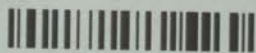


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THE
ORIGIN AND PROGRESS
OF
THE MECHANICAL INVENTIONS
OF
JAMES WATT

ILLUSTRATED BY HIS CORRESPONDENCE WITH HIS FRIENDS
AND THE SPECIFICATIONS OF HIS PATENTS.

BY JAMES PATRICK MUIRHEAD, ESQ., M.A.

Ex-d-25

IN THREE VOLUMES.

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etc

VOL. II.

EXTRACTS FROM CORRESPONDENCE.

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EXTRACTS

FROM

MR. WATT'S PRIVATE CORRESPONDENCE.

[83.]

MR. WATT TO DR. SMALL.

Glasgow, Sept. 9th, 1770.

. DEAR SIR,—After so long a silence on both sides I wish to renew our correspondence by excusing myself. I think in my last I gave you an account of some unsuccessful experiments on the engine, and told you I was about making some others, from which I hoped better. I also wrote you of my having undertaken a survey in Strathmore for a canal. I was obliged to go to that survey before the experiments were completed. My stay in Strathmore was much longer than I expected. I had to examine and survey a country of 36 miles in length, and to hunt about for a course for a canal through country where Nature had almost done her utmost to prevent it;—indifferent health, and weather viciously cold and stormy, were the attendants on my survey. The winds from the snowy Grampians, and snow even in the valleys a foot thick on the 10th of May, convinced me of

the utility of what I was about;—for nothing can be more dismal than such weather in a country which nature and art have deprived of fuel.

I was in that country six weeks. On my return I was obliged to attend another disagreeable operation, viz. the removing my household furniture and utensils to another house;—when this was over, I had just got to Kinneil to finish my experiments on the engine, when, on a day's warning, I was called to Glasgow to attend a survey of the river. Before that was finished, the canal I had projected last winter, for which an Act had been obtained, was wanted to be begun under my inspection. I had now a choice whether to go on with the experiments on the engine, the event of which was uncertain, or to embrace an honourable and perhaps profitable employment, attended with less risk of want of success:—to carry into execution a canal projected by myself with much trouble, or to leave it to some other person that might not have entered into my views, and might have had an interest to expose my errors; (for everybody commits them in those cases.)

Many people here had conceived a much higher idea of my abilities than they merit;—they had resolved to encourage a man that lived among them rather than a stranger. If I refused this offer I had little reason to expect such a concurrence of favourable circumstances soon. Besides, I have a wife and children, and saw myself growing gray without having any settled way of providing for them. There were also other circumstances

that moved me not less powerfully to accept the offer; which I did; though at the same time I resolved not to drop the engine, but to prosecute it the first time I could spare.

Nothing is more contrary to my disposition than bustling and bargaining with mankind:—yet that is the life I now constantly lead. Use and exertion render it rather more tolerable than it was at first, but it is still disagreeable. I am also in a constant fear that my want of experience may betray me into some scrape, or that I shall be imposed upon by the workmen, both which I take all the care my nature allows of to prevent. I have been tolerably lucky yet; I have cut some more than a mile of the canal, besides a most confounded gash in a hill, and made a bridge and some tunnels, for all which I think I am within the estimate, notwithstanding the soil has been of the very hardest, being a black or red clay engrained with stones. We are out altogether 450*l.*—of which about 50*l.* for utensils: our canal is four feet water and sixteen feet bottom. I have for managing the canal 200*l.* per annum; I bestow upon it generally about three or four days in the week, during which time I am commonly very busy, as I have above 150 men at work, and only one overseer under me, beside the under-takers, who are mere tyros, and require constant watching. The remainder of my time is taken up partly by headaches and other bad health, and partly by consultations on various subjects, of which I can have more than I am able to answer, and people pay

me pretty well. In short, I want little but health and vigour to make money as fast as is fit.

Now, doctor, if you and your friend Hygeia can impart to me these blessings, I may be a rich and happy man : otherwise, I can scarcely be either. I expect soon to have another touch at the engine ; meantime, it will give me great pleasure to know how you and all our other friends do. Have you done anything with the wheel, or have you been as idle as I? After reading the above and guessing some other things, you must contrive to excuse me for not writing you. I ever remain,

Dear Sir, your affectionate friend,

JAMES WATT.

[84.]

DR. SMALL TO MR. WATT.

17th Sept. 1770.

Hopes of seeing both you and our friend Dr. Roebuck here long before now, and desire to tell you in my first letter good news of the circular engine, have drawn me against my conscience into a shameful silence, which I have great pleasure in quitting. The news your letter contains about yourself give me the utmost satisfaction, and convince me that in time your genius and virtues will, in spite of the absurdity of mankind, render you a thriving man. I did suppose avocations and reasons which cannot be written took away your attention from fire-engines. Mine has continued, but has been ineffectual, from most ridiculous causes ; for, spite of letters innumerable, and four expresses, the people of Colebrook-dell sent us the

castings for the circular machine only a month ago. They were unsound, and totally useless, and done over with some stuff to conceal their defects. An eminent caster has settled during the summer at Bilston. We were obliged to have recourse to him, but he has not yet sent the things, though he says he will in a few days. The other parts are in tolerable readiness. What Mr. Boulton and I are very desirous of is, to move canal boats by this engine; so we have made this model of a size sufficient for that purpose. We propose first to operate without any condenser, because coals are here exceeding cheap, and because you can more commodiously than we make experiments on condensers, having several already by you. My money has been ready since Midsummer, but we must all meet, I believe, before any proper method can be pitched upon of carrying this affair on. We have found tolerable workmen, and above 150 boats are now employed in these new waveless canals, so, if we can succeed, the field is not narrow. But let nothing divert you from the business of engineering. You are sensible that both Boulton and I engaged in the patent scheme much more from inclination to be in some degree useful to you than from any other principle, so that, if you are prosperous and happy, we do not care whether you find the scheme worth prosecuting or not. I am astonished at the cheap execution of your canal. If your bill is anything considerable, you have done for 450*l.* what would have cost us 2000*l.*, or more. Do send me an account of the

price of labour, and of the number of cubic feet of earth you have dug out, and of what your tunnels and bridges are built. Your health will daily improve from constant employment and from success in your undertakings. You will make fewer blunders than any of your brethren, though some might be made by every mortal; but if you do not reveal them yourself, most of them will remain secrets. Take high fees for consultations. You shall hear the moment we have tried the circle, what the event may be. A canal is projected here, the water to supply the locks of which is to be raised by fire-engines. Boulton and I are of the committee. The projectors will apply to Parliament next session. So, if your reciprocator can be ready, let it be so. Yours with great affection.

[85.]

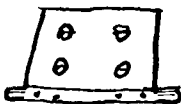
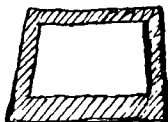
MR. WATT TO DR. SMALL.

Sept. 30th, 1770.

I received yours; the renewal of our correspondence gives me great pleasure: I was afraid that, somehow or other, you thought me to blame.— Now you begin to make models you will have some idea of the time and pains I have bestowed upon them, which I shall not reckon lost if you take up the affair where I lay it down. I wish I was with you to tell you all the observations I have made on the minutiae of the matter; they might save something, but I doubt not but your own observation will much sooner render you master of them than mine did me. You have less

at stake upon it than I had, and will be less tender in searching every sore to the bottom, and will, consequently, easier find a remedy for it. There are three things that will materially plague you:—

First, the making the great valves tight. I would make these valves thus:—A square ring of iron, for the valve to shut upon; the valve should cover the hole $\frac{1}{4}$ inch all round:—the valve made of a thin flat piece of plate iron, having two pivots at the back edge, which play in two ears that are fastened to the square ring; (this



valve is made tight by being covered with coarse broad-cloth soaked with linseed oil, boiled up to the consistence of honey;) the cloth is then to be baked in a stove till dry, when it is to be again supplied with oil, and again baked until all the pores of it are shut; it is then to be scraped smooth on one side and painted with white lead and oil, and returned to the stove (the painting must be twice done); the shoe varnish I gave you a recipe for does very well for soaking the cloth, and must be melted in with a hot smoothing iron. This cloth is fastened to the valve, by being screwed between it and another smaller plate, and must

not be used for a hinge to the valve (the place of which is supplied by the pivots).



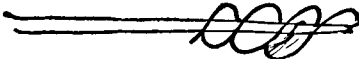
The cloth must be filed flat on the painted side (which is intended to go next the ring), the use of the paint being to keep it from sticking. I find by experience that no metal valve keeps tight without the interposition of soft sub-

stances, for the least bit of dirt keeps it open, whereas it soon makes itself a bed in the other. The metal of the valve should be thin, both for lightness, and because, if thin, the pressure will soon make it apply itself better than anybody can fit it. This valve may be opened and shut by making one of the pivots come out through a hole in the wheel and applying a handle to it, or may be shut by a spring and opened by the fluid. The best spring is a spiral wire, or a spring like the main-spring of a gun. (I believe I have written you the greatest part of this before, but am not sure that I have.)

The second plague you will have is the mercury going into the steam-pipe; for this I suppose you have a remedy provided.

The third plague will be the condensed water resting on the top of the mercury. I once contrived a remedy for this, but have forgotten it; however, if you have a cock to let it off at beginning, it will not plague you much afterwards.

I approve much of your going to work without the condenser; you will save yourself an immense trouble, and if your boiler be strong enough to stand a pressure of 30 feet of water, you will do above half of what the engine can do with a condenser, and perhaps for your boats you can dispense with some misapplication of fuel. Have


 you ever considered a spiral oar for that purpose, or are you for

two wheels?

I don't know if I told you in my last that I had

had a visit of Mr. Smeaton on our canal, and that he behaved to me in a most gentlemanly, friendly manner. He is trying experiments on fire-engines, and had heard something of what you are doing at Birmingham. I told him as much about my engine as is contained in the specification, or thereabouts; principally with a view to check the ardour of his invention; however, I said very little to him about the circular engine. He told me of an experiment he had made on the New River engine, which seems to say that common engines can be made to do more than I had imagined.

I am this day labouring under a stupefaction I have in place of a headache; can't you tell me some method of driving off these cursed complaints?

I defer answering you about canals till my next. Have you ever considered whether the velocity of falling bodies has anything to do with the velocity of our wheel? The weight is in a state of rest; the velocity of air or steam rushing into vacuum is almost infinite. It will be retarded by the *vis insita* of the matter of the wheel; but this, going always one way, will accelerate, until the friction of the machine, the *vis insita*, and gravity of the water to be raised bring it to an equilibrium; all this is subject to calcul, put your pen to it. I once mentioned to you a circular engine, consisting of a right-handed and left-handed bottle-screw spiral, involved in one  another. If we are subject to no narrow limits in point of velocity, a small pipe and small quantity of fluid in one of these engines may do a great deal of

work, and will require the opening of only two valves for twenty turns of the machine, if you choose to give it so many helices. The smallness of the valves will also ensure the possibility of making them tight. Thus, if a velocity of 10 feet a second can easily be given (which is ten times the velocity of common engines), a 52-inch cylinder may be reduced to a spiral pipe one foot square, and the quantity of fluid to 1600 lbs., or thereabouts; and if the wheel is 6 feet diameter, $3\frac{1}{2}$ turns of it will be equal to one stroke of the engine. If the great valves cannot be made sufficiently tight, an excellent reciprocator may be made of a spiral of two or three turns, working cranks, and which may work both in going and returning. This has, however, some inconveniences which you will see. I have another circular reciprocator without a weight, though with mercurial piston; the outside wheel is fixed, and the piston moves. But, after all, if the great valves can be made tolerably tight, the scheme you are upon is the best and simplest. I cannot sufficiently thank Mr. B. and you for your good wishes towards me; you have deceived yourselves into a better opinion of me than I deserve; the only virtue I can lay claim to is honesty; that inclines at present to tell you my failings; but I never studied to conceal them, and it is rather a mortifying subject. I long much to see you, but am at present chained until winter turn my people adrift. Adieu.

[86.]

DR. SMALL TO MR. WATT.

5 Oct. 1770.

I have tried models of spiral oars, and have found them all inferior to oars of either of the other forms; I believe because a cylinder of water immersed in water can be easily turned round its axis. This, I dare say, you perfectly know, so more need not be written. We propose to try gun-lock springs with the fixed part, as it is called, longer than the moving, though both parts will move. We also propose to let the valve be loosish on its hinges. If we cannot render metal tolerably tight, we will have recourse to what you have so obligingly and clearly described. But as we must work by steam of great heat, will it not destroy cloth, however impregnated with other substances? I shook the compound metal in a heat a little greater than that of boiling water—with melted tallow in a phial for a long time, and it seemed to be more metallified, and not calcined. We shall first heat our wheel, and then pour tallow into it, and turn it several times round, and then admit steam hotter than boiling water. This method, we hope, may both hinder calcination of metal and collection of water, and perhaps cause our valves to fit a little better, as oil seems to cause the lid of my digester to fit better. As to mercury entering the steam-pipe, that, we think, may most easily be prevented by making the engine of large diameter, which, on many accounts, I think it ought to be. I admire your scheme for spirals, but shall

soon be in a rage with workmen, and fancy them incapable of executing any ingenious invention whatever. As to boilers, we shall use small retorts of cast-iron; if one dozen should be too few, we shall put two dozen, and heat them in a reverberatory furnace, with one safety-valve for all. Pray tell me what Smeaton said about the common engine, but do not let him pump you. I make no scruple of late of speaking of your invention in the terms of the specification, but in no other, by way of inducing a few people to wait for it. It is a great misfortune that spiral oars are but indifferent. We can have fuel on our canal for nothing, for boats. I have considered the velocity of the wheel, in all the lights I have been able to view it in, and still think it cannot be great. Steam will rush into it very fast. Air rusheth into a vacuum (when the barometer is at a mean height, and the thermometer about 60°) with a velocity greater than 1200 feet in a second, and less than 1300. By the way this is the reason why projectiles moving in the atmosphere faster than 1200 feet in a second are so exceedingly resisted, according to the experiments of Robins, for they must leave vacuum behind them. Steam will rush faster than air, in the ratio of the square root of its density to the square root of the density of air. Still, for many reasons, the machine, I fear, will move slowly.

I have few schemes, and those few are chiefly chemical, and not valuable, at least none is so but

X

one, which I shall never execute, although the best and easiest of all possible schemes. I grow infamously lazy, and think of buying a small annuity, and passing the rest of my life in sleep, which I have discovered to be the best of all human things. I have heard of no capital scheme of any other projector neither. The French, you know, offer large præmia for time-keepers. Were I idle I should try to win one of these. But physic exhausts my whole faculties, and pays but indifferently. I am so made that I suffer no fatigue from thinking ever so long and attentively on a subject in which I can get forward; but if I am absolutely puzzled, and see no clue, my head turns round, and I speedily become more tired than a galley-slave. Physic very fortunately furnishes abundance of these profitable points. My best compliments to Dr. Roebuck and to Mrs. Watt. Get into a warm bath, especially of a decoction of rosemary, when your head aches or when you are dull. I have had a bath made which is either a hot bath or a cold bath, an air bath or a steam bath, a medicated bath or a simple bath, and is of no trouble and small expense, and stands in any bed-chamber. Farewell.

[87.]

MR. WATT TO DR. SMALL.

Oct. 20th, 1770.

Your heat will not destroy cloth, as you only require 150° to make steam equal to the atmosphere, and 175° to make it equal to two atmospheres. I do not see how you are to supply your

cast-iron retorts with water when needed. Take my advice :—a hammered iron bottom and a copper top. I have found experimentally no boiler will answer that does not contain a magazine of steam. On considering spirals, I do not continue fond of them. * * *



You complain of phisic :—I find it sufficiently stupefying to be obliged to think on any subject but one's hobby, and I really am become monstrously stupid, and can seldom think at all. I wish to God I could afford to live without it, though I don't admire your sleeping schēme ;—I must fatigue, otherwise I can neither eat nor sleep. In short, I greatly doubt whether the silent mansions of the grave be not the happiest abodes. I am cured of most of my youthful desires, and if ambition or avarice does not lay hold of me, I shall be almost as much ennuyé as you say you are.

Smeaton started some objections about the air that would enter with the steam, which I answered ; he then said a good deal in favour of the contrivance, and desired me to push it ; but that cannot be at present. Write me in your next how far you are advanced with the engine, and if anything hinders your progress.

[88.]

MR. WATT TO DR. SMALL.

Glasgow, 21 Dec. 1770.

I have long wished for a letter from you ; I have little or nothing for you. Notwithstanding the desperate weather I am almost constantly at the

canal. It costs me many a fit of chagrin; shows me many of my imperfections, &c.; but for all that, I find myself more strong, more resolute, less lazy, less confused, than I was when I began it. However, I have no abatement of my headaches, in quantity or quality.

I have lately made a plan and estimate of a bridge over our river Clyde, eight miles above this; it is to be of five arches and 220 feet waterway, founded upon piles on a muddy bottom. So much for self. * * * Your acquaintance, my friend Robison, is just gone to Russia with Admiral Knowles, as his secretary; they say this will be worth 400*l.* per annum to him. * *

[89.]

DR. SMALL TO MR. WATT.

14 Feb. 1771.

Having been of late exceedingly plagued with affairs of other people, and having had nothing interesting to write, I have forborne to trouble you with any letter. At present I am to tell you something of consequence, about which it will be proper to speak with Dr. Roebuck, to whom I offer my best respects. A friend of Boulton and me in Cornwall sent us word four days ago that four or five copper-mines are just going to be abandoned, because of the high price of coals, and begs me to apply to them instantly. The York Building Company delay rebuilding their engine, with great inconvenience to themselves, waiting for yours. Yesterday application was made to me, by a mining company in Derbyshire, to know when

you are to be in England about fire-engines; because they must quit their mine if you cannot relieve them.

We have a scheme for making a canal here, which would have been in some forwardness had not a most violent persecution arisen against our present one, of which that was to have been a continuation. The continuation would have required more than common ability in the engineer; and I hoped to induce the projectors to employ you, that you might be here upon good terms to pursue the fire-engine: but that must stand still now till the winter. * * *

I am ashamed to tell you that the wheel-engine is not yet finished, from the idleness and folly of workmen. I have daily a better and better opinion of it, though I still think it cannot go fast, chiefly from effects of centrifugal force.

The workmen complain of difficulty in fitting valves to the circular machine as we had it cast. * * * I wish we could all meet anyhow about this same fire-engine. The fourteen years will soon be over. I have perfected my clock with one wheel of nine inches diameter, which is to tell hours, minutes, and seconds, and strike, and repeat, and be made for thirty shillings.

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[90.]

MR. WATT TO MR. TURNBULL.

Glasgow, Feb. 23rd, 1771.

DEAR SIR,—Mr. Sandeman's letter of the 11th ultimo is now before me; he desires me to write

you about the application of your water-wheel to drive a mangle. I have at times had my thoughts a good deal upon the subject, but have not hit upon anything decisive: only in general it appears to me that a crank of a sufficient sweep will be by much the sweetest motion, and perhaps not the dearest, if its durability be considered. A crank of a three feet sweep for a water-engine costs about 12*l*. * *

[91.]

