men of Theory".

Laycock's approach has been continued by a "Harrison Research Group" and provides the focus for most contemporary work. Although vindication for Harrison, and condemnation of neglect and hostility, remain high on their agenda, it is important that appreciation of his mechanical achievement is being advanced, as the machines will always be the foundation of Harrison's reputation and significance.[5] However, there are other questions — eighteenth-century issues that will require analysis every bit as sensitive as the mechanical subtleties — which Harrison's history allows us to address.

In fact, things were by no means so polarized and straightforward as is popularly imagined. Harrison's first exploratory visit to London was made worthwhile through the positive contacts he established with Edmond Halley and George Graham. Halley's official work, of course, was aimed at longitude by lunars and Graham, as well as being the capital's most prominent horologist, was Halley's instrument maker. When Harrison returned to London in 1735 with his first timekeeper, Halley and Graham were valuable intermediaries and were two signatories to a certificate by a group of Fellows of the Royal Society, urging public encouragement for Harrison. Two others were Robert Smith and James Bradley — both priests and philosophers — and the fifth was John Machin, who worked on the theoretical complement to Halley's observations and who in 1727 had considered himself entitled to half of the full longitude prize.[6] A further certificate signed by twelve Fellows, including the President Martin Folkes, was arranged in 1741,[7] and Harrison was awarded the Copley Medal in 1749.

The Board of Longitude encouraged Harrison, at least in the earlier years, making him grants documented by Quill: these come to a hugh total of £3,000 (of the order of £130,000 at today's prices) between 1741 and 1761. This represents a grant made on each occasion when Harrison appeared before the Board and covers the period while he was making his third timekeeper. Since this occupied nineteen instead of the promised two-and-a-half years, such generous use of public money might even seem reckless.

From the beginning, some of the Board's anxieties are evident from their minutes. Their grant of £500 made at their very first meeting was in respect of projected work on a much smaller machine to be made in two years, and it was stipulated that both machines were to become the property of the Commissioners of the Navy, "for the Use of the Public".[8] The latter condition was repeated at the second meeting in January 1741.[9] Similarly it was promised that the third machine would not only be smaller but "being of a simpler and plainer Construction it will be easier adjusted & will serve as a better Model for Workmen to make others by: so that ships may be furnish'd with like Machines at a Cheaper rate".[10] This passage could scarcely be a less accurate description of what emerged as the third timekeeper.

As time passed, the Board became more exercised by the magnitude of

their responsibilities. Perhaps it was the success of Harrison's watch (the fourth and, at last, very much smaller timekeeper) on its first voyage to the West Indies — to Jamaica — that concentrated their minds on the actual possibility of making the major award and so announcing in the most public manner imaginable that the longitude had been solved. The original Longitude Act of 1714, which the Commissioners must have poured over repeatedly, was not without ambiguities. It began in a practical vein, setting out the need for a reliable method in terms of "the Safety and Quickness of Voyages, the Preservation of Ships and the Lives of Men" and of the "particular Advantage to the Trade of Great Britain".[11] When it came to defining what a solution might be, however, the guidance was very incomplete. It provided for trials at sea, stipulated levels of award for certain degrees of accuracy and required the Commissioners to "Declare and Determine how far the same is found Practicable, and to what Degree of Exactness". The Commissioners could derive some measure of exactness from the trials they might arrange, but practicality was much more difficult to decide.

The particular form the question took when it finally confronted them was this. A unique watch has kept time in an appropriate trial so as to qualify for the highest award. The title of the Act referred to a reward for "such Person or Persons as shall Discover the Longitude at Sea". Had the discovery now been effected? Could one trial, or one watch, determine such a question — could two, or three? The principles of the watch were as yet unknown. Could it be made at a reasonable cost in large numbers? The evidence the Board accrued on this front was discouraging. Could the watch be copied by other makers and managed at sea by naval officers? The astronomers on the Board were certainly aware that in their own field mechanical success at the highest level had come to depend on the skills of a very few individuals. The wording of subsequent clarifying legislation and the variety of defensive requirements and conditions imposed by the Board clearly indicate the direction of their concerns — they wanted to be reassured that they were releasing the famous prize for a "method of common and general Utility".[12] Otherwise, the whole reason for their existence and their entire public responsibility would founder.

The Commissioners themselves pointed to the ambiguities in the Act. Acknowledging that the performance of Harrison's watch on the Barbados voyage had been well within the most exacting limit, their further conditions were designed to determine whether "the said Invention might be adjudged practical and useful in Terms of the said Act, & agreeable to the true Intent and Meaning thereof".[13] The anonymous author of a pro-Harrison tract referred to "a scrupulous Nicety, in the Disposition of publick Money".[14]

The issues are clearly set out in Quill's biography, but have yet to be explored in detail by historians of science interested in the apparatus for public sponsorship. Other issues concern the rights to intellectual property, and to the machines themselves — questions hotly disputed between Harrison and the Board, in a contest between public utility and private protection.[15] How were the principles of the watch to be made public? General utility required

publication, but how could a published account communicate a process that depended so intimately on manipulative skill? Would Harrison retain any privileges or protections after any reward? Who would retain his timekeepers? Who would have access to them for making copies? Harrison was particularly resistant to demonstrational (as distinct from written) disclosure and to parting with the machines — "nor will I ever come under the directions of Men of Theory".[16]

As if these problems were not sufficiently fraught, at the very time when Harrison was making his principal bid, the rival astronomical method, based on lunar distance measurement, was becoming a serious contender and the Board were being lobbied on behalf of some of those involved, such as Tobias Mayer and John Bird.[17] It would always be easier for the "Men of Theory" to trust a technique demonstrable in astronomy and mathematics, and to determine when such a method had been proved. How would the Board weigh the authority of mechanical trials against mathematical demonstrations? How could they decide between such incommensurables?

