II. *A Description of the* Water-Works *at* London-Bridge, *explaining the Draught of* TAB. I. *By* H. Beighton, *F. R. S.*

THE Wheels are placed under the Arches of *London-Bridge*, and moved by the common Stream of the Tide-Water of the River *Thames*.

AB the Axle-tree of the Water-Wheel, 19 Feet long, 3 Feet Diameter, in which C, D, E, F, are four Sets of Arms, eight in each Place, on which are fixed GGGG, four Rings, or Sets of Felloes, in Diameter 20 Feet, and the Floats HHH, 14 Feet long and 18 Inches deep, being about 26 in Number.

The Wheel lies with its two Gudgeons, or Centers, AB, upon two Brasses in the Pieces MN, which are two great Levers, whose Fulcrum, or Prop, is an arched Piece of Timber L, the Levers being made circular on their lower Sides to an Arch of the Radius MO, and kept in their Places by two arching Studs fixed in the Stock L, through two Mortises in the Lever MN.

The Wheel is, by these Levers, made to rise and fall with the Tide, which is performed in this Manner. The Levers MN are 16 Feet long; from M, the Fulcrum of the Lever, to O the Gudgeon of the Water-Wheel, 6 Feet; and from O to the Arch at N, 10 Feet. To the Bottom of the Arch N is fixed a strong triple Chain P, made after the Fashion of a Watch-Chain, but the Links arched to a Circle of one Foot Diameter,

Diameter, having Notches, or Teeth, to take hold of the Leaves of a Pinion of caſt Iron Q, 10 Inches Diameter, with eight Teeth in it moving on an Axis. The other looſe End of this Chain has a large Weight hanging at it, to help to counterpoiſe the Wheel, and preſerve the Chain from ſliding on the Pinion. On the ſame Axis is fixed a Cog-Wheel R, 6 Feet Diameter, with 48 Cogs. To this is applied a Trundle, or Pinion, S, of ſix Rounds, or Teeth; and upon the ſame Axis is fixed T, a Cog-Wheel of 51 Cogs, into which the Trundle V, of ſix Rounds, works; on whoſe Axis is a Winch, or Windlaſs, W, by which one Man, with the two Windlaſſes, raiſes or lets down the Wheel as there is Occaſion.

And becauſe the Fulcra of theſe Levers, M N, are in the Axis of the Trundle K, *viz.* at M or X, in what Situation ſoever the Wheel is raiſed or let down, the Cog-Wheel I I, is always equidiſtant from M, and works, or geers truly.

By Means of this Machine the Strength of an ordinary Man will raiſe about fifty Ton Weight.

I, I, is a Cog-Wheel fixed near the End of the great Axis, 8 Feet Diameter, and 44 Cogs working into a Trundle K, of 4½ Foot Diameter, and 20 Rounds, whoſe Axis or Spindle is of Caſt Iron 4 Inches in Diameter, lying in Braſſes at each End, as at X.

Z Z is a quadruple Crank of Caſt Iron, the Metal being 6 Inches ſquare, each of the Necks being turned one Foot from the Center, which is fixed in Braſſes at each End in two Head-ſtocks faſtned down by Caps. One End of this Crank at Y is placed cloſe abutting to the End of the Axle-tree X, where they are at thoſe Ends fix Inches Diameter, each having a Slit in the Ends, where an Iron Wedge is put, one half into the End X, the other half into Y, by Means of which the Axis X turns about the Crank ZZ.

The four Necks of the Crank have each an Iron Spear, or Rod, fixed at their upper Ends to the respective Libra, or Lever, *a* 1, 2, 3, 4, within three Foot of the End. These Levers are 24 Feet long, moving on Centers in the Frame *b b b b*; at the End of which, at *c* 1, 2, 3, 4, are jointed four Rods with their forcing Plugs working into *d* 1, 2, 3, 4, four Cast Iron Cylinders four Feet three quarters long, seven Inches Bore above, and nine below where the Valves lie, fastened by skrewed Flanches, over the four Holes of a hollow Trunk of Cast Iron, having four Valves in it just over *e e e e*, at the joining on of the Bottom of the Barrels, or Cylinders, and at one End a sucking Pipe and Grate *f*, going into the Water, which supplies all the four Cylinders alternately.