DR. SMALL TO MR. WATT.

Birmingham, 19 Oct. 1771.

Nothing but aversion to tell you disagreeable news, and daily hopes of being able to communicate such as should be very much otherwise, could have rendered me silent to you. I hated to tell you that Boulton and I found we could not serve you effectually in the subscription way, which was your last proposal; because people, as no engine had been made upon your principles, doubted whether any could be made. This we found so frequently, that we feared to hurt you by pressing even our most intimate acquaintances. On the other hand, everything has been ready for above two months in the circular engine, excepting what depends on millwrights, who have disappointed us times without number. The valves have been made with very great care, and ground flat to fit properly, in Smeaton's method. We have bought quicksilver enough for this experiment, because, if it should not succeed, it can be sold more advan-

tageously than mixed metal can. We employed a clockmaker, whom we picked up, about the valves and nice parts. Now, as I said above, I was very desirous that my first letter should inform you this machine had answered your expectations. The last hindrance to it has been a fever, and a relapse into the fever, which has rendered Mr. Boulton totally unfit for business for five weeks, so that I cannot even yet show him your two last letters. For this reason I can say nothing at present about the Kinneil engine. * * * *

I beg you may reconcile yourself more to engineering in the vulgar manner: it will by degrees give you both reputation and fortune, and even sell your fire-engines. I will make any calculation for you I can. I admire your delicacy about being paid for your genius and industry: pray, what do lawyers and doctors do? Nothing of late years has vexed me so much as the peculiar circumstances that have retarded your fire-engine, for I think of it and of you just as I always did, that it is a most capital invention, and that you have as much genius and as much integrity, or more than any man I know. I hope most heartily you may be sent to Parliament. I have now proper accommodation for you, and indeed have kept a whole house in my power in case you may come to live here. * * * *

I shall write again as soon as I can consult Boulton; so farewell. I shall always be, with great esteem and affection, your most faithful friend and humble servant.

[92.]

DR. SMALL TO MR. WATT.

16 Dec. 1771.

* * * Your engine is within about one fortnight of being fit for trial in the forcing way, not the condensing. I attend exactly to what you say on both these methods, and am entirely of your opinion about the facility of condensing, and the facility of adding a condensing apparatus to a forcing engine. For many purposes the forcing engine will be very useful, I think, in this country of coals, and will be liked on account of the simplicity of construction.

As to sending your reciprocating machine hither, Mr. Boulton thinks that had better be done some time hence, especially as you have given us hopes of seeing you soon. * * *

What I most dread in the circular engine is rust rubbing off the inside, and calx of mercury, however little, hindering the valves from shutting steam-tight; having observed very small dust to hinder my digester from containing steam. * *

I hope your health improves; which is all that is necessary to secure you a certainty of improving your fortune. * * *

My clock of one wheel, that shows hours, minutes, and seconds, and strikes the hours and repeats them, is nearly finished. The striking and repetition are good, the rest is gimcrack. I believe I have told you this before. But company comes in and obliges me to bid you farewell. .

[93.]

MR. WATT TO DR. SMALL.

Glasgow, 24 Dec. 1771.

* * * I advise you to begin your trial of the engine with water in place of mercury, and by blowing into it with a bellows. You may thus find out and remedy some faults more easily than with mercury and steam. Place a tight wooden or iron vessel like a grindstone-trough under your wheel whenever you begin with mercury, for some will unavoidably spill at first. I have seen cast-iron *tinned tacks* come from Birmingham:—quære, how are they made, and could not our engine-work be cast in the same manner? the metal files well. * * * I shall say no more of the reciprocating engine, but that I wish it was agreeable to you to have it.

I am still much troubled with headaches, laziness, and confusion of ideas; but am not so much addicted to low spirits and despair as I used to be.

I found the other day, upon considering my circumstances, that, supposing the engine to stand good for itself, I am able to pay all my debts, and some little thing more; so that I hope in time to be on a par with the world. But I must say that my present life is a life of much vexation, besides bodily fatigue, of hunger, cold, wet feet, &c., which I could not endure had I the least of the gout, the gravel, or many other diseases. I don't know how it is, but I think my health rather better in these gloomy months of December and November than it was in summer. I have a hundred men at work

just now, finishing a great hill we have wrought at this twelvemonth. The nastiness of our clay grounds is at present inconceivable; the quantities of rain have been beyond measure.

I admire your condenser scheme. You wrote me before of your clock with one wheel. Did I ever mention to you a striking-part, regulated by a balance pendulum with live scapement, which had only one wheel? I wish greatly to be able to spend some time with you; we have much to talk over; and, failing other hopes, if I can lay my hands upon thirty or forty guineas, I shall not reckon them thrown away in making you a visit. The Doctor promises to give me full power to settle all matters with you about the engine: I shall not delay concluding with you in some shape, so soon as you are assured whether it is worth anything or not; and the terms I shall propose shall be lower than those he offered you, which I thought too high.

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[94.]

DR. SMALL TO MR. WATT.

11 July, 1772.

I have un-ordered all your presents, and had great pleasure in so doing, because I wish you to become rich, as much at least as the lady does who cautioned you against projectors. In the present times ready money cannot be preserved too carefully. Everybody is too much engaged for the prosecution of schemes, so that even my clock is

not prosecuted, and I have only one, which I cannot send to you.

The news you have sent me is terrible. What I most dread is the ruin of some of the infant manufacturers in your part of the world. I have suffered nothing, nor have any of our friends suffered much, but all are anxious and apprehensive. What has become of Dr. R. ? I shall soon write a long letter, but am now called away.

[95.]

DR. ROEBUCK TO MR. WATT.

London, August 20, 1772.

Mr. Boulton and Dr. Small have got the vertical machine ready for trying as soon as they receive the quicksilver from London. If this circular engine should not answer, I should not be discouraged to try the reciprocal one. I think it may be executed with sufficient accuracy to answer.

* * I have a plan by which I can command 200*l.* towards the 500*l.*; and Mr. Russell will, I hope, provide the rest from some of our friends.

[96.]

MR. WATT TO DR. SMALL.

Glasgow, Aug. 1772.

This day yours of the 16th came to my hand: had I conceived you or our friend Mr. B. to be interested people, I should never have entertained an idea of a connection among us. Your attachment to me, which I am sensible I do not merit, has not failed of producing the same in me for you; and though I am perhaps naturally too open even

to imprudence with all people I conceive to be my friends, yet there is no person to whom I have so fully explained my inmost thoughts as I have done to yourself, and I have no fear of ever having cause to repent it. But I do fear that in this affair I may have urged you too far and with too little delicacy; and that you have some reason from them to think more meanly of me than I deserve. I assure you, whatever I have said as to price, &c., I only meant in respect to my friend the Doctor, who I am of opinion ought not at present to risk anything of consequence, and has too much at stake in the matter. As to myself, I have never thought of receiving money for any part of my own property in it, and shall perhaps be willing to hold a much smaller share in it than you would ask me. Although I am out of pocket a much greater sum upon these experiments than my proportion of the property of the engine, I do not look upon that money as the price of my share, but as money spent upon my education. I thank God that I have now reason to believe that I can never while I have health be at any loss to pay what I owe, and to live at least in a decent manner. More I do not violently desire. I therefore beg, my dear Sir, if I have descended anything in your good opinion, you will allow me to climb up again, if not at once, at least by degrees. Meanwhile I beg of you to go on with the experiments as fast as convenient.

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[97.]

MR. WATT TO DR. SMALL.

Glasgow, Aug. 30th, 1772.

I wrote you last Sunday, pressing you to make agreement with Dr. Roebuck about the engine. I had not then time to say so much upon the subject as I wished, but from what I have formerly written you, I hope you will excuse my being so instant that something was done. I beg leave to recapitulate some parts of it. I pursued my experiments till I found that the expense and loss of time lying wholly upon me, through the distress of Dr. Roebuck's situation, turned out to be a burthen greater than I could support; and not having conquered all the difficulties that lay in the way of the execution, I was obliged for a time to abandon the project. Since that time I have been able to extricate myself from some part of my private debts, but am by no means yet in a situation to be the principal in so considerable an undertaking. The Doctor's affairs being yet far from being reinstated give me little hope of help from that quarter; in the meantime, the time of the patent is running on. It is a matter of great vexation to me that the Doctor should be out so great a sum upon this affair, while he has otherwise such pressing occasion for the money. I find myself unable to give him such help as his situation requires; and what little I can do for him is purchased by denying myself the conveniences of life my station requires, or by remaining in debt where it galls me to the bone to owe.

Notwithstanding my natural despondence, I am

convinced that the machine may be made to answer in a very considerable degree, and in more forms than one, but that I am by no means a proper person to carry it into execution.

The Doctor is on the contrary too sanguine, and always thinks things easier than they are. His present exigencies may also tempt him to insist upon higher terms for his property in it than it is really worth. But I expect, if you still think it worth while to engage in it, that you will both give him what you judge the value of it to you, and be at some pains to convince him of its being his interest to accept of it. I shall be content to hold a very small share in it, or none at all, provided I am to be freed from my pecuniary obligations to him, and have any kind of recompense for even a part of the anxiety and ruin it has involved me in. I cannot add to what I have formerly written you, nor would I have troubled you at present, but that I fear something may come in the way of my seeing you this year. I have laid my heart open to you, and beg if you shall not do anything with the Doctor, to let me know your proposals, and if I shall see them to be his interest, I will not fail to press his acceptance of them. Further, if circumstances shall have rendered it improper for you to engage in it, I expect your advice how to proceed.

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[98.]

DR. ROEBUCK TO MR. WATT.

Kinneil, 5 Sept. 1772.

By this time Dr. Small and Mr. Boulton will probably be trying the circular engine. But as they cannot well succeed without a double atmosphere, I told them I considered the experiment as imperfect; though if it does not answer their expectation, they may condense the steam in this circular machine according to your original plan.

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[99.]

DR. SMALL TO MR. WATT.

Birmingham, 29 Oct. 1772.

Before I received your last letter, Dr. Roebuck was in London, or in Scotland, as you would learn, so nothing could be done in compliance with the proposals it contained. From my letter of yesterday to Dr. Roebuck, you would see the reasons of the delay of the wheel-engine. Indeed, unless we can concert some plan of pushing this affair with a very small capital, I begin to fear in the present state of commercial matters, let the merit of either engine prove what it will, that we shall not be able to do justice to you or your inventions. Everybody seems to tremble for the effects of the approaching Christmas, and everybody finds it absolutely necessary to be provided against larger demands than usual. * * Dr. Roebuck wrote to me about a cylinder for a very small engine. I have understood that you have at Kinneil most of the apparatus necessary for one of 18 inches. If so, I

will order a cylinder of 18 inches the moment you give me leave; because by that the experiment will be made in a more satisfactory manner, and the machine will pay for its own expense.

In your last you talk of interesting me more deeply in the success of the engine. Nothing can interest me more than I am already, but want of power is a great evil.

Dr. Roebuck will probably show you what your friends here think about your being employed in canals here. This is what I most earnestly wish, because it would make way for everything.

Why does your canal stop, and why are you to decline pushing it? Ours has cost above 4000*l.* per mile. If you are disengaged, I wish you would pass part or all of the winter with me, for I ever am with the utmost affection, &c.

[100.]

MR. WATT TO DR. SMALL.

Glasgow, 7 Nov. 1772.

Your letter of the 29th ult. is now before me, but I have heard nothing from the Doctor of the contents of yours to him. I am exceeding sorry to hear of our friend's loss; and the more so, that the calamity is general. As to the engine, I am not afraid of being able to carry it on with a small capital, or almost none, provided the success was certain, or that I was in such circumstances as to be able to make the necessary experiments for establishing its merit. I have often mentioned to you that nothing gave me so much pain as the having involved Dr. Roebuck so deeply in that

concern; and when I wrote you last, I would willingly have given up all prospect of profit to myself from it, provided he could have been indemnified. He is now willing to part either with the whole, or the greatest part of his property in it, upon such terms as, I dare say, in better times you and Mr. B. would have had no hesitation of accepting. Since Dr. R. saw you he is totally disappointed of the lease of the colliery at Wemyss, and was here lately in lower spirits than I ever saw him. His enterprising mind being by that means turned off from the coal schemes, his Bo-ness affairs going on badly, and he having no voice in the management of them, he had turned his thoughts towards the engine, and flattered himself he could finish the experiment on a small engine, not recollecting that I had been sufficiently successful with an engine of that size formerly, and that it was only in the 18-inch engine that the difficulties appeared. I have, however, dissuaded him from it, as, without flattering myself, I cannot imagine that he can find out in a few days all the difficulties, and the means of avoiding them, which have cost me so much labour. I had also two other reasons against it, the exposing the contrivance to ignorant strangers, and that he could not go on with it without directions, plans, and visits from me, which in my present situation I cannot make.

I talk of interesting you more in the success, because generosity *ought* to go a small way in directing our actions, and you have hitherto had little other motive excepting a promise of being

concerned if we could agree upon terms. We may disagree about terms; we may from caprice or interest break that promise; or we may suddenly be called by death to another state, and our heirs may laugh at any promise that is not written upon stamped paper. Consider what I have said. Consider also that Dr. R. owes Mr. Boulton money, which will go in part of the price, which can never be so low as at present. I am sorry that there is occasion to ask a price, but it cannot be helped; the Doctor's circumstances oblige him to demand it if he parts with any great part of the property.

I by no means intend to insinuate by this that I consider it necessary that you should pay down a sum of money before we would assign to you *any* part of the property; on the contrary, I think that you and Mr. B. ought to have a *certain* share without advancing to the Doctor or me, provided you took upon you the charge of the future experiments, and of finding money to carry on the business in case of success. What that share should be must be the result of some conversation between us. But I would much rather have the matter so settled that *at least* the half of the property should belong to Mr. B. and you. At any rate let us be on such a footing, that the experiments may go on, and the matter be concluded. If it is at all in my power, I will spend some time with you this winter; there is nowhere I so much wish to be; I have very much to tell you I cannot write, and there are many things I want to learn from you.

Our canal has not stopped, but is likely to do so,

from our having expended the subscription of 10,000*l.* upon seven miles of the navigation, and having about two miles yet to make. We have, however, made a canal of four feet water for one of three feet subscribed to, and have also paid most abominably for our land.

I decline only being the manager, and not being engineer. I wrote you before how grievous that first part of the business was to me, and it daily becomes more so. Everything has been turned over upon me, and the necessary clerks grudged to me; I am also indolent, and fearfully terrified to make bargains, and hate to settle accounts. Why therefore shall I continue a slave to a hateful employment, while I can otherwise, by surveys and consultations, make nearly as much money with half the labour, and, I really think, with double the credit? for a man is always disgraced by taking upon him an employment he is unfit for. I have no quality proper for this employment but honesty, which reproaches me for keeping it so long.

Remember in recommending me to business, that what I can promise to perform is, to make an accurate survey and a faithful report of anything in the engineer way; to direct the course of canals; to lay out the ground, and to measure the cube yards cut, or to be cut; to assist in bargaining for the price of work, to direct how it ought to be executed, and to give my opinion of the execution to the managers from time to time. But I can upon no account have anything to do with workmen, cash, or workmen's accounts, nor would I choose to

be so bound up to one object that I could not occasionally serve such friends as might employ me for smaller matters. Remember also I have no great experience and am not enterprising, seldom choosing to attempt things that are both great and new; I am not a man of regularity in business, and have bad health. Take care not to give anybody a better opinion of me than I deserve; it will hurt me in the end.

I cannot forgive you writing me so seldom, and never but when I have dunned for a letter. Let me beg to hear from you oftener, or I must rest satisfied that mine are very troublesome to you. We have abundance of matter to discuss, though the damned engine sleep in quiet. Let me know how Mr. B., Captain Keir, and my good friend Dr. Darwin are; remember me to them.

Yours sincerely,

JAMES WATT.

[101.]

DR. SMALL TO MR. WATT.

Birmingham, 16 Nov. 1772.

Besides the difficulties in money, you must be sensible there is another, which is insuperable at present. It is impossible for Mr. Boulton, or me, or any other honest man, to purchase, especially from two particular friends, what has no market price, and at a time when they might be inclined to part with the commodity at an under value. We have, and have had from the beginning, no other wish in this affair, as I have often said to you, except that of assisting you and the Doctor,

and of promoting the introduction of a capital invention. Were you here, you could do no more to hasten the trial of the wheel than we have done, and do. And Wilkinson has at last given his promise solemnly, that the boiler shall be ready next week, if not this. Should the experiment succeed, *or prove likely to succeed*, you ought to come hither immediately upon receiving the notice which I shall instantly send. In that case, we propose to unite three things under your direction, which would altogether, we hope, prove tolerably satisfactory to you, at least until your merit shall be better known. * * *

Having lived in constant expectation of seeing you here soon, and having found that several of my letters to ingenious men had been opened at the Post-office in quest of projects, I have seldom written, and only the needful.

Mr. Keir, Dr. Darwin, Mr. Boulton, and all other philosophers here, commemorate you often with great cordiality, and regret your absence much. * * * As for me, I am *mortellement ennuyé*; and form no projects, excepting such as promise soonest to deliver me from all human affairs. * * *

I hope Dr. R. will soon recover his spirits. A few months will probably restore mercantile matters to their former ease, and he has infinite resources. My best respects to him, if you please. My dear friend, take care of your health. I have just ordered a pendulum clock to be made with no wheel at all. Have you lately invented many

gimcracks? For my part I have given almost all my attention to some points which had occurred to me in my own profession; of which, the universal medicine is not one.

I am with great affection and esteem, &c.

[102.]

MR. WATT TO DR. SMALL.

Glasgow, 24 Nov. 1772.

I admire your delicacy. I have urged the Doctor to sell, and you to purchase, perhaps further than I ought to have done. I have had reasons which I cannot further explain by letter; when you know them all, (and I dare say you guess at some of them,) I suspect you will acquit me of selfish designs in teasing you so much. Acquit me of these, and accuse me as much as you please of imprudence or folly: to them I plead guilty, and hope for pardon from your friendship; promising not to give any further trouble on that head till I see you. Then, indeed, you must expect another onset, unless you shall positively say that you do not think it a practicable or profitable scheme.

You complain I have not been sufficiently particular about our canal. As to the canal itself, it will, I hope, by Christmas be complete for seven miles, and of immediate and profitable use, because even from that termination we can afford to undersell others.

[Then follows a particular description, with measurements in cubic yards and superficial feet respectively, of the various cuttings, embankments, bridges, tunnels, and other works of the canal.]

