lordſhip's ſuperior judgment, being with all poſſibl reſpect,

My Lord,

Your Lordſhip's moſt obedient

humble ſervant,

London, Mar. 8, 1756.

Robert Dingley.

LXXV. *Thoughts on the Reverend Dr.* Hales's *new Method of Diſtillation by the united Force of Air and Fire. By* William Brownrigg, *M. D. F. R. S.*

To the Rev. Dr. Hales, *D. D. F. R. S.*

Dear Sir, Whitehaven, Dec. 3, 1755.

Read Feb. 26, 1756. I Duely received the favour of your letter, written ſo long ago as the latter end of May laſt; containing an account of your important diſcovery of raiſing large quantities of water by the united operation of air and fire, in your new method of diſtillation. In obedience to your commands, on the receipt of your letter, I immediately ſet about conſidering to what uſes your ingenious invention might be applied, beſides the great one of ſupplying navigators with freſh water; and ſhortly after wrote out the incloſed paper relating to the improvement

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provement of the fire-engine. This I preſented, with your letter, to my worthy friend and relation, Mr. Carliſle Spedding, then ſuperintendent of our coal-mines, who was an excellent mechanic, and had then the charge of five fire-engines, ſeveral of which had been under his care and management from the time, that thoſe machines were firſt brought into uſe, and had himſelf made conſiderable improvements in them. He was pleaſed to expreſs his approbation of what I had written, and was of opinion, that future improvements of the fire-engine muſt depend chiefly on the right ſolution of thoſe two propoſitions, viz. "To increaſe the quantity of ſteam from a given "veſſel and a given heat, by means of mechanical "agitation; and, to augment the elaſtic force of a "given quantity of ſteam by means of fire:" and wiſhed, that proper experiments could be made in theſe matters, which he thought would prove too expenſive for moſt private people. His untimely and much lamented death put an end to theſe enquiries; and a variety of neceſſary avocations prevented me from ſooner communicating to you the reſult of them. They are chiefly conjectures, which experience muſt ripen into uſe. I dare not aſſert, that the theory is altogether faultleſs; therefore very unfit to appear before the public. The honour you did me of communicating my rough plan of a hiſtory of damps to the Royal Society, I eſteem a particular marks of your kindneſs and affection; altho' that plan was only intended for your own private uſe, and would not have appeared before that reſpectable body, (eſpecially in its preſent form) had it not

been for your partial regard to it. I ſhould be ſorry to ſee any part of it publiſhed in the *Tranſactions*, eſpecially as I long ago laid aſide the deſign, which from the anſwer I received to the letter, of which I ſent you a copy, I did not then think myſelf at liberty to proſecute, and do not think, that I ſhall again find leiſure to reſume it. I have long been of opinion, that, in order to attain a perfect knowledge of the nature of the air, we muſt trace it from its hidden ſources in the bowels of the earth; and muſt own myſelf ambitious of treading in your ſteps, and of proſecuting your enquiries concerning the nature of its vivifying ſpirit;

Non ita certandi cupidus, quam propter amorem,
Quod te imitari aveo.

With this view, I had collected, under proper heads, all that I found in authors relating to that ſubject; and had prepared an apparatus, and alſo made ſome experiments to diſcover what alterations were produced in various kinds of air by ſtagnation; and what effects the different kinds of air, as well ſimple as compounded, had on animals included in them; and by theſe and ſuch-like experiments, I might perhaps entertain too ſanguine hopes of making ſome uſeful diſcoveries concerning the nature, and even the component ingredients, of the vivifying aerial ſpirit.

An ingenious friend, on reading the account of your method of diſtillation, was pleaſed to ſuggeſt, that the quantity of ſteam might perhaps be increaſed by heating the air, that is forced through the water contained in the ſtill. This might be done conveniently enough, by paſſing an iron pipe, that goes from

rom the ventilator through the furnace, which oils the water in the body of the ſtill.

Dear Sir,

Your moſt affectionate and

moſt obedient ſervant,

W. Brownrigg.

Thoughts on the Rev Dr. Hales's *new Method of Diſtillation by the united Force of Air and Fire.*

Read Feb. 26, 1756. IN the proceſs of diſtilling ſea water, as deſcribed by the reverend Dr. Hales, the great increaſe of vapour raiſed by his method, above what is raiſed by the common method of diſtillation, may be attributed, chiefly, to the violent agitation of the water contained in the body of the ſtill, by the motion of the air continually preſſed through it. Although the air, by attracting the watry particles, may alſo contribute to produce this effect. It is however certain, that a ſimple mechanical agitation of warm water will greatly promote its evaporation, by increaſing its ſurface, from whence the vapours ariſe, and by putting its heated particles in a briſker motion, and exciting between them actions and reactions, and ſo diſpoſing them to fly off in elaſtic vapours.

Of this we have inſtances in warm water, when ſtirred about in veſſels, or poured out of one veſſel into another; from which the vapours viſibly ariſe

in

in larger quantities than from the ſame water, when it is not moved by ſuch mechanical agitation.

