

A Navigational Instrument of the Harappan Sailors

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The Harappans were the first builders of a carefully designed tidal dock of the world in 2300 B.C. at Lothal at the head of the Gulf of Cambay on the Gujarat Coast of Western India. (S.R. Rao 1991 146-147). This dock could accommodate as many as 30 ships of 20 m length at a time in the vast basin measuring on an average 210 X 35 m with a draught of 4.15m. It was larger than the Bombay Merewether dock measuring 152.4 X 19.96m and the Vizagapatnam dock (111.56 X 18.29m with a draught of 4.27 m below LW). The unique feature of Lothal dock is its water-locking arrangement in the spillway (outlet) provided in the southern arm opposite the inlet channel through which ships were sluiced in low tide. With a high tidal range of more than 10 m in ancient times in the Gulf of Cambay the sea-sailing vessels could easily ply between Lothal port and the Gulf. The marine engineers of Lothal had designed the Lothal dock after studying tides, waves and currents (Panikkar and Srinivasan, 1971). That the basin served as a dock has been proved by the discovery of stone anchors in the basin and by the analysis of sediments in the basin by Rajiv Nigam (Nigam 1988, 20-21).

The Harappan sailors must have crossed the Arabian Sea without confining themselves to the coast, for, the occurrence of terracotta models of gorilla and mummy at Lothal indicates trade with Egypt. Similarly the chessmen of Lothal are almost identical with those found in the tomb of Queen Hatshepsut (Tobler LXXIV b, LXXXIV) Be that as it may, even if they hugged to the coast their night sailing needed help from the celestial agencies. The position of stars and moon gave the clue to direction and distance. The heliacal rising of stars and Sun were important too.

The town-planners of Harappa, Mohenjo-daro, Lothal and other cities knew geometry very well as is evident from the layout of streets, drains and network of passages, airvents of warehouses and granaries. All this needed a proper measuring instrument. The integrated linear scale of the Harappans with decimal graduations on the Lothal and Mohenjo-daro scales (S.R. Rao 1991, 312-314) is noted for its great accuracy. There are a few shell ring-like objects found in the excavations at Mohenjo-daro, Lothal and Dholavira. (Fig. 1) A study made regarding their use is quite revealing.

Lothal was an important shell-working centre of the Harappans. The species *Xancus (Turbinella) pyrum* (Linn) which is confined to Indian waters occurs in abundance in the Gulf of Kutch (Shirwaiker Prita and Parulekar, 1988, 133-34). Dwarka, Bet Dwarka, Nageswar and Todio were important shell-fishing ports. Lothal has yielded a large variety of tools, instruments and ornaments made of *Xancus*. Shell workers' workshops have also been laid bare. The Shell artefacts recovered include, among others, bangles, bracelets, rings, pendants, beads, ladles, engravers, scrapers, awls, needles, gamesmen and a couple of hollow cylinders. One of the cylinders has eight slits, four each on the upper and lower margins. Marshal considered similar objects found at Mohenjo-daro as ornaments, but they are not suitable to be used as rings or pendants. The threads get stuck up in the slits if the object is used as a pendant in a necklace and it is too thick to be used as finger or ear ring. Dholavira, another Harappan site in Kutch has yielded a hollow cylinder of shell with twelve slits, six on the lower margin and six on the upper margin. A careful study of the cylindrical object with slits

indicates that it was used as a compass.

Compass

The slits in the Lothal object are the result of sawing at regular intervals across the margins (Fig. 2). If the opposite slits on the upper margin are joined by stretching cords they cut each other at right angle, so do the other four slits. If all the intersecting lines eight or twelve in number meeting at the centre of the circle are drawn on a plain surface each of the 8 or 12 angles so formed out measures 45° or 30° . It is thus clear that the object could be used as a compass. These hollow cylinders with the slits must have been used for measuring angles and fixing the alignment of roads, lanes, drains and houses in the towns and cities and perhaps for the purpose of land survey also. The method of using the compass has been demonstrated in Fig. 3. The Lothal compass was found in Phase IV and is therefore datable to 2200 B.C. (Calibrated 14C date). The shell cylinder with twelve slits found at Dholavira also served the purpose of a compass and might have been symbolic of the division of the zodiac into twelve parts of 30° each.

