Transport before Steam

3.1 Water Transport

(1) The sea and ships

(2) Waterways

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(1) The sea and ships

Three main interests here: (a) the vessels themselves
and (b) navigation
and (c) the human side

(a) A study of boats and ships is immensely complicated. Here we can take just a few main points and some illustrations.

Obviously logs must have been used as "boats" from prehistoric times. The dug-out canoe was an early stage of evolution as soon as fire and primitive tools were available. Skin boats with wicker frames were also early forms, although still used in GB to-day (e.g. Teifi in Cardigans.).

Boats as such originated perhaps around 3000 BC and were certainly known in Ancient Egypt in the form of reed boats, made up of bundles of reeds and shaped into the canoe form. Used paddles.

Sails were certainly in use by the middle of the 3rd cent B.C. In reed boats a bipod mast used with square sail. (i.e.~2500 BC).

I suppose everyone knows the Romans were a naval and marine power. Their vessels used oars or sails and were thus of two types.

(a) galleys, with large numbers (e.g. 30 or 40) of oars rowed by slaves. These were warships.

(b) sailing ships, square-rigged, used for trading purposes.

Galleys were, of course, a function of slavery, and so died out.

Sailing ships developed slowly through the years.

Open, simple, ships of the Vikings (9th Century AD.in plate VI of "Sailing Ships").

More complex decked structures later (e.g. ship of the Cinque Ports 13th Century, in plate VII)

- larger ships, more and more decks, general pattern well-known, up to about 800 tons, although 300 - 400 tons more usual for ocean merchant ships.

contd.

After the advent of steam, there was the "clipper" development - sleeker, faster, larger ships. Originated in U.S. (New England) around the 1840's and used for the various gold rushes in California and Australia. By 1850 sizes were up to 1800 tons and the Atlantic could be crossed W-E in 14 days.

Iron gradually came to be used, first for frames only, then for plating. The final stage was the Australian wool clipper, all iron, length/beam ratio 6.7, up to about 2,000 tons, built in 1870's and 1880's. Australia - England took around 80 days. Average speed for a whole fleet over a whole year was just over 6 knots. Max. speed 18 knots.

One of the longest-lasting sailing types in our country was the Wherry. But sail used for fishing until quite recently (e.g. between wars) in many places.

(b) The history of <u>navigation</u> (i.e. of techniques for finding the way from place to place) really starts with the lead line, used to this day. (We assume that sailing from A to B in clear weather by day when B is visible is not worth calling navigation). With a blob of tallow on the lead, not only could depth be found, but also the bottom material. Five centuries BC the approach to the Nile from the north could be recognized by the yellow Nile delta mud even 60 miles out from the coast.

Navigation by the stars was known in ancient Greece. The story of Odysseus is full of navigational data, involving the Great Bear, the Pleiades, etc. The Pole Star was known several centures B.C.

First the sun and stars were used for getting direction. Later also for getting latitude. Pytheas (~300 BC) introduced, or used, the gnomon - a vertical pillar throwing shadow on horizontal base. Bisection of the angle between two shadows of equal length gave the meridian. The ratio of noon shadow-length at equinox to height of pillar gave cotangent of latitude. Pytheas sailed from Greece into the Arctic and reached Thule (Iceland) and recognized (in effect) the Arctic Circle.

About this time, too, masters and pilots of trading ships were sufficiently literate for written sailing directions to be produced for their use. One trouble, though, was the inaccuracies in measuring distance owing to lack of standard definitions of units. ± 30% error could exist in distances unless expressed in astronomical terms (i.e. degrees).

It is also probable that charts or maps accompanied these sailing directions.

Long ocean voyages were, however, older than Pytheas. The Phoenicians, as far back as 600 B.C., had been sailing to Cornwall for tin and reported that the people of Brittany sailed to Ireland in skin boats.

The inhabitants of the North were undoubtedly able to navigate over long ocean stretches, but without instruments. Irish missionaries in the first milleniun A.D. regularly visited the Faroes, Iceland, etc. and the Vikings visited Greenland (and beyond?)

A most important discovery was the lodestone-or magnetic compass-around 1000 (A.D.).

The determination of longitude and latitude

Latitude had been measurable, at least crudely, from very early times (e.g. the ancient Greeks), either by observing the motion of stars, or of the sun. (Certain stars just graze the horizon at certain latitudes and these could be identified - but of course this meant observation over many days. The height of the Pole Star also gives latitude. So also does the height of the sun at its zenith). The introduction of instruments for measuring angle above the horizon led to more accurate and speedy determination of latitude. But even at the end of the 16th cent. the accuracy was little better than $\frac{1}{2}^{\circ}$ or say 30 miles. The development of optics, however, and the proper use of mirrors, led to great improvements, and the sextant (or octant, according to angular segment covered) gave by 1750 an accuracy of about 2′ of arc.

