



LONGITUDE

The

True Story of a

Lone Genius

Who Solved

the Greatest

Scientific Problem

of His Time



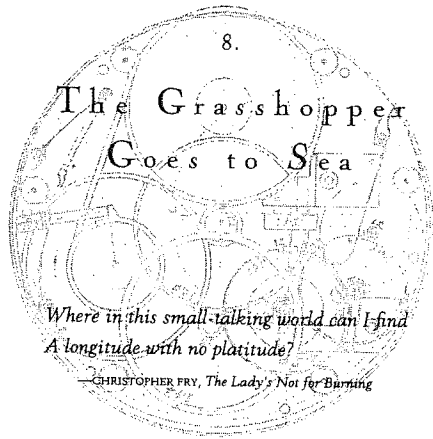
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When John Harrison arrived in London in the summer of 1730, the Board of Longitude was nowhere to be found. Although that august body had been in existence for more than fifteen years, it occupied no official headquarters. In fact, it had never met.

So indifferent and mediocre were the proposals submitted to the board, that individual commissioners had simply sent out letters of rejection to the hopeful inventors. Not a single suggested solution had held enough promise to inspire any five commissioners—the minimum required by the Longitude Act for a

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with astronomers, mathematicians, and navigators. Halley himself spent most of his days and nights working out the moon's motion to further the lunar distance method of finding longitude, yet he kept an open mind.

Rather than march Harrison into the lion's den, Halley sent him to see the well-known watchmaker George Graham. "Honest" George Graham, as he was later called, would be the best judge of the sea clock Harrison proposed to build. At least he would understand the fine points of its design.

Harrison feared Graham would steal the idea from him, but he followed Halley's advice anyway. What else could he do?

Graham, who was about twenty years older than Harrison, became his patron at the end of one long day together. As Harrison described their first meeting in his inimitable prose, "Mr Graham began as I thought very roughly with me, and the which had like to have occasioned me to become rough too; but however we got the ice broke . . . and indeed he became as at last vastly surpris'd at the thoughts or methods had taken."

Harrison went to see Graham at ten o'clock in the morning, and by eight that evening they were still talking shop. Graham, the premier scientific instrument maker and a Fellow of the Royal Society, invited Harrison, the village carpenter, to stay to dinner.

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quorum—to bother gathering together for a serious discussion of the method's merits.

Harrison, however, knew the identity of one of the most famous members of the Board of Longitude—the great Dr. Edmond Halley—and he headed straight for the Royal Observatory at Greenwich to find him.

Halley had become England's second astronomer royal in 1720, after John Flamsteed's death. The puritanical Flamsteed had reason to roll over in his grave at this development, since in life he had denounced Halley for drinking brandy and swearing "like a sea-captain." And of course Flamsteed never forgave Halley, or his accomplice Newton, for pilfering the star catalogs and publishing them against his will.

Well liked by most, kind to his inferiors, Halley ran the observatory with a sense of humor. He added immeasurably to the luster of the place with his observations of the moon and his discovery of the proper motion of the stars—even if it's true what they say about the night he and Peter the Great cavorted like a couple of schoolboys and took turns pushing each other through hedges in a wheelbarrow.

Halley received Harrison politely. He listened intently to his concept for the sea clock. He was impressed with the drawings, and he said so. Yet Halley knew that the Board of Longitude would not welcome a mechanical answer to what it saw as an astronomical question. The board, it will be recalled, was top-heavy

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When Graham finally said good night, he waved Harrison back to Barrow with every encouragement, including a generous loan, to be repaid with no great haste and at no interest.

Harrison spent the next five years piecing together the first sea clock, which has come to be called Harrison's No. 1, for it marked the first in a series of attempts—H-1 for short. His brother James helped, though neither one of them signed the timepiece, strangely enough. The going train ran on wooden wheels, as in the pair's previous collaborations. But overall, it looked like no other clock ever seen before or since.

