

Figure 1.6
Newcomen steam engine and water pump, 1717. This is the earliest known drawing of a Newcomen engine. These enormous machines (see man in left foreground) were first used to remove water from coal mines in England. Within 20 years after the first such engine was built, in 1712, more than 100 were at work throughout Europe.¹³

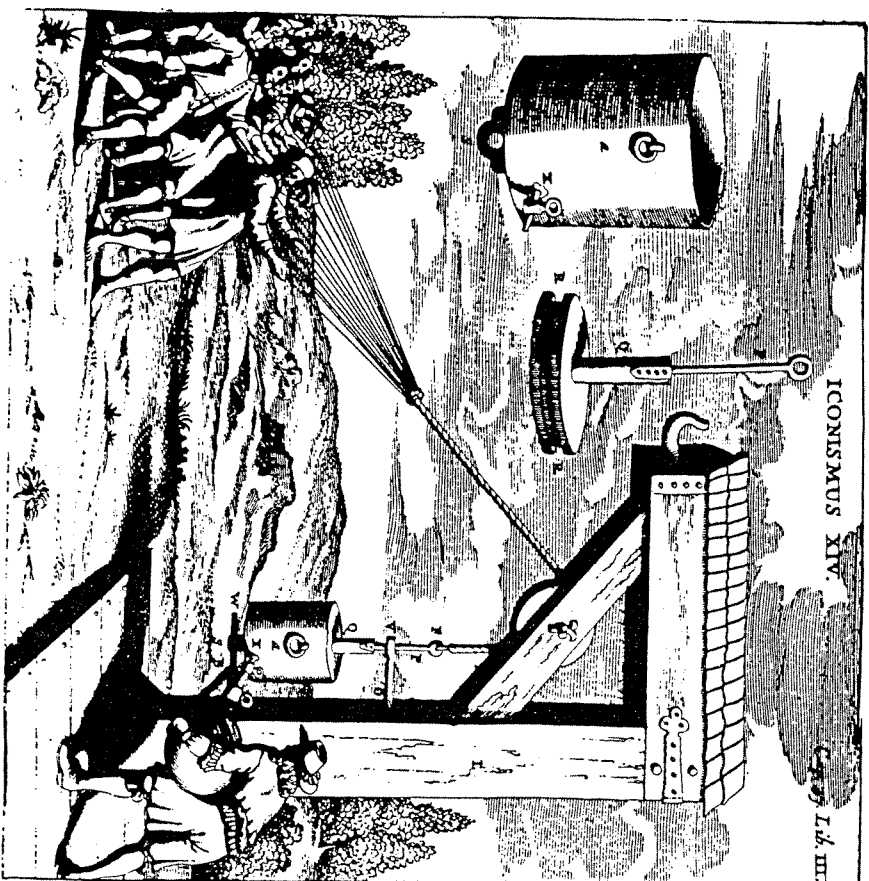


Figure 1.7
Steps toward the Newcomen atmospheric steam engine, 1. The atmosphere pushes a piston into a partial vacuum, producing work (defined as a force acting through a distance). The man at right evacuates the cylinder with an air pump. The piston in the cylinder moves downward, overcoming the resistance of men holding ropes.¹⁴