Our whole expense, act, surveys, &c., will be about 10,000*l.* spent. I have surveyed, levelled, planned, staked out, and measured the cube yards cut, of the whole, personally; I have also made bargains, superintended the work and accounts, and by myself and one clerk paid the cash. I have to the bargain been obliged to oversee every piece of work that was in the least out of the common road. I am now, in spite of a most [inclement] season, from five to six hours in the fields every day, and ride about ten miles. This is the one side. On the other, I am extremely indolent, cannot force workmen to do their duty, have been cheated by undertakers and clerks, and am unlucky enough to know it. The work done is slovenly, our workmen are bad, and I am not sufficiently strict. I am happy in the friendship of the principal residing proprietors, and am welcome to their houses as to my own, otherwise my wretched health could not have borne the fatigues I have undergone. What provokes me most is, that I am sensible that most people could in the same time have done much more and better work, possibly with as little trouble to themselves. I would rather face a loaded cannon than settle an account or make a bargain. In short I find myself out of my sphere when I have anything to do with mankind; it is enough for an engineer to force Nature, and to bear the vexation of her getting the better of him. Give me a survey to make, and I think you will have credit of me; I can draw tolerably; set me to contrive a machine, and I will exert myself; in whatever way

you choose to employ me, I shall endeavour to follow your advice.

As to gimcracks, I have contrived a new micrometer, made by drawing two converging lines upon glass. I believe from trial it will answer. I mentioned a dividing screw; it has a wheel fixed upon it with 150 teeth and only $1\frac{1}{4}$ inch diameter: it is moved any portion of a turn or number of turns by a straight-line rack, the teeth of which fit it, without shake, and is moved by the hand or foot. It divides distinctly an inch into 400 equal parts.

* * * *

[103.]

DR. SMALL TO MR. WATT.

Birmingham, 3 Dec. 1772.

The cheapness of your canal astonishes me who have contributed to pay about 4500*l.* for each mile of another, which, locks excepted, had no difficulties to be compared with those you have surmounted. Among other instances of our wisdom, we have employed engineers, clerks, head-carpenters, &c. in such swarms, that their salaries have amounted to 1200*l.* per annum. And yet so invincible a propensity have mortal men to being duped, that the strongest and clearest remonstrances, and even want of money, could not enlighten us. But let that pass. I shall take care that the difference of your management shall be known. If the wheel engine should go, we intend to apply it instantly to a boat, and send it a trading voyage along as many of the canals as now communicate. I like

your boat, but your micrometer still more. I am not so clear about the screw machine. * *

The *ennui mortel* has totally ruined me for an experimental philosopher. I have now about ten capital points in philosophy, original, important, unthought of, all capable of procuring fame, and two of procuring fortune, and yet I cannot resolve to prosecute them. I flatter myself that I shall soon be "*pulvis et umbra*," and fold my arms to sleep. Who will call me projector now?

When my clock with one wheel was finished, I found it too complicated, and have now got one with no wheel, and only one sector with seventy-five teeth. It strikes, repeats, shows hours, minutes, and seconds, and goes eight days, with the usual descent of the weight. This is to be ranked in mechanics, as riddles and rebuses are ranked in poetry.

As to treaties about the engine, I have only to repeat what I said before, that I will do anything to promote your interest that will not much hurt my own.

Several good methods of raising water have lately occurred to me, no gimcracks nor riddles. I dare say you will have invented, since I saw you, 500 capital engines. This fatigue does your health and your genius good. *Vale, et me ama.*

[104.]

MR. WATT TO DR. SMALL.

Glasgow, 17 Jan. 1773.

It is not my business to cry down my own abilities, but I am sensible that I have not done well,

though I can conceive that your people may have done worse.

As to clocks, I do not fully conceive how you can make yours go eight days with the ordinary descent of the weight, unless by pulleys or something equivalent, which would only be a quibble upon a wheel. As to your doubts about the screw, I intend to annihilate them when I see you.

* * * I am making a new surveying quadrant by reflection, having the uses of a semi-circle as taking angles to 180° ; the principle, that of Bird's octant, in which the objects are only once reflected. In this I am making, the fixed glass stands at 45° to the first radius; and by shifting the place of the eye, the head is never in the way. I am going to make another altogether of glass, with nonius of the same. I have nothing else now. * * * Your "*pulvis et umbra*," and folding your arms to sleep, is absolutely a project, but a most disagreeable one to your friends. We like you better when you talk of making the world more comfortable by annihilating the winter. I would like to hear somewhat about your water-machines.

[105.]

DR. SMALL TO MR. WATT.

Birmingham, 27 Jan. 1773.

* * * * Now that kings have discovered a method of acquiring realms without the discharge of one musket, I am not without hopes they may be prevailed upon to burn their gunpowder in the execution of the grand project.

Could I be sure of this, I would keep awake some years longer to see the consequences; for my curiosity in less matters is tolerably gratified. I have lived to see the discovery of the longitude; the perfecting of the steam-engine; and indeed everything but the perpetual motion, the stone of the philosophers, and Spring eternal!

At last your boiler is ready, and we are adjusting everything for trial, which will be retarded by Mr. B.'s being obliged to pass several weeks in London, where he now is. We hoped, from some passages in your former letters, to have seen you at Birmingham by this time. If tolerably convenient, pray come soon.

I remember to have much admired your schemes about improving instruments for measuring angles by reflected light. Dollond has lately, as I have heard, made some inconsiderable but saleable alterations of Hadley's Quadrant, as it is called, though the invention is Newton's, which you no doubt know.* Pray think of my micrometer, and make and sell it, if saleable.

* "The sextant, or quadrant, commonly called *Hadley's*, from its reputed inventor, though the priority of invention belongs undoubtedly to Newton, whose claims to the gratitude of the navigator are thus doubled, by his having furnished at once the only theory by which his vessel can be securely guided, and the only instrument which has ever been found to avail, in applying that theory to its nautical uses.

"Newton communicated it to Dr. Halley, who suppressed it. The description of the instrument was found, after the death of Halley, among his papers, in Newton's own handwriting, by his executor, who communicated the papers to the Royal Society, twenty-five years after Newton's death, and eleven after the publication of Hadley's invention; which might be, and probably was, independent of any knowledge of Newton's, though Hutton insinuates the contrary."—*Sir J. F. W. Herschel's Treatise on Astronomy*, 1833, p. 102; 1849, p. 115.

So also Oltmanns has said, "John Hadley fit construire le premier

There is no quibble in my clock, and we have now found a tolerable workman for the execution of it. One is now making, which will show, with much more accuracy than any other clock has hitherto done, the spheric phenomena relating to astronomy, sidereal and mean time, hours, minutes, and seconds, with only one wheel and one sector. It will also strike and repeat the hours. The wheel has 72 teeth and the sector 75 only.

I am attempting the improvement of telescopes, and still more anxiously of microscopes, because the present microscopes deceive their users; but I find it very difficult to procure good lenses. Could you make an achromatic lens of half an inch focal distance? Dollond's patent is out.

* * * *

I have executed no water-engine, because they should first be worked by your steam circulating-machine. The centrifugal force is the principle, and if this letter was to be carried by a person of trust I would send you a detail, but I care not to commit it to the post.

* * * *

[106.]

MR. WATT TO DR. SMALL.

Glasgow, 7 March, 1773.

* * * My dividing-screw can divide an inch into 1000 tolerably equal and distinct parts on glass. I have invented two problems for clearing the observed distance of the moon from a

sextant à réflexion, dont l'invention appartenait à Newton."—*Discours Préliminaire, Voyage d'Humboldt et Bonpland. Quatrième partie.* Tome i. p. 27, ed. 1810.

star of the effects of refraction and parallax; one trigonometrical, by Mercator's sailing,—the other instrumental, by a sector having a line of chords on each limb and a moveable portion of a circle of the same radius, which, if of three feet, the problem may be solved to ten seconds. If I have time I will make a model of it, and bring it when I come. Moreover, I can solve the same problem according to Dunthorne's method, by two lines of natural cosines upon a sliding rule.

I have also solved another problem more essential to me, which is determining what force is necessary to dredge up a cubic yard of mud under any given depth of water. *Satis inveni, nunc est perficere.* What has become of the engine?

[107.]

DR. SMALL TO MR. WATT.

Birmingham, 15 March, 1773.

* * * I like your astronomical instrument. All the problems of astronomy and of sailing might be sufficiently well solved, especially the last, and I have often wondered such instruments were not in use. Harrison's watch begins to make a great noise again. The king has had it tried under his own inspection, with vast success. Sooner or later it will eradicate astronomy from navigation, which is unlucky for your inventions. I am exceedingly happy to find you talk of coming hither. I shall be preserved one year longer at least from this lethargy, which must at last compose me for ever.

Pray, how have you determined your dredging, by calculation or experiment? I told you that Boulton was gone to London to procure an Act of Parliament. He is not yet returned, to my great vexation and his own great loss, and to the total stop of work on the engine. * * *

I am told two or three Professorships are vacant at Edinburgh; I wish they would choose me to fill one of the vacancies, that I might force you to pursue this capital affair. My amiable friend Dr. Gregory,* whom I have loved for twenty-two years, is no more. Not that I should like to succeed him, but if they would make me Professor of Mathematics, I * * could pass my time in talking with you wise men, who are not to be had here.
* * * *

I have had Harrison's scapement put into two watches, both of which went worse for it when oil was not put upon the pallets, but better when it was. I have had a new scapement made for watches, of such marvellous virtue, that if the maintaining power is quadrupled, or decupled, the number of the vibrations will be lessened, but not above ten in twenty-four hours. The above phenomena of Harrison's scapement I think very strange, for the particulars are these:—before the pallets were oiled, the effects of heat and cold were very great; two or three minutes in an hour between frost and the heat of my body in a warm room:—after oiling they became scarcely sensible. Yours till death.

* Dr. John Gregory, Professor of Medicine in the University of Edinburgh; grandson of James Gregory, the inventor of the Gregorian telescope.

[108.]

MR. WATT TO DR. SMALL.

Glasgow, 28 March, 1773.

There is no vacancy in the Professorship of Mathematics. Dr. Stewart's son teaches the class at present, and his father proposes to resign in his favour so soon as he can bring it to bear. Dr. Gregory's Professorship, the Theory of Medicine, is vacant; the town-council are the electors; they hear the Professors' opinions in private, but admit of no public recommendations from them. If you think of the place, you must immediately apply, or get some friend to do it for you,—Dr. Roebuck the most proper, who already interests himself for you. Your friend ought at the same time to point out every person of eminence in London or elsewhere, who will be disposed to evidence your abilities. This may perhaps shock your delicacy, but must be done. The profits of the place are about 300*l.* a year, but you may also have a share in the clinical lectures, which is worth 60*l.* per annum. So far Dr. Black, whom I consulted on the subject, and who is greatly prejudiced in your favour.

I know not how to advise you in this affair. Perhaps a Professorship is not so much a sinecure as you imagine. Men of learning are peevish, envious creatures, and your income is as good where you are, and may grow better; indeed, you may practise at Edinburgh too, but that is a slow thing, and perhaps would be disagreeable to you. But if you wish for the thing, and can make your

abilities known as they deserve to be, I doubt not but you will get it, though there are several candidates; for exclusive of the interest both the town and professors have in choosing men of merit, the professors would rather have a stranger than one of their medical brethren in Edinburgh, as they expect he would less interfere in their practice. I foresee one advantage from this matter:—it may give your spirits a fillip, and drive away for a time the tedium that infests you. I am almost ready to visit you, unless you visit us first, in which case I would be happy to have you for companion upon the road on your return; for I will go up with you. If you think any further in this matter, advise in course; and if you come down, come here first, by the Carlisle road, and I will accompany you to Kinneil and Edinburgh. I need not say that your *will* will be our law in this matter, and that no pains shall be spared.

The dredging was determined by the experiment that the power necessary to dredge or fill the spoon was less than the weight of the spoon and materials in air; the rest by calculation. * *

[109.]

MR. BOULTON TO MR. WATT.

London, 29 March, 1773.

DEAR SIR,—I am this day informed by a letter (which I ought to have received a week ago, as it is dated the 10th instant) from my friend Doctor Roebuck, that a meeting is requested by many of his considerable creditors, to be held at Mr. John McGowan's the 2nd of April, to take into con-

sideration the state of his affairs, they being alarmed that under the management of the present trustees a very large additional debt has been incurred, instead of a fund raised from the profits of Borrowstoness to discharge his debts.

Now, Sir, if I knew where to find an honest man that could better afford to give away his time than you, I certainly would not encroach upon your good nature; but as I despair of finding such a man, even if I was to take a lantern and candle, I therefore take the liberty of appointing you my lawful attorney, and hereby empower you to vote and act for me in whatever relates to the debt owing from Doctor Roebuck to me and my partner Mr. John Fothergill; hereby certifying that whatever you shall say, do, or sign in behalf of me or my partner, it shall be binding as effectually as if I had done it myself. Whatever you would do on this occasion, if it was your own affair, pray do the same for me without reserve, and whatever expenses you are put to I will reimburse you with thanks. I hope to hear soon that the Doctor's affairs are put into such train as is satisfactory to the majority of his creditors and comfortable to himself.

I am, with great esteem, dear Sir,

Your obliged humble servant,

MATTHEW BOULTON,
Of Soho, near Birmingham.

[Annexed to this letter is a copy of Mr. Boulton's claim on Dr. Roebuck for a balance of 630*l.* 11*s.* 3*d.*, due by the latter on their account current.]

[110.]

DR. SMALL TO MR. WATT.

3 April, 1773.

I am very particularly obliged by your letter of March 28, which I received this morning. Dr. Roebuck was so good as to write to me on the same subject on the 14th March, but in so general terms that I could not absolutely determine what was proper to be done. Next to the quiet enjoyment of a good estate, I should prefer a Professorship of Mathematics in a noted University, although I am no stranger to the inconveniences of an academical life; next to that, a Professorship of Natural Philosophy; and, in the third place, of the Theory of Medicine. But, in my present situation, I cannot resolve to take the steps that you have told me are necessary in order to succeed my late amiable friend. I am so indifferent to fortune, that though I should suffer in that respect by coming to Edinburgh, I would come if the electors would choose me, and would endeavour to do my duty in such a manner that they might not repent of their choice; but unless I was in want of bread, nor even then I believe, could I appear as a suppliant candidate with commendatory letters. I thank Dr. R. and you very heartily for your friendship in this matter, and I am very happy to be favoured with the good opinion of Dr. Black, whose talents and character I much respect.

Dr. Darwin and I, for Mr. Boulton is still in London, are endeavouring to persuade the Coventry Canal Company to be so much their own friends as

to send for you to help them out of great difficulties. For this reason, do not set out upon your journey hither before you have had another letter from me or from them. Pray who is likely to succeed Dr. Gregory as King's Physician? Pray make my very best compliments to Dr. Roebuck, and believe me to be always with entire affection, &c.

[111.] MR. JOHN ROEBUCK, JUN. TO MR. WATT.

18 April, 1773.

My father entirely coincides with our ideas concerning the agreement with Mr. B., that is, of cancelling the whole debt, and reserving a small share to himself of the profits as they may turn out; and he will settle your own account when he sees you at Edinburgh in a manner *quite to your own satisfaction*. We shall have leisure soon to read over and copy your letters respecting the engine, and will send them to you as soon as possible.

[112.] DR. SMALL TO MR. WATT.

Birmingham, 1 May, 1773.

In the first place I congratulate you upon the acquisition of avarice, the only good quality you wanted except strength, which in the opinion of some philosophers is a great virtue.

I do believe I may survive the disappointment at Edinburgh, though I could have made that station subservient to purposes of consequence besides physic. Had Dr. G. lived and another died, and I could have been colleague to G., I should have

liked that much. The practice of medicine is worse than a gaol.

The negotiation at Coventry we fear will fail. The poor subscribers have spent their whole 50,000*l.* upon 14 miles of canal, and more than 16 remain to be done, and all the locks. The 14 produce about 300*l.* a year only, so they seem at present to be afraid of hazarding more money.

I am exceedingly shocked at the melancholy state of Dr. R.'s affairs. I hope you may be useful in persuading the creditors to their own good. Mr. Boulton was here for a few days during the recess of Parliament for Easter. He told me of the proposal about the engine.

Your very pleasing friend Mr. Hamilton was here on Thursday last, but could not stay. * * * He told me you were to make a canal at Cantire. Of late a project has been talked of in England of making a passage for ships from Inverness to the Western Sea. It is said that it might be done easily, for that the ground between the two lakes, Ness and Oich, is level. Could you possibly survey this and judge of it, we could contrive to render the survey useful to you perhaps. Consider, and if possible do it before you come hither.

Fatigue will do you good. You have read how Cæsar restored his health. * * *

[113.] DISCHARGE BY MR. WATT TO DR. ROEBUCK.

In the year 1767, Doctor John Roebuck at Kinneil entered into partnership with James Watt

at Glasgow, to verify and carry into practice an improved fire-engine invented by the said James Watt. Doctor Roebuck was to pay a debt of 1000*l.* incurred by the said James Watt in making the experiments tending to the invention of the engine, and also to pay the expense of the patent and further experiments.

James Watt was to attend and conduct the experiments, and assigned to the Doctor two-thirds of the property of the said invention, retaining one-third for his own use.

Dr. Roebuck has paid the thousand pounds, but the expense of the other things has been principally paid by James Watt.

In consideration of the mutual friendship subsisting between Dr. Roebuck and myself, and because I think the thousand pounds he has paid more than the value of the property of the two-thirds of the inventions, I hereby take upon myself all other sums I have laid out or paid upon it, also all other debts I have contracted upon that head, relieving the Doctor from the same, and meaning this as an absolute discharge for all sums he may have been owing me before this date.

JAMES WATT.

Kinneil, May 17th, 1773.

Having examined the above narration of facts, I acknowledge the same to be just, and hereby discharge the account.

JOHN ROEBUCK.

Kinneil, May 17, 1773.

[114.]

MR. WATT TO DR. SMALL.

Kinneil, 20 May, 1773.

On Monday last I concluded bargains with Dr. R. for his property in the engine, according to Mr. B.'s letter to me, which I have delivered to the Doctor, and have received his missive to Mr. B., accepting of the offer, that is to say, Mr. B.'s renunciation of the Doctor's debt to him, with a reference to you and me what part of the annual free profits shall be paid to the Doctor, in case of success, during the term of the patent, or of such agreements as we may make under its authority and may continue longer.

As I found the engine at Kinneil perishing, and as it is from circumstances highly improper that it should continue there longer, and I have nowhere else to put it, I have this week taken it in pieces and packed up the iron works, cylinder, and pump, ready to be shipped for London in its way to Birmingham, as the only place where the experiments can be completed with propriety. I suppose the whole will not weigh above four tons. I have left the whole wood-work until we see what we are to do, conceiving it not to be worth carriage. I would not have been in such a hurry sending it off without consulting you, but it could not be delayed, for reasons I shall advise at meeting. * * .In relation to your Inverness navigation, I know something about it. It would cost much money and time to make such a survey as I could set my hand to, and I am afraid the estimate would frighten you.