This excellent invention of Dr. Hales may probably be applied to other purpoſes beſides that, which he had principally in view, viz. the diſtilling of ſea-water with greater eaſe and expedition, with leſs fuel, and in ſmaller veſſels, than has hitherto been practiſed, for the benefit of navigators.

It might be of ſingular uſe, if it could be applied in the fire-engine. The great expence of large boilers in the conſtruction of that machine, and the vaſt conſumption of fuel in the working of it, render its uſes much leſs extenſive than they would be, could thoſe expences be contracted. Various contrivances have with this view been tried; and it is to be wiſhed, that others could be diſcovered, that would more effectually anſwer the end propoſed.

But air cannot be applied, in this engine, to increaſe the quantity of the elaſtic ſteam, ſince it would paſs with the ſteam from the boiler into the cylinder, and prevent a vacuum from being there produced, and hinder the piſton from moving therein.

A mechanical agitation of the water in the boiler of the fire-engine may however be produced by other means, ſo as that a larger quantity of ſteam may probably be raiſed than can be effected in engines as commonly now conſtructed; by which means the expences of conſtructing and working thoſe uſeful machines may perhaps be greatly leſſened.

If, for example, the boiling water, inſtead of being agitated by air, as in Dr. Hales's method, was briſkly ſtirred about by a wheel placed in the boiler of the fire-engine; it is probable, that by this means the

Fig. 1.

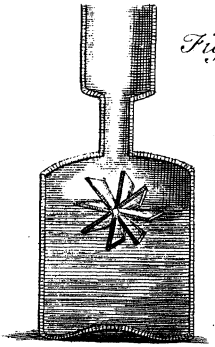


Fig. 2.

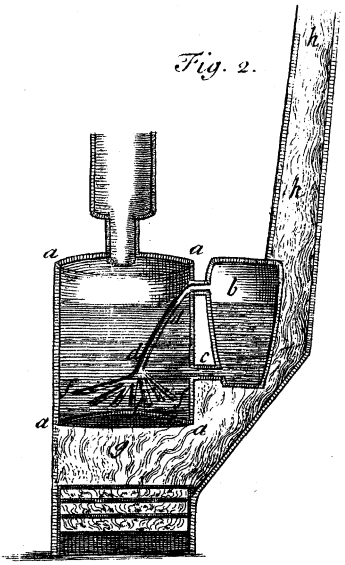


Fig. 3.

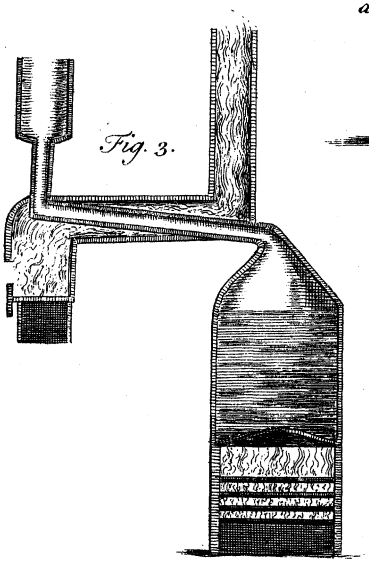
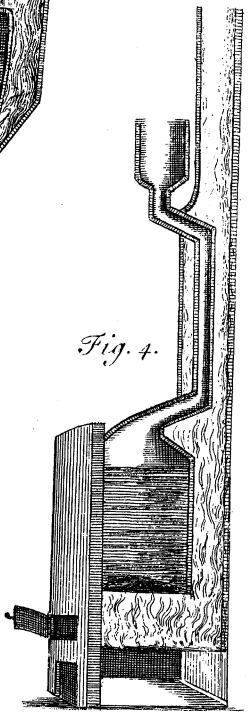


Fig. 4.



J. Myers Sc.

the quantity of elaſtic vapour raiſed might be conſiderably encreaſed, and leſs fuel and a leſs boiler might then ſerve the purpoſe. The wheel might be turned round by the water drawn up by the engine; or might receive its motion from the beam of the engine by means of a crank; or a labourer might be employed in turning it round with the hand. See TAB. XVI. Fig. 1.

But the deſired effect might, in all probability, be better produced by means of elaſtic ſteam driven briſkly through the boiling water. The ſteam of water, as an elaſtic fluid, poſſeſſes many of the properties of common air.

Like air, when driven briſkly from the æolipile, it is obſerved to blow up fire; and when forcibly driven through water, will doubtleſs produce the the ſame agitation therein, as is done by common air in Dr. Hales's experiment; and may probably have the like effect with air, in elevating a larger quantity of elaſtic vapours.

In order to excite an agitation in the boiling water of a fire-engine, by means of elaſtic ſteam, the following ſimple and eaſy method may be tried.

Fig. II.

aaaa. The boiler of the fire-engine.

b. An æolipile, or ſmaller boiler, annexed to the larger, receiving boiling water from it by the pipe (*c*), and continually emptying ſtrongly elaſtic ſteam into it, by the alembic and tube (*dd*); which tube towards the bottom of the boiler is divided into many ſmaller tubes (*fff*)

per-

perforated with holes, thro' which the ſteam paſſing produces a violent agitation in the water contained in the large boiler, and ſo increaſes the quantity of elaſtic ſteam.