*un'azione di un ago
che varia la*

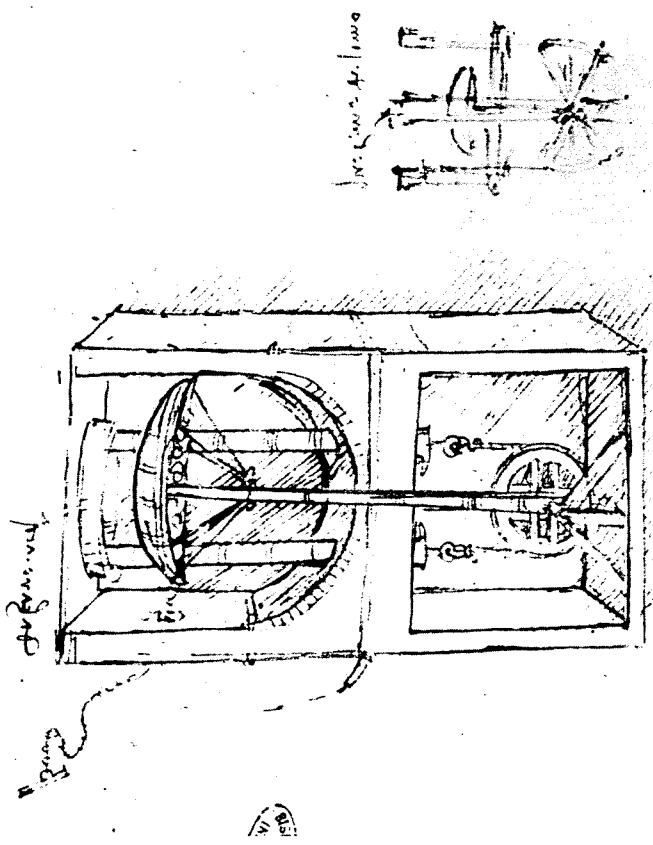


Figure 1.9
Steps toward the Newcomen steam engine, III. Leonardo's two-cylinder water pump (c. 1500) included a boat-shaped pendulum attached to a wheel overhead. At left, Leonardo substituted for the wheel a pair of sector arms. Beneath the sketch are the words "quel medesimo" ("the same").

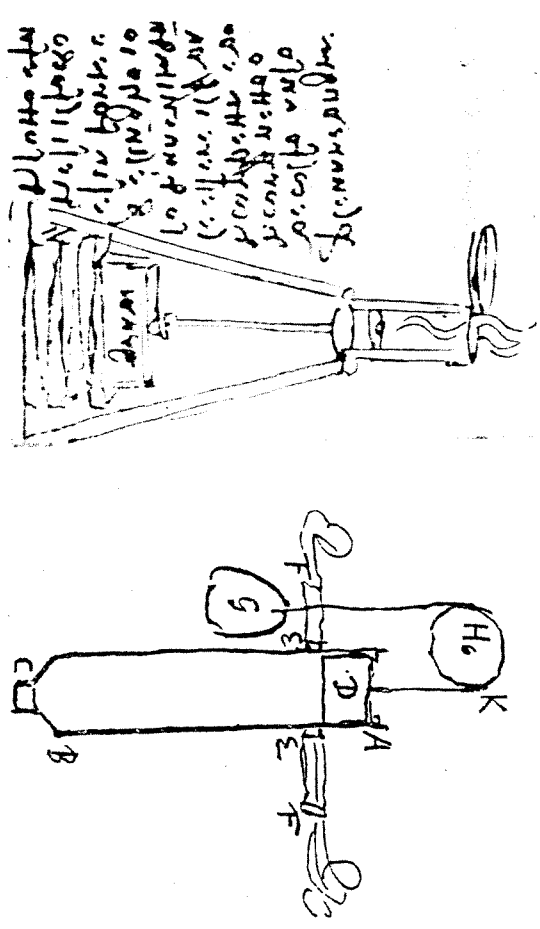


Figure 1.10
Steps toward the Newcomen steam engine, IV. In Leonardo's gunpowder engine (c. 1500), gunpowder is placed on pan near the bottom of a cylinder; when it heats the air and expels most of it from the cylinder. If the flat cap is quickly over the mouth of the cylinder, pressure in the cylinder drops below atmospheric pressure (attached by a rod to a rectangular weight) rises; if wedges are instantly placed, the weight remains at its higher level.¹⁷

Figure 1.11.
Steps toward the Newcomen steam engine, V. Christian Huygens' 1673 gunpowder engine is an improvement on Leonardo's but employs the same principle.¹⁸

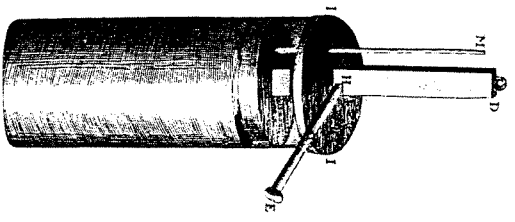


Figure 1.12
Steps toward the Newcomen steam engine, VI. In Denis Papin's steam cylinder (1690), water was evaporated in a cylinder and condensed by dashing water over it. This steam cylinder, whose piston was pushed down by the atmosphere when steam condensed, was described in a journal published in 1690.¹⁹