The ground between Loch Oich and Loch Lochy is 50 feet high, and probably hard ground ; the whole height, deducting the said 50, is 110 feet, the country hilly and rocky, few inhabitants, and labour very dear. I would like well to survey it, if paid for it ; but I like better to come and visit you.

Please acquaint Mr. Boulton with the contents of this letter, and believe me ever yours,

JAMES WATT.

[115.]

DR. SMALL TO MR. WATT.

Birmingham, 2 June, 1773.

When I received your letter Mr. Boulton was in London. Though he was expected home daily, I forwarded to him the contents of your epistle. He is now with me, and neither of us has at present more to say than that we hope nothing will happen to defeat your intention of coming hither soon, as the further arrangements cannot be made by correspondence.

The machinery should have been sent to Gainsborough, not to London ; and if sent off, must be ordered from London to Gainsborough back again, to avoid expense and damage.

You can scarcely imagine the pain we feel on the account of Dr. R. ; but that is no proper subject for a letter. What kind of engagements would be agreeable or fit for his sons ?

The reasons for my pressing you to consider the project for joining the lakes were these :—It has been published by Pennant that an almost level

course might be found for a canal. Your survey would be the first, and as things *now* stand, both you and it could be warmly commended to Lord Dartmouth, who is at the head of the Council of Trade, to Lord Sandwich, the First Lord of Admiralty, and to Lord North. Changes may in one year, you are very sensible, ruin these possibilities. The object is of great importance, and is tolerably well understood to be so, and may be further explained so as to be rendered popular. Advantages might arise from your having only proposed such a scheme to those great men, and having been shown to be most fit for executing it.

Mr. Edgeworth has returned to England, and is engaged very earnestly in endeavouring to move wheel carriages by steam. All friends here salute you. Adieu.

[116.]

MR. BOULTON TO MR. WATT.

12 June, 1773.

DEAR SIR,—I am favoured with your obliging letter of 31st May, covering Dr. Roebuck's missive, which I herewith return, for the following reasons: 1st. Although there is nothing in Dr. R.'s letter but what is agreeable to the spirit of my proposal, yet the explicit declaration of the advantages I proposed to allow him in case of success in the engine, must in all probability become known to his creditors; in consequence of which they will possess themselves of those advantages as part of his property, and thereby my intentions of benefiting the

Doctor must be defeated and the creditors will receive no benefit, as it cannot be supposed that they will co-operate in forwarding the engine, or that I should forward it singly, whilst part is the property of strangers.

When I last wrote to you from London I was surrounded with so much business, that I had not considered this business in all its necessary lights. Particularly I did not suspect that the Doctor's affairs were so near to a crisis, and therefore had no scruple to make a bargain at that time. Now I have some scruple, because some creditors, who do not understand the subject, may suppose that I am making some capital acquisition to their disadvantage. Besides, I have some difficulty on this subject with my partner, who is interested in the debt due from the Doctor. Upon the whole, it appears to me that I can be of more service to Dr. Roebuck, which is my principal intention, by still remaining his creditor, and by purchasing the engine of the trustees, should matters come to extremities, than by concluding any immediate bargain. Should that disagreeable event take place, I shall continue disposed to prosecute the engine upon the same amicable terms, both with you and the Doctor, as formerly proposed.

I am, dear Sir, with great esteem,

Yours sincerely,

MATTHEW BOULTON.

[*Postscript to the above, by Dr. Small.*]

I sat by Mr. Boulton whilst he wrote the preceding letter. There are so many circumstances to be considered, that I know not how anything can be finally determined without our meeting, nor how we can advise you to have the trouble of a journey hither in so uncertain a state of the affair, especially as you have not told us in what manner and with what haste the creditors of the Doctor mean to proceed. Much must be left to the discretion of yourself and the Doctor, who are one; yet proceeding upon this principle, that Mr. Boulton, and I as far as my own little power extends, shall agree to everything advantageous to you both that is perfectly reputable and not disadvantageous to us. I am your most affectionate friend,

W. SMALL.

I own to you that I am afraid of being supposed to be concerned in any collusive bargain that the creditors might suppose injurious to them. At the same time I am satisfied, should the share of the patent be exposed to sale, that we may buy it for our common advantage, probably upon good terms. You know how cheap the generality of mankind hold unexecuted projects, however valuable.

[117.]

MR. WATT TO MR. BOULTON,

Glasgow, 4 July, 1773.

DEAR SIR,—Upon my arrival yesterday from Campbelton, I received your letter of the 12th ul-

timo, enclosing Dr. R.'s missive. Your motives for refusing it are honourable and perhaps prudent. As your agent, I was bound in honour to transmit you the Doctor's missive, which was obtained as near the tenor of yours as I could.

Had there been no clause allowing the Doctor a share of the profits, I should have thought that you bought the property too cheap, even at the time I received the missive from the Doctor, when I thought that he might be able to pay 10s. per pound. But since that time I have thought that besides the small share of the clear profits he asked, you ought, in case of success, to have paid somewhat to his creditors, because I have some reason to believe that if his affairs continue under the management they are in, from which I am dubious they cannot be retrieved, no one of his creditors will receive a single shilling. Besides, the one part of your debt you have no legal claim for, and perhaps they might, if it was mentioned, construe that money as advanced with a view of profit as a partner, whereby you might be subjected to a greater loss than that of the capital. The only claim you have, then, upon the subject, is that of the 630*l*. At the time I received the missive from the Doctor, I valued that at half-price; but I considered that in justice you had a preference to the whole extent of the 500*l*. and interest, which had been in circulation, because I understood that you had advanced that money upon the faith of being admitted a partner in the engine. I have no letters from the Doctor, and I do not understand that there has been

a meeting of his creditors yet. From the sentiments I heard some of them express, I expect none soon; but if there are any, I shall, if you please, propose to them in your name that you will discharge the debt of 630*l.* if they will empower the Doctor to make over to you his property in the engine invention; for all the models, &c. are mine.

You may depend upon it that neither the Doctor nor I will desire you to do a disreputable thing; and had all his creditors acted as generously, he had been able to make a better dividend.

My heart bleeds for his situation, and I can do nothing to help him. I stuck by him till I have much hurt myself; I can do so no longer; my family calls for my care to provide for them. Yet, if I have, I cannot see the Doctor in want, which I am afraid will soon be the case. I shall write again as soon as I can send any news of the Doctor, and remain, dear Sir, ever yours,

JAMES WATT.

[118.]

MR. WATT TO DR. SMALL.

Glasgow, 25 July, 1773.

DEAR SIR,—I wrote you and Mr. B. upon my return from Cantyre, since which nothing material has happened. The Doctor's creditors have never called a meeting, nor do I expect one soon. I have not heard from him very lately, but I understand that he is at law with them for his "aliment," and, I am afraid, in the last distress for money to support his family. I cannot help him, as with some small

sums I have lately paid for him I can barely support myself and keep untouched the small sum I have allotted for my visit to you.

I have again read yours and Mr. Boulton's. You do not conceive the difficulty of my situation; I want your advice. I am told the missive from the Doctor to you is valid. None of his creditors value the engine at a farthing. I have retained the missive; shall I obtain from him a power to make the alterations you want, or to dispose of it to others in case of your refusal, or shall I, in a court of justice, call upon the Doctor to fulfil his engagements to support me in the undertaking, or abandon it to me? He would not refuse the latter; but I can see no way in which he can so easily do Mr. B. any justice as by making it over to him; and should he make it over to me for a consideration in case of success, that consideration ought to be greater than what he ought to receive from Mr. B., who is his creditor, and the assigning a sum of money would have a much worse appearance than that of an invention not fully proven. It is, in fact, paying one bad debt with another.

Before I received yours, the engine was sent off for London, in the Duchess of Hamilton, — Forbes, master, to be heard of at Hawley's wharf, in boxes No. 5 to 17, marked "M. B. Birmingham." If you do not choose to have the engine to Birmingham, as I think you ought, I must beg you will cause care to be taken of it upon my account till I see you. I shall see the Doctor soon, and expect to hear from you. As to my coming up, I would

do it whether or not, so that makes no odds. With compliments to Mr. B., yours sincerely,

JAMES WATT.

[119.]

DR. SMALL TO MR. WATT.

8 Aug. 1773.

Before this day I have had no opportunity of conferring with Mr. Boulton about your last letter. We are in exactly the same difficulties about the engine that you are. It is plain nothing can be done with safety, nor without great embarrassment, whilst the affairs of our unfortunate friend remain in their present state, unless it is possible and agreeable to him to alienate his share. As to his making it over to Mr. B., we can see no method of doing that so as to avoid very great inconveniences, as we have before mentioned and you are thoroughly aware of. Your proposal about the amicable suit in a court of justice seems to be much the most eligible, and the sooner you favour us with a visit after the proper steps shall have been taken to promote such a suit, the more we shall be pleased to see you. But still, if you should not think fit to commence suit, and you are tolerably at leisure, pray come to us and complete the engines, for they are now both at Soho; and let us endeavour to find some plan that may be beneficial to yourself and the Doctor, and just to his creditors, for it seems to be impossible to pitch upon such a plan without meeting. The wheel-engine might be tried in a very few days after your arrival, at least in the

forcing way. I repeat, that in every light we can view it, the amicable suit is much the most eligible plan ; but first be sure you state every circumstance of the case to an able and experienced advocate, rather in conversation than in writing. So wishing you all good things, I remain very affectionately, &c.

[120.]

MR. WATT TO DR. SMALL.

17 Aug. 1773.

DEAR SIR,—Yours of the 8th received, and note the contents ; but can send no immediate answer about the lawsuit. The Doctor is, I hear, re-established in his “aliment,” and some alteration is made in the direction of his affairs, rather more to his mind. But I look upon all this as a temporary relief. However, anything is of advantage that gives him time. I will meet him and settle some plan for your security in the engine.

I am appointed by the Court of Police to make a survey of the canal from Inverness to Fort William, and set out the week after next. I accepted of this merely in consequence of your desire, otherwise I should have delayed it till next season. I send you two covers ; you forward your instructions and ideas of the utility in one of them, and your letter will probably reach me at Inverness, to which place it will be forwarded from Glasgow in case of my being gone.

I have been reading De Luc lately, and I have tried a curious experiment to determine the heats at which water boils at every inch of mercury from

vacuo to air. De Luc's observations and mine agree; but his rule is false. I have some thoughts of writing a book, the 'Elements of the Theory of Steam-engines,' in which, however, I shall only give the enunciation of the perfect engine. This book might do me and the scheme good, and would still leave the world in the dark as to the true construction of the engine. Something of this kind is necessary, as Smeaton is labouring hard at the subject; and if I can make no profit, I ought not to lose the honour of my experiments. We shall talk of this at meeting. Compliments to Mr. B.

Yours,

JAMES WATT.

[121.]

MR. WATT TO DR. SMALL.

Glasgow, 24 Aug. 1773.

DEAR SIR,—This day I received the enclosed from Dr. R. You see the composition agreed to by his creditors is very low, which I am sorry for on several accounts: in the first place, for himself and family, and also because it decreases the value of his debt to Mr. B., and may be a motion for making him a larger allowance in case of success in the engine. I set out for the North upon Monday next, and whenever I return shall set out for you, though I am against making any experiments until the whole property is settled; but I hope, as you can by that time have full security, that that will be done immediately upon our meeting, at least no obstacle shall be upon my side. I think Mr. B.

should write him and me whether he accepts of the composition, as his doing it may be a motive for others, and may help to extricate a worthy man.

I have tried some more experiments upon heats of water under various pressures, and think I see plainly the whole faults of the condenser, and their remedies. Compliments to Mr. B.

In haste yours,

J. WATT.

[122.]

DR. SMALL TO MR. WATT.

29 Sept. 1773.

I have pressed our friend B., until I am quite ashamed, to reply to your last letter, which enclosed Dr. R.'s proposal to his creditors; but he has not been able hitherto to force himself to write. Nor can I tell you what he probably will write, nor when, for this is an affair of too much delicacy for me to inquire into. I had great satisfaction in hearing that the Doctor was restored to his income, as I had also in the success of your experiments, and in your reputable appointment to make the survey, in which I suppose you to be now employed.

In my whole life I have never experienced so long a fit of languor as I am now in, so that I am and have been totally unfit to send you anything tolerable about the canal I am so desirous of seeing executed. But probably you already have learned much more about it than I know.

When the herring-fishery was attempted by the people on the Eastern coast, they found their own

sea furnished neither plenty of the fish, nor fat ones; therefore they tried to send vessels to the Western Sea. At the best season, these ships could seldom get round by the Orkneys, on account of periodical westerly winds and currents; and the voyage through the two channels is long and dangerous. Had the canal then existed, I believe the fishery would by this time have been established; and for want of it, besides the disappointment in that contingency, a vast number of the fishing people that used to swarm upon the Eastern coast have left the kingdom, the people having changed their diet, and now using less fish. Besides, it was necessary, on account of the nature of the voyage, to use too large and expensive vessels.

Next, could a canal be made to admit armed vessels, no enemy could ever venture into the Irish Channel, or near the Western Isles.

The returning voyage, even to London from America, would be shortened one-third upon an average, by steering round the North of Ireland for this canal, on account of the wind in those latitudes. The banks of the canal would prove a seminary of herring-fishers, whale-fishers, and Newfoundland-fishers, for canals tend more to breed watermen than even sea-towns.

More artisans living on the eastern coast of Scotland than on the western, and they daily growing more expert, they would have more easy access to the American market, the only one that is likely to be long supplied with manufactures from Britain, &c. &c. besides all the inland advantages.

But at present I neither can think nor write ; so farewell, and tell me how you go on.

I exceedingly approve your scheme of writing. It might be a paper in the ‘ Philosophical Transactions,’ which afterwards you might publish for your own benefit. We will take care that it be put in by a respectable member.

[123.]

MR. WATT TO DR. SMALL.*

* * You are happy, Small, that have no such connection. Yet this misfortune might have fallen upon me when I had less ability to bear it, and my poor children might have been left suppliants to the mercy of the wide world. I know that grief has its period ; but I have much to suffer first. I grieve for myself, not for my friend ; for if probity, charity, and duty to her family can entitle her to a better state, she enjoys it. I am left to mourn.

* * * *

Let me leave this tale of woe. As far as I saw of the canal, it is practicable. Loch Oich is 100 feet above the sea, and the summit of Lagan na Drum, that separates from Loch Lochie, only 20 feet above Oich, and all good gravel. There is plenty of water, and Oich 4 miles long for a reservoir. I left Morison, my surveyor, who is tolerably accurate, to complete the survey. I had a miserable journey home, through the wildest country I ever saw, and the worst conducted roads : an incessant

* Fragment, without date, of a letter, in which Mr. Watt appears to have announced the death of his wife.

rain kept me for three days as wet as water could make me. I could hardly preserve my journal-book. * * Adieu, God bless you.

[124.]

DR. SMALL TO MR. WATT.

8 Oct. 1773.

I most deeply condole with you, and wish I could comfort you also. But though I have long cultivated the species of philosophy that is said to be the most consolatory, no remedy in such cases is equal to that of turning the attention to other objects, and never suffering it, even for an instant, to be engaged on the irretrievable one. Come to me as soon as you can.

Pray does the country you have surveyed furnish timber fit for ship-building, or wood for charcoal, or mines of any valuable kind? I had no suspicion that Loch Oich was so far above the sea, and therefore had hopes that ships might be built in it, and their cannon, ballast, &c., might be cast on its banks, and their bolts, &c., be made there. Could many small canals be cut from the lakes and the great canal, on both sides; I mean such as could carry boats from one to three tons burden? You say the road from the fort is badly planned. Pray mention this to the Commissioners of Police, who I understand are your present employers. It may produce both an improvement and employment for you for years.

Boulton has not yet written to the Doctor.

The more I consider the propriety of your pub-

lishing about steam, the more I wish you to publish. Smeaton has only trifled hitherto; but he may perhaps discover something. He told Boulton some time ago that the circular engine would not do. He said he had considered it, and was sure of this. As B. does not much respect his genius, this had no effect. I have had pretty correct intelligence about the observations and experiments he has been making. He has found that the load upon the common engine ought to be less, and that nothing like vacuum is produced in the cylinder. The 'Philosophical Transactions' are your best vehicle, I still think. * *

[125.]

DR. SMALL TO MR. WATT.

16 Oct. 1773.

Had I never complained to you of ennui and its effects, I should never have known how profound a stoic you are. However, in spite of all sects of philosophers and of all their doctrines, one maxim is infallible,—life must be spent either in labour or in ennui. Which is best or which is worst of the two I cannot easily determine. Unfortunately, in my case, labour seldom alleviates and often increaseth the ennui, and almost always disorders my stomach. * *

Your micrometer is excellent, but should be called by a name that would imply its use in measuring distances. It will require optical corrections, which may be easily made and tabulated. As to the quadrant, if it is intended only to perform tolerably,

and to be portable, it is good; but you do not mean, I suppose, to rank it with quadrants of some other forms. And how do you intend to keep the parts of it in the same, or in parallel planes, and to contrive that your line of chords should constantly be the base of an isosceles triangle? This last is not very difficult; but the other, I fear, is. Then you must have a faithful table of chords, which is still to be formed; for the published ones are not correct. Lastly, a man of your reputation must never exhibit an inferior invention. * * *

[126.]

DR. SMALL TO MR. WATT.

Birmingham, 27 Oct. 1773.

I engage in no controversy with you about grief, or the indulgence of it; only I tell you it is injurious to such health as yours, and that I should be very sorry (pardon the Irishism), were I dead, if you should grieve for me, although living I very highly value your affection. As to your toothache, Pascal is said to have employed his attention on a curve so entirely, as to have been insensible of a most raging pain. Besides, there is a vast difference between a sensation you are compelled to feel and another which you cannot feel without exerting your memory. On this account I advised attention to other objects. Formerly I have thought, as you seem to do, that yielding to regret was a virtuous concession; but having suffered and grown older, I never allow myself now to be rendered miserable

by irremediable objects, of which I can either think, or not think, as I please. * *

I do not wonder the people migrate from the country you have described, to America, or anywhither. Pray have not all these mountains formerly been forests, and why does not timber now grow upon them, as they are not cultivated? Nothing but *incessant* cultivation can hinder any spot in America, from latitude 50° southwards, from producing trees. I am led by this and many other reasons to suppose, nay to believe, that the frozen space of the globe is annually increased, at the rate of about the 300th part of a degree of latitude at a medium, or more; so that after a certain number of years all Europe, and finally the whole surface of this earth, will be frozen, as the moon is now and has long been. *Voilà une théorie*; one good property of which is, that I shall not live to suffer the disgrace of seeing it refuted by experience. And then it ought exceedingly to forward the execution of my project for producing perpetual summer; of which I will be bold to say, that if all the gunpowder which has been spent by their Imperial and Royal Majesties the Emperors and Empresses of Constantinople, Germany, and Russia, the Kings of France, Spain, Britain, and Prussia, within these last twenty years, had been laid out upon it, the powder would have produced at least as much benefit to every one of them as it has done by being expended on their own schemes. I have had thoughts of writing a circular letter to these potentates, and if you give me any encouragement,

notwithstanding my laziness, I will still do it, although there is but little to be made of kingly heads, I fear.

