

Leonardo's Bell Ringer

Duke of Buckingham: Why let it strike?

Richard III: Because that, like a Jack, thou keep'st the stroke Betwixt thy begging and my mediation.

Shakespeare. *King Richard the Third*, act IV, scene II, 116–118

Leonardo's Bell Ringing Jacquemart (c. 1510) represents the last and most highly developed of his automata. In what follows, we see how Leonardo's project to design a hydraulic clock that rang the hours relates to earlier renditions of hydraulic devices, fountains and water clocks.

Ancient Models

Leonardo's major source of information about hydraulic devices in antiquity would certainly have been Heron of Alexandria of the first century, an author made known by the humanists, and whose *Book of Pneumatics* greatly appealed to him, particularly for the so-called Heron Fountain. The latter was first described by Alberti, illustrated by Andrea del Verrocchio, and applied many times by Leonardo in his hydraulic devices, such as in the beautiful table fountains at Windsor (Fig. 4.1). Heron's *Book of Automata*, best known in Bernardino Baldi's 1589 edition, includes a number of theatrical devices as well.

There is another great hydraulic achievement of antiquity that must have appealed to Leonardo. This is the Tower of the Winds, located in the Agora in the center of Athens (Fig. 4.2). Constructed by Andronicus Kyrrhestes of Macedonia during the Roman period in the second quarter of the first century B.C., it was one of the few structures from antiquity to have survived intact. Built of marble and octagonal in shape, it is 43 feet (13 m) tall. It was a marvel of antiquity, boasting complex sundials on top; a frieze on each of its eight sides; and according to one ancient account, a weathercock at its pinnacle in the form of Triton, son of the sea god Poseidon; clepsydra; a planetarium and possibly automata. Leonardo was certainly acquainted with the Tower of the Winds through Vitruvius and other sources¹. In the middle 1960s, Derek De Solla Price reconstructed the clepsydra under a grant from *National Geographic* magazine². It represents the state-of-the-art of ancient water clock technology, or "horologion"—an "hour indicator." The following description of the clock is based on Price's reconstruction.

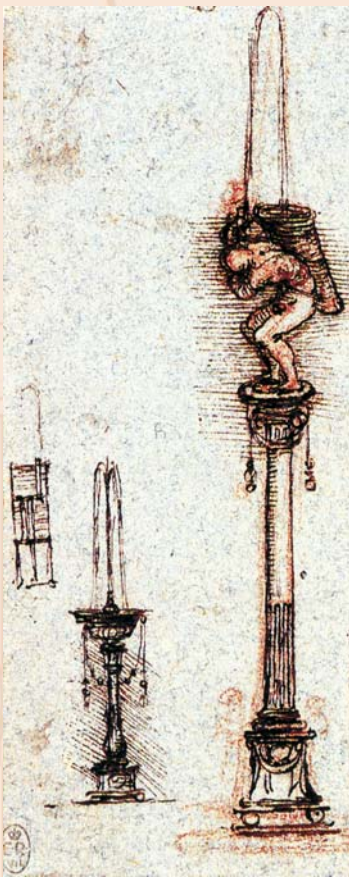


Fig. 4.1. Table fountains, Windsor, RL 12690

¹ Derek De Solla Price, *Gears from the Greeks: The Antikythera Mechanism. A Calendar Computer from ca. 80 B.C.*, New York, Science History Publications, 1975, pp. 51–62. As Price relates: "The Tower of Winds, located in the Roman Agora in the heart of Athens, was built by Andronicus Kyrrhestes of Macedonia about the second quarter of the first century B.C. It was a monument designed in accord with the science of the day with an especially complicated sundial on each face of its octagonal tower, a wind vane and a frieze of the gods of the prevailing wind above that, and a whole series of marvelous astronomical and probably other showpieces inside. It was a sort of Zeiss planetarium of the classical world".

² Derek De Solla Price, Athens' Tower of the Winds. *National Geographic*, CXXXI, no. 4, April 1967, pp. 586–596.