Figure 1.13
Horsehead oil-pumping rig in Oklahoma, 1973. Driven by the internal-combustion engine at extreme left, the T-shaped crank arm lowers and raises the left end of working beam. The Newcomen-inspired sector at right raises and lowers a calcrating a pump deep in the well below the rig.¹¹⁰

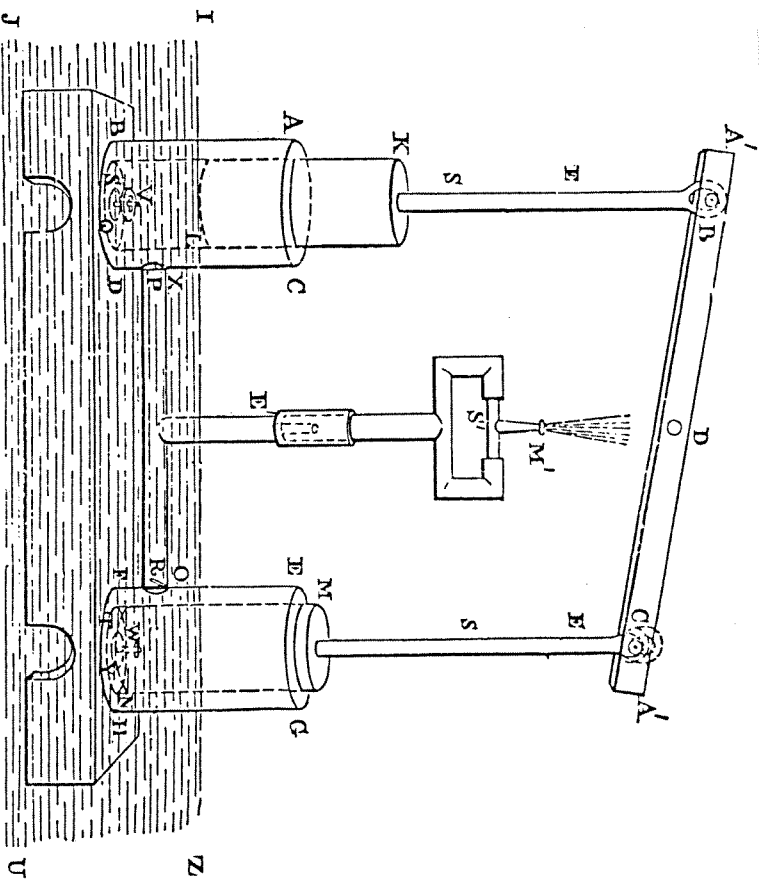


Figure 2.2
James Watt's double-acting rotative steam engine, 1787. The mechanism for the vertical guidance of the upper ends of the steam piston rod and the water pump rod in "parallel motion" is among the most ingenious of Watt's many original contrivances.¹²²