Built of brightly shining brass, with rods and balances sticking out at odd angles, its broad bottom and tall projections recall some ancient vessel that never existed. It looks like a cross between a galley and a galleon, with a high, ornate stern facing forward, two towering masts that carry no sails, and knobbed brass oars to be manned by tiers of unseen rowers. It is a model ship, escaped from its bottle, afloat on the sea of time.

The numbered dials on H-1's face obviously tie it to the telling of time: One dial marks the hours, another counts the minutes, a third ticks off the seconds, and the last denotes the days of the month. Yet the look of the whole contrivance, fairly bristling with complexity, suggests that it must be something more

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than just a perfect timekeeper. The large coiled springs and unfamiliar machinery tempt one to try to commandeer the thing and ride it into another era. No fanciful movie about time travel, despite the best efforts of Hollywood set design, ever presented a time machine as convincing as this one.

The Harrisons housed H-1, which weighs seventy-five pounds, in a glazed cabinet four feet in every dimension—high, wide, and deep. The case may have hidden the whirligig aspects of the timepiece. Perhaps only the face, with its four dials surrounded by eight carved cherubs and four crowns in a tangle of serpentine ropes or leafless vines, showed from the outside. However, the cabinet, like the cases of Harrison's early clocks, has been lost, exposing the works to general scrutiny. H-1 now lives and works (with daily winding) in an armored-glass box at the National Maritime Museum in Greenwich, where it still runs gamely in all its friction-free glory, much to the delight of visitors. The decorated face clashes with the skeletal works—the way a well-dressed woman might look if she stood behind an imaging screen that bared her beating heart.

Even at the start of its long career, H-1 constituted a study in contrasts. It was of its age but ahead of its time, and when it came along, the world was already weary of waiting for it. Although H-1 did what it set

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miralty, Sir Charles Wager, sent the following letter of introduction to Captain Proctor, commander of the *Centurion*, on May 14, 1736:

Sir, The Instrument which is put on Board your Ship, has been approved by all the Mathematicians in Town that have seen it, (and few have not) to be the Best that has been made for measuring Time; how it will succeed at Sea, you will be a Judge; I have writ to Sir John Norris, to desire him to send home the Instrument and the Maker of it (who I think you have with you) by the first Ship that comes. . . . [T]he Man is said by those who know him best, to be a very ingenious and sober Man, and capable of finding out something more than he has already, if he can find Encouragement; I desire therefore, that you will let the Man be used civilly, and that you will be as kind to him as you can.

Captain Proctor wrote back right away to say,

[T]he Instrument is placed in my Cabbin, for giving the Man all the Advantage that is possible for making his Observations, and I find him to be a very sober, a very industrious, and withal a very modest Man, so that my good Wishes can't but attend him; but the Difficulty of measuring Time truly, where so many unequal Shocks, and Motions, stand in Opposition to it, gives me concern for the honest Man, and makes me fear he has attempted impossibilities; but Sir, I will do him all the Good, and give him all the Help, that is in my Power, and acquaint him with your Concern for his Success, and your Care that he shall be well treated. . . .

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out to do, it performed so singularly that people were perplexed by its success.

The Harrison brothers took H-1 out for trial runs on a barge on the River Humber. Then John carried it to London in 1735, and delivered on his promise to George Graham.

Much pleased, Graham showed the wonderful sea clock—not to the Board of Longitude but to the Royal Society, who gave it a hero's welcome. Concurring with Dr. Halley and three other equally impressed Fellows of the Society, Graham wrote this endorsement of H-1 and its maker:

John Harrison, having with great labour and expense, contrived and executed a Machine for measuring time at sea, upon such Principle, as seem to us to Promise a very great and sufficient degree of Exactness. We are of Opinion, it highly deserves Public Encouragement, In order to a thorough Tryal and Improvement, of the severall Contrivances, for preventing those Irregularities in time, that naturally arise from the different degrees of Heat and Cold, a moist and drye Temperature of the Air, and the Various Agitations of the ship.

