

being well acquainted with the specific difference of each plant, before it ripens its seed, it is not a little difficult to distinguish them one from the other. This specific difference will be best furnished by the leaves. Thus in the henbane, the leaves of the white are placed upon long footstalks; those of the black have none, but the lower extremity of the leaf surrounds the stalk.

XXIX. *The best Proportions for Steam-Engine Cylinders, of a given Content, consider'd; by Francis Blake, Esq; F. R. S.*

Read May 23. 1751. **T**HE fire-engine, or (to term it more properly) the steam-engine, for draining of mines, is a master-piece of machinery, a very capital contrivance in the works of art, and meriting our attention for further improvements. This is univerfally allowed, as well upon account of the theory it is founded on, as its usefulness in practice. And is it arriv'd then at the last degree of perfection, that we appear at a stand? I think not. The prodigious vessel of water to be kept always boiling, when only an inconsiderable part of it is employ'd in the work, favours too little of the frugality of nature, which we ought ever to imitate. But waving that now, what I would inquire into here, and endeavour to regulate, is, the cylinder's proportion of the altitude and base; which hath not, as I know of, been hitherto noticed.

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It is evident, in the first place, from a fundamental law of mechanics, that, the content of the cylinder remaining the same, the quantity of water discharged at each lift will in all cases be equal, by only changing the distance of the center of the piston from the fulcrum of the balance. You will agree likewise (for I suppose the principles and working-part to want no description) that the excess of the pillar of atmosphere above that of the water is a weight on the piston, driving it to a depth of five feet, or thereabout, by the present construction, within the cavity of the cylinder; acceleratedly till friction and an impediment from the steam, which remains in the cylinder even after the jet d'eau, and is increased in elasticity, whilst its bounds are diminish'd, shall equal the accelerative force; and that then again the piston is retarded the rest of the way. It may be convenient to remark too, that if the rarefaction be so complete, that the descent would be greater than the construction admits of, the retardation is augmented by a *brachium* of the balance pressing upon springs. But to say nothing of friction here, we can, notwithstanding this diminution of force by the remainder of steam within the cavity of the cylinder, demonstrate the ratio of the velocities, and the times of descent of the pistons, in cylinders of unequal altitudes, to be exactly the same, as if the resistance was nothing; whence we shall without difficulty arrive at some conclusion in this matter.

MN is the working-part of a steam-engine cylinder, of the usual height, equal in diameter to a shorter one *mn*; and the rarefaction in both of them being supposed the same, $AQ=aq$, $RQ=rq$, and

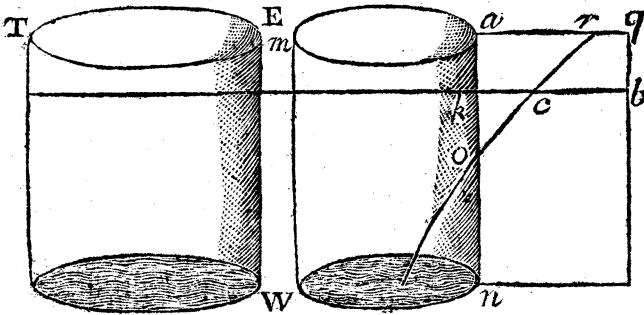
and $AR=ar$, may represent the excess of the atmosphere's weight above the pillar of water, the resistance to the pistons from the remainder of steam, and the effective force, respectively, *e. g.* at the beginning of the descent. Take, then, every-where $ak:AK::an:AN$, and at all similar positions the resistance bc of mn and force kc on its piston will equal the resistance BC of MN and force KC on its piston; and by what Sir Isaac Newton has demonstrated (*Book 1. Prop. 39.*) of the descent of bodies, we have $\sqrt{akcr}:\sqrt{AKCR}::$ celerity in k : celerity in K . But these areas being evidently as the corresponding parallelograms kq and KQ , and they again as their heights, the celerities generated are in the subduplicate ratio of $ak:AK$, as tho' the resistance had been nothing; and by an obvious enough reasoning from the said proposition, the times also appear to be in the above-mention'd ratio; which ratio is not any way varied, tho' the resistance prevails from the intersecting points O .

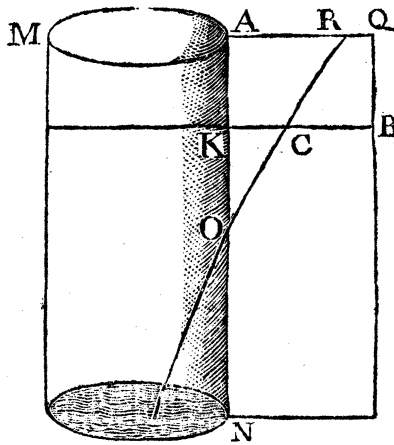
Now, to apply what has been said to the business in hand; if TW be a cylinder of equal content with the cylinder MN , the quantity of water delivered by both will, as a consequence of the fundamental law of mechanics observed above, be the same at each lift: but the cylinder TW is no higher than nm , and *ex hypoth.* their rarefactions are equal; and therefore, by what has been proved with regard to the times, the time of the piston's descent in TW will be to that of the piston's descent in $MN::\sqrt{EW}:\sqrt{AN}$; whence in any given time the broad cylinder TW will perform more than the longer one MN of equal content, and that in the ratio of their diameters;

for $\overline{ET}^2 \times EW = \overline{MA}^2 \times AN$, *ex hypoth.* $EW:AN :: \overline{MA}^2:\overline{ET}^2$, and consequently $\sqrt{EW}:\sqrt{AN}:: MA:ET$. The friction too is diminished with the slowness of the motion, and because the periphery increases in a less ratio than does the area of a circle.

The result of the whole then is in favour of the broad cylinder; and still the broader the better; for unless some mechanical considerations should limit the problem, 'tis evident in a geometrical sense, that there is no limitation. A disadvantage might arise perhaps to the effect of the jet d'eau from thus increasing the breadth; which however would be remedied, I think, by a number of these jets: but be that as it will, 'tis certain, that to augment the diameters, and diminish the lengths of the smaller kind of cylinders, now used, could have no such inconvenience, nor fail of being attended with an augmentation of force.

What I think might be further observed for the improvement of this engine is in the boiler and steam, but more connected with experiments; which should I have an opportunity to make, I may resume perhaps the subject, if they answer my expectation.





XXX. *Mr. John Bradley's Observation of the Occultation of Venus by the Moon; communicated by Mr. James Short, F.R.S.*

Read June 6. 1751. **M**R. Gael Morris having favour'd me with the observation of the late occultation of Venus by the moon, taken at Greenwich with great exactness by Mr John Bradley, I am induc'd to lay the same before the Royal Society, in order to shew its very near agreement with those phases, which Dr. Bevis observed at my house in Surry-street, allowing for the difference of meridians. I must take notice, that, besides the advantage of a six-foot reflector with a great magnifying power, which shew'd the planet's limb very well defined, he had also another, which the doctor had not, I mean
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