As early as 1756 Mayer's case was being represented to the Board, with support from Bradley.[18] At the very meeting when they considered the implications of the trial voyage to Barbados, the Commissioners heard from Maskelyne of his practical success with the lunar distance method for longitude on a voyage to St Helena, using Mayer's tables and a Hadley quadrant, and were assured that the only thing required to make the method "generally practicable at sea" was an appropriate ephemeris.[19]

Harrison reserved his greatest animosity for the lunar method and its proponents — "the Devil may take the Priests", with their "infamous Nautical Almanac". To him the lunar method was so manifestly inferior — subject to errors in its tables, instruments and observations, requiring hours of calculation, unavailable when the moon was close to the sun and rendered impossible by cloudy weather — that it could only be the power differential between himself and "the Lunar-Men" that made the contest conceivable: "my being neither University-man, Knight nor Earl, &c, insomuch, that even an Act of Parliament could not possibly, or at least, not so well, as on my Behalf stand good." Imagine, he suggested, his treatment if they had a fine, working, tested timekeeper, and he were to arrive "out of the Country from where I did come", with a scheme based on "the improper, troublesome, eroneous, tedious Method" of lunar distances.[20]

John Harrison introduced himself to the world as "Clock=Maker at Barrow; near Barton upon Humber; Lincolnshire"; by the close of his career his adopted distinction became "Inventer of the Time-Keeper for the Longitude at Sea".[21] The episode is a rich resource for the historian. It involves the Royal Society, the Board of Longitude, Parliament, the King. It centres on the use of public funds for technological speculation and the implications for the inventor and the public. It sets the mechanic against the "Priests at Cambridge and Oxford", his workshop practice against their "high Algebra".[22] The contest was public and the prize famous. If work on John Harrison is to realise its potential, we must complement the current

mechanical debates with answers to many other questions surrounding his enigmatic success.

APPENDIX

A famous meeting took place at John Harrison's house in Red Lion Square, London, in August 1765, when six nominees of the Board of Longitude, with Maskelyne in attendance, witnessed Harrison dismantling and explaining his prize-winning watch. A hitherto unnoticed first-hand account of the meeting has recently come to light in the archives of the Royal Astronomical Society, and is reproduced with the Society's consent.[23] It was written by John Bird, the only instrument maker among those present, in a letter to Thomas Hornsby, who as Professor of Astronomy at Oxford was an *ex-officio* member of the Board. The date is 20 August 1765, which means that it was written before the meeting was concluded; the certificate presented to Harrison by his examiners was dated 22 August.[24] Bird draws attention to the watch's maintaining power, the remontoir, the temperature compensation applied to the balance spring, and the pin for achieving isochronism, where he has caught Harrison's terminology by calling it a "Cycloid". It was the fitting of this pin that led Harrison to abandon a rate adjustment — as Bird says, there is no "Slide". Perhaps the most interesting feature of the report is Bird's comments on the practicality of manufacturing the watch; we can now add his opinion to the known doubts on this critical question of three other examiners, Ludlam, Mitchell and Kendall.

London 20th. Aug. 1765

Dear Sir,

I did not write to you last Saturday because, then, I could only give you a partial account of our proceedings with M^{r}. Harrison. We have now spent five days with him, in great good humour; he first explain'd the drawings, then took the Watch to pieces and explain'd every part; the Contrivance is curious, and executed with great accuracy, but several parts are, and must be done by a tentative method, which will always render the execution teadious and difficult. It is keep'd going while winding up, by a spring within the fusee, connected with the great wheel: except this spring it differs very little from common Watches till he comes to the Contrat wheel: this is curious, it contains the spring (spiral) which winds, by means of a dittent, 8 times in a minute [new line] beyond this is nothing more than the ballance wheel and ballance, in which I include the ballance spring which is regulated by a Thermometer: this lies across the frame plate; and between the time of its coming from Jamaica and its going to Barbadoes, he added a Cycloid, or rather substitute thereof — The Watch has no Slide. When I receive your money of Mr. Ibbetson I will lay it safely by, till you draw for it, or come to receive it — Pray help the Dean of Durham to

rectify the line of Collimation of his Quadrant by a Star near y^e^ Zenith, and you'll much oblige

Dear Sir yours Sincerely

John Bird

Nothing yet about the observatory at Oxford

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10. *Ibid.*, p. 11; *An account* (ref. 7), 21.
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