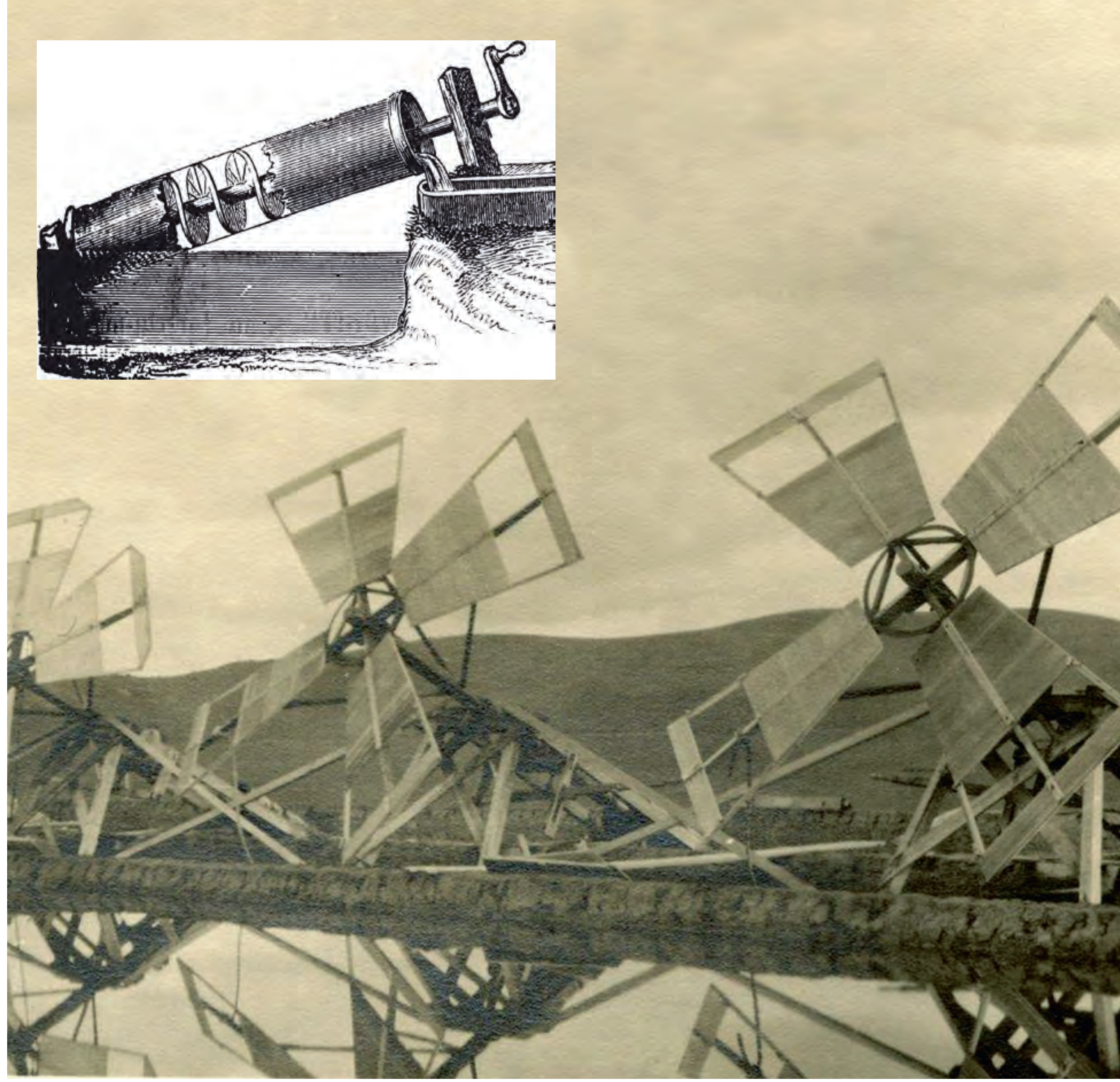
In concept, the screw pump is commonly attributed to Archimedes (ca. 287 to ca. 212 BCE), the famed Greek mathematician and engineer. The pump featured a large screw fitted inside a cylinder, situated at an angle. As the screw turned, the bottom end scooped up water, moving it up the cylinder, and discharging it at the top. The screw pump was manually powered until the seventeenth century when Dutch engineers developed a wind-powered version. The ASME landmark shown here, owned by the Cargill Salt plant in Newark, California, is one of the oldest-surviving wind-driven screw pumps in the United States. It represents a technology used in the salt industry in and around the San Francisco Bay Area from approximately 1820 through 1930. Those producers recovered salt through a solar-evaporation process that shifted brine from one concentration pool to another. Dating to 1890, this pump was moved from its original location when it was restored in 1978.

