XL. On the principles of pump-work, illustrated and applied in the construction of a new pump, without friction, or loss of time, or water, in working; humbly proposed for the service of the British marine, with the privilege of his majesty's royal letters patent

Benjamin Martin

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earthen ware well closed: the roots must be covered with syrup only to the depth of some lines.

“ Sometimes a dry consistence is given to these roots; for this purpose they are immersed in sugar *cuit à la grande plume*, leaving them to drain and to dry at each operation. If it be required to have them candied or crystallized in sugar, they are left in syrup of very white sugar boiled to a strong consistence.

XL. *On the Principles of Pump-Work, illustrated and applied in the Construction of a new Pump, without Friction, or Loss of Time, or Water, in working; humbly proposed for the Service of the British Marine, with the Privilege of His Majesty's Royal Letters Patent.* By BENJAMIN MARTIN*.

IN a civilized nation, every person, considered as a member of the community, is, by the first law of nature, obliged to exert every faculty in his power towards establishing, supporting, and preserving the public good; since the happiness of individuals must result from, and therefore is necessarily dependent upon, that of the commonwealth. And when every thing is duly considered, no person will be found endowed with talents not considerable enough to render them of importance to the public some way or other.

There is no case wherein this maxim of politics is more conspicuously verified than in that of sea-faring men. The marine is well known to be the bulwark of every commonwealth circumstanced like ours; and therefore the life of every man in that respectable and momentous body must deserve the first regard of the higher powers, or regency of such a state.

But when we consider their mode of living, as it were, founded in instability, and liable to all the fortuitous events that the four elements can expose them to, their situation merits all the care of government, and the concurrent assistance of every person in the community, to protect them

* This article is copied from a pamphlet by the ingenious Benjamin Martin, with which we were favoured by a friend. As the pump described in it possesses great merit, and many advantages over any pump we have seen, it ought to be generally known; which we find it is not, though the invention was published in 1766. The same kind of piston is, if we recollect right, noticed in Desaguliers's Natural Philosophy, but only applied to one working barrel; one great advantage in Mr. Martin's pump arises from employing two.—We gave an engraving of this pump in our last Number, Plate Y.

against

against the numberless casualties that hourly await them, fluctuating on the surface of the ocean.

Among these perils by sea, we may justly reckon a leaking ship the most dreadful and fatal of all others: here not only one man or a few men perish, but every creature breathing on board the sinking ship, the brave commander with the meanest of the crew, are equally devoted to destruction by such an irresistible catastrophe: if a ship strike against a rock, and is wrecked, some lives may be saved by floating planks and rigging: if the magazine takes fire, death comes instantaneous, and kills, perhaps, in the most gentle manner: but, in the desperate case of a leaking ship, how slowly does the awful monarch advance, arrayed in all the terrors possible! How are all their united forces successively applied, and as constantly defeated by the unabating torrent, which rushing in, and gradually overpowering them, plunges them at last into the bottomless deep!

Now, as in such a melancholy situation all their hope and expectation of help and safety must be placed in the pump, of what prodigious estimation and consequence does such a consideration render that machine! and how much must it import every commander of a ship (to whom the lives of his men are committed) to take the utmost care that the ship be supplied with such pumps as will best provide against and ward off those impending dangers! By any negligence in this respect, he may become guilty of destroying his own life, the lives of his men, and of the ruin and misery of many families. It is therefore his duty to see that his ship be furnished with the best pump that can be procured for evacuating the hold of the water that may at any time get in, with the least force and in the shortest time.

Here, then, a question of the most serious concern will naturally offer itself for discussion; viz. whether that hydraulic machine, called a chain-pump, now used in ships, be as proper and effectual a construction to evacuate the ship as that of a real pump; I say a real pump, because the chain-pump is not such,—and, properly speaking, it is no pump at all.

Now, by considering the true nature of a pump, I apprehend, it will appear that its structure is the best adapted to answer the above purpose of any machine whatsoever, because it will raise just as much water whose weight is equal to the force of the men employed; and to pretend to any thing more would be absurd.

I here speak of the just or genuine construction of a pump, such as it ought to be; and not such as are in common

mon use, for they are faulty in many respects, particularly the two following: 1. They have, in general, a great deal of friction, to overcome which a part of the given force must be applied. 2. One half of the time employed in working them is lost: and since every moment of time is precious in a ship that has sprung a leak, it is evident a common pump is by no means to be depended upon in any such pressing exigence. These are two essential defects of structure; I pass over all circumstantial ones that render their application on ship-board every way improper.