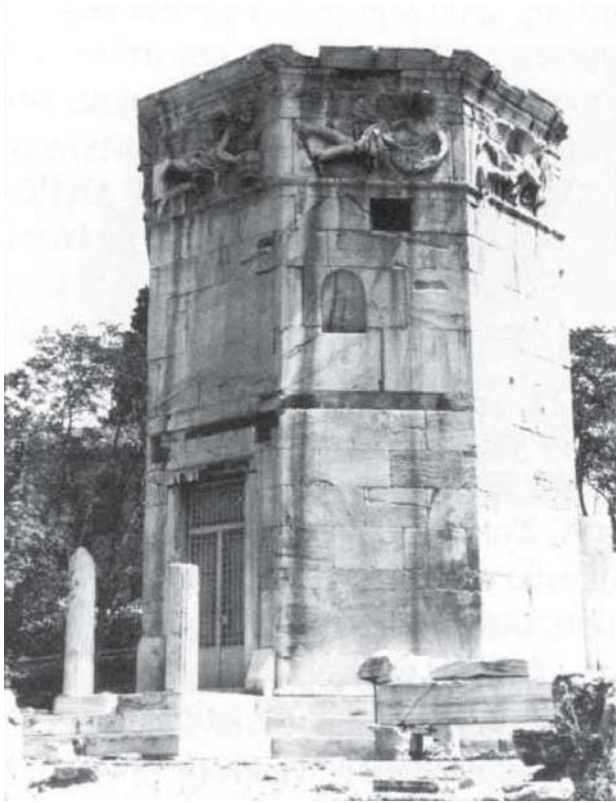


Fig. 4.2. Tower of the Winds

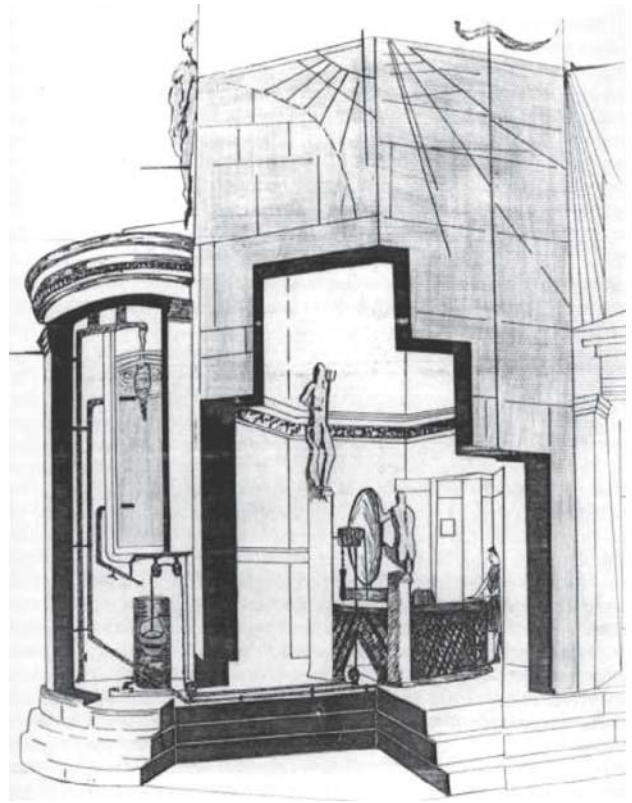


Fig. 4.3. Tower of the Winds mechanism

The Tower of Winds Water Clock was designed along the lines of Ctesibus about the middle of the third century. It appears to be the first to introduce a float into an inflow vessel. In Ctesibus' design, an indicator rod is carried by the float which shows the time by its position above the vase. A large tank (Fig. 4.3) is fed constantly by an outside pipe from a brackish spring located high on the Acropolis.³ The lower pipe pours a constant stream of water that slowly raises the float in the smaller container. When fully raised, the float releases a chain, which is wrapped around a pulley and terminates in a counterweight. Gradual descent of the counterweight rotates the clock disc. The clock disc, Price speculates, was made of bronze and depicted "a model of the universe moving in harmony with reality. Among Andromeda, Perseus, and the figures of the zodiac, a golden sun, pegged into the proper hole for the time of year, moved behind a wire grid which indicated the hours of day and night and the lines of the horizon and meridian". The wire grid, perhaps held by Atlas or Hercules, is accented by three fountains fed by the middle overflow vertical pipe running along the same channel as the chain.

Every two days, the attendant would reset the sun peg into its new location. No doubt the same attendant would reset the clock every 24 hours by emptying the small tank via a square opening in the floor, starting afresh the clockwork universe. Thus started, the bronze clock disc rotates clockwise, as have all of our clocks for over 2000 years.

³ Derek De Solla Price, op. cit. in note 2 above, p. 591.