



# REVOLUTION

SOME WATCHES REVOLUTIONISED WATCHMAKING BUT JOHN HARRISON'S MARINE CLOCK, THE FIRST CHRONOMETER, DID SOMETHING EVEN MORE EXTRAORDINARY: IT CHANGED THE COURSE OF HISTORY. HIS CLOCK MADE IT POSSIBLE TO CALCULATE LONGITUDE AT SEA AND NAVIGATE WITH PRECISION. BEFORE THEN, SEAFARERS AND CARTOGRAPHERS HAD FUMBLLED ALONG, OCCASIONALLY MISTAKING ISLANDS FOR THE MAINLAND AND RUNNING AGROUND. TODAY HARRISON'S CLOCK, AND THE PROTOTYPES WHICH PRECEDED IT, CAN BE SEEN IN A NEW GALLERY AT THE ROYAL OBSERVATORY IN GREENWICH.

WORDS MICHAEL DEE

On 25 March 1714 the British Parliament received an urgent, not to mention desperate, petition from the leaders of the navy and merchant fleet. They demanded that Parliament once and for all address the major navigation headache: longitude. "The longitude problem," as it was called, caused chaos and lots of shipwrecks quite simply because there wasn't an exact method of calculating longitude. Latitude was no problem. The parallel latitude lines run from north to south and are fixed by the laws of nature. An experienced sailor could easily calculate the latitude by working out the length of the day or the height of the sun or stars over the horizon. Figuring out longi-

tude was a different matter entirely. Since the day of Ptolemy the geographer, its zero point, the primary meridian, had been placed according to personal or political preference, including Rome, Paris and St Petersburg, before it was finally placed in Greenwich.

Unlike latitude, longitude is calculated with time. Once you are out on the high seas you need to know what the time is onboard the ship and also what the time is at the exact same moment in another place whose longitude you know. Using the time differences, a navigator could then calculate the difference in geographical distance.

This is simple enough today, but in the early

18th century the primitive pendulum clocks were anything but reliable. They were often slow and at sea the rolling of the waves and the changes in humidity and temperature made them deviate even more. After a few days on the ocean it was almost impossible to guess what time it was on land.

Of course, this caused enormous problems. You never knew how far west or east you were. You could be 10 miles offshore or 100 miles. Islands with dangerous reefs were mistaken for land and it wasn't just navigation that was made more difficult – cartography also became tricky. The longitude problem not only cost human

lives, it also cost huge amounts of money, especially for Great Britain which at the time was the world's leading maritime nation. In the end, the British seafarers and traders had had enough and marched to Parliament with their petition.

After much deliberation, the Board of Longitude was set up to deal with the problem. The board decided to offer a reward to anyone who could come up with a method for calculating longitude at sea. It was set at £10 000 if the method was within one degree, £15 000 within two thirds of a degree, and £20 000 within half a degree. This was a huge amount of money: £20 000 is the equivalent of about £2 million today, and so this set the best scientists and con men of the day thinking.

Of course, this wasn't the first time that people had tried to solve the longitude problem. For over two centuries it had been a constant challenge for the sharpest minds in Europe. Prominent scientists like Galileo Galilei, Jean Dominique Cassini and Sir Isaac Newton had tried to solve it. But they all sought the solution in the stars using astronomy and failed. Most people thought it was ridiculous that a method based on clocks could work because everyone knew that clocks were unreliable. But the scientific establishment hadn't reckoned with John Harrison.

Harrison was an outsider. He was born in 1693, the oldest son of a poor carpenter in Foulby in Yorkshire, northern England. When he was an old man he recalled how, when he was six years old and in bed recovering from smallpox, his parents had placed a watch on his pillow. He was fascinated by it and the memory etched itself into his consciousness.

The young John Harrison was his father's apprentice but when he was a little older he earned extra money on the side as a land surveyor and used the money to buy books on mechanics and physics. He also taught himself to repair clocks and he was soon so skilled that he became a full-time watchmaker. However, Harrison wasn't content to trust contemporary manufacturing methods. He started to methodically improve different parts of the mechanism, starting with pendulums. At the time they were made of iron or steel which expanded in the summer and made the clocks run too fast. In the winter they contracted, which made the clocks too slow. Harrison eliminated this by making a pendulum with brass and iron rods in which the combined contraction and expansion of the metals cancelled each other out.

Another of Harrison's inventions was the Grasshopper Escapement, a completely new type of control mechanism that gradually released the clock's driving power. It was almost frictionless, didn't need oiling and was a major breakthrough in watchmaking. In the end, Harrison had enough self-confidence to have a go at the longitude problem. He collected his clocks, his models and a drawing of the marine clock he intended to build, and in 1730 he headed for London to present his idea to the Board of Longitude.