The effect of a pump is, with a given force, to raise the greatest quantity of water to a given height, in the shortest time. From this definition it follows, that every pump, or hydraulic machine, which has any friction, or loses any water in its operation, must, in its own nature, be unfit for all naval purposes. And that one or the other of these deficiencies is inseparable from the structure of a chain-pump, must be evident to every intelligent person; for, if the pallets touch the pipe, there will be friction; and if they do not, there will be loss of water, which is the same thing as loss of time. Therefore it is manifest a chain-pump cannot be used in a ship without hazarding the loss of the ship, the cargo, and the lives of all his majesty's subjects on board the same.

It will be in vain to allege any thing in favour of a machine which is in its own nature bad, and of dangerous consequence to be used; to say the lower part of the pipe is so fitted to the pallets that the water raised cannot there run out and be lost, is to confess a friction; for no person who understands the force and effect of the pressure of the atmosphere, will pretend that any pump or engine whatever can be made water-tight, without friction to a degree superior to the pressure of the air; since by the pressure of the air the water endeavours to descend between the piston and the barrel, which can only be prevented by the close application of some springy substance about the piston, as cloth, leather, &c., producing the friction above mentioned.

The chain-pump is not only subject to the friction of the piston and water-pipe, but to much more besides, arising from the two wheels and axles in each: from the common principles and experiments of mechanics, it appears that near a third part of the power is lost in most mechanical machines, as being employed to overcome friction unavoidable in their structure; and this impediment we shall in vain attempt to remove by friction wheels in the chain-pump, whose con-

struction is necessarily too clumsy and coarse to admit of any benefit from such nice applications.

I take no notice here of the small power (or purchase, as it is called) that the manner of working this pump allows of; nor the great disadvantage of applying the power in a circular motion; with many other things that one would think no judicious mechanic could ever appear an advocate for. And therefore it must be presumed the chain-pump could never have continued so long in use, but because other pumps, not subject to the same imperfections and inconveniencies, have not, as yet, been offered, though many have been contrived and proposed in lieu thereof.

The ill success of others, however, has not deterred me from speculations of this kind. I thought, if pumps could not be made without friction and loss of water or time in working them, it should seem as if nature itself had been in this case wanting in its usual perfection. But as no such thought could be admitted, it was clear to me that the most perfect method of constructing pumps had not yet been made public. As I knew it was a matter of the last consequence, I applied myself to consider which way water might be raised without friction or loss of time; and with little reflection, it appeared that nothing was wanting but a right application of the several parts concerned in the structure of a pump, to make it answer all the purposes which could be expected from the principles of hydrostatics, hydraulics, and mechanics, all united together.

That the public may have no doubt of this, I have for their satisfaction given a summary of all those principles (as far as pump-work requires), and illustrated the same in a variety of copper-plate figures: every position or principle here advanced the reader may find demonstrated in my *Philosophia Britannica*, and *Physico-Mathematical Institutes*. These principles I have here put together in one view, as I know of nothing more wanting in our language, to assist the mind in forming a right judgment of the nature and due construction of a pump. And I must further observe to the reader, that whoever may think fit to criticize upon the pump here offered to the public, unless he is known to understand these principles, his judgment, objections, or censure, ought to pass for nothing.

However, it would, after all, be trifling with the public to talk to them about a pump in theory only. I knew so well the nature of the construction which the theory directed to, that I made no demur about putting it into execution at large;

large; and when I had finished it, I found it answer all my expectation, and, indeed, beyond what the common theory of pump-work required.

For, as the theory has hitherto considered a pump consisting only of a single barrel and piston upon the sucking-pipe, it supposes that no water rises into the barrel but while the piston is ascending; which is true in all common or single pumps: but in a double pump, or that here proposed with two barrels upon one pipe, the case is otherwise; for the water not only rises while the piston rises, but continues to do so even after the piston begins to descend; and therefore we soon found the pump delivered more water than was expected from calculation.

To account for this hydraulic paradox, it must be considered, that as this pump has both its large pistons working (alternately ascending and descending) at the same time, there must be produced a constantly rising column of water in the pipe, whose velocity through a bore of five inches to supply the barrels of twelve inches diameter each, must be so great, that it cannot be checked or stopped at once, or upon the first descent of the piston, and therefore a surplus of water must be produced, as we found there actually was, by the experiment.

This is therefore an argument which alone proves the superior perfection of this construction of a pump, as such an effect can never be produced in any other.

