

Longitude

by Dava Sobel (1995)

For the longest time, sailors who track their latitude (lines parallel to the equator), but not their longitude (long lines from pole to pole). Sailing on latitude alone created well-travelled traffic lanes that were vulnerable to pirates. As maps got more accurate; land got smaller & oceans larger. This led to King Louis XIV of France to say he lost more land to his astronomers than his enemies.

The North Star (in the handle of the little dipper) helped sailors navigate at night & the sun by day. Both were only visible in good weather. In the 1500's there was no accurate map of the stars or way to measure them. A telescope could not be used on a tossing ship.

The circumference of the Earth at the equator is 24,901 miles. At one rotation per day that would be 1038 mph (obviously less near the poles). There are 360 degrees in a circle & 24 hrs in a day so $360/24=15$ degrees per hr (or about 1 degree every 4 minutes world over). **The difference between the time of day at home port & local time would give them their longitude.** However, the clocks in that era were not as reliable as needed.

22 Oct 1707 Two thousand men died when 4 warships ran aground after 12 days in the fog (not knowing they were too close to an island). As a result, Parliament passed the Longitude Act to give a king's ransom (several million dollars today) to find a practical way to determine longitude to within $\frac{1}{2}$ degree. And the race began between the astronomers & watch makers.

Galileo saw that the length of a pendulum determines its rate, but he never made a clock. Compasses were helpful, but there was a discrepancy between magnetic north & true north. $\frac{1}{2}$ degree at the equator would be 34 miles or a watch could only be off 3 seconds in 24 hrs. Due to the earth's rotation, a star comes out 4 minutes earlier than the night before.

The quadrant or sextant could measure distances between stars, but then a mathematician would take 4 hrs to consult almanacs or tables & make complex calculations to determine longitude & latitude.

John Harrison [JH] (1693-1776) made his 1st clock (all wood) at age 20 after reading a math book loaned to him. 1722 he made a tower clock that is still running today. He used a tropical hardwood (lignum vitae) that exudes its own grease (no need to lubricate). He combined two different metals to overcome varied speed of the clock's rate due to temperature. He spent 19 years working on H-3. 1749 he was awarded the Copley Medal (late Ben Franklin & Albert Einstein would get it as well). He would use diamonds to fight against friction. H-4 would have to be lubricated & cleaned every 3 yrs.

Halley studied old celestial records & determined when a comet would return (named after him for it). He encouraged JH, but Nevil became his nemesis. JH should have won the prize on several occasions, but he was always met with resistance from those on Board of Longitude (BoL) who wanted astronomers to win it. Both Nevil & Kendall (K-1) were on the BoL.

England's booming watch industry led them to master the seas & the British Empire. In 1770 the K-1 cost 500 £, while a sextant & lunar tables cost 20lbs.

England's early astronomer royals were John Flamsteed (1675-1719), Ed Halley (1720-1742), James Bradley (1742-1762), Nathaniel Bliss (1762-1764), Nevil Maskelyne (1765-1811), John Pond (1811-1835).

1514 German astronomer Johannes Werner suggested mapping the moon passing the stars
1610 Galileo (1 of 1st to use a telescope) saw the predictability of Jupiter's moons eclipses
1650 by now, maps have been redrawn more accurate per Galileo's methods
1675 Royal Observatory built in Greenwich Park, England
1676 English astronomer John Flamsteed spent 40 yrs charting stars
1676 Roemer measured the speed of light for the 1st time (schedule variations vs. orbits)
1677 Halley determined Venus transit of the sun could tell us the distance to the sun
1712 Newton & Halley got impatient waiting for Flamsteed so they published a pirated copy
1714 Parliament passed the Longitude Act & created the Board of Longitude (BoL)
1714 Jeremy Thacker coined the name *chronometer* for the marine timekeeper
1725 Flamsteed's star catalog published
1735 H-1 completed at 75 £ & 4 ft cubed
1737 BoL met for the 1st time in 23 yrs to discuss H-1, but the perfectionist JH wanted to wait
1741 H-2 completed at 86 £
1757 Tobias Mayer completed lunar tables & John Bird invented the sextant
1759 H-3 completed at 60 £ & 2' x 1'
1760 H-4 completed at 3 £ & 5" diameter
1762 H-4 was tested at sea & only lost 5 sec in 81 days at sea
1765 BoL reqd HJ to turn in his drawings, then dismantle & reassemble the watch
1766 Nevil published JH drawings to the general public & his astronomical almanac
1766 Nevil had a warrant for the sea clocks, but most were damaged in route
1767 Nevil put the clocks to the test fully intending to fail them
1769 Charles Mason & Jeremiah Dixon (PA/MD line) observed Venus transit
1770 H-5 completed & turned over to the king himself
1772 capt Cook took sauerkraut (vit C), but the BoL would not let him take H-4
1773 Harrison went to King George III to ask for help – parliament paid JH the balance owed
1775 capt Cook returned from his trip around the world & praised K-1 (pirated version of H-4)
1776 JH died (exactly 83 yrs to the day of his birth)
1780 Thomas Earnshaw made watches affordable (65 £)
1785 John Arnold opened a factory to mass produce watches (80 £)
1789 K-2 was on the munity of the Bounty (capt Bligh)
1815 5000 chronometers were at sea
1828 Board of Longitude disbanded after disbursing over 100,000 English pounds
1884 Greenwich is declared prime meridian (zero degrees longitude)
1920 Lt Rupert Gould spent 12 yrs without pay refurbishing the Harrisons (H1-4)
Today the Harrison clocks are still running (Except H-4) at the Maritime Museum in London

Quotes: "Time escape irretrievably, as we watch." (Dava Sobel) [The present is like a photo in that it is only a snapshot of time].