

*The Answer of Dr. Papin to several Objections made by Mr. Nuis against his Engine for raising Water by the rarefaction of the Air, whereof a description is given in No. 178. of these Transactions.*

**H**aving seen in the *Nouvelles de la Republ. des Lettres* of the Month of *December* last, some difficulties which Mr. *Nuis* doth find in my new way for raising Water, published in the *Philosophical Transactions* of the month of *January*; I am obliged to answer them as clearly as I can in these short notes.

In his first Objection he saith, that it would be a very hard matter to hinder but some Receptacles would come to be fill'd too much: So that the water filling also the pipes *CDD* would hinder the effect of the Engin. To this I answer that it being necessary to let out the water of the highest Receptacle, I thought it might be conceived that the water may also be let out of the inferiour Receptacles by inserting into each of them a crooked pipe, reaching a pretty way downwards, and having its lower aperture shut up with a valve; whereby the water might run out when the Receptacle should be fill'd to a certain height: and so I did not Iudge it needfull to prevent this Objection.

The second Difficulty, which I had very well foreseen (as it is plain in my first explication) lyes in the great quantity of Air to be rarefied: So that Mr. *Nuis*, by his computation, doth find that the Pump's should every one contain, 84 cubick feet of rarefied Air to raise water at 12000 foot distance. To this I may answer, first that I have not positively promised a good success but for *Windsor* and *St. Germain*; but when I spoke of *Versailles* I used the word *perhaps*, thereby shewing that before any one should go about such a great undertaking he should reflect vpon it

it more than I would then do, not having occasion for such work: but since I have seen Mr. *Nuis* his Objection, I have been Obliged in order to answer him to make the following computation.

Let the distance as he supposeth be 12000 foot, and the Capacity of each Receptacle be about one half of a cubick foot: I might make the wheel with the *Axis* to make their revolution in one minute of time, and so order all things that the Air under the ascending plugs might come to be rarefied to such a degree, that by its Elasticity it might not counterpoise more than 7 foot of water: but at the same time the Air in the Receptacles A A, B B, would even in it's greatest dilatation be able to counterpoise 17 foot: so it is plain that the Air will be driven from the Receptacles into the Pumps by a strength equivalent to ten foot of water: Now if we compute after the method publish'd in the Transacti-  
*on* of the month of *October* last, what should be the Velocity of the Air driven by such a pressure: we shall find that the said Velocity will be about 740 foot in a second: So that in half a minute, during which the plug goeth up, this Air might pass above 22000 foot, although it were not rarif'd at all; but being raref'd, as we do suppose it to be, it might go a great deal further.

I must now take notice that according to the Honourable Mr. *Boile's* Experiments quoted by Mr. *Nuis*, the Rarefaction of the Air is much lesser than he takes it to be: For the Water contain'd in the Pipe N O. is so far from causing the Air to fill up a space four times bigger, that it will not extend it self to a space once bigger than before; considering therefore the Velocity of the Air and the small dilatation it doth suffer, if any one will take the trouble to compute, he will find that if the Pumps have in Diameter the Diagonal of a Square Foot, and the same height: and if the small Tubes of communication be made of  $\frac{1}{3}$  part of an Inch in Diameter, so that being 12000 Foot long, they may contain about one cubick Foot of  
Air:

Air, that would be more than sufficient to make the necessary Rarefaction in the Receptacles: And thus much might answer Mr. *Nuis* his Objection.

But for the good success of the Engine it is not enough to make the Air pass from the Receptacles into the Pumps, it must also return from the Pumps into the Receptacles: Now for this intent it would be necessary to set the Receptacles but five Foot above one another; so to drive the Water up the Pipe *NO*, it would be enough that the Air in the Receptacle *B* should press with a strength equivalent to 23 Foot of Water: For it is plain that 5 Foot in the Pipe *NO*, together with a pressure equivalent to 17 Foot which I have supposed to be in the upper Receptacle *A*, will make but 22 Foot in all: and therefore 23 Foot pressing in the Receptacle *B* must prevail and cause the Water to ascend: now the pressure in the Receptacle being but 23 Foot, and the Air in the Pump returning to its ordinary pressure, which is about 33 Foot; it is plain that the Air going back to the Receptacle will be driven by a strength equivalent to 10 Foot, as well as it had been in coming from the Receptacle towards the Pump: and so the bigness assigned for the communication-Pipes will also prove more than sufficient to this effect.