To the field of mechanical engineering Archimedes' screw pump contributed a simple, fault-free mechanism for moving substances from one elevation to another. Besides pumping brine, Archimedean screws found widespread use in agricultural irrigation and drainage and in dewatering mines before the eighteenth century. Oliver Evans incorporated Archimedean screws into his design for the automatic flour mill in the 1780s. More recently, mechanical engineers have used forms of the Archimedean screw to move grain to and from storage elevators, to transport fish around dams, to blow snow, and to stabilize the Leaning Tower of Pisa.



ARCHIMEDES' SCREW PUMP (1890)

Direct descendents of a key ancient Greek invention, screw pumps like these once worked miles of brine pools, their rotation driven by the wind. Courtesy of Cargill Incorporated.

Inset: Cross-section of a basic Archimedes style Screw Pump.

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NORIA AL-MUHAMMADIYYA (1361)

Raising water for urban use, the Noria Al-Muhammadiyya, a restored fourteenth-century water wheel near Hama, Syria, represents one of humankind's earliest uses of non-muscular energy to distribute municipal water supplies.
Courtesy of iStockphoto / Thinkstock.

As early as the third century BCE, engineers made their mark by devising ways to harness the natural power of flowing water. Classical societies used water wheels for a variety of purposes, including irrigation, grinding grain, and possibly metalworking. In medieval Syria, millwrights tapped the power of the fast-flowing River Orontes with a multitude of special-purpose waterwheels, called norias. These simple, gearless machines raised water to irrigate farmland and provide municipalities with water. As part of this group, the Noria al-Muhammadiyya is one of the largest and oldest water wheels in the world. Built entirely of wood in 1361 and restored in 1977, this machine derives its power solely from the river's strong current, raising water by means of buckets or troughs attached to the rim of the wheel. An elevated aqueduct distributes the water it transfers from the river to a nearby mosque, public bath and garden, and to the houses of the surrounding neighborhood. The wheel delivers approximately 50,000 gallons of water per hour during the dry season. The Noria al-Muhammadiyya's simple yet thoughtful application of mechanics and water power makes it a forerunner of the more powerful water wheels that would later power the early stages of the First Industrial Revolution. It is likely the world's earliest surviving example of the prime mover in a municipal water supply.

Philadelphia was among the first cities in the United States to provide a municipal water supply to residents, opening two steam-powered pumping stations in 1801 to lift water from the Schuylkill River and distribute it through wooden pipes to customers. In 1815, the city inaugurated the Fairmount Water Works to replace its initial system, and Fairmount became the first large-scale application of steam pumping to water service in the country.

Renowned for its "park-like" setting, the Fairmount Works combined exemplary neoclassical architecture with superb hydraulic engineering. Its history demonstrates the application of three distinct systems for supplying water: steam engines, breast wheels, and water turbines. Though the Works initially used steam engines, the city moved to waterwheels in the 1820s under the pressure of a booming population and the mounting costs of maintaining the steam-powered system. From 1826, large, efficient breast wheels pumped water to wealthy customers in Philadelphia's metropolitan area. The application of newly developed turbine technology circa 1850 provided the city with an even more efficient and affordable means of distributing water, by then through cast iron pipes.