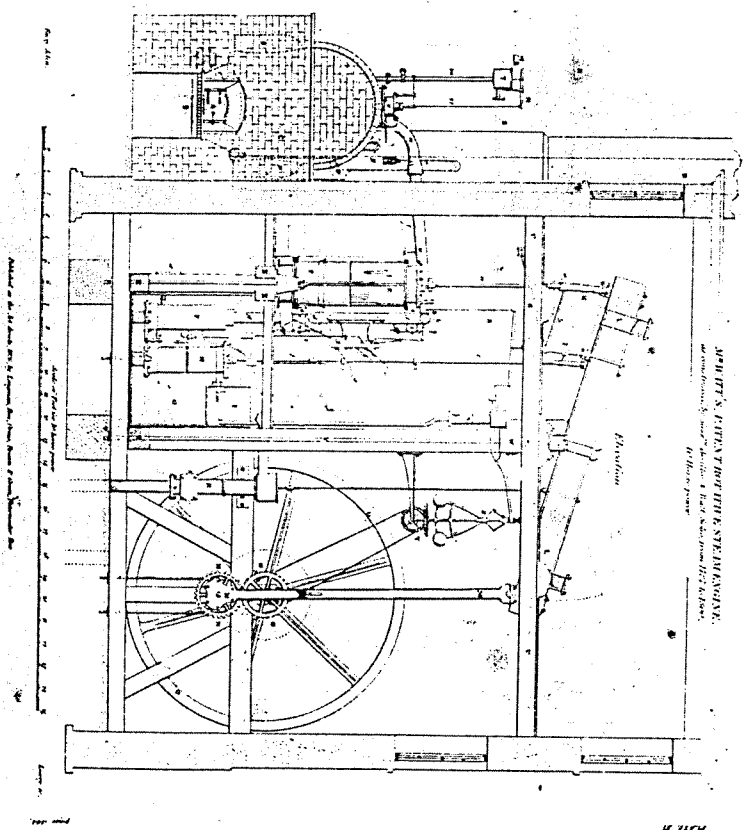
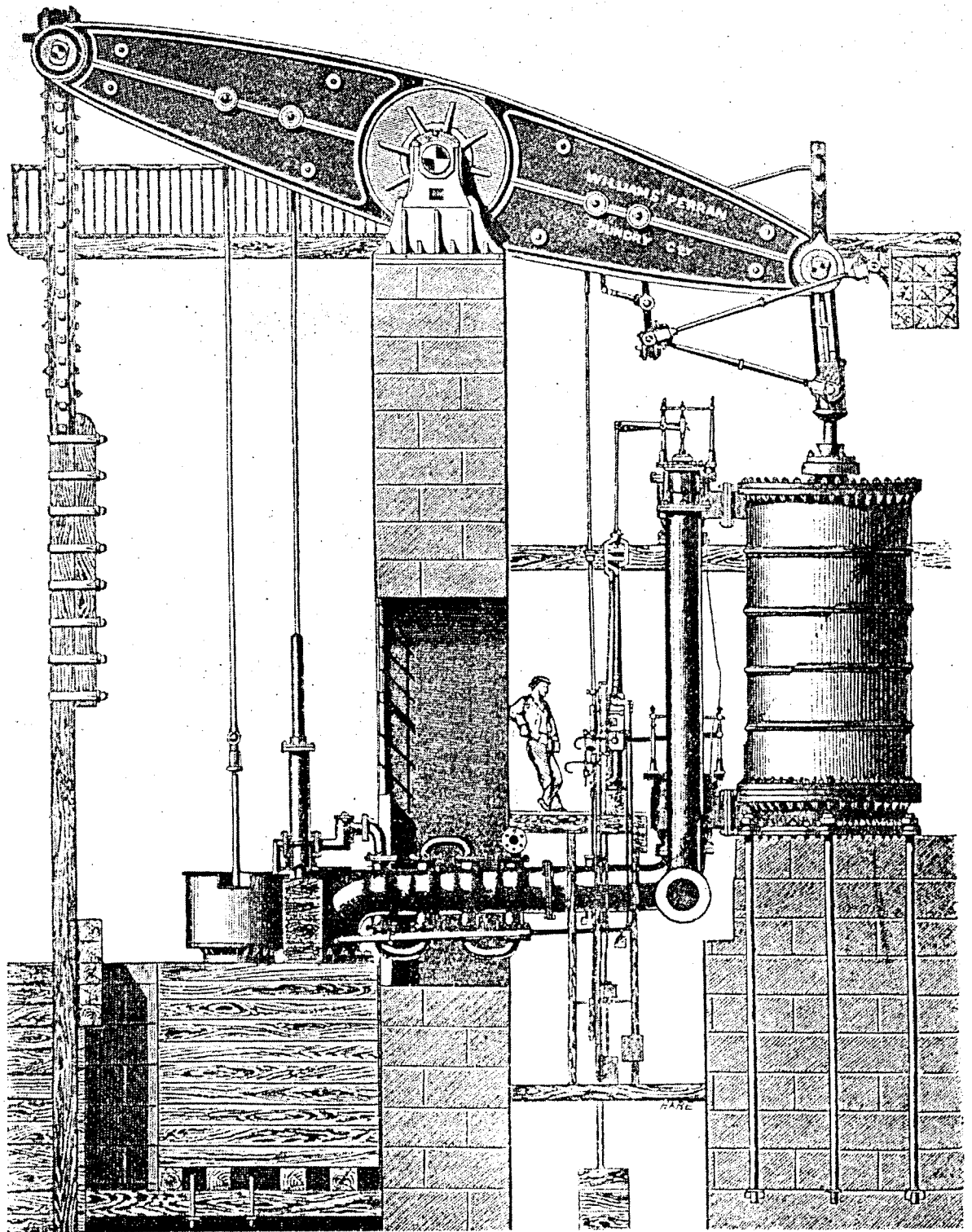
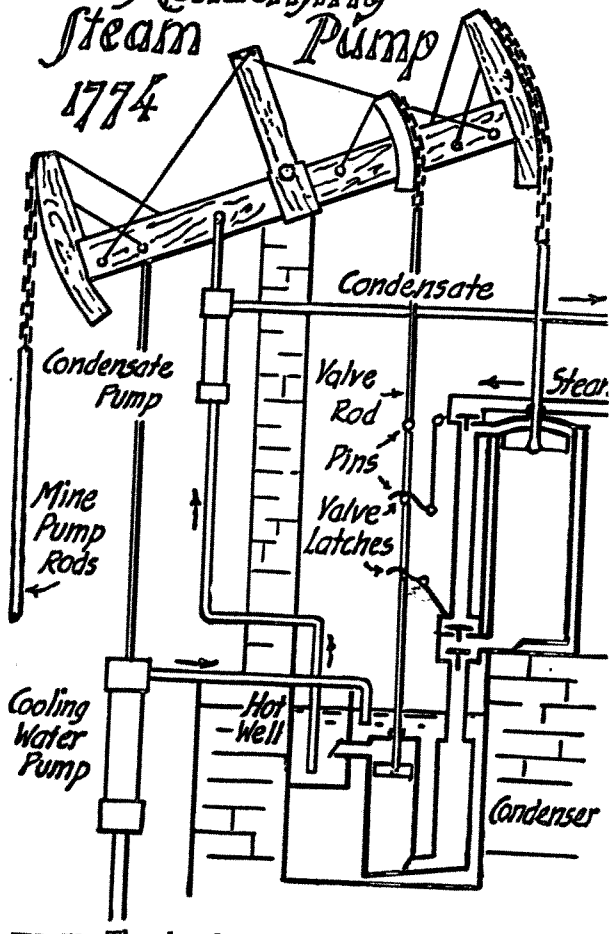