From what I have been saying it is plain, that in great distances there should be made as many Pumps as Receptacles, as I had propounded in the first explication of my Engine: and for to raise Water but 60 Foot high, there should be required 13 or 14 Receptacles and as many Pumps of the bigness aforesaid. Some people may take this for a great difficulty. But I answer that in this Engine this is not so much as it seems at first; because the pressure being all from without, there is no need of any great strength to resist it, and so the Metal for the Pumps will cost but little: there may also be found occasions where to make so good use of them, that such an Engine as I have described would in a years time save labour enough to pay for

for many Pumps, since it might every hour raise about 1800 pounds of Water to the height of 60 Foot: Mean while I don't pretend to have given here the best proportion for the bigness of every part of the Engine; but it may be, by altering the Capacity of the Pumps, of the Pipes, or of the Receptacles, a much more considerable effect might be produced: but I'll leave this to be lookt after by those that may have occasion for it; and for my part I content my self having shewn the truth of what I had at first, though but doubtfully, propounded: For the River *Seine*, where it is nearest to *Versailles*, not being above 20000 Foot distant, it is easie to see that, to supply this increase of distance, we might lessen at pleasure the capacity of the Receptacles, or increase the capacity of the Pumps and of the Pipes, or cause the wheel to spend more time in its revolution: 'tis true the Engine would produce less effect, but upon a great River the number of the Engines might be multiplied, and vast quantitys of Water still be raised. I shall therefore, to prevent new difficulties, add only this: that as well as in the Receptacles I have a way to prevent the overflowing with Water; so in the Pumps I might also prevent the overfilling with Air, by making a Valve that should open as soon as the Air in the Pump should be more compressed than the outward Air: So the Air getting in through any pores would constantly be let out.

As for the third objection wherein Mr. *Nuis* says that it doth not appear how the Water in our Engine may, by Rarefaction, ascend higher than 32 Foot. I answer that the Water doth not at any time ascend higher than from a lower Receptacle into the next upper Receptacle, which height is but 12 Foot: So that it is plain enough that the pressure of the Air may be sufficient to drive it up. It is indifferent whether it be by Rarefaction or otherwise that the Water comes into the Receptacle *A*; it is enough that the Water is there, and that the Air presses upon

upon it with such a strength as will prevail against all that opposeth it, as I have shewn above.

To the fourth Difficulty I answer: That although the use of the Pipes be meerly for the conveying of Air: They may nevertheless easily be fill'd with Water when need requires, and so the defects in them may as well be found out as in the Pipes that are used for the conveying of Water. This is all I may answer at present, and I shall make an end with assuring Mr. *Nuis* that I'll make use of his advice when ever he will be pleased to give it me.

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*An answer of the same to the Author of the perpetual Motion.*

**I**N the last papers I published in *Phil. Transact.* N. 184 against this perpetual Motion described in N. 177. I intreated the Author to permit me to say nothing as to what alterations he might make in his Engine; resolving to leave it to others to shew him that upon that principle all he can do signifies nothing. But I find since, in the *Nouvelles de la Republ.* for *December* last, that he still persists to urge some new contrivances, which being added he conceives his Engine must succeed. To this I answer that I undertook only to shew that his first device would faile, which yet I should scarce have done, if I had thought a dispute of this nature could have lasted so long. To come therefore to the point, where he saith that this Engine may well succeed without alteration, because he hath tryed with Liquors put into Bellows immersed in Water: I again say that I grant him the truth of the Experiments, but deny the consequences he would

