

Figure 1.2
Engraving showing use of capstans in the erection of an obelisk at the Vatican in 1586. (The penalty for disrupting work was death.) (From N. Zabaglia, *Castelli e Ponti* [Rome, 1743].)

in what is termed a good "impedance match." We would call this good impedance match an optimum gear ratio.

One medieval example of the use of appropriate muscles in a good impedance match is the capstan (figure 1.2). Several people walked in a circle, pushing on radial arms, to winch in a rope. The capstan's diameter was chosen to give comfortable working conditions, and each pusher could choose a preferred radial position on the bar.

Other relatively satisfactory uses of muscle power were the inclined treadmill (figure 1.3) and Leonardo da Vinci's drum or cage for armaments (rotated by people climbing on the outside) (Reti 1974, 178–179), and treadmill-driven pumps (figure 1.4). This type of work may not have been pleasant, but per unit of output it was far more congenial than that of a galley slave.

The path of development, in this as in most other areas, was not a steady upward climb. Even though relatively efficient mechanisms using

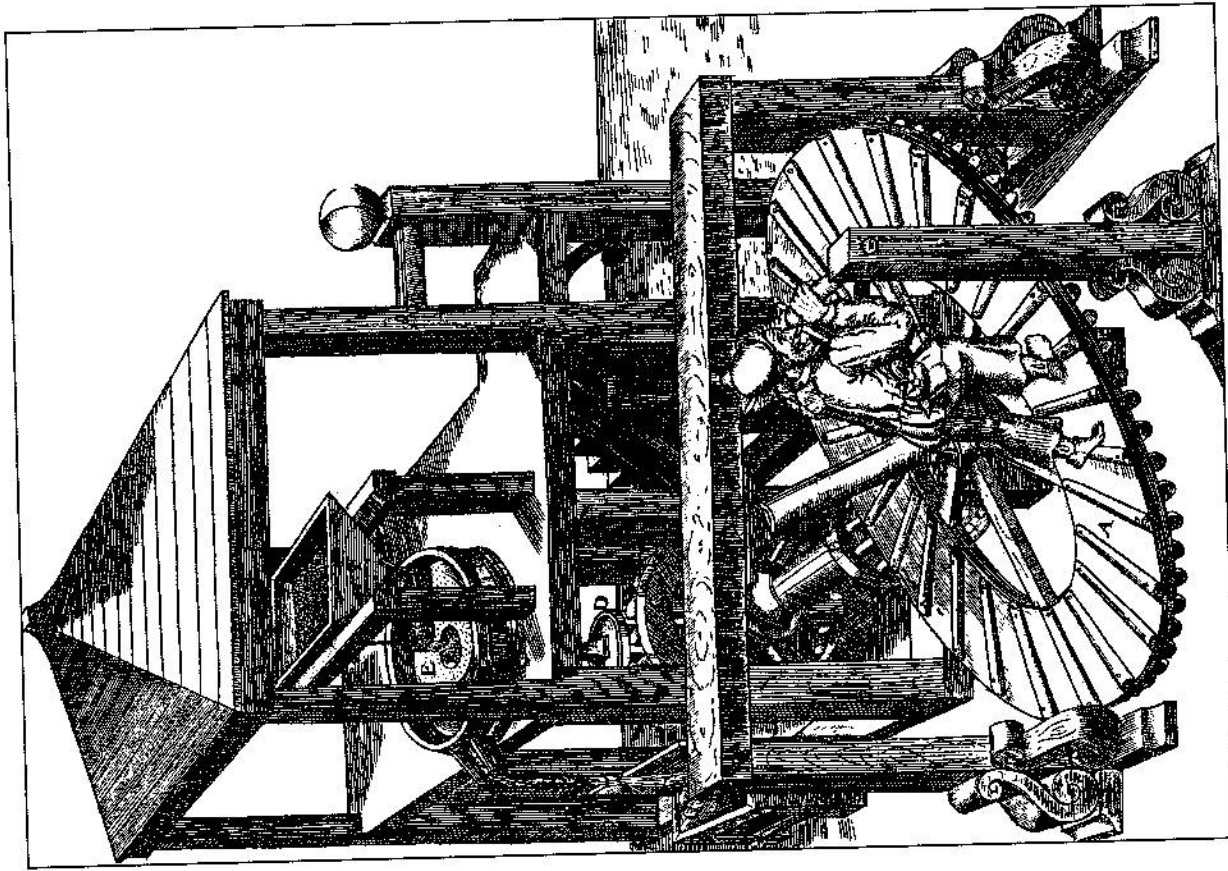


Figure 1.3
Inclined treadmill powering a mill. (From Gruidi and Ferguson 1987.)