Longitude was a very different matter. There was no practicable way of determining it within several degrees until the 18th century. Sailors had to sail to the correct latitude and then sail along the line of latitude in the appropriate direction until the desired land was sighted. Many explorers in the Pacific, right up to the 18th cent, had errors of many hundreds of miles in their longitudinal location and could not identify the islands they found - obviously the charts available had the same sort of error too.

All sorts of mistaken theories of longitude were propounded - e.g. that it could be determined from magnetic declination - but a correct method of determining longitude from observation of the angular positions of the moon and a fixed star was proposed by Jean Rotz in the mid 16th cent. Knowing from astronomical tables the proper relative position at a given time of day at a reference point on the earth, and measuring the actual relative positions at the unknown point at the same time of day, it could be calculated what the difference in true time was between the unknown and reference points, and hence the longitude was known. But there were no instruments available of sufficient accuracy. An error of only 5′ in reading the moon's position would lead to an error of over 2° in longitude - i.e. over 100 miles. And the typical reading accuracy was not 5′ but 30′ - i.e. an error of around 700 miles. Even by 1750 the accuracy of this method was not better than about 50 miles.

The only solution lay in being able to measure true time at sea so that the sun's zenith (or the zenith of some star) could be accurately timed relative to its known time at a reference line of longitude. In 1714 a Board of Longitude was established in England, and it offered a reward of £20,000 to anyone who could solve the longitude problem to an accuracy of better than 30′ on a voyage to the West Indies and back. By the chronometer method this required accurate timekeeping to within 2 minutes of time over a period of months. The man who achieved this was John Harrison, a clock-maker by trade, whose 1735 chronometer was excellent but not accepted by the Board, but whose 1761 watch-type chronometer achieved an accuracy of 5.1 secs over 81 days at sea and handsomely met the specification. Sad to say, the Board made many difficulties over paying the reward, and Harrison got the first £10,000 only in 1765 and the remainder not until 1775, the year before he died. This was a great English technological advance - although the French were not far behind.

With this problem solved, accurate charts could at last be produced, and the Navy took on the main responsibility for them.

Note on the log-and-line

In the days before longitude could be measured, it was essential to calculate position by dead-reckoning and this meant knowing the ship's speed. This was determined by the log. A log of wood on the end of a thin line was thrown overboard, and a sand-glass started. The line was paid out at such a rate that the log was able to float without moving relative to the water. When the sand had finished, the length of line paid out was observed and this measured the ship's speed through the water. The line was knotted at appropriate points so that the number of knots paid out indicated the speed in naut.miles/hour - i.e. in "knots". This was first published in 1574 but had evidently been in use on English ships long before that.

3.1 Water Transport

(c) The human side of the sea is too long a story to go into properly. A few facts about ocean voyages in the 15 - 16th century will suffice. The work of the great explorers is exciting, but rather outside our scope. The dangers and discomforts of ordinary people at sea will be our subject.

The Portuguese were the leading maritime nation in the 15th and 16th centuries. Prince Henry the Navigator in the early 1400's led the world in directing exploration and in compiling charts and sailing books.

The round voyage from Lisbon to Goa (in India) was called the "Carreira da India". The ships used were carracks and galleons. The former was a large merchant ship of 400 tons (later becoming much larger). A galleon was primarily a fighting ship, rather smaller. Around the later part of the 16th century, a sizeable number of ships left Lisbon annually for Goa. The round voyage was supposed to last 18 months. Owing to monsoons, it was recognized that ships should leave Lisbon by the end of Feb. But red-tape was rife, and ships often got delayed by a couple of months, and then either had to turn back or be lost. Similarly on return. Sometimes they stayed in Mozambique and most of the people died from fever.

There was no hygiene on the ships and disease was often rife. Many people had to live the whole journey on the open upper deck. Food inadequate and rancid, water scarce & putrid. Thus mortality heavy even in successful and punctual voyages. Quite common for 300 - 400 to die on outward voyage in a total complement of passengers and crew of 600 - 800.

(Compare passenger/ton ratio of carrack and modern liner)
(Carrack 1/1, liner say 1/20.)

In some years there were great losses of ships on this carrerira.
In 1590-2, only 2 out of 17 survived
In 1607-8, only 3 out of 33 survived.

130 ships lost on carreira between 1550 & 1650. (1 in 10 average ?) Usually losses occurred on homeward voyage when ships overloaded and in poor condition.

(2) Waterways (Rivers; Canals)

Rivers were used for communication by boats from earliest times. But canals are also of great antiquity; the Egyptians had 80 canals around 1300 BC, including the Grand Canal (Nile - Red Sea) which was 37 miles long, 100 ft. wide and 40 ft. depth! Main purpose irrigation but also used for trade. Babylonians similarly.

Romans also built canals and improved river navigations. Probably the earliest canal in Britain was the Caer Dyke from Nene at Peterboro to the Witham at Lincoln, built by Agricola (AD 40 - 93). (Not to be confused with the German metallurgist Georg Bauer Agricola!) This was restored to navigation by Henry I in 1121.