By the 1840s, the Fairmont Works had a wide reputation for combining advanced mechanical engineering and architectural beauty in a public works system. Unfortunately, the primary water supply for the Works, the Schuylkill River, became a dumping ground for industrial and public waste, its water declining in quality as the century progressed. By the 1870s, the city determined that it needed to purify its water before distribution, and the antiquated Fairmount Works lacked the space for the new systems. The city created a new treatment and pumping facility, and Fairmount pumped its last water from the Schuylkill River in 1909. Many of its structures, however, survive in a beautifully restored setting today.

FAIRMOUNT WATER WORKS (1815)

With its neoclassical architecture, the façade of the Fairmount Water Works on the Schuylkill River saluted early Americans' reverence for the ancient Roman republic while housing a thoroughly modern and steam-powered urban water supply system. Jack E. Boucher, photographer. Library of Congress, Prints & Photographs Division, HAER PA,51-PHILA,328—174 (CT).

SAUGUS IRON WORKS (1647)

The replica buildings with their water-powered equipment at Saugus, Massachusetts, commemorate the beginnings of the iron industry in the western hemisphere in the mid-seventeenth century. Courtesy of the National Park Service / Don Woods, Photographer.

As the first successful iron works in the New World, Saugus has been called the birthplace of industry in colonial America. Located in Saugus, Massachusetts, near Boston, the site operated under the name "Hammersmith" from 1647 to circa 1670, producing about 200 tons of iron annually. An integrated works, Saugus contained a blast furnace that made pig iron and cast iron products and a forge that fabricated wrought iron goods. Nearby ore and limestone deposits provided ample raw materials, while the region's forests and streams offered fuel for the works' blast furnace and the power for its hammer and rolls. Though its tenure and profitability were short-lived, the Saugus works drew skilled immigrants from the Old World, provided a measure of economic self-reliance by making locally produced goods available for regional and international trade, and initiated an industry that would eventually contribute to American political and economic independence.

The Saugus Iron Works also demonstrates the transfer of advanced technologies from England to its colonies in an industry that would drive American industrial production in the nineteenth century. Today it is an important educational resource for historians, students, and enthusiasts. Excavations and reconstruction of the Saugus works began in the 1940s, and in 1968 the reconstructed Saugus Iron Works was designated a National Historic Site by US Department of the Interior.

This smock-style windmill is the largest and oldest operational mill of its type in the United States. A local sailor named Nathan Wilbur built the structure in the mid-eighteenth century to grind locally grown grain on Nantucket Island, where consistent winds allowed year-round operation. The 50-foot octagonal structure's basic design, copied from Dutch models Wilbur had observed while travelling, provides an example of the transfer of European mechanical technology to the Americas. Wilbur's design allowed the "cap" of the building to swivel to readily face its 30-foot sails into the wind. The cap was manipulated from the ground by a 50-foot tail pole. Like most European mills of its type, the windmill's rotating sails (or vanes) turned large wooden gears reinforced with iron, which in turn rotated a grinding stone. The grinding stone fit into a cavity in a larger stationary stone, and pulverized the grain in the cavity like a pestle spinning in a mortar bowl. Wilbur's thoughtful application of Dutch windmill designs improved grain production on the island, and his mill could process about five bushels of corn an hour—producing approximately 5,000 pounds of corn meal in the summer months alone. In the nineteenth century, the application of water and then steam power eventually displaced windmills as the American milling industry expanded. The Old Mill changed hands several times before it was donated to the Nantucket Historical Association in 1897. The Association maintains the mill, providing tours and demonstrations during the summer months.

OLD MILL IN NANTUCKET (1746)

Traditional smock windmills, like the Nantucket mill, converted wind energy into mechanical power. Operators pushed the long diagonal pole to swivel the cap as needed to position the mill's sails into the wind. Frank C. Brown, photographer. Library of Congress, Prints & Photographs Division, HABS MASS,10-NANT,6—1 and 2.