But when Harrison arrived in London he couldn't find the board, because it didn't have a permanent address. The fact is that it never convened and that was because the ideas that it had received were so poor or downright absurd that no-one on the board thought it was worth wasting their time, much less the reward money, on them.

However, Harrison wasn't about to give up that easily. He knew the name of one of the Board members, Edward Halley, an astronomer at the Royal Observatory in Greenwich, and he travelled there immediately. Halley received Harrison kindly and looked at his idea. He was impressed with what he saw but he knew that most of the board were completely focused on an astronomical solution to the longitude prob-

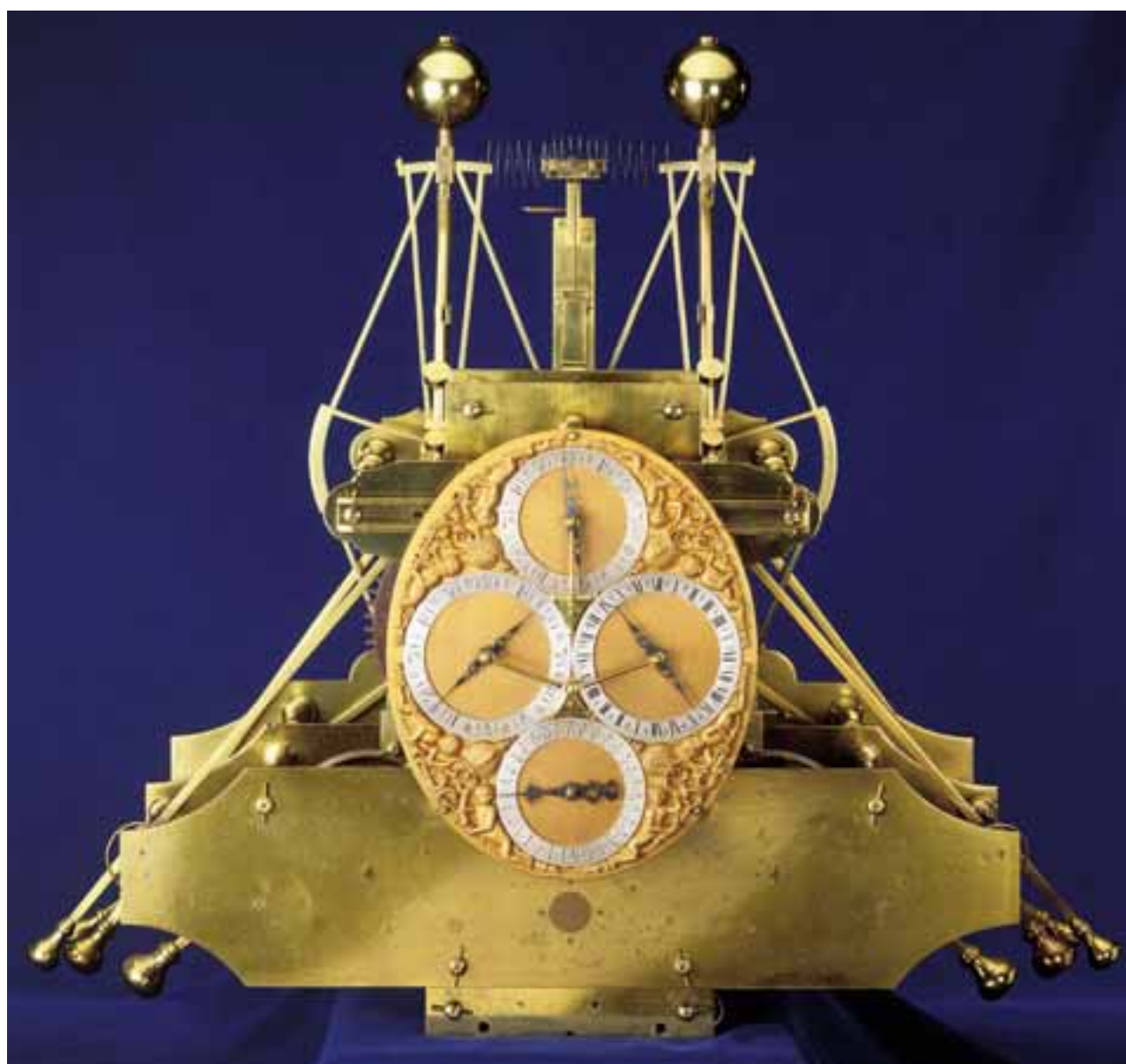
lem and that they would reject any method based on clocks in advance without even looking at it. Rather than send Harrison into the lion's den, Halley advised him to go to George Graham, known as the foremost watchmaker in the country. Graham was so impressed with Harrison's idea that he lent him money so he could realize the marine clock.