In China, canals used from very early times. The Imperial Canal connected Canton to Peking, 825 miles by crow, over 1000 miles of canal.

In Britain, as in other countries like it, coastal shipping was the most important means of communication over thousands of years, and the ships penetrated up rivers. Hosts of small ports arose and functioned even into recent years. Sea-going ships penetrated far inland - e.g. Gloucester, Peterboro, Ipswich (to this day), London (to this day), etc. So there was emphasis on improving river navigations.

Generally sea-going ships penetrated only as far as the tide went. Above this, rivers used for power and there were many mills and weirs. So the interests of millers and navigators conflicted, espec, when there was drought. Boats got by weirs by means of "flashes"; i.e. the river level above the weir was raised for a while by closing a sort of gate, called a "stanch", and then gate was opened, and boats went up or down on the short-lived rush of water. Boats could often travel up to 12 miles a day. Haulage upstream by horses or by men - latter often wading up to the chest in the water. Barges used to get up the Wye to Monmouth, Ross and Hereford by this means even up to the end of the 19th century.

Obviously better systems than this were desirable, and also water transport was needed where there was no river. It was the "pound lock" that led to big improvements and especially to canals over varied terrain.

Britain was far behind in this development.

Exeter canal was constructed in 1563 and was the first in Britain to use the pound lock, variously attributed to China, Italy, Holland.

This canal allowed small sea-going ships to get up to Exeter. But no further canal building in Britain until 1760.

But canals were built in various parts of Europe. The Naviglio Grande in Italy linked Milan to the Ticino River, 31 miles in the early 13th century, overcoming differences in water level with weirs and inclined planes over which barges pulled by winches. Leonardo da Vinci was responsible for adding pound locks to this in 1497 when he built a number of extensions. Locks also used on R.Brenta near Padua in 1488 in association with a weir.

Throughout the 16th & 17th centuries there was a lot of canal building in Europe, e.g. in Low Countries, France. One of the greatest was the Languedoc Canal in France, completed in 1681. 180 miles long, 144 ft.wide, 6 ft. deep. Locks were 102 ft. long, 20 ft wide.

Although river navigations were improved, Britain did nothing about canals until the growing pressure of the industrial expansion necessitated improved communications urgently. Sankey Brook canal from Mersey to St. Helens in 1760. But the real development of our canal system was due to James Brindley (1716 - 1772), an illiterate but inspired millwright, who provided the practical knowledge for Francis Egerton, 3rd Duke of Bridgewater, born 1736 died 1803. Duke wanted canal from his Worsley colliery into Manchester in 1759, and Brindly planned it, using tunnels and aqueduct to keep level, and built it in 1761. Great success. Bridgewater became canal and industrial promoter, with Brindley as engineer, and was financially very successful. Got £80,000 p.a. return on his canal investments.

Thereafter British canal system grew quite large. (See maps from Hadfield). But preceded railways by too short a time to have a long profitable life. Most of them ceased to be profitable well before 1850.

<u>Other engineering matters of importance</u>

(a) getting canals watertight. Brindley developed the method of puddling clay using human feet to "heel" it. Clay is mixed with a little sand and wetted, placed in the canal bed, and then worked or puddled. Clay unworked is not watertight, but puddled clay is as long as it is kept wet. Method still used to-day.

(b) tunnels. Brindley made them of small section and boats had to be legged through. Telford (after Brindley's death, say around 1827) made them larger and included a towpath.

(c) aqueducts. Early ones of stone kept tight with puddled clay. Telford introduced cast iron (cheaper) and built some very notable acqueducts - e.g. Pontcysyllte near Llangollen, (2000 ft long counting approaches & 121 ft. above R. Dee.), and Chirk (length 400 ft, 70 ft. above R. Ceriog).

(d) swing aqueducts. Manchester Ship Canal constructed one for the Bridgewater Canal which it had to pass under. Cast iron trough 19ft wide x 7 ft. deep on top of a swing bridge. Gates at each end and at the canal abutments to prevent loss of water.

(e) canal lifts to replace locks. The Anderton electric lifts in Cheshire.

(f) inclines. In the early days of small canals using tub boats rather than barges, inclines using rails and wheels and ropes often used.

Modern ship canals

Manchester (1882 onwards): 26 ft. deep. 53½ million cu yds of earth and rock removed. Process involved 228 miles of railway, 173 locos, 6300 trucks.

Suez (opened 1896)

Kiel (1914) Busiest canal in world in terms of ship numbers

Panama (1916) 40 miles long. Took over 30 yrs to build and cost thousands of lives with fever, etc.

St. Lawrence Seaway (opened 1959) - altogether a 1200-mile waterway. Locks 800 ft. long, 80 ft. wide, 30 ft. deep.

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