FrameWork 1/19

Evelyn Feldman on Ian Carr-Harris

Ancient water-lifting devices

The bilge is in the bottom of a ship. Wooden ships leak continuously. Water seeps between timbers of the hull, and collects in the bilge. Dewatering devices for bailing are critical in order to prevent ships from sinking.[i]

The bucket (ἀντλητήρια / antleteria)[ii]

The earliest bailing device. The bucket is a short cylinder, open at one end, with a curved handle bridging the open side.

The water screw

Also known as an Archimedes' screw. It is a long tube with blades fixed in a spiral around the core, arranged at an angle, such that the turning of the spiral core pushes water up the tube.

Vitruvius, Roman architect and engineer in the first century BC, describes the water screw.

> "THERE is also the method of the screw, which raises a great quantity of water. The method of constructing it is as follows. A beam is selected, the thickness of which in digits is equivalent to its length in feet.

Placing the beam in a horizontal position, let perfectly straight lines be drawn from one end to the other. So the intervals will be equal in the directions both of the periphery and of the length. Where the lines are drawn along the length, the cutting circles will make intersections, and definite points at the intersections.

Other withes are fastened on the line of the first, and on these still others, all smeared with liquid pitch, and built up until the total diameter is equal to one eighth of the length. These are covered and surrounded with boards, fastened on to protect the spiral.

> It is to be set up at an inclination corresponding to that which is produced in drawing the Pythagorean right-angled triangle: that is, let its length be divided into five parts; let three of them denote the height of the head of the screw; thus the distance from the base of the perpendicular to the nozzle of the screw at the bottom will be equal to four of those parts."[iii]

The water screw's invention is credited to Archimedes, and it can be dated to his life, sometime between 287 and 212 BC.[iv]

The water screw as a ship-bailing device appears only in writing. No remains have been found in wrecks.

The force pump

Uses simple but effective principles of physics which are still used in pumps today. In the force pump, water flows through one valve and then a piston pushes it out another. Vitruvius also describes this pump, "the machine of Ctesibius, which raises water to a height."

> "IT IS made of bronze, and has at the bottom a pair of cylinders set a little way apart, and there is a pipe connected with each, the two running up, like the prongs of a fork, side by side to a vessel which is between the cylinders. In this vessel are valves, accurately fitting over the upper vents of the pipes, which stop up the vent holes, and keep what has been forced by pressure into the vessel from going down again.
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> Over the vessel a cowl is adjusted, like an inverted funnel, and fastened to the vessel by means of a wedge thrust through a staple, to prevent it from being lifted off by the pressure of the water that is forced in. On top of this a pipe is jointed, called the trumpet, which stands up vertically. Valves are inserted in the cylinders, beneath the lower vents of the pipes, and over the openings which are in the bottoms of the cylinders.
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> Pistons work with their rods and levers upon the air and water in the cylinders, and, as the valves stop up the openings, force and drive the water, by repeated pressure and expansion, through the vents of the pipes into the vessel, from which the cowl receives the inflated currents, and sends them up through the pipe at the top."[v]

Parts of four bronze force pumps were found in the Dramont D wreck, near Agay, France, dating to around the first century AD.[vi]

Vitruvius's attribution of the force pump to Ctesibius allows its invention to be dated to around 270 BC. Ctesibius's work is lost, but is preserved by authors like Vitruvius, who reproduce his ideas.

The chain pump

Formed of disks along a loop of rope that is pulled through a tube to lift water.

Remains of chain pumps have been found by archaeologists at several wrecks, including the La Cavalière wreck, the oldest evidence of such a pump, dating to around 100 BC.[vii] The chain pump is not described in any ancient writing. The large number of archaeological finds suggest that the chain pump may have been the most common kind of bilge pump.[viii]

The ancient economy

Larger ships have larger hulls and more surface area, and will thus take on more water, faster. Larger ships also have deeper bilges, farther from the surface level of the ship, and the bilge water must therefore be moved farther to get out of the ship. Buckets become unwieldy. Thus, building larger ships requires more efficient bailing devices.

The invention of better pumping devices, thanks to ancient inventors like Archimedes and Ctesibius, allows for larger ships, which can hold more cargo, which creates more trade, which means a growth of the economy.

better pumping devices → larger ships → more cargo → more trade → larger economy

Bilge pumps are important![ix]

A paradox

Paradoxes are frameworks. They are simplified structures. They are thought experiments, games for our mind. They do not need ancillary details like bilge pumps.

In the Ship of Theseus thought experiment, the hero Theseus's ship is preserved and kept safe in a harbour, like an artifact in a museum. But wood rots (unless it sinks to the bottom of the sea), and so over time the ship's parts are replaced. Eventually, all of its parts have been substituted. Is the ship now the same object as the original? What if each of the rotting pieces was stored elsewhere, their rotting halted, and eventually, after every part had been replaced, these old parts could be reassembled into a second (first) ship?

Did Theseus's ship have a bilge pump? What happened to it? Who bailed the ship? How did the ship stay afloat?

Bits of things preserved over time

Our version of the ancient world is just bits of things preserved over time.

We know about ancient bilge pumps because of scientists whose writing survives, and because of pieces of pumps preserved in wrecks beneath the sea. We do not have the originals of the inventors Ctesibius's or Archimedes' work, but we have Vitruvius's writing, which passes their ideas on to us. We do not have the originals of Vitruvius's work either: like wood, paper disintegrates. But we have versions of it that have been copied and recopied such that they still survive for us. This is how we remember much of the ancient world.

When a ship, an object, a text, an idea, has had each of its components replaced, is it still the same ship, object, text, idea? How do we know it was replaced exactly like the old version?

Our version of the ancient world is the things that survive as copies to us. What is the original *Iliad* or *Odyssey*? How do we know what the original said? How do we know what parts have been added? Where does the name "Theoris" come from?

The ancient world is like ships of Theseus. How do we assemble our version of it? What parts form its picture? What has been lost forever? Does the original exist?

The ship of Theseus

I like the contrast of bilge pumps and "*Theoris:* a paradox." Bilge pumps are highly technical mechanical devices meant to keep ships afloat. "*Theoris:* a paradox" presents a framework for deep thought, raising philosophical questions about existence. How do we construct a complicated bilge pump? How do we assemble existence?

[i] Lionel Casson, *Ships and Seamanship in the Ancient World* (Baltimore: Johns Hopkins University Press, 1995),176 note 39.
[ii] *Ibid.,* 176.
[iii] Vitruvius, *The Ten Books on Architecture*, trans. Morris Hicky Morgan (Cambridge: Harvard University Press, 1914), 10.6.1-4.
[iv] John Peter Oleson, *Greek and Roman Mechanical Water-Lifting Devices: The History of a Technology* (Toronto: University of Toronto Press, 1984), 60.
[v] Vitruvius, *Ten Books on Architecture*, trans. Morgan, 10.7.1-3.
[vi] Oleson, *Mechanical Water-Lifting Devices*, 206.
[vii] *Ibid.*, 93.
[viii] Federico Foerster Laures, "Consideration on Force Pumps in Roman Times," *The International Journal of Nautical Archaeology and Underwater Exploration* 14, no. 3 (1985): 264.
[ix] Andrew Wilson, "The Economic Influence of Developments in Maritime Technology in Antiquity," in *Maritime Technology in the Ancient Economy: Ship Design and Navigation,* eds. W. V. Harris and K. Iara (Portsmouth, RI: Journal of Roman Archaeology, 2011), 211-33.