From the lower Part of the Cylinders *d* 1, *d* 2, *d* 3, *d* 4, come out Necks turning upward Arch-wise, as *g g g g*, whose upper Parts are cast with Flanches to skrew up to the Trunk *h h h h*; which Necks have Bores of 7 Inches Diameter, and Holes in the Trunk above communicating with them, at which Joining are placed four Valves. The Trunk is cast with four Bosses, or Protuberances, standing out against the Valves to give room for their opening and shutting; and on the upper Side are four Holes stopped with Plugs, to take out on Occasion, to cleanse the Valves. One End of this Trunk is stopped by a Plug *i*. To the other, Iron Pipes are joined, as *i* 2, by Flanches, through which the

the Water is forced up to any Height or Place required.

Besides these four Forcers, there are four more placed at the other Ends of the Libræ, or Levers (not shewn here to avoid Confusion, but to be seen on the left Hand) the Rods being fixed at *a* 1, 2, 3, 4, working in four such Cylinders, with their Parts *d d*, *&c.* *e e*, *f*, *g g*, and *i*, as before described, standing near *k k*.

At the other End of the Wheel (at B) is placed all the same Sort of Work as at the End A is described, *viz.*

The Cog-Wheel	I.	The four Levers *ac*, *ac*, *&c.*
The Trundle	K.	8 forcing Rods *a d*, *a d*, *&c.*
The Spindle	X.	8 Cylinders *d e*, *d e*, *&c.*
The Crank	Y, Z.	4 Trunks, such as *e e*, *h h*.
The sucking Pipes	*f*.	2 forcing Pipes, as *i*.

So that one single Wheel works 16 Pumps.

All which Work could not be drawn in one perspective View, without making it very much confused.

A Calculation of the Quantity of Water raised by the Engines at London-Bridge.

In the 1st Arch next the City is one Wheel with double Work of — — —		16 Forcers.
In the 3d Arch	1st Wheel double Work at one End, and single at the other	12
	2d Wheel in the Middle —	8
	3d Wheel — —	16
	In all	52 Forcers.

One

One Revolution of a Wheel makes in every Forcer — — $2\frac{1}{5}$ Strokes.

So that one Turn of the 4 Wheels makes 114 Strokes.

When the River is at beſt, the Wheels go ſix times round in a Minute, and but $4\frac{1}{2}$ at middle Water — — 6

The Number of Strokes in a Minute 684

The Stroke is $2\frac{1}{2}$ Feet, in a 7 Inch Bore, raiſes 3 Ale Gall.

They raiſe *per* Minute 2052 Ale Gall.

That is, 123120 Gallons = 1954 Hogſheads *per* Hour, and at the Rate of 46896 Hogſheads in a Day, to the Height of 120 Feet.

This is the utmoſt Quantity they can raiſe, ſuppoſing there were no Imperfections or Loſs at all.

But it is certain from the Conſiderations following, that no Engine can raiſe ſo much as will anſwer the Quantity of Water the Cylinder contains in the Length of the Forcer, or Piſton's Motion : For,

Firſt, The opening and ſhutting of the Valves loſe nearly ſo much of that Column, as the Height they riſe and fall.

Secondly, No Leather is ſtrong enough for the Piſton, but there muſt continually ſlip or ſqueeze by ſome Water, when it is raiſed to a great Height; and when the Column is ſhort, it will not preſs the Leather enough to the Cylinder, or Barrel: But eſpecially at the Beginning, or firſt moving of the Piſton, there is ſo little Weight on it, that before the Leather can expand, there is ſome Loſs.

Thirdly, And this Loſs is more or leſs, as the Piſtons are looſer or ſtraighter leathered.

Fourthly, When the Leathers grow too ſoft, they are not capable of ſuſtaining the Pillar to be raiſed.

Fifthly, If they are leathered very tight, as to lose no Water, then a great Part of the Engine's Force is destroyed by the Friction.

By some Experiments I have accurately made, on Engines whose Parts are large and excellently performed, they will lose $\frac{1}{5}$ and sometimes $\frac{1}{4}$ of the calculated Quantity.

However, the Perfections or Errors of Engines are to be compared together, by the calculated Quantities or Forces; for as they differ in those, they will proportionably differ in their actual Performances.

The Power by which the Wheels are moved.

The Weight of the Pillar of Water on a Forcer 7 Inches Diameter, and 120 Foot high.

7 × 7 = 49 lb The Pounds *Averdupoise* in
40 Yards high. [a Yard nearly.
1960 lb on one Forcer.
8 Forcers always lifting.

The whole Weight 15680 lb = 140 *Ct.* = 7 Tun Weight on the Engine at once.

Then the Crank pulls the *Libra* 3 Feet from the Forcer, and 8,3 Feet from the Center,

7 Tun
× 11.3
8,3)79.1(9,5 Tun on the Crank.

Tun.
Wallower 2,2)9,5(4,3 on Trundle.
The Spur Wheel 4
The Radius of the great Wheel 10) 17,2(1,72 Tun.
20
The Force on the Floats 18 *Ct.* 40 lb 34,40 *Ct.*

But to allow for Friction and Velocity, may be reckoned 1 Tun $\frac{1}{2}$.