The flame of the fire (*g*) aſcending up the chimney (*hh*) may in its paſſage heat the water in the æolipole (*b*).

N.B. Either, or both, of the above contrivances may be applied to the boiler of an alembic, in the diſtillation of ſea water for the uſe of navigators, in imitation of the method invented by the rev. Dr. Hales.

Further Experiments relating to the Fire engine, by leſſening the expences of conſtructing and working it.

Theory.

It is found by experiments, that, *cæt. paribus*, the elaſticity, or expanſive force of common air, is in proportion to its denſity. And alſo that *cæt. par.* its elaſticity is proportional to its degree of heat. And therefore, that its elaſticity is proportional to its degree of heat,

The ſame probably holds true in other elaſtic fluids; and particularly in the ſteam of water; ſince, like all other bodies, it is capable of rarefaction (at leaſt to a certain degree) by heat; and its elaſticity, or expanſive force muſt augment in proportion to the degree of heat which it receives.

Ex-

Explanatory Example.

Let us ſuppoſe, for example, that the heat of the ſteam in the boiler of a fire-engine is now 300 degrees of Fahrenheit's thermometer; it is evident, that if the ſame ſteam could, by any art, be heated to 600 degrees, its expanſive force would be greatly increaſed; ſo that a much ſmaller quantity of ſteam thus heated would overcome the preſſure of the air, and elevate the piſton of the fire-engine, than is now applied for that purpoſe. And this ſmaller quantity of ſteam might be raiſed in ſmaller veſſels, and with leſs fuel than is now uſed in the working that engine.

Practical Obſervrtions.

The heat of the ſteam now applied muſt be nearly the ſame with the heat of the water, from which it is raiſed. The heat of boiling water, in open veſſels, is found, at a medium, about 212 degrees in Fahrenheit's thermometer; in cloſe veſſels, it is often conſiderably greater; but, in the boiler of the fire engine, can ſcarce exceed 300 degrees; it is certain, that it never approaches near to the heat of melted lead, ſince the ſides of the boilers are often made of that metal. And it is obſerved, that the fire, when it touches the ſides of the leaden boiler, where it is only filled with ſteam, does not melt the lead; the ſteam having the ſame effect with water in keeping the lead cool, to which the fire is applied.

From the following inſtance it nevertheleſs ſeems probable, that the ſteam of water may be brought to ſo great a heat, as to melt lead, to which it is applied. The pipe, which ſupplied the boiler of a fire-

engine with water, was by ſome accident ſtopped; and the water in the boiler was ſo exhauſted, that the crown of the boiler, (or the middle part of the iron bottom, which is moſt elevated) became quite dry, and was heated red hot. And altho' there was only ſo ſmall a quantity of water remaining in the boiler, the engine ceaſed not to work; but, on the contrary, was obſerved to move with unuſual briſkneſs; until at length, the ſtrongly heated, and extremely rarified ſteam melted the pewter, wherewith the joints of the top of the boiler (which was of copper) were ſoldered, and burſt through them with great impetuoſity.

Concluſion from the foregoing Experiments and Obſervations.

The foregoing experiments ſeem to prove, that the ſteam of water is capable of being heated and rarified to a much greater degree than the ſteam is heated, which is now applied in the fire-engine; and that the expanſive force of ſteam is greatly increaſed by heat, and conſequently, that a much ſmaller quantity of ſteam, moſt ſtrongly heated and rarified, will work an engine, than is now applied of cooler ſteam: Which ſmaller quantity of ſteam may be raiſed in ſmaller veſſels, and with ſmaller fires, than are now uſed in working thoſe engines.

Practice.

The ſteam of water may probably be heated and rarified to a very great degree, for the uſe of the fire-engine, by the following method.

To

To the head of the boiler let a pipe of caſt iron be fitted nearly in an horizontal poſition, as in Fig. 3. but inclining a little towards the boiler; and let this pipe be continually kept red hot, by the fire of an air-furnace, through which it may paſs; and thro' this pipe let the watry ſteam be conducted to the cylinder of the fire-engine.

Or the ſteam may be rarified by making it paſs from the boiler to the cylinder, through an iron pipe or cylinder fixed in the flue of the furnace, of which contrivance a rude ſketch is given in Fig. 4.

N. B. The evaporation from the boiler may perhaps be conſiderably quickened by the rarefaction of the ſteam.

It may not be improper to make trial of one or both of the above methods of heating the ſteam, or of other methods, that are more commodious; and alſo to add to the boiler the above recommended apparatus for raiſing a larger quantity of ſteam, by means of mechanical agitation. The fire-engine, as firſt invented by Savery, was rude and imperfect; and ſince his time many ingenious men have been continually making improvements therein; neither doth it yet ſeem to have attained to its greateſt degree of perfection. There is even reaſon to hope that, by one or both of the methods here pointed out, viz. (either by encreaſing the quantity of ſteam, or by augmenting its force) it may be brought to work with much ſmaller boilers, and with a very moderate expence of fuel; and under ſuch circumſtances it might be applied to a vaſt variety of purpoſes, and would become of much greater uſe to mankind.