Despite the hoopla, the Admiralty dragged its feet for a year in arranging the formal trial. And then, instead of sending H-1 to the West Indies, as the Longitude Act required, the admirals ordered Harrison to take his clock down to Spithead and board H.M.S. *Centurion*, bound for Lisbon. The first lord of the Ad-

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Proctor needn't have worried about the performance of Harrison's machine. It was the man's stomach that gave him grief. The rough crossing kept the clockmaker hanging over the rail much of the time, when he wasn't in the captain's cabin, tending his timekeeper. What a pity Harrison couldn't fit his own insides with the two dumbbell-shaped bar balances and four helical balance springs that helped H-1 keep its equanimity throughout the journey. Mercifully, the strong winds blew the *Centurion* swiftly to Lisbon within one week.

The good Captain Proctor died suddenly as soon as the ship reached harbor, before he'd written up any account of the voyage in his log. Only four days later, Roger Wills, master of H.M.S. *Orford*, received instructions to sail Harrison back to England. The weather, which Wills recorded as "very mixed with gales and calms," made for a monthlong voyage home.

When the ship neared land at last, Wills assumed it to be the Start, a well-known point on the south coast around Dartmouth. That was where his reckoning placed the ship. Harrison, however, going by his sea clock, countered that the land sighted must be the Lizard on the Penzance peninsula, more than sixty miles west of the Start. And so it was.

This correction greatly impressed Master Wills. Later, he swore out an affidavit admitting his own mistake and praising the accuracy of the timekeeper.

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Wills gave this certificate, dated June 24, 1737, to Harrison as an official pat on the back. It marked the start of a banner week for Harrison, because on the 30th, the commissioners of the Board of Longitude convened for the very first time—twenty-three years after the board was created—citing his marvelous machine as the occasion.

Harrison presented himself and H-1 to the eight commissioners who sat in judgment of his work. He recognized several friendly faces among them. In addition to Dr. Halley, already a booster, he saw Sir Charles of the Admiralty, who had written the letter of concern on the eve of H-1's maiden voyage, urging that Harrison get a fair shake. And there was Admiral Norris, head of the fleet at Lisbon, who had given Harrison his sailing orders. The two academics in attendance, Dr. Robert Smith, the Plumian Professor of Astronomy at Cambridge, and Dr. James Bradley, the Savilian Professor of Astronomy at Oxford, also supported Harrison, as both of them had signed their names to the letter of endorsement that Graham wrote on behalf of the Royal Society. Dr. Smith even shared Harrison's interest in music and had his own odd views on the musical scale. Sir Hans Sloane, president of the Royal Society, rounded out the scientific representation at the meeting. The other two board members, unknown to Harrison, were the Right Honorable Arthur Onslow, speaker of the House of Com-

once he had turned over the finished product to a ship's captain of the Royal Navy, ready for a road test. At that point, according to the agreement recorded in the minutes of the meeting, Harrison would either accompany the new timekeeper to the West Indies himself, or appoint "some proper Person" to go in his stead. (Perhaps the commissioners had heard tell of Harrison's seasickness and were already making allowances for him.)

One last provision completed the compact. Upon the return of the second timekeeper from its trial at sea, Harrison would surrender it, along with the first sea clock, "for the Use of the Public."

A better businessman might have balked at this point. Indeed, Harrison could have argued that while the board was entitled to the second machine, as thanks for its subsidy, it had no claim to the first, which he had built at his own expense. But, rather than quibble over rights of ownership, he took the board's proprietary interest as a positive incentive. He inferred that he was in their employ now, like an artist commissioned to create a great work for the throne, and so would be royally rewarded.

Harrison wrote this assumption prominently, a bit pompously, on the face of the second timekeeper when he finished it. Above the austere, unornamented dial of H-2 is an engraved silvered plate, with flourishes of scrolls surrounding the inscription, "Made for

mons, and Lord Monson, commissioner of Lands and Plantations, who reflected the board's political clout.