Are you writing your book? I would have it published by Christmas, or immediately after your return from France, that the curiosity of the English may be raised to see the philosophical and *travelled* engineer. * * *

I have taken out a patent for improvement on clocks and other time-pieces, and want you vastly to help me to draw up the specification, which must be given in soon. I have made a church-clock, consisting only of one wheel of 126 pins, and one sector of 75 pins, and a hammer, with a scapement for the sector and another for the hammer. It strikes the hours, shows hours, minutes, and 20th parts of minutes, and goes eight days. And I have given drawings of a pocket watch, which is to consist of one wheel and two sectors, and is to show hours, minutes, and seconds, and to have only 142 pins in the whole watch, and to have no chain nor fuzee, the kind of scapement rendering them unnecessary. But I have had hitherto villainous bad workmen. The axis of the pendulum of my clock is a cylinder, and rolls upon curves, which render the vibrations isochronous, and it has two rolls for one impulse.

[127.]

MR. WATT TO DR. SMALL.

Glasgow, 11 Dec. 1773.

DEAR SIR,—I know not when I was so long in literary debt to you. I have been absent a month

upon a survey of some improvements of the Upper Forth. I had many cold fingers and feet, and have much boiled my brains suiting a report to Lord Cathcart's genius, which I do assure you is no easy matter. He is, however, a most honest and friendly man, and much my friend.

I have only invented a drawing-machine, the board horizontal, the index almost as long as you please, and consequently the size of the picture large; a telescopic sight; no specula; the whole being performed by a most simple joint. When the index does not exceed two feet long, the instrument and apparatus consist of a box 14 inches long, $1\frac{1}{2}$ deep, and $4\frac{1}{2}$ inches broad, which opened is the drawing-board, and contains the apparatus, except a light wooden tripod head for the pocket, and a staff for the hand, of the ordinary size. By help of this machine I can draw from an eminence a draught of level grounds that shall be a true projection of them, and shall measure by a scale of equal parts. It also draws all kinds of perspective draughts, reduces maps, &c., the board being always horizontal, whether the objects be vertical or not.

I rejoice in your clocks and watches, wishing much that you could send some of them here. I want a good watch much myself.

This ennui of yours is vilely infectious; I believe, like the plague, it can come by post. It has seized upon me. I am not melancholy, but I have lost much of my attachment to the world, even to my own devices. Man's life must be spent, you say, either in labour or ennui; mine is spent in both.

I long much to see you,—to hear your nonsenses and to communicate my own; but so many things are in the way, and I am so poor, that I know not when it can be.

I am heart-sick of this country; I am indolent to excess, and, what alarms me most, I grow the longer the stupider. My memory fails me so as often totally to forget occurrences of no very ancient dates. I see myself condemned to a life of business; nothing can be more disagreeable to me; I tremble when I hear the name of a man I have any transactions to settle with.

The engineering business is not a vigorous plant here; we are in general very poorly paid. This last year my whole gains do not exceed 200*l.*, though some people have paid me very genteelly. There are also many disagreeable circumstances I cannot write; in short I must, as far as I see, change my abode. There are two things which occur to me, either to try England, or endeavour to get some lucrative place abroad; but I doubt my interest for the latter. What I am fittest for is a surveying engineer. Is there any business in that way?

I begin to write my report of the Grand Canal next week. Write soon.

[128.]

MR. WATT TO DR. SMALL.

Glasgow, 24 Dec. 1773.

As you are a great advocate for the Inverness Canal, and main adviser for my undertaking the

survey, now I find myself in a kind of scrape, I must call upon you to help me out. The case stands thus:—Freight from Forth to Clyde and back, 20s. per ton; time of passage from 10 to 40 days; ordinary passage 20 days. Distance by outside Orkneys 635 geographical miles; by Pentland 575. From Buchan-ness to Mull by Orkneys 375; by Pentland 315. By the canal, distance by sea, Buchan-ness to Inverness 105; artificial navigation 23 English miles; Freshwater loughs 30½ geographical ditto; Fort William to Mull 30 ditto. Average rate of vessels sailing, founded upon a twenty days' passage, 30 miles per diem. Passage, Buchan-ness to Mull by Orkneys, 12½ days; by Pentland 10½. Time of passage by canal, the sea part 135 miles, 4½ days; the loughs one day; the four canals, 23 miles, two days: total by canal, Buchan-ness to Mull, 7½ days. Saving over Orkney passage five days; over Pentland passage three days. Summer insurance round Orkney 30s. per cent.; winter ditto about 3*l.*; but no wise underwriter will put his name to such a policy. Winter insurance from Clyde to Fort William 25s. per cent.; from Murray Firth to Leith 20s. The expense of making a canal for 10 feet water will be about 160,000*l.*, besides land. *Voilà les faits.* I want your opinion of the proper method of proving the advantages and valuing them in money, so that it may appear what toll can be afforded, and whether it will compensate the expense. Be as full as you please; for unless some strong arguments appear, I am afraid, as a just judge, I must myself

pass sentence of condemnation, or leave the poor canal to the mercy of the public.

Give me your opinion of the best manner of digesting a report of this matter, and of the size of the plan. I think of doing it in one long plan, upon a scale of an inch to the mile; it will be five feet long, and may be printed in three pieces, if it merits that expense. A lesser scale would not show the parts, and a larger would not show the connection.

Since my last I have been close writing upon this subject. I caused to be made a part of the machine I mentioned in my last; it has only one fault, which is, that it will not do, because it describes conic sections instead of right lines. * *

[129.]

DR. SMALL TO MR. WATT.

Dec. 1773.

Dr. Roebuck some time ago wrote that you intended to pass this winter in France, and Mr. Boulton and I ever since have been in daily expectation of seeing you in your journey, and now you send a letter that says nothing either of going to France or of coming hither. Had you been here, in all probability you would have been consulted about a difficult canal, and should you come soon you may still; but we cannot persuade the people to send into Scotland for you, or for anything else. Shall you come soon or not?

I would have you puff in the newspaper about this drawing-machine, and agree with some instru-

ment-maker in London about selling it *directly*. Why do you not write the paper, or the book, about steam? After that, you might settle in this country whenever you should choose to do so.

Is the report about the northern survey to be printed and published? If it is, I desire to see it before the printing.

Dr. R. has not yet been here, so we are quite where we were about the engine, &c. I have no doubt that after a little time you might have good business in England as an engineer, could you once find an opportunity of giving a specimen of your talents.

You might live by inventing only an hour in a week for mathematical-instrument makers. I do not like to hear of your going abroad, nor do I know any post abroad worthy of you,—I mean in the foreign dominions of England. Smeaton was first distinguished by writing. Pray write the book about steam; or send me the facts, and I will write it for you, and get it presented respectably to the Royal Society.

I am glad you are employed by Lord C., although he may give you trouble. Should you come hither soon, pray consider aqueducts in the meantime, and the conveyance of water in pipes, and the expenses of both. Surely the Romans did not pay for theirs so extravagantly as we do; nor do the modern Sicilians, nor the Portuguese. Also consider the price of lockage very minutely. I long to see you. Farewell. Bring a drawing-machine when you come, that you may astonish the world.

[130.]

DR. HUTTON TO MR. WATT.

Edinburgh, [Jan.] 1774.

Mes amis, I wish you all a happy year ; may it be fertile to you in lucky events, but no new inventions ! Invention is too great a work to be well paid for in a state where the general system is to be best paid for the thing that is easiest done. No man should invent but those that live by the public ; they may do it through gratitude, and those who from pride choose to leave a legacy to the public. Every other man should invent only as much as he can easily consume himself and serve his friends. It is in this view that I admire so much your reciprocating engine. I dare say Mr. Boulton's mill will never want water in the dryest summer.

* * I am sincerely of opinion that a short account of the machine should be made out, with a distinct estimate of its value compared with the common one, and then represent that besides the invention of this uncommon advantage, it has cost many years' labour and expense to bring it to the perfection of utility, and that such is the difficulty attending this operation, that without an accurate description of the method necessary to render this invention practicable, it may remain as useless as in the head of the inventor. Therefore application should be made to Parliament, and give the choice either of buying the public use and description of the invention, or of giving an exclusive privilege for a sufficient length of time, as it cannot be

expected that anything worth the value can be got whilst the present engines subsist; for though the expense of change would be well repaid, yet the natural want of confidence in a new thing, and the outlay of money, would prevent its taking effect.

* * * *

[131.]

DR. SMALL TO MR. WATT.

Birmingham, 23 Feb. 1774.

I have been engaged in business more than usually, and have since that been sick for four days. For these reasons I have not hitherto answered your letter of the 6th. We have tried no experiment with the circular engine. The engine is mounted, the boiler is ready, the piece that connects the boiler to the steam-pipes is also ready, but not ground to exclude air; lastly, the quicksilver is ready. The valves were ground very carefully, but whether they are steam-tight we know not.

Probably nothing more will be done before you come, for neither Mr. B. nor I have leisure to attend the trials or the workmen; and to employ workmen on articles of this kind, without superintendence, we have experienced to be too expensive. Besides, you ought to see all the facts that may occur.

* * * *

I desire you will bring with you the drawing-machine. I have never much considered that subject, and hope to profit by it. My head aches so excessively, that I can write no more. Farewell and farewell.

[132.]

MR. WATT TO DR. SMALL.

Glasgow, 3 March, 1774.

I received yours. I am sorry for your illness, which I hope you have now got the better of. I have been working this fortnight making thermometers and trying the heats of water boiling from the open air to vacuo under different pressures. I think that the experiments seem to say that at vacuum the heat is infinitely little, but when in vacuo it can support a column of one inch, the heat is about 94° , and at 15 inches 180° . I have also tried saturated brine and sp. vini in the same way, and likewise the heats of columns from 1 inch to 57 inches in the air. I think that taking the pressures in equal parts, the heats will be the ordinates of a logarithmic hyperbola.

I have still to try the expansion from 212° to 230° when the steam is not pressed, and also the quantity of air contained in water, when I think our theory will be tolerably complete. There is no conceiving the time and labour such experiments cost. I am ruined by most painful headaches three times a week, and dare hardly go out but I catch one extra.

I had occasion to use my last dividing screw for the first time the other day. It divided 9 inches into 20ths, and did not err the $\frac{1}{200}$ th of an inch in the whole 9 inches. I did not find that there was the least inequality among the divisions, though I subjected them to the most severe trial, and I have found a way by which I can divide a foot into $\frac{1}{1000}$ ths of an inch without erring above $\frac{1}{200}$ th of an inch in

the whole length, and the divisions shall be equal among themselves; so that I reckon that machine exceeding near perfect, and find it very useful, as it saves much needless compass work, and, moreover, can divide lines into the ordinates of any curve whatsoever. * *

[133.]

DR. SMALL TO MR. WATT.

29 March, 1774.

I answer yours of March 3rd, which I ought to have answered a week ago, or more. I am most sensible of the great importance of the course of experiments you are engaged in, both to the engine and to the improvement of Natural Philosophy. But I am solicitous you should convert your discoveries into fame and money as fast as possible. For this reason, pray lose no time that cannot be better employed, (I mean more profitably, in the mercantile sense of the word;) but, *if you judge the title to the engine to be clear*, and your experiments to be sufficiently advanced for a *reasonably* good construction of it, come hither as soon as possible.

Besides your engine, a patent has been taken out for my clocks and watches, and there is reason to hope they may become an article of commerce. I am ready to make over to you all my interest in the patent, provided that can be done so as to benefit all concerned, which, if you can be established in this country, might be the case.

I rejoice in all your improvements, but have many optical difficulties that lessen my confidence

in observations made with the most accurately divided instruments. For example, no optical instrument hitherto constructed, catoptric or dioptric, or catadioptric, produceth an exact copy of any object; so that all the visible points of every object of sensible apparent diameter are represented in the field of the instrument in situations in relation to each other very different from what they ought to occupy, &c. &c. The *unsteady* refractions of light passing through the atmosphere are also vile things; not those mentioned by astronomers only, but others I will show you when we meet, &c. &c.

In one of my barometers the scale floats within the tube, and is of such specific gravity, and of so accurately expansile matter, that it constantly shows the weight of the atmosphere correctly. This is difficult to be made. The other is very easy. The bason is large; a float of metal, with a hole for the tube in its middle, lies upon the surface; a scale stands upon the float, and expands and contracts just as much as mercury. You can easily imagine how both may be rendered portable.

[134.]

MR. WATT TO DR. SMALL.

Glasgow, 9 April, 1774.

I begin now to see daylight through the affairs that have detained me so long, and think of setting out for you in a fortnight at furthest. I am monstrously plagued with my headaches, and not a little with unprofitable business. I don't mean my own whims; these I never work at when I can do any

other thing; but I have got too many acquaintances. * *

I admire your expansile scale, the idea of which I had before, but had none of the possibility, as I know nothing that expands so much by heat as quicksilver, unless Newton's metal does it. I have objections to the floating, which I defer to meeting.

I have now finished my reports and plans of the Inverness Canal, and have sent a copy of them to Lord C., who would not fail to show them about. The principal copy of the report I only finished this week; that I sent to Lord C. was only an outline. I intend to bring copies of several of my reports and plans with me to show to you and friends. * *

[135.]

MR. WATT TO DR. SMALL.

Glasgow, 6 May, 1774.

* * * *

My friend Dr. Irvine in winter discovered what is the lowest possible degree of heat, or the real beginning of the scale; by which means thermometers may be made, showing the real quantity of heat in bodies.

I have persuaded my friend Dr. Hutton, the famous fossil philosopher, to make the jaunt with me, and there are some hopes of Dr. Black's coming also. I shall bring my dividing screw to convince you and other infidels. * *

[136.]

DR. ROEBUCK TO MR. WATT.

12 Nov. 1774.

Your favour of October 31 gave me great pleasure. I hope you will have it in your power to inform me that your willow piston continues tight after it has been worked some weeks. I do not wonder that your condenser should be imperfect; I am rather surprised that it should work at all, considering the slightness of the materials and its long exposure to the injuries of the weather. When you have tried the fusible metal in your circular machine, I shall wish to be informed of the experiment.

You have now effectually established the justness of the principles on which your machine is constructed, and the generous and spirited gentleman you are connected with will never suffer it to fail for want of exertion to carry it into execution.

[137.]

MR. WATT TO HIS FATHER.

Birmingham, 11 Dec. 1774.

* * * *

The business I am here about has turned out rather successful, that is to say, that the fire-engine I have invented is now going, and answers much better than any other that has yet been made; and I expect that the invention will be very beneficial to me. * *

[138.]

MR. WATT TO MR. BOULTON.

London, Jan. 13th, 1775.

* * * *

Mr. Wedderburn's answer to me about the patent was, that we might surrender up the present patent, and that he did not doubt a new one would be granted. * *

[139.]

MR. BOULTON TO MR. WATT.

Soho, Jan. 26, 1775.

* * * *

I wrote to Wilkinson about the cylinder, but have neither seen nor heard anything of him since your departure. However, I will in a day or two send him a line of stimulation. * *

I hope you will be able to get such law information as to conclude positively what's to be done about the engine. I like the plan of surrendering the patent and taking out a new one. Pray bring down the rate of perfection and power of the York Building engine, and Smeaton's at the New River Head; also the Chelsea engine. * *

[140.]

MR. WATT TO MR. BOULTON.

London, Jan. 31st, 1775.

* * * *

I have a prospect of two orders for fire-engines here; one to water Piccadilly, and the other to serve the south end of Blackfriars Bridge with water.

. I have taken advice of several people whom I could trust about the patent; they all agree that an Act would be much better and cheaper, a patent being now 130*l.*; the Act, if obtainable, 110*l.* The present patent (which is in Mr. Handley's keeping) has eight years still to run, bearing date January, 1769. I understand that there will be almost an unlimited sale for wheel-engines to the West Indies, at the rate of 100*l.* for each horse's power. * *

* * * *

[141.]

MR. BOULTON TO MR. WATT.

2 Feb. 1775.

* * * *

I note what you say about fire-engines, and only regret that we have not one of each species ready to work, as two working models would clear their way into the House of Commons better than blind words can do. * *

[142.]

MR. BOULTON TO MR. WATT.*

Temple Row, [Birmingham, 25 Feb. 1775.]

DEAR SIR,—The last scene is just closed; the curtain is fallen, and I have this evening bid adieu to our once good and virtuous friend for ever and for ever.

If there were not a few other objects yet remaining for me to settle my affections upon, I should wish also to take up my lodgings in the mansions

* On the death of Dr. Small

of the dead; and those objects I am fearful of diminishing. * * *

Your going to Russia* staggers me. The precariousness of your health, the dangers of so long a journey or voyage, and my own deprivation of consolation, render me a little uncomfortable; but I wish to assist and advise you for the best, without regard to self. Good night, and good health attend you.

M. BOULTON.

[143.]

MR. WATT TO MR. BOULTON.

London, Monday Night, [Feb. 1775.]

To pretend to offer you consolation under the weight of your present sorrow, I know to be in vain. I only beg leave to repeat to you the sentiments which that dear friend we lament expressed to me upon a similar occasion. It is our duty as soon as possible to drive from our minds every idea that gives us pain, particularly in cases like this, where our grief can avail nothing. Remember, my dear Sir, that our friend enjoys that repose he so much desired; and we ought not to be so selfish as to render ourselves unhappy by the perpetual recollection of our own misfortune, however great we may think it, for it is also irreparable and was

It elsewhere appears that a situation in that country, with a salary of about 1000*l.* per annum, had been offered to Mr. Watt, on the recommendation of his friend, Dr. Robison. In reference to this, Mr. Boulton afterwards writes (11 March, 1775)—“ I shall rejoice at every good that befalls you; yet, nevertheless, I find I love myself so well that I should be sorry to have you go to Russia, and I begin to repent sounding your trumpet at the ambassador’s.”

inevitable. Mr. Small offered to go down with Dr. Heberden; but he will upon no account go from London, and said he could be of no service, as he conceived the disease to be one of the stomach, and incurable.

Come, my dear Sir, and immerse yourself in this sea of business as soon as possible, and do not add to the griefs of your friends by giving way to the tide of sorrow. I again repeat that it is your duty to cheer up your mind and to pay a proper respect to your friend by obeying his precepts. I wait for you with impatience, and assure yourself no endeavour of mine shall be wanting to render life agreeable to you.

[144.]

DR. ROEBUCK TO MR. WATT.

Bath, March 3d, 1775.

I have spoken to Mr. William Adam and desired him to give you his assistance in procuring a Bill to secure to you the right of your invention of the fire-engine, and he has promised me to be so obliging as to enter into a minute detail of it so as to be thoroughly master of the subject, which he will defend for you in the House if necessary. Let me know by the return of the post the day that the first reading comes on. My kind compliments to Mr. Boulton. We have lost a most valuable friend, a gentleman of extensive knowledge and learning.* You must let me know from what quarter the opposition comes, and who are the prin-

* Dr. Small.

cipal actors in it. If it is like to be formidable, perhaps it would be better not to move for the Bill till I return to London, and till the plan is regularly formed for defence, &c.