How deservedly this pump may be considered as without friction, will appear from its own nature, and from experiments that have been made upon it. With respect to the nature and construction of the piston, it is evident that no friction can arise from thence; for, while any body is in a fluid, it is affected by a pressure every way equally, and is therefore in the same condition as if it was not acted upon by the fluid at all; that is, it will be absolutely free to move. Now this is the case of the leathern pistons in this pump; they touch not the surface of the barrels, but produce their effect by a motion of the several parts in water only, and therefore entirely preclude even the very possibility of friction from that quarter.

The only source of friction, then, must be in the axle, arising from the pressure of the lever, pistons, &c. But how very small and inconsiderable this is will be evident from two experiments made on a pump at large, viz. the height sixteen feet, the diameter of the piston twelve inches, and the length of the stroke nine inches.

Experiment I.

The double lever (of iron) and both its pistons weighed 178lb. ; and less than one pound weight laid upon the end of the lever or handle, made it descend directly ; which plainly shows the friction arising from the pressure of 200lb. is not more than equal to one single pound weight ; a sufficient proof of the great simplicity and perfection of the structure of this pump.

Experiment II.

After this, the axle was laid upon the surface of perpendicular moving bars of twelve inches in length, which were tantamount to friction wheels of two feet diameter ; and it was found that much about the same weight, viz. nearly one pound, was then also necessary to make the end of the lever preponderate. Whence it appears, that the friction of the axle may be entirely neglected, or, being so very small, may be esteemed as nothing.

This fact was also further verified by the men who worked the pump ; for they all unanimously declared, that they found not the least difference whether they worked with the friction bars, or without them. These are all convincing proofs, that the construction of this pump is not liable to the common objection of friction.

As to the other imperfections of pump-work, viz. loss of time, and which is unavoidable in common pumps, it is as evident, that it can have no place here, as being inconsistent with the very construction of the pump ; for, since one piston or the other is always ascending, the water (conducted in one pipe) must be always rising ; therefore no time can be lost.

Neither will the construction of this pump admit of any water being lost in working it ; for it is self-evident, that it has such a structure of the pistons and valves, as necessarily renders them not only water-tight but air-tight likewise ; and consequently no water is necessary, and no time lost, in fetching this pump, as is the case with all others of the common construction.

Long after this pump was erected, and its effects publicly shown, it was objected by some, that the invention was not new ; for it could be proved that, years before, pumps had been made with two barrels upon one pipe ; and also that leather had been applied to a piston for raising water without friction before now. To all this I answer, 1. That I had never heard of any such construction of two barrels upon one pipe, when I made mine. 2. That upon inquiry, I find

no

no such application of the barrels to the pipe in them, as appears in mine, where the course of the water from the pipe is directly into each barrel; but in them it is very oblique, and the force of the water must be greatly broken. 3. None of these double-barrelled pumps have pistons, like those in mine, without friction. 4. The leathern piston above mentioned was applied to a single pump, and not in a double one, as in mine. 5. This leather piston was of a different form from mine, and admitted of but a very short stroke. 6. Not only the construction, or application of the parts of this pump is very different from that of all others, and their essential defects thereby removed; but it is attended with many circumstantial advantages which cannot fail of recommending it to all who have occasion for a machine to raise water.

The great velocity and force with which the water rises in the pipe, carries up every thing that lies in the way, as heavy pieces of iron, &c.; therefore it can be no ways liable to be choked as other pumps are too often, as is well known by fatal experience.

One thing here is of too great importance not to be mentioned, viz, that whereas in common pumps a fissure or crack in the water-pipe, by which the air can get in, stops the operation of the pump entirely; in this pump, if the fissure be not very large, the water will continue to rise, as we have experienced by making a hole in the said water-pipe 1-fourth of an inch wide. An effect, I believe, never before heard of in pump-work.

The structure of this pump is so very simple that it cannot be often out of order; and when it is, it may be rectified in a very short time, without any difficulty or trouble.

And a peculiar advantage in this pump is, that while one piston is mending, the other may be kept working; and how great a succour and relief this must afford to the dejected mariners in a leaking ship, they best can tell whose lives have been deeply endangered by an unavoidable cessation of the operation of the pump.

This pump may be made of any size, and constructed with an air-vessel, as in the common stream engine for putting out fire; may be wrought with men, water, wind, horses, &c. for all the purposes of raising water to supply reservoirs, extinguish fires, water gardens, evacuate ponds, &c.

[To be continued.]