If Graham had expected quick results, he was mistaken. Harrison went back to Yorkshire and got to work. It took him a total of seven years. Hi, as the clock was later called, was almost a metre high. Harrison had tried to do without as many moving parts as possible. Instead of pendulums he had invented a system of two brass balancing weights which were connected

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## TIMEWATCH



HARRISON'S FIRST MODEL, THE H1 (ABOVE), WHICH HE COMPLETED IN 1737 AND ITS SUCCESSOR, THE H2, PRESENTED IN 1741 (LEFT).

with wires. These weights were always in opposite movement, so that the effect of the ship's movements on one were countered by the other.

The clock was finally finished and Harrison went to London and showed it to the Board of Longitude. Although many of the board members were extremely sceptical, they still reasoned that the clock was "promising" and that it would therefore be tested. This testing took place in 1737, during a voyage to Lisbon. The ship's captain, George Proctor, was also sceptical when they set sail and wrote of the watchmaker: "He makes me feel that he has attempted the impossible."

Back in England, it became clear that Harrison had precisely calculated the longitude using his

clock. The board still didn't consider this enough proof. The route to Lisbon was well-known and they needed more evidence. They also wanted the clock to be less bulky, and decided to give Harrison more funding to improve his clock. Harrison returned to Yorkshire and went back to work. In 1741 he presented a new clock, known today as H2. The board examined it with great interest but leading names in the navy advised against testing it. England was at war with Spain and it would be disastrous if the clock fell into enemy hands.

Harrison still hadn't seen a penny of the reward. Working on the clock had completely taken over his life. He returned yet again to

Yorkshire, determined to improve it again. The next clock, H3, took 17 years to finish. When it was finally completed he didn't even hand it over so it could be tested at sea, he immediately started work on another clock. The H4 was finished in four years and was very different from its heavy, box-like predecessors and resembled a large pocket watch, 12 centimetres in diameter. Harrison wrote that it contained "50 years of self-denial, tireless work and endless concentration."

The H4 was tested in November 1761 when the Deptford set sail for Jamaica. After nine days the longitude was calculated using "dead reckoning" at 13 50' W, but according to the clock it was 15 19' W, a difference of 160 kilometres. The ship's captain decided to trust the clock and the next day they reached Madeira, exactly as predicted by the clock.

The H4 proved just as reliable on the return voyage, despite heavy storms, and when they got home they found that their clock's margin of error was within the half degree that the board had stipulated for the reward.

But despite the result, the board refused to pay the money. They said that the clock could have produced the results as the result of a fluke. After much debate they gave Harrison 2 500 pounds and then demanded that he hand over the clock to the board so that they could study its mechanism in detail and conduct more tests. Harrison was forced to accept. The clock was sent for more tests and this time the margin of error was even smaller than before. Even so, the board still refused to hand over the rest of the reward and now demanded that Harrison not only account for every part of its design, but also hand over the other clocks. The board also ordered him to make a simpler version of the clock, known today as the H5. Harrison felt he was forced to agree to their demands and he started work on another clock. The H5 contained the same mechanism as the H4 but had a much simpler exterior.

Harrison was still refused the money. In the end King George III stepped in. He had followed the testing of the H4 and became increasingly indignant at how Harrison had been treated. He made sure that Harrison could plead his case to parliament. In 1773 they decided that Harrison, who by now was an old man, would be awarded the remainder of the money. But the remainder was paid by parliament, not The Board of Longitude. The board added new demands and insisted on a number of other tests for the clock; the result was that the prize money was never formally paid because in their opinion the longitude problem was still unsolved.

But Harrison knew what he had achieved and so did the rest of the world.

The H5 was too expensive for mass production. Other watchmakers, including Larcum Kendall, Thomas Mudge, John Arnold and Thomas Earnshaw, started making cheaper versions and soon produced the "chronometer," as it was now being called by the navy and by cartog-



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raphers and explorers, including Captain Cook.

Harrison's efforts laid the foundation for modern precision navigation. Over 200 years after his death, Neil Armstrong, the first man on the moon, was invited to 10 Downing Street and he took the opportunity to propose a toast to Harrison: "He enabled men to explore the Earth with precision and, when most of the Earth had been explored, to dare to build navigation systems for voyages to the Moon."

Harrison's clocks are owned by the Ministry of Defence and are on permanent loan to the National Maritime Museum which put them in a new elegant gallery this spring in the Royal Observatory in Greenwich, fittingly called "Time and Longitude."