It must however be noted that if the only purpose of cutting eight or twelve slits in the hollow cylinders was to measure angles on a plain surface the inventors of this instrument would have cut all the eight or twelve slits on a single margin instead of having half the number in the upper margin and the other half in the lower margin. There must be a greater purpose in having slits on both margins. It is observed that since the upper slits are exactly opposite the lower slits the instrument could be used to measure whole sections of the horizon and sky and not merely lines, points and angles on a plain surface. It could serve more or less the purpose of a sextant. All that is needed is to suspend the cylinder with a copper or bronze wire passing through a hole in the centre of a disc. Such discs have been found at Lothal and other Harappan sites.

Copper and bronze wires and rods are also reported. With this instrument it was possible for the Harappan sailor to measure angles and position of the stars for navigational purpose. In brief, almost two thousand years before the ancient Greeks thought of an eightfold or twelvefold division of the sky and the horizon the Harappans had already invented an instrument to measure the angles and position of stars.

"The night-sky to those whose avocations demanded that they should watch it — sailors, shepherds and astronomers — gave as quite indications of the direction as the day. The appearance and disappearance of the stars divide the whole horizon into an eastern and western half and some astronomers considered the north-south meridian line merely as the boundary between east and west. It is the line along which each star in its turn and at its own moment ceased to ascend and began to descend on which, that is to say, it culminated. The whole northern quarter, however was picked out unmistakably for the sailor by a brilliant group of seven stars called *Riksha* by the Harappans. The word *Riksha* stands for Bear in Indo-Aryan language. The epithet *sasa* used with the numeral sign for 7 implied shining Seven (Lothal seal inscription 86: S.R. Rao 1991, 62) which later came to be called "*Sapta Risi Mandala Dhruva Nakshatra*". The stars are conceived as sages. The Seven Stars circle round and round like a wheel about the axle and help to define the still point (*dhruva*). For the Greeks the word for Bear — *Arctos* — was also the word for North, while the latins called the North *Septentri* which is synonymous with the much earlier Harappan term *trisapta* used in the seal inscriptions.

The Seven Star Group mentioned in the Indus Seals and by the Egyptians played an important role in their astronomy.

Harden observes "The point in the heavens about which the whole starry pattern appears to wheel is not, in actual

fact, a fixed point. ". It shifts through the centuries extremely slowly along an elliptical path which astronomers can trace out so that we know how the stars appear to be observed in relation to the pole during the vedic and post-vedic periods. The slow shift of the axis of rotation among the stars is not observable in the course of a lifetime and the pattern of the circumpolar stars — that is those that never set — could therefore be used for establishing latitude

If the pole is, say 30° above the observer's horizon, then a star 30° from the pole will make a circle that just grazes the horizon at its lowest point, actually at the north point of the horizon. The elevation of the pole at any point of observation is equal to the latitude of that point, that is, to its distance from the equator

It is said that the Greeks used to judge whether the places were in the same latitude by finding out whether at each place the same star or stars just grazed the horizon. Although this was a matter of simple observation, the Harappans devised a measuring instrument of the horizon.

The performance of various types of sacrifices demanded determination of the exact time, date, month, season and commencement of the year. This meant calendrical calculations based on the movement of the sun and moon. In order to keep count of the days, the Rigvedic people performed a year long sacrifice known as "the *gavamayana*" cow's gait or sun's gait. The Harappans also performed a similar sacrifice in which a bull seems to have been offered as attested by the presence of bovine bones in the sacrificial altars of Lothal and Kalibangan. The names of sacrifices namely *asvasattr*, *pancaha*, *ekaha* and *happtaha* also find mention in the Indus seal-inscriptions. The cylindrical shell instrument of the Harappans could be used for finding the heliacal rising of the stars, sun and moon. The ancient Indian astronomers were interested in the selection of suitable stars and constellations which

centred round the sun's path which the Rigvedic sages called *rta*, that is the elliptical. They were able to provide a stellar frame of reference against which to follow and measure planetary motions. The system is known as the system of Nakshatras, the origin of which is traced to the Rigveda where the term is used both in the sense of stars and lunar mansions. At least two Nakshatras are mentioned in the Rigveda (RV, III 54.19).

