What’s on?

All at sea

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Finding your way on land is simple enough with a map and compass. The map will indicate natural and man-made features, whether a church has a spire or tower, and so on. It is easy to get one’s bearings.

The sea is a different matter; there are, by definition, no landmarks. Once out of sight of land, it is a featureless tract, an unpunctuated expanse. Direction is easy enough; the compass points to magnetic North and the pole star will give a rough indication of latitude (the height of the pole star in degrees above the horizon is the latitude of the observer, within a degree or so). The latter applies only to the northern hemisphere of course and explains why the majority of the great voyages of discovery began in the Mediterranean or from Northern Europe.

The determining of a ship’s latitude, its North-South position, can be determined with simple instruments. But the determination of its East-West position, its longitude, is far from easy and taxed the greatest minds. Exploration and trade depended on the solution.

Although The Royal Observatory in Greenwich was founded in 1675 specifically to carry out observations “to find out the so much desired longitude of places for the perfecting of the art of navigation”, it was the Longitude Act of 1714, that gave fresh impetus to the quest, offering a prize of £20 000 (about £2.52 million today) for a method that could determine longitude within 30 nautical miles (56 km).

The National Maritime Museum is celebrating the Tercentenary of the passing of the Longitude Act with an exhibition, ‘Ships, Clocks & Stars: The Quest for Longitude’, that looks at the history of navigation and the mental and mechanical challenges of fixing longitude.

In what I assume to be a bit of whimsy, the exhibition is rather hard to find; the signs peter out early (it’s downstairs, through the inevitable shop).

The first room has a painting of a double shipwreck, some salvaged goods and a globe from about 1650. Next is a display of tools for measuring the angle of the sun and celestial bodies above the horizon and hence latitude; cross-staffs and back-staffs. To determine longitude, early mariners used dead-reckoning: the distance sailed along a compass bearing was plotted on the chart. This works well on land, indeed it is an essential tool for the cartographer, but a ship is subject to currents, winds and tides: all of which can pull her off course.

Other ways of determining longitude were suggested; as early as the 2nd Century BC, Hipparchus proposed comparing the local time of a place with an absolute time. In 1612, Galileo advocated using the orbital periods of Jupiter’s four brightest moons (Io, Europa, Ganymede and Callisto) as a universal clock. Newton brought these together in a letter to the Lords Commissioners of the Admiralty (displayed here) suggesting a combination of lunar observation, the observation of Jupiter’s moons and an accurate timekeeper as a solution.

The Longitude prize attracted both the finest and the most eccentric minds of the Georgian age. Five serious proposals emerged; Humphry Ditton and William Whiston suggested rockets, fired from vessels moored at fixed locations. Navigators could gauge their distance from the explosions by sight and the difference between the flash and the report of the explosion would give them distance. Trials at Hampstead Heath and Blackheath were promising, but there was the practical difficulty of mooring vessels in deep water and...
preventing them drifting off-station. Newton, who had fallen out with Whiston, dismissed it as “rather for keeping an account of Longitude at sea than for finding it if at any time it should be lost, as it may easily be in cloudy weather.”

A second proposal, from Edmond Halley, relied on magnetic variation (declination), the difference between magnetic North on the compass and true North from the sun or other stars; a positive value means that magnetic North is east of true North, a negative value that it is to the west. Magnetic inclination, or dip, was another promising avenue but both approaches suffered because of the variation of the earth's magnetic field over time. The exhibition has a program where you can test the rocket and the magnetic methods.

The other three proposals all hinged on the same thing: the time difference between a ship's current position and the time at the ship's home port. This was the suggestion of Hipparchus and for it to work it needed what neither Hipparchus nor the mariners of 2000 years later possessed: a reliable timekeeper.

The clocks of the 18th Century were pendulum clocks and so were affected by the motion of the ship. The exhibition really puts on a full spread of canvas here, with a dazzling array of intricate and beautiful clocks designed to overcome this problem. There is a reconstruction of Huygen's sea clock of about 1671 and a marine timekeeper by Henry Sully of about 1724. The Sully clock has some interesting features; the large balance wheel is mounted vertically on friction rollers and driven by a Debaufre-type escapement. The pendulum action was generated by a weight at the end of a horizontal lever attached to the balance by a cord. This overcame the problem of thermal expansion, which afflicted steel balance springs.

Unfortunately, Sully's timepiece was affected by the ship's motion and was only really accurate in calm. The general principles were followed by John Harrison, and his timekeepers are the stars of the show.

Harrison’s first attempt was H1, built from 1728–1735, featuring a ‘grasshopper’ escapement. In place of a pendulum, the clock used a balance spring with two 5 pound weights connected by brass arcs (the whole clock weighed 72 pounds). As the moving parts were controlled and counterbalanced by springs, H1 was independent of the direction of gravity unlike a pendulum clock. The linked balance mechanism made sure that any change in motion which affects one of
the balances is compensated for by the same effect on the other balance. The exhibition has a very good animation of how it all works, and includes Harrison's own description of his workings and there is a good Python program demonstrating the physics here (http://zulko.wordpress.com/2012/10/13/physics-of-harrisons-h1-clock/).

It was the first clock that the Longitude Board considered worthy of a sea trial and so, in 1736, Harrison sailed to Lisbon on HMS Centurion (of which there is a magnificent model in the exhibition) and returned on HMS Orford. It succeeded and correctly predicted the ships' landfalls.

Although the Longitude Board called for a transatlantic voyage, it was impressed enough with the H1 to give Harrison £500 for research and development. This led to the H2, taller and heavier than the H1, with the works in a solid brass frame, like the heart in the ribcage. Three years of work went into its building and another two of testing. The War of Austrian Succession prevented a sea trial and, in any case, Harrison had found a design flaw in the bar balances, which could be affected by the pitching action of the ship.

He built the next sea watch, the H5 and gave it to the king (George III) for testing. The king reported that the watch was accurate to within one-third of one second per day and advised Harrison to petition Parliament for the full prize. In 1773, by which time he was 80, Harrison received £8750 from Parliament and died 3 years later. Neither he, nor anyone else, collected the full official prize.

All five of Harrison's timekeepers are in the exhibition; the care of the workmanship, the beauty of the construction and the graceful intricacy of the movements attracted rapt attention.

Although Harrison occupies a commanding part of the exhibition, the curators have been careful not to let his (posthumous) fame overshadow others who worked hard to solve the longitude problem; the lunar tables of Tobias Mayer, the padded suit worn by Nevil Maskelyne while making astronomical observations and Babbage's difference engine, designed for calculating lunar distances for the Nautical Almanac but which proved, like so many an IT project since, to be too complex and expensive.

There is a section dedicated to Cook’s voyage (he took a copy of H4, the K1, with him on his third voyage) and a smaller one to Captain Bligh’s heroic feat of navigation after he had been set adrift by the mutineers of HMS Bounty.

The exhibition is remarkably even-handed, intelligently organized and contains many objects that one would be unlikely to see again (not many will have the chance to see all of Harrison’s timepieces together). The only small criticisms I would make are that it is too dimly lit to read the captions easily and there are a couple of gimmicks it could have left out: actors playing a coffee-house crowd deriding the search for longitude and the members of the Longitude Board at their deliberations. The accompanying book by Richard Dunn and Rebekah Higgitt is a bargain.