[145.]

DR. DARWIN TO MR. WATT.

Lichfield, March 29, 1775.

* * * *

Lord, how frightened I was when I heard a Russian bear* had laid hold of you with his great paw, and was dragging you to Russia! Pray don't go if you can help it. Russia is like the den of Cacus: you see the footsteps of many beasts going thither, but of few returning. I hope your fire-engines will keep you here.

[146.]

MR. BOULTON TO MR. WATT.

Soho, April 24, 1775.

* * * *

The cast-iron cylinder is arrived; it seems tolerably true, but is an inch thick and weighs about 10 cwt. Its diameter is about as much above 18 inches as the tin one was under, and therefore it is become necessary to add a brass hoop to the piston, which is made almost two inches broad. Joseph hath promised to do all his work well, and to complete it and pumps, &c., so as to set it to work

* "Which made old Ben and surly Dennis swear,
No Lord's anointed, but a Russian bear!"

Pope's Imit. of Hor., B. ii. Ep. i., l. 388.

by this day fortnight. The kettle-bottom being cast very much bigger than it was ordered, and the cylinder being also bigger, have necessitated us to increase the size of the wooden cylinder, which I have this day put into the hands of our cooper for that purpose.

There are several engines now wanted in Cornwall; some of the proprietors of mines are impatient to know the event of our Bill and the terms we will propose. I have ventured to say to Mr. Glover (who was requested to wait upon us on that subject) that we will undertake and contract to make an engine or engines capable of doing any quantity of work that shall be requested and described, for as little money as common engines will cost that are capable of doing as much work, and we will guarantee them to do that work with half the expense of fuel that common ones will require, provided we are allowed a sum that shall be equal to its further savings over and above the said half.

I am fearful we shall be in danger if we risk a battle before the return of Solicitor Dundas, Sir William Bagot, Gilbert, and other friends. I hope we shall steer clear of the 10 per cent., which would not pay travelling charges for inspection. There is not only the merit of the invention that ought to be rewarded, over and above the loss of so many years and the expense of some thousand pounds, but there is likewise a great risk in sinking many more thousands; for after that is done, suppose another ingenious man starts up with another new discovery that should prove to be seven times better

than the common engine, whilst ours is only three times, what then becomes of all the fabric we have raised, and of the visionary profits? And let me tell you that there is great probability of it, for there is a very ingenious man at Henley-upon-Thames, who asserts that he hath made such a discovery; as I believe some gentlemen in this honourable House can testify. I think improvements of this nature ought not to be discouraged when nothing is asked for but the fruits of the improver's labours. God knows there are few projectors that grow rich, although they often contribute to the benefit of their country. This may be one amongst other arguments for the House.

Pray bottle up some spirits against I come, and against the decisive day; for good spirits are better than great riches! Which the Lord grant you, is the fervent wish of

M. BOULTON.

[147.]

MR. BOULTON TO MR. WATT.

Soho, [May, 1775.]

* / * * *

The engine goes marvellously bad. It made eight strokes per minute; but upon Joseph's endeavouring to mend it, it stood still. Nor do I at present see sufficient cause for its dulness. I have a few minutes ago had the top taken out, and find that I can pump down the piston, and although I can hear the air pass by it into the cylinder, yet the error is not sufficient to account for its bad

going. The piston is now taken out, and although the cylinder is not perfect, yet there doth not appear any very gross error. The outside of the piston is hat, filled up with paper chewed. It is nine inches thick at least, which I fear makes much friction. I have ordered a bottle of oil to be put into the papier maché; which will drain through the hat and lubricate the sides. It is certain, by another experiment I made, that much steam escapes, as the water which passed through the condenser continued to be hot. * *

The pattern for the wheel-engine will be finished in a few hours.

[148.]

MR. BOULTON TO MR. WATT.

[May, 1775.]

* * * *

I again attended to the engine, but could not raise nine strokes per minute, even with steam that supported nine inches of mercury. I therefore this day set myself to examine the cause. First, I found the sliding-valve very much out of truth, and it admitted air freely; secondly, the two convex pieces of copper which are soldered upon the bottom side of the cast valve-frame were unsoldered in many places, and admitted air to pass in quantities. Both of these errors we have rectified, and can readily exhaust the cylinder by hand, and the piston will be, I dare say, two hours in returning; so that I should suppose that part of the engine perfect enough.

The next experiment was to exhaust the cylinder by hand; and having suddenly opened the valve, I found nevertheless that the beam returned very slowly, which shows there is a great friction either in the cylinder, piston, or pump, because the pump-end of the beam is about four cwt. heavier than the cylinder end, besides the consideration of the pump-end of the beam being one-sixth longer than the cylinder end. I then ordered the cylinder piston-rod to be detached from its chain, and suffered to fall freely, which it did; but it descended very slow, even not a quarter so fast as when working, which shows that the friction of that piston is at least equal to 200 lbs., that being about the weight of it, for there is about 90 lbs. of lead lying upon the papier-maché. I also fear that the resistance to the descent of the pump in the water is great, owing, I suppose, to the weight of the valve, and to the water not having sufficient passage. In order to remedy that point, *quære*, if the working-barrel were four times the area, the admission for the water would be four times as great, and the descent of the piston four times as slow, and the friction of the sides would also be less; in which case that end of the beam should be four times shorter than the other. These are my occurring thoughts, which you will in an instant see the absurdity of, perhaps, as you have considered these subjects with more attention than I have. Perhaps large working barrels may require valves composed of a great number of little doors rather than two large heavy ones. I propose to put in a fire again to-morrow,

and will inform you of the result. * *

Quære, if the sliding steam-valve had more surface of metal in contact, would it not be more air-tight? and it would wear much longer.

[149.]

MR. WATT TO HIS FATHER.

London, May 8th, 1775.

DEAR FATHER,—After a series of various and violent opposition, I have at last got an Act of Parliament vesting the property of my new fire-engines in me and my assigns, throughout Great Britain and the Plantations, for twenty-five years to come, which I hope will be very beneficial to me, as there is already considerable demand for them.

This affair has been attended with great expense and anxiety, and without many friends of great interest I should never have been able to carry it through, as many of the most powerful people in the House of Commons opposed it. It has been in Parliament ever since the 22nd of February, which is a very long time to be kept in suspense.

I shall be obliged to stay here a few days longer, after which I return to Birmingham to set about making some engines that are ordered; after which I intend to give myself the happiness of seeing you and the dear children. * * My warmest wishes and affection ever attend you; may God render your age comfortable is the prayer of your ever affectionate and dutiful son,

JAMES WATT.

[150.]

MR. BOULTON TO MR. WATT.

[June, 1775.]

I have had a touch with the engine to-day. We took the lead-weights off the papier-maché, and put on the old light cast-metal ones, which hath lessened the friction in the cylinder much.

N.B. The papier-maché lies within *hat*, i. e. it is hat that is in contact with the cylinder, and seems to do very well. I really could not find any fault with either piston or steam-valve. We set to work and very soon made eleven strokes per minute.

The heat of the water running into the cistern was 66° , and in some parts of the cistern 68° , and the running-out water was 80° . The steam raised the mercury to near nine inches, when it made eleven strokes; but upon loading the safety-valve so as to raise the mercury to 10 and $10\frac{1}{2}$ inches, the engine made twelve strokes per minute. Although the running-out water was 80° , yet there is no doubt but the water in the pipes at the time of condensing is above 100° . I presume the present deficiency arises in the condenser. I think it should be larger, and I think some sort of *meter* should be annexed to it, by which one may see the rate of vacuum; suppose a glass tube. I took all the lead pins out of the condenser; but there was neither alteration in the number of strokes nor in the heat of the water. The thermometer, when lying upon the holes in the condenser, stood at 84° . You will please to remember that when you last tried the engine, the coming-in water was about 40° instead

of 66° or 68°, which makes much difference in condensing. *Quære*, if we should try black-lead dust upon the piston, as it works well with iron? *Quære*, how would you have the flanches to the wood pattern of the wheel made? Give us directions, as it is now ready. I think these engines will work to loss when they exceed twelve strokes. My respects to the Doctor.

[151.]

MR. BOULTON TO MR. WATT.

June, 1775.

I received yours to-day, and am glad you are tired of London, that you may relish Soho the better. I have only time to say a few words upon this day's going of the engine: 500 strokes per hour as per clock counter; 1 cwt. of coals brought the water to boil and engine to work; 1 cwt. of ditto burnt in 50 minutes; 1 cwt. of ditto burnt in 80 minutes; 9 to 12 inches high the mercury in the gauge; 68° of heat coming-in water; 80° going-out water: only 12° gained. No leaks; the piston and valve good; the piston can't leave the papier behind, as it's enclosed in hat, and iron weight lying upon it. I think we must contrive to have all the cold water raised out of the mine pass through the condenser, for I believe the present imperfection arises chiefly from want of more cold. Upon reflection, I think the stamping of thin plates, as you proposed, would make good condensers, thus



[152.]

MR. BOULTON TO MR. WATT.

[June, 1775.]

* * * *

I have for the last two days worked the engine with a mercurial gauge to the condenser, which rises to 28 inches high, and sometimes $28\frac{1}{2}$, sinking at each stroke about three inches, and then rising again. When we work the pumps by hand, the gauge will not rise so high as when worked by the engine, because the latter takes rather a longer stroke; from which I am entirely of your opinion that new pumps, with longer strokes, will render our vacuum more perfect, and I likewise conclude that the condenser ought to be double the size. In working engines at mines, one may always procure cold water; but in the present case large condensers and large quantities of water are necessary. The pressure on the present piston must be nearly equal to a column of mercury of 38 inches high, because the vacuum raises it 28 inches, and the elastic force of the steam raises its gauge from 10 to 11 inches high. I am preparing a double cock, agreeably to your directions; but the vacuum cock must be shut when the piston ascends, and opened each time it descends, otherwise you would blow the mercury out of your bason. The present gauge is amusing to look at, is not liable to disorders, and shows you every minute disorder of the condenser. It answers very well, yet nevertheless we will have both. I have not measured the coals to-day, but will to-morrow. We have greased the piston, and put black-lead powder. The hat seems to do very well,

for we examined it this morning, and all was right. I don't think the regulating valve bad; but if you have contrived a better I shall be glad, as I am sure it will be a good one. We have a gauge to see the decrease of the water in the boiler; but it moves in a jack-head, and doth not move freely. Joseph hath just been to inform me that the engine goes very badly, although the steam is 11 inches high, owing to the valves of the condenser-pump not opening and shutting properly, which he is going to alter. Certain it is that the condenser and its pumps are the very vitals, nay, the very soul of the engine, and therefore they should be so made as not to be liable to disorder. * *

I am vexed about the Doctor's fickleness, and, I think, unreasonableness. I begin to think there was more in the hint given me about him than I then thought of, viz., *he will always stick by his friends, whether they will or no*; i. e. he will never loose his hold, but will for ever keep some claim upon them. There are certain burthens one may cheerfully carry through life; but so soon as they begin to gall one, and one finds they can't be shuffled off, it excites one to run rusty. I wrote my undisguised sentiments to Mr. Matthews* last night, to which I refer you. To-day I have received a letter from Mr. Matthews, which confirms in some degree the opinion I am beginning to form of the Doctor. I perceive *they* don't quite agree in what shall be called the first 1000*l.*; but in order to

* Mr. Boulton's banker in London.

settle that matter, it shall be the very first 1000*l.* profit, without repayment of any that is already sunk, that arises from and after the day on which you and I commence our partnership for profit and loss. As to your third of that thousand, I will account to you for it, because I have no right to give away your share of it; but I am determined that I will not have a twenty-five years' partnership with the Doctor and his trustees, &c., but will draw a positive line at all events.

[153.]

MR. BOULTON TO MR. WATT.

[End of Aug. or Sept.], 1775.

* * * * *

The engine makes 2000 strokes with one cwt. of coals. The piston remains good, and I think lacks no improvement. All the parts of the steam-wheel are screwed together with pasteboard, and the wood pattern for the axis we turned at Soho, and sent it to Littlegain to cast. The great water-pump from J. Wood's is arrived at Soho; but it must be bored, as it's not true. The copper bottom for Bloomfield engine is come, and Mr. Hurst promises to forward the others directly. The new forging-shop looks very formidable; the roof is nearly put on, and the hearths are both built. The two small 7-inch pumps for our own condenser are this day arrived; but we can't bore them until we have got a block cast for fixing the boring-knives in, which I shall hasten. Wilkinson hath been here, and says that all his neighbours are impatient to see the event of his

engine. Some, he says, have suspended their new erections until his is finished; and all of them, he is sure, will have their engines altered, which he says will be a better trade than new erections, and that work alone will be sufficient for our lives. I like his warm enthusiastic zeal. * *

[154.]

MR. BOULTON TO MR. WATT.

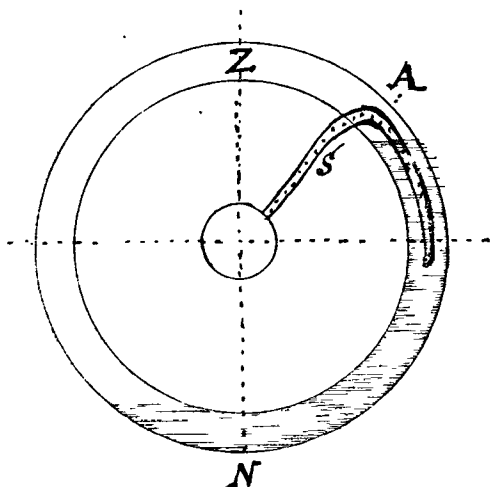
Soho, Feb. 24th, 1776.

* * * *

I observe you are thinking of making an inverted cylinder. Pray how are you to counterbalance the descent of the piston and pump-rods, which will be a vast weight? If by a counterweight, you get nothing; but if you can employ the power that arises from the descent of that vast weight to strain a spring that will repay its debts,—if by it you can compress air in an iron cylinder, which in its return will contribute to overcome the *vis inertiae* of the column of water to be raised, you thereby will get quit of *that* unmechanical tax, and very much improve the reciprocating engine. But how to make your piston steam-tight requires——I know not what. * *

There seems to be a vacancy in our great smith's shop at present, and therefore I intend on Monday morning to divide the wheel-engine amongst them, and get it finished out of hand. I forget the specific gravity of our metal; but I fear it's so light as to rise above the centre of this wheel, and so run out at the three steam-pipes; at least you'll be confined

to work with a weak steam; but that defect may be remedied by making the pipes bent thus :



Hence the fluid metal may rise, if necessary, as high as A; the steam-pipe S may be continued by the side of the wheel up to A, and then turn toward the axis.

You seem to think of setting the engine to work by the end of the week; but from your own account of what is undone, I think you will not quite so soon.

Pray, tell Mr. Wilkinson to get a dozen of cylinders cast and bored, from 12 to 50 inches diameter, and as many condensers of suitable sizes; the latter must be sent here, as we will keep them ready fitted up, and then an engine can be turned out of hand in two or three weeks. I have fixed my mind upon making from twelve to fifteen reciprocating, and fifty rotative engines per annum.

The Empress of Russia is now at my house, and a charming woman she is. * *

[155.]

MR. BOULTON TO MR. WATT.

Soho, [Mar. 1776.]

* * * *

I have had Mr. Henderson with me all this day, and have shown him such performances of our engine as have quite depressed his spirits and excited in a strong degree my compassion. He is almost at the Land's End, and distress will overtake him unless some scheme or other answers. He exhibited his tin-wheel over our parlour fire; little Matt. stood by, in high expectation of seeing it; at length it began to creep about three or four revolutions per minute, at which Matt. expressed his disappointment rather too strongly. However, poor Henderson gave him the wheel, and I fancy it will be the last model he will make. I yesterday tried the burning of 30 lbs. of coke, but it did not do quite so much as the same weight of coals. I repeated the experiment of burning 60 lbs. of coals; each 60 lbs. evaporated ten feet of water and made 1800 strokes each, i. e. 3600 strokes with one cwt. of coals, by which you'll see that there was less steam lost than in any former experiment. Each half-hundred of coals lifted lasted 2 h. 24 m., in which time there were 23 lbs. of water condensed in the outside cylinder; and it appears, by experiments made before the cylinder was clothed, that 90 lbs. were condensed in the same time, and 70 lbs. by another, so that the clothing has reduced that

loss two-thirds. * * Pray let the hairy coat of your cylinder be at least three inches thick.

[156.]

MR. BOULTON TO MR. WATT.

[March, 1776.]

I rejoice at the well-doing of Willey engine, as I now hope and flatter myself that we are at the eve of a fortune. I wish to see you at Soho as soon as possible; there are many things want you, and I find myself exceedingly hurried. People are daily coming to see the engines. Cornwall begins to inquire how we go on. I will reserve particulars until I see you. * *

[157.]

MR. BOULTON TO MR. WATT.

Soho, July, 1776.

* * * *

It may be difficult to say what is the value of your property in partnership with me. However, I will give it a name, and I do say that I would willingly give you two, or perhaps three thousand pounds for the assignment of your third part of the Act of Parliament. But I should be sorry to make you so bad a bargain, or to make any bargain at all that tended to deprive me of your friendship, acquaintance, and assistance, hoping that we shall harmoniously live to wear out the twenty-five years, which I had rather do than gain a Nabob's fortune by being the sole proprietor.

I would without hesitation have sent you the assignment and the article of partnership, had it been in my power; but Mr. Dadley, the lawyer,

is suddenly called to London, and it cannot be had before his return; but if you want to show it to any of your friends, you may give them a copy of the following heads, which I have extracted from our mutual missives, and are to the best of my knowledge all that our articles contain:—

1st. You have assigned to me two-thirds of the Act of Parliament, on the following conditions:

2nd. I to pay all expenses of making all the experiments, and of obtaining the Act of Parliament, and all other expenses relative to the engine which were incurred before June, 1775; and I am also to bear all the expenses of future experiments, and all such money is to be sunk by me, and not to bear any interest, nor be carried to my account with you; but the experimental machines are to be my property, as they are purchased at my expense.

3rd. I am to advance all the stock necessary for carrying on the engine trade, for which I am to receive lawful interest.

4th. The profits arising from the trade, after paying or deducting interest, (as in 3rd,) workmen's wages, and all debts owing by our engine trade, to be divided into three parts; you are to take one-third, and I to take two-thirds.

5th. You are to make drawings, surveys, and give directions; the engine company to pay travelling expenses when upon business.

6th. I am to take care that the books are kept accurately, and that they are balanced once a year; and I am also to assist in managing workmen, making bargains, or doing whatever we may jointly think is for the interest of the trade.

7th. A book to be kept wherein are to be entered such transactions as are worthy of record, and, when signed by us both, to have the same force as our articles of partnership.