The

The Ladles or Paddles 14 Foot long, 18 Inches deep, -- } = 22,4 square Feet.
The Fall of Water is sometimes 2 Feet.

44,8
6 Gall. in a Cub. Ft.

)268,8
10, ℔ in a Gallon.

112)2688.(24 Hundred.

The Velocity of the Water, 4 Feet in 21‴ of Time.
21‴ — 4 Ft. :: — 60″: = 685 Feet *per* Minute.
The Velocity of the Wheel = 310 Feet *per* Minute.
Quantity expended on the Wheel, according to the Velocity of the Stream 1433 Hogsheads *per* Second.
But at the Velocity of the Wheel 645 Hogsheads *per* Second.
The Velocity of the Wheel to the Velocity of the Water, as 1 to 22.

Some Observations on these Water-Works.

Although they may justly be esteemed as good as any in *Europe*, yet are there, as I conceive, some Things which might be altered very much for the better.

First, If instead of sixteen Forcers they worked only eight, the Stroke might be five Feet in each Forcer, which would draw a great deal more Water with the same Power on the Wheel; for then there would be but half the opening and shutting of Valves, consequently but half that Loss: And a five Foot Stroke draws above double the Quantity of two Strokes of 2 ½ each, by near ⅓, in regard the Velocity is

 double,

double, which is the moſt valuable Conſideration in an Engine, where the Pipes will ſuſtain ſuch Force.

Secondly, The Bores that carry off the Water from the Forcers are too ſmall, there being (nearly) always two Pillars of 7 Inches Diameter, forcing into one Pipe of the ſame Diameter, and $7 \times 7 = 49 + 49 = 98$.

Therefore thoſe Pipes of Conveyance ſhould be near nine Inches Diameter.

The Perfections of the Machine.

The Timber-work is all admirably well performed, and the Compoſition and Contrivance, for Strength and Uſefulneſs, not exceeded by any I have ſeen.

The caſt Iron Cranks are better than wrought ones, by reaſon they are very ſtiff, and will not be ſtrained, but ſooner break; but then they are cheap, and new ones eaſily put in.

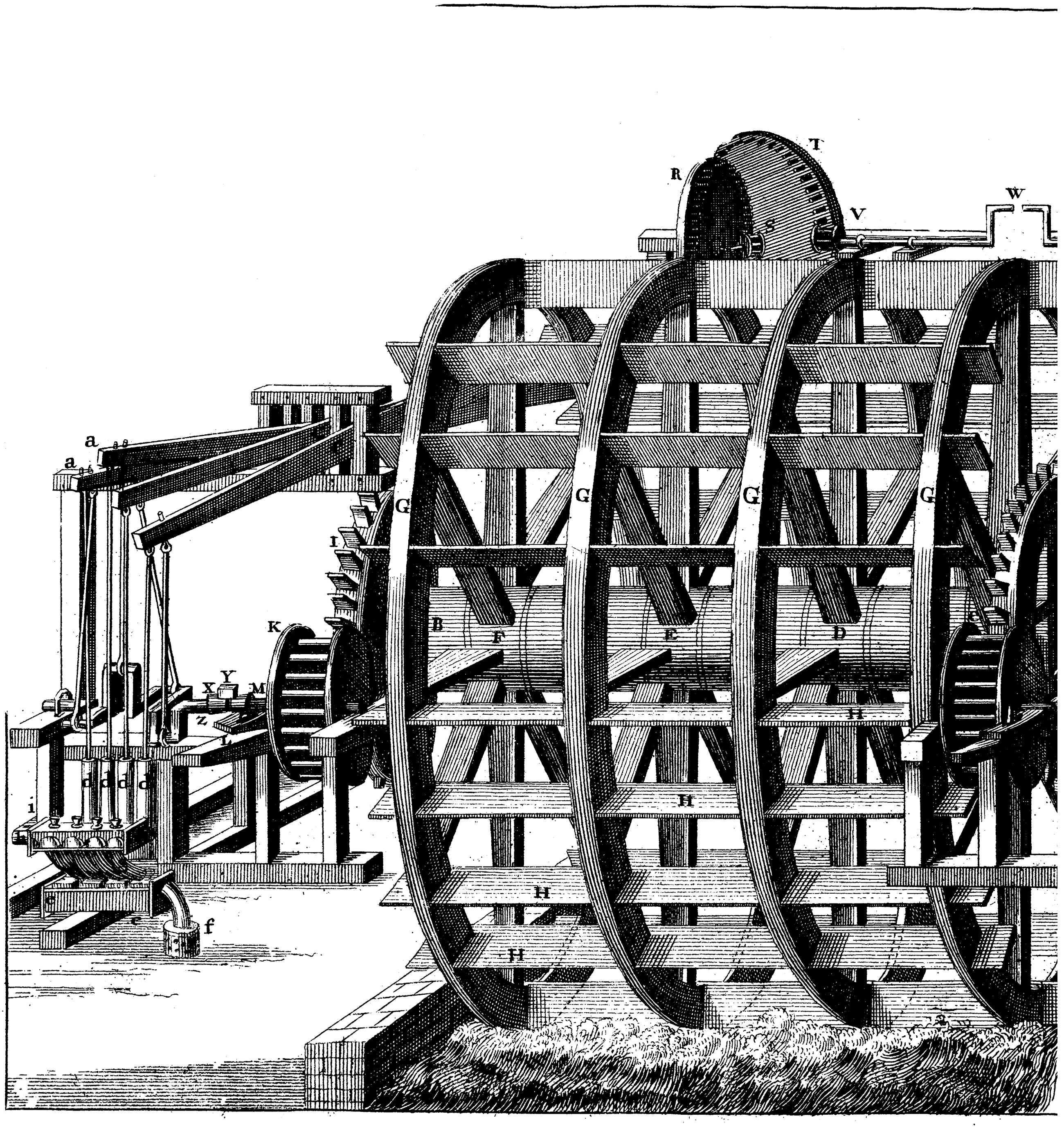
The Wedge for putting on or releaſing the Crank and Forcers, is better than the ſliding Sockets commonly uſed.

