

# Al-Jazari's Water Pump

Muslim engineers were exploring new methods for increasing the effectiveness of water-raising machines. Al-Jazari was the most outstanding mechanical engineer of his time.

In 1206, he completed an outstanding book on engineering entitled "*Al-Jami baina al-'Ilm wal 'Amal al-Nafi Fi Sinat'at al Hiyal*" in Arabic. It was a compendium of theoretical and practical mechanics.

Al-Jazari described water-raising machines that show an awareness of the need to develop machines with a greater output than the traditional ones.

Al-Jazari was responsible for the design of five machines in the thirteenth century CE. His first two machines were modifications of the Shadouf. The machine used a flume-beam: instead of a pole, an open channel is connected to a scoop, with its spout elongated into a flume. The scoop dips into the water and when the beam rises the water flows back through the channel and releases into the irrigation system. The machines were animal-powered as in the Saqiya.

Al-Jazari's third machine was a development of the Saqiya in which water power replaced animal power. Flowing water turned a water wheel, which via a system of perpendicular gears led a chain of pots to raise the water. One such machine was located on the River Yazid in Damascus (13th century) and is thought to have supplied the needs of a nearby hospital.

The fourth machine also used a flume-beam and was animal-powered. The beam moved up and down by an intricate mechanism involving gears and a crank. This is the first known instance of the use of a crank as part of a machine, the earliest appearance in Europe of a crank as part of a machine occurred in the fifteenth century CE.

Al-Jazari's fifth machine, a water-driven pump, was a more radical device. A water wheel turned a vertical cog wheel which in turn turned a horizontal wheel. The latter caused two opposing copper pistons to oscillate. The cylinders of the pistons were connected to suction and delivery pipes which were guarded by one-way clack valves (i.e. hinged at one end). The suction pipes drew water from a water sump below, and the delivery pipes discharged the water into the supply system about 12 m above the installation. This pump is an early example of the double-acting principle (while one piston draws in, the other delivers) and the conversion of rotator to reciprocating motion.