8th. Neither of us to alienate our shares without the consent of the other; and if either of us should die, or be incapacitated from acting for ourselves, the other is to be sole manager, without control of heirs, executors, or assigns; but the books are to be subject to their inspection, and the acting partner to be allowed a reasonable commission for his extra trouble.

9th. The contract to continue in force for twenty-five years from the 1st of June, 1775.

10th. Our heirs, executors, &c., are bound to observe the contract.

11th. In case we both die, our heirs, &c., to succeed upon the same plan.

This is the essence of all that is contained in our articles of partnership; but, being fearful of losing the post, I have written in a great hurry, and have but ill expressed myself. I wish I had more time to tell you all the circumstances that have occurred in the engine trade, but that shall be the subject of my next. All is well, and you'll be quite charmed at the simplicity and quietness of Soho engine. * *

[158.]

MR. BOULTON TO MR. WATP.

Soho, 10th of July, 1776.

* * * *

Our copper bottom hath plagued us very much by steam leaks, and therefore I have had one cast,

with its conducting pipe, all in one piece; since which the engine doth not take more than ten feet of steam, and I hope to-morrow to reduce that quantity, as we have just received the new piston, which shall be put in and at work to-morrow. Our Soho engine never was in so good order as at present. * *

[159.]

MR. BOULTON TO MR. WATT.

Soho, July 25, 1776.

* . * * *

I have an application for an engine from a distiller at Bristol, to raise 15,000 ale gallons per hour 60 feet high; I have another for a coal mine in Wales, another for a Mr. Langdale, of Holborn, a distiller, and another for Mr. Liptrap, at Mile End, a distiller. The wheel-engine is ready for trial, except the steam-pipe; the boiler is set, and many wheels will be wanted so soon as they are ready for sale. I did not sleep last night, my mind being absorbed in STEAM; and thus I reasoned in my waking dreams:—

Power of one atmos- phere costs . . . }	1012°	of heat or of money, } which amount to }	1012	per atmosphere.
	40			
Do. of two	1052	„	526	„
	23	„		
Do. of three	1075	„	358	„
	15			
Do. of four	1090	„	272	„

Hence the price of the power of one atmosphere is reduced from 1012 pence, or shillings, to 272 pence, or shillings, which is almost four times better. Then as to boilers and steam-pipes, let them be as strong as cannon; but as the fire will not be applied so advantageously through thick metal, let it be applied in copper spheres within the water, and then four or five atmospheres will not compress such forms. The great boiler may be framed with scantlings of cast-iron, well screwed together with wrought-iron plates half-inch thick, well fitted and screwed within; and then, the greater the elastic force of the steam, the closer they will be pressed, as the lid of a digester is. As to the piston, it may be laid with asbestos cloth, if oakum will not stand the heat, and by this means the present construction of engine will do. But certainly it's a desirable thing to invent an engine to work with the expansive and contractive power of steam, as I am clear the principle is sound. * *

[160.]

MR. BOULTON TO MR. WATT.

[1776.]

* * * *

If we had a hundred wheels ready made, and a hundred small engines like Bow engine, and twenty large ones executed, we could readily dispose of them. Therefore let us make hay whilst the sun shines, and gather our barns full before the dark cloud of age lowers upon us, and before any more Tubal-Cains, or Watts, or Dr. Fausts, or Gains-

boroughs, arise, with serpents like Moses', that devour all others. * *

When we have got our two-foot pumps, I think it would be right to try our Soho engine with a steam strong enough to work the pumps with the axis in the centre of the beam, which will be almost 19 lbs. upon the inch. * *

[161.]

MR. BOULTON TO MR. WATT.

Soho, Nov. 31, 1776.

* * * * *

We have a positive order for an engine for Ting-Tang mine, and from what I heard this day from Mr. Glover, we may soon expect other orders from Cornwall. Our plot begins to thicken apace, and if Mr. Wilkinson don't bustle a little as well as ourselves, we shall not gather our harvest before sunset. * * I perceive we shall be hard pushed in engine work, but I have no fears of being distanced, when once the exact course or best track is determined upon. * *

[162.]

MR. BOULTON TO MR. WATT.

20 April, 1777.

* Smeaton said it [the engine at Stratford-le-Bow] was a pretty engine, but it appeared to him to be too complex. But that might in some degree be owing to his not clearly understanding all the parts. * * Smeaton intimated to Hadley that he could improve the common fire-engine very

much, and that he had a new scheme which he is going to apply to York Building engine; but Hadley says he doth not know what it is yet.

[163.]

MR. WATT TO MR. BOULTON.

Birmingham, 2 May, 1777.

* * * *

The sum of intelligence concerning Perrier is, that, through interest, he has obtained the King's *arrêt* empowering him to raise water from the Seine to supply Paris, and erecting a company, copy of which I shall send you; that W. Wilkinson went over to solicit order for the pipes, &c.; that Perrier, when he went to Broseley, was resolved to have common engines; that afterwards he was convinced that ours were much superior, and then wanted Wilkinson to make them for him, as he did not see the use of applying to us, being out of our jurisdiction; that W. represented that he would be liable to prosecution, and that he was bound by honour and interest not to do it but through us; that W. thought, as being out of our jurisdiction, we should serve Perrier upon moderate terms, should take out our premium in *actions*, which would be saleable as bearing 6 per cent. interest; that W., if employed for pipes, &c., takes 100 shares at 50*l.* each.

I answered that Perrier had not behaved to us with prudent openness or consideration, and had attempted bribing people to betray us at London; that we had friends in France of interest, who had

long ago assured us of the protection of the Crown, and that the State would see the propriety of having us to erect our own machines; and that if they did not, we would not serve Perrier so cheap as if they did; that some of our principal secrets were still in our own breasts; that it was more our interest to work at home, without France was secured to us; that you had, upon a suspicion of Careless going to Russia, procured proper warrants to secure him and his bribers, even though he was an useless, drunken fellow; that Wilkinson's interest, as well as ours, lay in our having a patent for France: all which he seemed to be convinced of, and offered his assistance in procuring one, which I declined, alleging we could do without it. Perrier has met with great opposition from great folks, and if we were to make propositions to ministry, we might be heard, and have the interest of his opponents; among the rest, the Académie des Sciences. Perrier is a smith to trade, and reckoned a man of ingenuity; but his scheme is undigested, and he is ignorant even of the proper method of conducting the water.

The Lieutenant of Police is the ultimate judge of disputes in Perrier's scheme. Rather than fail, suppose we were to erect one or two engines for Perrier upon easy terms, provided he and his interest concurred in securing our property in France.

* *

[164.] MR. WATT TO MR. BOULTON.

Birmingham, May 3d, 1777.

* * * *

Wilkinson is going to work in the forge way, and wants an engine to raise a stamp of 15 cwt. thirty or forty times in a minute. I have set Webb to work to try it with the little engine and a stamp hammer of 60 lbs. weight. Many of these *battering rams* will be wanted if they answer. * *

[165.] DR. ROEBUCK TO MR. BOULTON.

Kinneil, Bowness, Oct. 30, 1777.

DEAR SIR,—I had the pleasure to hear of the success of your engine, and that you had got commissions from Cornwall. I should be glad to have the report confirmed by yourself. It will give me much satisfaction to hear that you and Mr. Watt have a substantial return for the great fatigue and risk which you have undergone in this adventure. * *

[166.] DR. PATRICK WILSON * TO MR. WATT.

Glasgow College, July 2d, 1778.

The Abbés Boscovich, Fontana, Rochon, Maskelyne, are a very creditable junto of philosophers,

* Dr. Patrick Wilson was the second son of Dr. Alexander Wilson, celebrated not only for his accurate and ingenious observations on the solar spots, but also for having introduced a new era in the art of type-founding in this country : (see Humboldt's *Cosmos*, vol. iii. pp. 273 and xcvi ; *Phil. Trans.* for 1774, vol. lxiv. pp. 6-13 ; Preface to the *Foulis*

who are at present drawing some attention as inventors of a prismatic micrometer. My father and I feel a wish of seeing your name added to that band of improvers. Your invention, though

Homer, vol. i. p. viii; and the interesting biographical memoir published in Brewster's Edinburgh Journal of Science for Jan. 1829, pp. 1-17.) The son shared largely in all his father's pursuits, and in 1786 became his successor in the astronomical professorship at Glasgow. His aptness for philosophical experiments was made favourably known by his paper in the Phil. Trans. for 1781 (vol. lxx. p. 451), entitled 'An Account of a most Extraordinary Degree of Cold at Glasgow in January last; together with some New Experiments and Observations on the Comparative Temperature of Hoar-frost and the Air near to it, made at the Macfarlane Observatory belonging to the College;' together with 'Further Experiments on Cold,' &c. (Phil. Trans., vol. lxxi. p. 386); and 'Experiments and Observations on a remarkable Cold which accompanies the separation of Hoar-frost from a clear Air' (Trans. of the Royal Society of Edinburgh for 1788, vol. i. p. 146), as well as by his paper, also published in the Phil. Trans. (for 1782, vol. lxxii. p. 58), proposing an 'Experiment for determining, by the Aberration of the Fixed Stars, whether the Rays of Light, in pervading different media, change their Velocity according to the law which results from Sir Isaac Newton's ideas concerning the cause of Refraction, and for ascertaining their Velocity in every medium whose refractive density is known.'

Having in 1799 resigned the chair of Practical Astronomy in order to go and reside near London, in the society of the Herschels and other friends distinguished in pursuits congenial to his own, he on that occasion, "as a mark of his high regard" for the learned body "so long and so intimately known to him, and in testimony also of his desire for the future prosperity of the office of Professor of Practical Astronomy in the said College, which was first filled by his ever-honoured father," endowed the University of Glasgow with a fund of considerable amount, for the purpose of purchasing astronomical books and apparatus, as well as of bestowing occasionally a gold prize medal on meritorious students of his favourite science. Dr. Patrick Wilson died at Kensington, 31st December, 1811. (See 'Deeds instituting Bursaries, Scholarships, and other Foundations in the College and University of Glasgow.' Privately printed for the University. 1850. pp. 253-258.)

very little known, was several years prior to any of theirs. If you choose to assert this priority by any publication, it will give us great pleasure to contribute our evidence in your favour. * *

[167.]

DR. W. IRVINE TO MR. WATT.

Glasgow, July 2d, 1778.

* * * * *

Pray have you seen the last volume of the Transactions? You must surely know that it contains the description of a certain micrometer, that shall be nameless, made by one J. Watt six or eight years ago, and which has been in Macfarlane's Observatory in Glasgow for several years past. Would you not think it proper that the said J. Watt should claim this discovery? And as the authors of these papers in the Transactions have brought witnesses, he might bring Dr. Reid, Dr. Wilson, Pat. Wilson, G. Hamilton, &c., who are ready and willing to attest the same, and who are surely as respectable as Pat. Dollond and ——— Aubert; and to make the whole still stronger, I should imagine you could have no objection to join in the attestation. You may perhaps despise such unprofitable inventions; but to others they will procure fame, and perhaps fortune.

I am exceedingly happy to hear from various quarters, where you are not connected, that your engines answer well and give general satisfaction. I have now little doubt that they will supplant

the common engines entirely, and that long before that time you may retire to your *terre, et vivre comme il plait à Dieu.* * * I have lately made divers experiments on various subjects, some of which have led to tolerable notions; the rest are curious facts, but have hitherto amounted to no more. Of this last kind is the forming artificial stone from sand and the fluor acid; but of these I shall write you some other time, as you have too many notions of your own to attend to those of other people. * *

[168.]

MR. WATT TO DR. BLACK.

24 July, 1778.

* * * *

Our engines answer now in every respect, except the getting us money fast enough; they begin to do a little in that way, and promise exceeding fair, but the rascality of mankind is almost beyond belief. However, I perceive perseverance and dunning will conquer even that when one has a good cause. Mr. Garbett lately did us the favour to settle between a company here and us a bargain by which we get 217*l.* per annum where they had the effrontery to offer us 30*l.* a year not long ago.

I have lately discovered a method of copying writing instantaneously, provided it has been written the same day, or within twenty-four hours. I send you a specimen, and will impart the secret if it will be of any use to you. It enables me to copy all my business letters. * *

[169.]

MR. WATT TO MR. BOULTON.

Redruth, August 6th, 1778.

* * * *

I return you Jary's offer enclosed. I would adhere to our first demand and terms, otherwise we must lose money by the mere going to see the engine. As to contracting to be ready in September, we cannot do it; but he may be put next in course. As to his being the first in France, I look upon that as nothing, as it would be much our interest to erect no engines next year, but to take care of and settle those erected, which otherwise we shall not be able to do. * *

In relation to the Parisian engine, (for I would have nothing to do with the Dutchman at the Moere,) the first article is to find out some use for such a machine, otherwise it would be so much money, say 700*l.* or 800*l.* thrown away, perhaps upon nothing; for if we are to judge of the French by Jary, they will not be the most generous payers in the world. However, that we may not lose the benefit, if any can accrue, I would immediately begin and keep up a correspondence; perhaps a model would please them, and indeed I think something of that sort might be made to surprise more than even a large engine, particularly as all its parts could be measured and viewed more easily.

* * * *

[170.]

MR. WATT TO DR. BLACK.

Redruth, 12 Dec. 1778.

* * * *

I should long ago have written you of my proceedings, but did not think that what I could impart merited much attention from you; for though we have in general succeeded in our undertakings, yet that success has from various unavoidable circumstances produced small profits to us. The struggles we have had with natural difficulties, and with the ignorance, prejudices, and villanies of mankind, have been very great; but, I hope, are now nearly come to an end, or vanquished.

Mr. Smeaton has behaved with the utmost candour and friendship, and has even recommended a customer to us more than once.

Our success here has equalled our most sanguine expectations; we have succeeded in saving three-fourths of the fuel over the engines here, which are the best of the old kind in the island. The large engine at Chacewater, lately finished by us, is 63 inches diameter, has a 9-foot stroke, makes when going out of hand under its full load 11 strokes per minute, works a pump of 17 inches diameter and 53 fathoms deep, and moreover puts in motion a very strong connection-rod, 25 fathoms long, before it comes to the pump head, which rod, and the others which belong to three lifts of pumps, weigh above nine tons, the *vis inertix* of which, and its counterpoise, demands a very considerable

power. This engine, when going at the above rate, burns 128 bushels of Welsh coals per 24 hours. We have agreed to take 700*l.* per annum for our part of the savings by this engine.

The water of this mine formerly baffled two engines, one a 66 and the other a 64; but though this is the rainiest season, and the water the most plenty below ground, we keep it very well under hitherto. But that you may know what a job it was, we were three months going at the above rate in forking or unwatering the mine; the whole country declared it impossible, some on account of the known great quantity of water, and others from a belief that the engine could not work the pump to that depth.

An universal confidence of the whole county in the abilities of the engine is now fully established, and we have executed agreements for several others, one of which will pay us better still, and is also to do the work of two other engines larger than itself. Several mines, formerly abandoned, are likely to go to work again through virtue of our engines; we have five engines of various sizes actually going here now in this county, and have eight more in contemplation, so that our affairs wear a most smiling aspect to human eyes.

Le Roi de France, dans son Conseil, nous a accordé un privilège exclusif pour faire et vendre ces machines en France; and we have now an engine actually under hand for that kingdom; but this *entre nous*. Our affairs in other parts of England go on very well; but no part can or will pay us so

well as Cornwall, and we have luckily come among them when they were almost at their wit's end how to go deeper with their mines. * *

[171.]

MR. WATT TO DR. BLACK.

Birmingham, 13 Jan. 1779.

* * * *

Mr. Boulton brought with him a Mr. Perrier, engineer, from Paris, who has bargained with us for engines to raise water to that city; which we have found ourselves obliged to grant him on very moderate terms, because our *arrêt* not having yet the force of a patent, we durst not risk any opposition. Mr. Perrier stuck so close to me to get his plans concerted, that I had not an hour for conversation with Mr. B. during his stay. * *

Our business in France is only in its infancy yet; that is, we have obtained an *arrêt* of the King and Council for an exclusive privilege; but that cannot have the force of a patent until we have erected an engine, and, after trial made thereof, it has been reported by certain Commissaries, appointed by the *arrêt*, that our engine is superior to the common one, which we hope will easily be proved. We have agreed with a Mr. Jary that the trial engine shall be erected at a colliery he has near Nantes, in Brittany; and Mr. Jary, who is a very ingenious man, possessed of the necessary previous knowledge, has undertaken the care of the erection himself, all to the finishing, which will require the attendance of some person prac-

tically acquainted with the putting our engines together. Until this matter is finished, our property in the invention in that kingdom is dubious.

* * * *

The anxiety which I have suffered since I began this [the engine] business has been exceedingly great, as the difficulties have also been. It now begins to assume a more pleasing appearance; but as it has unavoidably incurred a very considerable debt, we cannot with propriety call the profits our own until that debt be discharged, which I hope will soon be the case. Another campaign in Cornwall will, I expect, do very great things; but to my sorrow I find, that as business increases, my cares increase in the same ratio, which in a very considerable degree prevents the enjoyment of life.

* *

[172.]

MR. WATT TO MR. BOULTON.

[Redruth], Feb. 12th, 1779.

Yesterday I sent per coach the drawings for Mr. Jary, packed up in a tin case, and directed to Mr. Magellan's care. It will be necessary to advise Mr. Jary by whom they are sent, that he may know to send after them.

* *

[173.]

MR. WATT TO MR. BOULTON.

Birmingham, June 27th, 1779.

Mr. Garbett called yesterday to have a proof of my copying to send to Mr. Payne. I sent him one

or two, but was remarkably unsuccessful by being hurried and over-zealous. I fancy he would not send them by what I said in my letter to him. I shall comply with your desire to-morrow, and hope to be more lucky.

[174.]

MR. WATT TO MR. BOULTON.

Birmingham, June 28th, 1779.

I send you enclosed some of Mr. Nobody's draughts, with authentic copies of them. * *
The copy will continue to grow blacker as other writing does, and I fancy you will find the originals rather blacker than they were before copying, and, as far as I can judge, not in the least defaced. * *

[175.]

MR. WATT TO DR. DARWIN.

Birmingham [*], 1779.

* * * *

I have fallen on a way of copying writing chemically, which beats your bigrapher hollow. I can copy a whole-sheet letter in five minutes. I send a copy of the other page enclosed for your conviction, and I tell you further that I can do still better than that copy. * *

[176.]

MR. WATT TO DR. BLACK.

2 Dec. 1779.

In relation to the copying scheme, the state of it at present is as follows :—I have given in a petition

* Without further date.

for a patent, and it is now in train; but as my occupations and health cannot permit me to follow that business myself, I have taken in two partners—Mr. Boulton, who is to be at the expense of the patent, and Mr. Keir, who is to manage the business.

