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.*

Having 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 C D D 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 Tranſaction 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 rarifi'd at all; but being rarefi'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 heighth: and if the ſmall Tubes of communication be made of $\frac{1}{9}$ 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 Recepticles 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

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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'le 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 compreſt than the outward Air: So the Air getting in through any pores would conſtantly be let out.

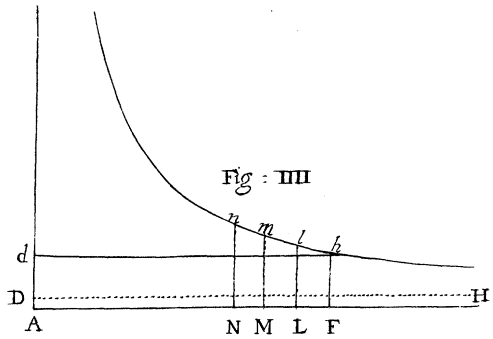
As for the third objection wherein Mr. *Nuis* ſays that it doth not appear how the Water in our Engine may, by Rarefaction, aſcend higher than 32 Foot. I anſwer that the Water doth not at any time aſcend higher than from a lower Receptacle into the next upper Receptacle, which heighth is but 12 Foot: 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 aſſureing Mr. *Nuis* that i'le make uſe of his advice when ever he will be pleaſed to give it me.

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

IN 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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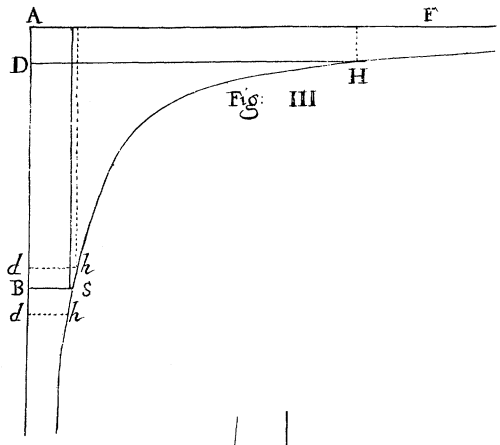
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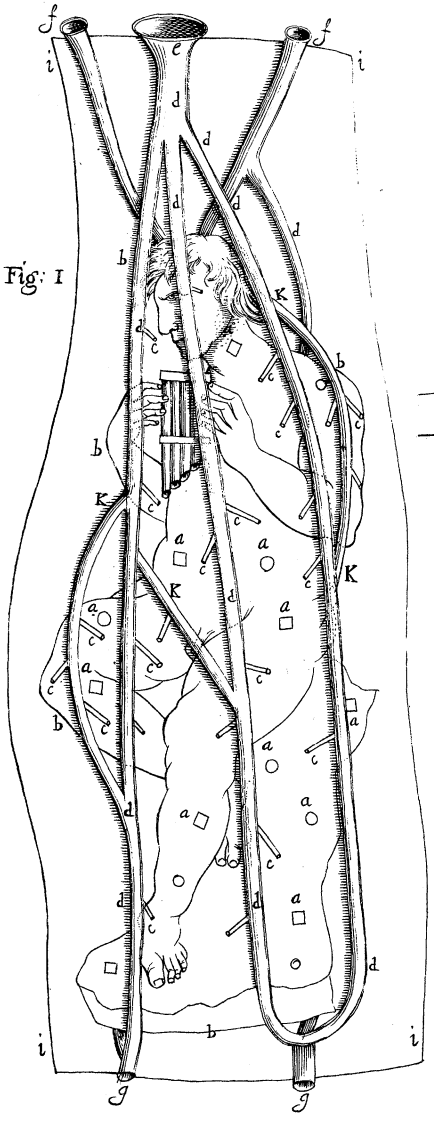
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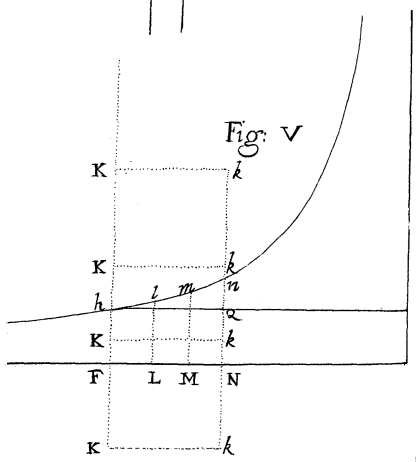
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