The forcing Barrels, Trunks, and all their Apparatus, are very curiouſly contrived for putting together, mending, altering or cleanſing, and ſubject to as little Friction as poſſible in that Part.

The Machine for raiſing and falling the Wheels is very good, though but ſeldom uſed, as they tell me; for they will go at almoſt any Depth of Water, and as the Tide turns, the Wheels go the ſame Way with it.

Theſe Machines at *London-Bridge* are far ſuperior to thoſe ſo much famed at *Marly* in *France*, in regard the latter are very ill deſigned in their Cranks, and ſome other Parts.

III. Epiſtola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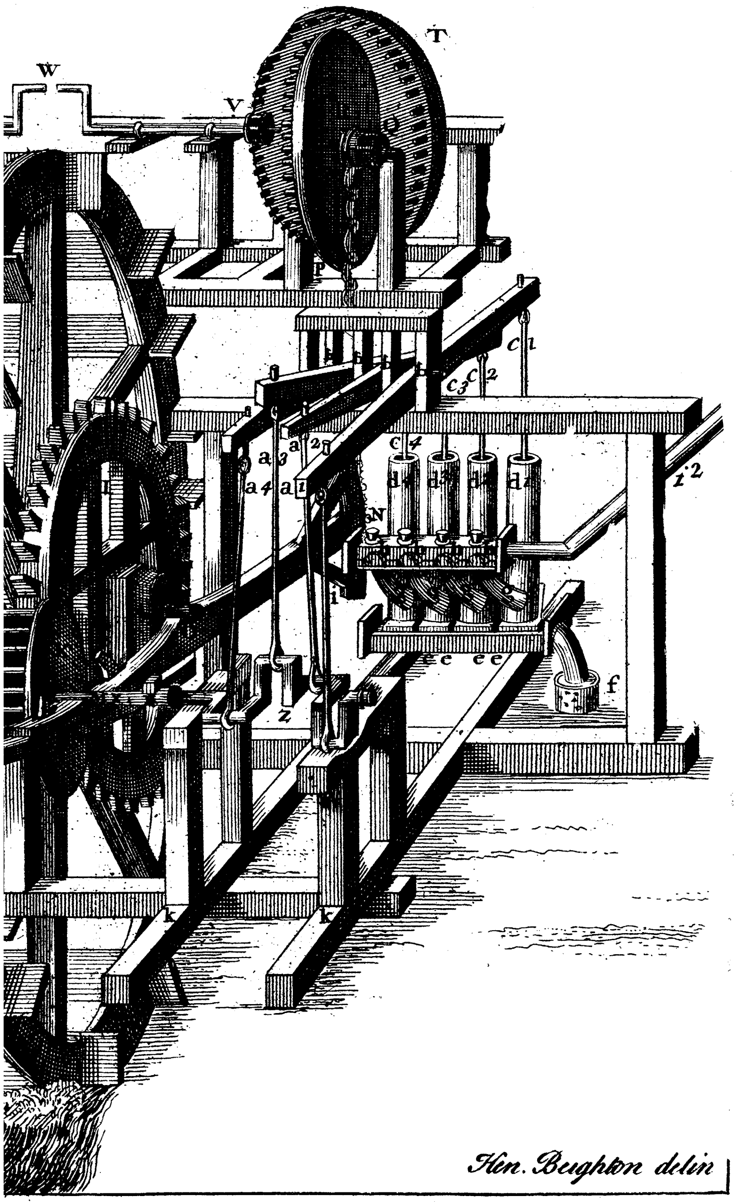
TAB. I.



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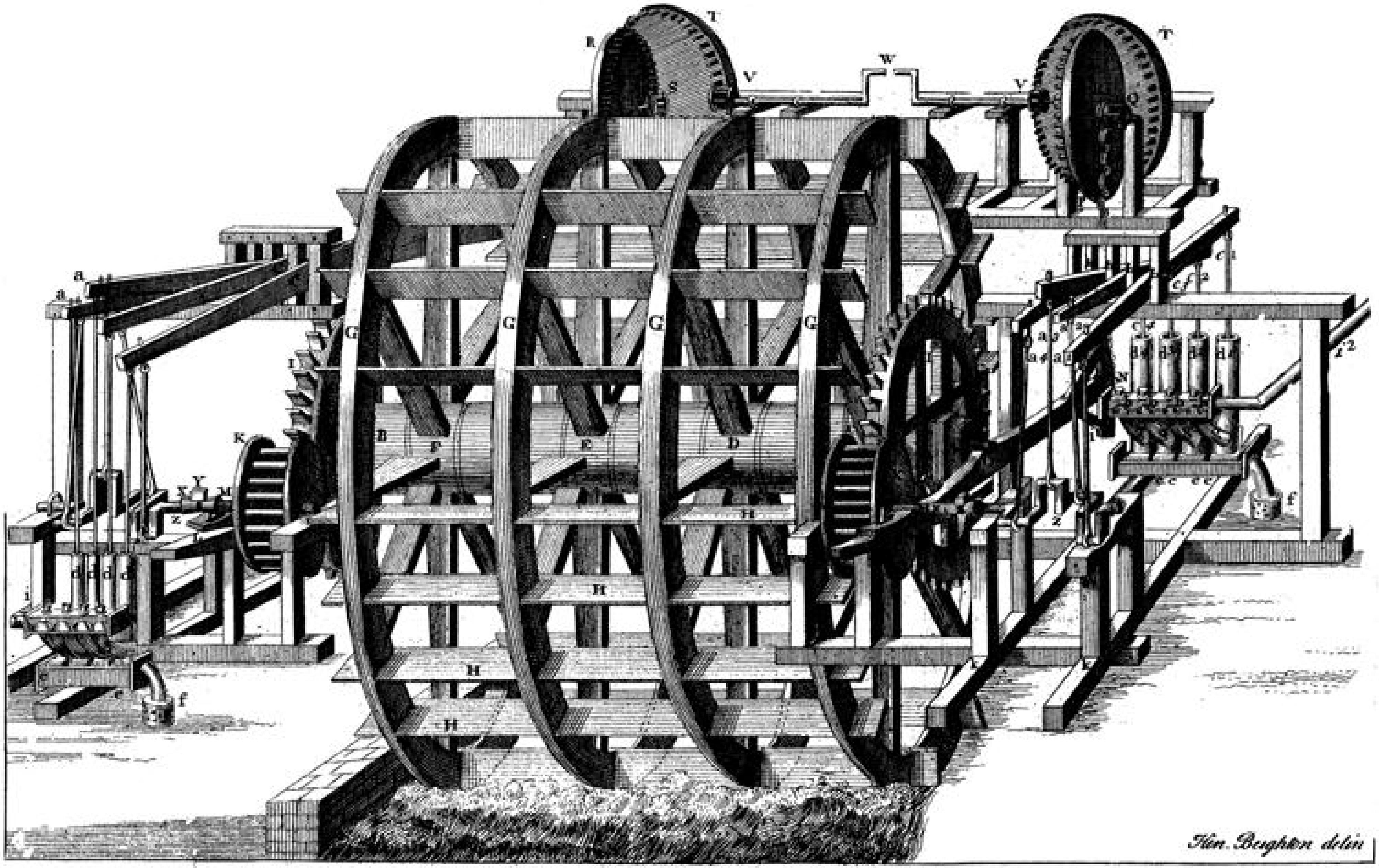

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