Harrison had everything to gain. He stood there with his prized possession, before a group of professionals and politicians predisposed to be proud of what he'd done for king and country. He had every right to demand a West Indies trial, to prove H-1 deserving of the £20,000 promised in the Longitude Act. But he was too much of a perfectionist to do it.

Instead, Harrison pointed out the foibles of H-1. He was the only person in the room to say anything at all critical of the sea clock, which had not erred more than a few seconds in twenty-four hours to or from Lisbon on the trial run. Still, Harrison said it showed some "defects" that he wanted to correct. He conceded he needed to do a bit more tinkering with the mechanism. He could also make the clock a lot smaller, he thought. With another two years' work, if the board could see its way clear to advancing him some funds for further development, he could produce another timekeeper. An even better timekeeper. And then he would come back to the board and request an official trial on a voyage to the West Indies. But not now.

The board gave its stamp of approval to an offer it couldn't refuse. As for the £500 Harrison wanted as seed money, the board promised to pay half of it as soon as possible. Harrison could claim the other half

His Majesty George The IInd, By order of a Committee Held on 30th of June 1737."

If Harrison harbored any illusions of grandeur about H-2, he dashed them himself in short order. By the time he presented the new clock to the Board of Longitude in January 1741, he was already disgusted with it. He gave the commissioners something of a repeat performance of his previous appearance before them: All he really wanted, he said, was their blessing to go home and try again. As a result, H-2 never went to sea.

The second timekeeper, which had turned out to be a brass heavyweight of eighty-six pounds (although it did fit into a smaller box, as promised), was every inch as extraordinary as the first. It embodied several new improvements—including a mechanism to ensure a uniform drive and a more responsive temperature compensation device, each of which constituted a minor revolution in precision. Also the whole machine passed many rigorous tests with flying colors. The 1741-42 report of the Royal Society says that these tests subjected H-2 to heating, to cooling, and to being "agitated for many hours together, with greater violence than what it could receive from the motion of a ship in a storm."

Not only did H-2 survive this drubbing but it won full backing from the Society: "And the Result of these Experiments, is this; that (as far as can be deter-

mined without making a voyage to sea) the motion is sufficiently regular and exact, for finding the Longitude of a Ship within the nearest Limits proposed by Parliament and probably much nearer."

But it wasn't good enough for Harrison. The same vicelike conviction that led him to his finest innovations—along his own lines of thinking, without regard for the opinions of others—rendered him deaf to praise. What did it matter what the Royal Society thought of H-2, if its mechanism did not pass muster with him?

Harrison, now a London resident and forty-eight years old, faded into his workshop and was hardly heard from during the nearly twenty years he devoted to the completion of H-3, which he called his "curious third machine." He emerged only to request and collect from the board occasional stipends of £500, as he slogged through the difficulties of transforming the bar-shaped balances of the first two timekeepers into the circular balance wheels that graced the third.

Meanwhile, H-1 stayed in the limelight. Graham had it on loan from Harrison, and kept it on exhibit in his shop, where people came from all over just to look at it.

Pierre Le Roy of Paris, the deserving heir to his father Julien Le Roy's title of king's clockmaker in France, paid tribute to H-1. Upon his 1738 visit to London, he called the timekeeper "a most ingenious

contrivance." Le Roy's archrival, the Swiss-born horologist Ferdinand Berthoud, echoed that sentiment when he first saw H-1 in 1763.

The English artist William Hogarth, well known for his obsession with time and timekeeping, who had actually started out as an engraver of watchcases, took a particular interest in H-1. Hogarth had portrayed a "longitude lunatic," scribbling a dim-witted solution to the longitude problem on the walls of Bedlam Asylum, in his popular work *The Rake's Progress* of 1735. Now, H-1 had elevated the whole subject of finding longitude from the status of a joke to the highest level of combined art and science. Writing in his *Analysis of Beauty*, published in 1753, Hogarth described H-1 as "one of the most exquisite movements ever made."