Figure 3.1
Ancient force pump with adjustable nozzle: an 1851 drawing of Hero of Alexandria's pump (first century A.D.).¹²⁵



A typical Cornish Pumping Engine, *circa* 1840, with 85-inch diameter cylinder, and 11-foot stroke.
Built by the Perran Foundry for the United Mines, Cornwall.
The greatest power produced by this engine was 220 horse-power.
Reproduced by courtesy of the Science Museum, London

Watt's Condensing Steam Pump 1774



Newcomen's Atmospheric Mine Pump 1705

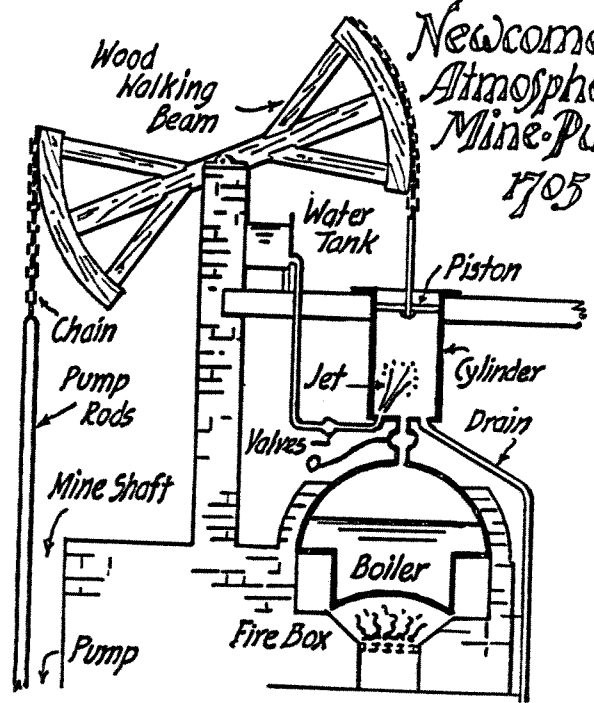


FIG. 50. The cylinder has been cut off at the top.