According to S.N. Sen the Nakshatra list began with *krittikas* in the *Taittiriya Samhita*, with *Bharanyah* in *Vedanga Jyotisha* and with *Asvini* in *Suryasiddhanta*. This is due to the precession of 1° in 72 years. The Harappan Nakshatra system must have begun with *Krittikas*, that is the Pleiades, the presiding deity of which was Agni, the Fire God according to *Vedanga Jyotisha*. Seal No. 430 of Mohenjodaro in which a devotee is making an offering to the Fire God and seven sages or chiefs are shown standing below and a sacrificial altar is depicted suggests the commencement of the sacrifice in *Krittika*. The seven sages symbolise the seven star group of *Krittikas* (Pleiades), and the goat behind the sacrificer symbolises *Indra*. (S.R. Rao 1991). The inscription in seal 430 of Mohanjo-daro reading *tridasa-sara* conveying the sense thirty (*tridasa*) of variegated colours (*sara*) refers to the constellations which were thirty before being reduced to twentyseven, among which *Tauri* (*Krittika*) was the first presiding deity of this constellation was Agni, according to Sloka 25 of *Rigvediya Jyotisha*. N. Mahadevan (1981) says that Agni being the first in the Nakshatra, the Nakshatra List must have been prepared when vernal equinox (*vasanta sampata*): *Uttarayana punyakala*, took place in *Krittika*. In due course the *Ritvijs* found the vernal equinox taking place in *Rohini* constellation, the preceding Nakshatra (Sloka 6) owing to the precession of the earth at the rate of 1° in 72 years and the story of *Prajapati* going to

his youngest daughter was concocted. Still later vernal equinox took place in Asvini (Sloka 14) and the list of Nakshatras started with Asvini.

It is fairly clear that the Harappans used the hollow cylindrical shell object as a navigational aid and for surveying purpose. That the Harappans were expert mariners and boat-builders becomes obvious from the different types of boats they had and different types of stone anchors they evolved for different seabeds.

The Seal No. 223 from Harappa excavated by Vats has a motif of a large ship or galley above which is an Indus sign reading *mhahah*. The big sail in it is hoisted high near the raked prow and there is a structure in the centre from where two oars are paddled out (M.A. Konishi 1985 146-151) A triangular anchor is hanging down from top of a raked stern. It is significant to note that a triangular stone anchor with a single hole has been recovered from the dockyard area of Lothal. (Fig 6.) Besides this triangular anchor three round anchors of stone with one or two holes have been found at Lothal.

Five terracotta models of boats two of which are intact have been found in excavations here. One undamaged model has three blind holes one of which was meant for fixing a wooden peg to support the oar and two others to fix the mast and secure the sail. Keeping these features in view the mast, sail, oar and the sailor figure have been restored (Fig. 4). It has a sharp keel pointed prow and a high flat stern. The second model is a masted ship with stern and prow both curved high up.

The keel is pointed and the margins are raised. In three other terracotta models of boats there is no provision for the mast. They are quite small, light and have a pointed prow. Their base is flat and perhaps served mostly as barges or country crafts for carrying goods and passengers on rivers or in estuarine waters. They might have been made of reeds. Another interesting type is a multi-oared boat painted on a potsherd from Lothal. It may be recalled that the Rigveda mentions multi-oared boats which rescued Bhujyu's ship-wrecked crew on the high seas (Ritti S.H. 1988)

The excavations by G.F. Dales at Mohenjo-daro has yielded a potsherd painted with a motif of boat having a high prow and stern and a sailor holding a steering. The mast and the furled sail are also depicted. The most interesting terracotta object unearthed by Dales is however an amulet on which a boat with a raked prow and stern, a cabin in the centre and two poles with standards are attached to the cabin. Two birds, *disakakas*, are also shown on the boat. One bird has flown out of the boat. Whether the two standards are masts with traces of sails, as envisaged by Moti Chandra is still controversial.

The use of a shell compass for finding out direction, distance etc, and shore-finding birds are important navigational aids of the seafaring Harappans which came to be used for three thousand years more in the Indian ocean. The compass served as an astrolabe for mariners as well as astrologers.

References

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Fig. 2. Hollow cylindrical shell instrument from Lothal with 5 "slits"



Fig. 4. Terracotta model of boat, Lothal