In brief, the first idea was the forcing the ink through thin paper, so as to appear on the other side; the second, the improving the colour by wetting the paper with an astringent; the third, the depriving astringents of their colour, without depriving them of their effects as astringents; fourthly, managing the operation so as to prevent the original being defaced, or forced through to the other side: but the greatest part resides in the mechanical manœuvre. All this to yourself *only* at present.

[177.]

MR. WATT TO DR. BLACK.

Birmingham, March 1st, 1780.

* * * *

I had lately a letter from Mr. Magellan. * *
 He made many inquiries about your latent heat, which I answered as far as was expedient. He wants to know when you invented it; I answered I could not tell, but that you taught it before the year 1763. He says that Bergman, of Stockholm, has published some memoir lately, in which he mentions “that a Professor Wilcke, of Stockholm, did publish nearly the same fact long ago, in the Memoirs of Stockholm Academy.” * *

[178.]

MR. WATT TO DR. BLACK.

Birmingham, March 9th, 1780.

DEAR DOCTOR,—I wrote to you the other day and mentioned that Mr. Magellan had written to me for some account of your discoveries, to which I had given such an answer as I thought was a prudent one; that is, I did not enter minutely into the subject, and told him the time I knew you taught it publicly. To-day I have another letter from him, telling me he has been so much harassed writing to his friends abroad concerning these new discoveries, as published by Dr. Leslie and Dr. Crawford, that he is printing in French a short account of them, in which he means to attribute the discovery to Professor Wilcke, and only to mention you in so far as your scholars have quoted you, which I think in all conscience is sufficiently little.* They seem to have been too full of their own theories to do justice to yours. I have written to him in answer, and insisted that he should do you justice as the first inventor.

Magellan is, I believe, well meaning, but no philosopher; a mere gatherer of scraps and a bad

* Professor Playfair says that, "of much that Dr. Black had done, the world had never heard anything but from verbal communications to his pupils; and on the subject of latent heat, no written document remained to ascertain to him the property of that great discovery." (Life of Robison, p. 170; Works, vol. iv.) Sir James Mackintosh also, after speaking of Black as "a man equally philosophical in his character and in his genius, the father of modern chemistry," adds that "his modesty and his indolence will render his name celebrated rather by the curious in the history of that science than by the rabble of its cultivators." (Autob. in Memoirs of Mackintosh, vol. ii. p. 21.)

writer ; but as he has an extensive correspondence, he may circulate erroneous doctrines to the prejudice of your honour. I have therefore done my endeavour to stop him ; and if you choose to furnish me with a few facts relative to the time, &c., of your invention, and an account of any publications in which it has been mentioned, I will cause him to publish them as from myself. I am really much vexed that you have let so many plagiarists rob you of the honour of the greatest discovery this age has produced ; but it is not yet too late to do well. I would write you the results of some experiments Dr. Withering here has made on heating iron red-hot by hammering (at my instigation) ; but my head aches. Let it suffice that they confirmed your theory, and were similar to what you once told me.

I have seen Bergman's book ; the date of Wilcke's publication is 1772. Bergman says very little on it, only that the heat thrown out by water in freezing is 72° of the Swedish thermometer.

I mentioned to Magellan that there have been several Swedish and Danish students at Edinburgh who understood your theories ; shall be obliged to you to confirm that by naming them. I ever remain, dear Doctor, your affectionate friend,

JAMES WATT.

[179.]

DR. BLACK TO MR. WATT.

Edinburgh, 15th March, 1780.

DEAR WATT,—I am in your debt for two letters of a late date. In the first you mention your

having packed up a small cask for me with fluor, &c. * * The rest of that letter and the last are chiefly concerning the subject of Latent Heat and Magellan's purpose of publishing some history of it. Your anxiety with regard to this matter gives me the greatest pleasure, as it proceeds entirely from your friendship for me, and there is no person whose friendship I value more highly. As Magellan has already got a prejudice upon this subject, it may not be easy to set him right; but I hope his authority will not have very great weight in the meantime; and my present intention is to publish myself next summer, if my health allows me, which I confess easily suffers from working a little.

As you must answer Magellan's letter, however, I give you the following facts:—

I began to give the doctrine of latent heat in my lectures at Glasgow in the winter 1757-58, which I believe was the first winter of my lecturing there; or, if I did not give it that winter, I certainly gave it in 1758-59, and I have delivered it every year since that time in my winter lectures, which I continued to give at Glasgow until winter 1766-67, when I began to lecture in Edinburgh. The winter 1760-61, I had among my scholars the Honourable Mr. Fitzmaurice, brother to the Earl of Shelburne, and Dr. Menish, now settled in England; both of whom took notes, I believe, of many parts of my lectures. I was also attended the same year by Mr. George Farquhar, who is a surgeon in London,

and who went from Glasgow to Paris to finish his education. The following winter I was attended by Dr. Irvine and Pat. Wilson; and about that time, or soon after, I read a paper upon this subject in the Philosophical or University Club at Glasgow. The winters '62-63 and '63-64 I was attended with numbers of gentlemen at Glasgow, many of whom will easily remember this doctrine; and the winter '64-65 I had Simeon Desnitzky and John Tretiakoff, the Russian students then at Glasgow.

Since I came here, Dr. Crell of Brunswick, who is now engaged in some periodical publications, attended these lectures in November and December, 1769; and in the same months of the year 1772, Dr. Henry Gahn from Sweden attended my course. I do not remember any other foreigners than the above, but could bring a multitude of other evidences to prove the early date of my doctrines on this subject; and I should reckon the testimony which you can give as equal to the greater part of them, you having been early acquainted with, and directed by it in your pursuit of improvements upon the steam-engine, and incited to make experiments with regard to it.

In your last letter from Cornwall you mentioned your being very busy about the Whéal Virgin mine; pray did you come to an agreement with the company?

I am ever, my dear Sir,

Yours affectionately,

JOSEPH BLACK.

[180.]

MR. WATT TO MR. MAGELLAN.

Birmingham, May 3d, 1780.

* * * *

You ask where I found the word "*plumali*?" Not in Cicero, I assure you; but at the end of the first edition of his Offices, printed 300 years ago by John Fust. It is part of some self-praise he indulges himself in, and I took the liberty to follow him, though not *pari passu*. He says, "*Non Atramento aut Plumali Canna sed Arte quâdam Novâ fecit Mogunticæ Johannes Fust.*" I quote from memory, and it is fifteen years since I saw the book; so perhaps I may have been mistaken; but if it be not a Latin word, it *might* have been one if Cicero had used it! * *

[181.]

MR. WATT TO MR. BOULTON.

Birmingham, May 4th, 1780.

* * * *

Another letter from Mr. Jary, concerning the forwarding of his machine. He mentions that Mr. Perrier's brother had been at Nantes and had seen his brother, and had told him that they were to erect three fire-engines, whereof one according to our plan, and the two others with "*changements qu'il avoit imaginé.*" If we mean to keep this our kingdom of France in proper subjection, it will be necessary that one of ourselves go over there soon; and if our subjects do not declare independence, leave some person in power to govern them: suppose Le Camus, as being Heronville's friend.

[182.]

MR. WATT TO DR. BLACK.

Birmingham, 25 Oct. 1780.

I am sorry that I cannot give you so good an account of our gains as you have heard. Our income, *if regularly paid*, would be perhaps about 3000*l.* per annum, but it is not so : there are many deductions to be made, and the expense of carrying on the business is great, as are our debts. However, our prospects are brilliant ; our income increases yearly, will have a considerable increase soon in Cornwall, and a much greater one when Wheal Virgin mine sets to work ; about a year hence they are to pay 2500*l.* per annum, and Poldice, which will go on at the same time, 1500*l.* My situation hitherto has been of the most uneasy sort ; and I am so habituated to disappointment, that even these splendid prospects cannot raise my spirits to par. Farewell.

[183.]

MR. WATT TO MR. BOULTON.

Birmingham, Oct. 31st, 1780.

* * * *

You have had occasion to know my sentiments from the beginning ; and know that, in place of this Act, which is such a grievance to them [the Cornish adventurers], I would willingly have taken 7000*l.*, and made the invention free to all men : but neither Parliament nor anybody else would then give me that sum ; though, by-the-by, I should not have put much of it in my pocket, yet I should have been much richer than I am now. After that, we have passed six years of a

most laborious and anxious life, and have spent many thousands of pounds in thoroughly establishing the powers of the engine to the conviction of all men; then the people who receive the greatest benefit from the invention, to whom we freely resigned two parts of the profits out of three,—those people propose to petition Parliament to take away the remainder! * * It appears by our books that Cornwall has hitherto eat up all the profits we have drawn from it, and all we have got by other places, and a good sum of our own money to the bargain. We have no power to compel anybody to erect our engines: what, then, will Parliament say to any man who comes there to complain of a grievance he can avoid?

[184.]

MR. WATT TO DR. DARWIN.

Birmingham, Jan. 3d, 1781.

I beg that you would impress on your memory the idea, that you promised to dine with sundry men of learning at my house on Monday next, and that you will realise that idea. For your encouragement, there is a new book to cut up; and it is to be determined whether or not heat is a compound of phlogiston and empyreal air, and whether a mirror can reflect the heat of the fire. I give you a friendly warning that you may be found wanting, whichever opinion you adopt in the latter question; therefore be cautious. If you are meek and humble, perhaps you may be told what light is made of, and also how to make it, and the theory proved both by synthesis and analysis.

[185.]

DR. DARWIN TO MR. WATT.

Beau-Desert, Jan. 6, 1781.

DEAR MR. WATT,—You know there is a perpetual war carried on between the devil and all holy men. Sometimes one prevails in an odd skirmish or so, and sometimes the other. Now, you must know this said devil has played me a slippery trick, and, I fear, prevented me from coming to join the holy men at your house, by sending the measles with peripneumony amongst nine beautiful children of Lord Paget's. For I must suppose it is a work of the devil! Surely the Lord could never think of amusing himself by setting nine innocent little animals to cough their hearts up? Pray ask your learned society if this partial evil contributes to any public good?—if this pain is necessary to establish the subordination, or different links in the chain of animation? If one was to be weaker and less perfect than another, must he therefore have pain as a part of his portion? Pray inquire of your philosophers, and rescue me from Manichæism.

As to material philosophy, I can tell you some secrets in return for yours; viz., that atmospheric air is composed of light, and the earth of water (and aqueous earth).* That water is composed of aqueous gas, which is displaced from its earth by oil of vitriol.

Pray make my best devoirs to all the Phlos., and pray tell Dr. Priestley that I wish he would

* Sic in orig.

try whether a plant insulated in ☿ will spoil air.

E. DARWIN.

[186.]

DR. PATRICK WILSON TO MR. WATT.

Glasgow College, Jan. 15, 1781.

I have never met with anything in the way of improvement which has given me more pleasure than your copying-machine; and I have become your debtor for one furnished me by Mr. G. Hamilton, now in use, and which I have strongly recommended to others.

The interest I take in everything relating to you, as one of our oldest friends, induces me on the present occasion to communicate some things which I flatter myself may not be unworthy of your attention, in the way of obviating some objections against the use of the machine. What I have chiefly in view relates to the preparing and moistening the paper. Many have said that a work of this nature is foreign to the train of things in a counting-house; and when set about in hurried seasons and in candle-light, would necessarily prove highly inconvenient. These kinds of surmises, which I had frequently met with in conversation before getting my machine, led me to think of a remedy which I have now tried, and found to answer well; and which has since reconciled many here very completely to your whole scheme.

My method is to prepare in daylight, and when at leisure, by the wetting book, as much paper as

will serve for a month, which I preserve in that state of moisture, by keeping the leaves betwixt boards of wainscot with TIN-FOIL next the paper. I have three sets of these boards, for the half-folio, quarto, and next size of paper; but the tin-foil is an inch beyond the leaves all round, so as to fold down; the more effectually to prevent the moisture from escaping. The uppermost board is loaded with sheet-lead, and the undermost has a handle, to draw them more conveniently from the under shelf of the copying-table, where they always lie when not in use. Yesterday I tried some sheets preserved moist in this way for 23 days, and the copy was extremely distinct and equal, owing to the moisture being more uniformly diffused than in the common way. * * But there may be still more commodious ways found of applying this principle in practice.*

It will be of importance also to the success of your sale that the rollers do not split in the keeping.† My two showed symptoms of this kind after the first three days in my room, upon which I immediately anointed the end wood with soft pomatum, which stopped the progress of the cracks.

* * * *

* As was accordingly done by the contrivance of *damping-boxes*, lined with tin foil or sheet lead.

† This refers to some of the first rollers, which were made of *lignum-vitæ*; but on the drawing attached to the specification they had been described as being “wooden or metalline;” and in practice, those of cast-iron, or in some cases of brass, were preferred and generally adopted.

[187.]

MR. WATT TO MR. MACGREGOR.

Birmingham, Feb. 4th, 1781.

DEAR SIR,—I send with this a drawing of the machine for drying linen, with explanations. It consists of three cylinders of copper which the cloth must turn over and under while they are filled with steam. I have also added to it a drawing of the method by which the water condensed may be returned to the boiler. The joinings of the parts may be made good with soft solder. * * I presume you understand the cloth is to be alternately wound off and on the two wooden rollers, by which means it will pass over the three cylinders in succession. * *

[188.]

MR. MACGREGOR TO MR. WATT.

Glasgow, March, 1781.

I duly received your much esteemed favour of the 4th ultimo, with a drawing of the machine for drying linen, for which I most sincerely thank you. I am greatly pleased with your method of getting clear of the condensed steam. I have shown your drawing to Dr. Irvine and Mr. Hamilton, who have cleared up to me some things I did not understand; and they have promised to give John Gardiner,* whom I mean to employ for the fitting up the machine, every assistance in their power. * *

* A mathematical-instrument-maker in Glasgow, of established ingenuity and repute, whom Mr. Watt had frequently employed.

[189.] MR. WATT TO MR. BOULTON.

Birmingham, April 2d, 1781.

* * * *

I think before we expose ourselves to any law-suit in the affair of the crank, we ought to have the advice of able counsel. I dare not make any new scheme lest we be betrayed again. * *

[190.] MR. WATT TO MR. BOULTON.

Birmingham, April, 1781.

* * * *

— when I know the contrivance [Wasborough's] is my own, and has been stolen from me by the most infamous means, and, to add to the provocation, a patent surreptitiously obtained for it. * * I know from experiment that the other contrivance, which you saw me try, performs at least as well, and has, in fact, many advantages over the crank.

[191.] MR. WATT TO MR. BOULTON.

Birmingham, 22 April, 1781.

* * * *

If the King should think Matt. Wasborough a better engineer than me, I should scorn to undeceive him ; I should leave that to Matthew. The conviction would be the stronger, as the evidence would be undeniable ! * *

[192.] MR. WATT TO MR. BOULTON.

Cosgarne,* June 28th, 1781.

* * * *

I have no objection to taking a patent for the ecliptics, &c., and shall, as soon as I can, make the necessary affidavits and transmit.

[193.] MR. WATT TO MR. BOULTON.

Cosgarne, July 26th, 1781.

Yesterday I went to Penryn and swore that I had invented "certain new methods of applying the vibrating or reciprocating motion of steam or fire engines to produce a continued rotative or circular motion round an axis or centre, and thereby to give motion to the wheels of mills or other machines;" which affidavit and petition I transmit to Mr. Handley by this post, with directions to get it past with all due expedition.

[194.] MR. WATT TO MR. BOULTON.

Cosgarne, September 3d, 1781.

I send enclosed drawing of double expansive engine, which I beg may be set about immediately. The drawing contains full instructions of all that concerns the working of it; and as to minutiae, you must do the best you can, as I cannot at present attend to them.

* In Cornwall.

[195.]

MR. WATT TO MR. BOULTON.

Cosgarne, 27 Sept. 1781.

* * * *

You desire my opinion about the questions to be put to Mr. Dunning. I think you should show him the Act, and have his opinion whether any man can [*i. e.* without infringing the patent] press down by steam on a piston, it having never been used but to press upon water or air:—secondly, whether a person condensing the steam in a separate vessel contained within the cylinder, or without the cylinder, but using no air-pump, but blowing out by steam, could evade us:—whether they could use oil as a fluid to keep the piston tight, it having never been used, except in small quantity to lubricate a new piston:—whether a patent would be good for using the expansion of the steam by admitting a smaller quantity than a cylinder-full, or if it could only be for the equalising beam or beams:—whether it would be a lawful evasion to mix other elastic fluids with the steam, or to use any one part of the invention without using the rest:—and whether any part of an invention being proved not new, would invalidate a patent as to the parts which were really new.

The method I propose to stop an engine when the pump-rods break, is by means of an air-bellows or forcing-pump, of a good large diameter, fixed in the shaft, and having a solid piston in it, which is wrought constantly by the engine, and quite easily

while it goes at its ordinary speed, because there is a large valve open in its bottom, or rather top, which suffers the air to pass and repass easily; but whenever the engine attempts to move quick, that valve shuts, and all exit for the air is cut off, and it becomes a feather-bed to save the blow of the engine. This is exemplified by turning the valve-hole of a common bellows upwards and stopping the nozzle, then working the bellows, first slowly and then quickly. I think this contrivance will be of great use, and may prevent damage; especially those bangs which occur in setting on an engine.

[196.]

MR. WATT TO MR. BOULTON.

Cosgarne, 1 Oct. 1781.

* * * *

If you have a notion that young Southern would be sufficiently sedate, would come to us for a reasonable sum annually, and would engage for a sufficient time, I should be very glad to engage him for a drawer, provided he gives bond to give up music; otherwise, I am sure he will do no good, it being the source of idleness. * *

[197.]

MR. WATT TO MR. BOULTON.

Cosgarne, 13 Oct. 1781.

I feared that Mr. Dunning would prove too much engaged to hearken to our affair with that attention he should, to approve of your having con-

sulted Mr. Palmer. You mention nothing of the forwardness of the rotative patent, nor whether you had laid our specification before Mr. Palmer, nor whether you had asked the question whether Savery and Blakey's pressing on the water by steam to be raised, can operate against our patent for pressing on a piston by it. * *

[198.]

MR. WATT TO MR. BOULTON.

Cosgarne, 15 Oct. 1781.

* * * *

I shall go on with the Irish patent as fast as you please, but must have instructions how I am to proceed, and particularly whether the affidavit can be taken before an English Master in Chancery. I cannot agree with Mr. Palmer's notion about the crank-engine; as, though a crank is not new, yet that application of it is new, and never was practised except by us.

[199.]

PROFESSOR ROBISON TO MR. WATT.

Edinburgh, Oct. 22, 1781.

I have twice written to you within these five months, and, as I have not received any answer, I am convinced that the letters have not come to your hands. My last related to an experiment on the gravitation of the earth, which I thought you would have an excellent opportunity of trying in Cornwall. Of this I shall write again very soon. I beg leave to trouble you on the subject of my first.

It was to solicit your employment for a young lad, a near relation of mine, Peter Ewart by name, who wishes to be educated as a millwright, or in any good branch of the business of a civil engineer. I could not find so proper a master as yourself, and I flatter myself that you would find him a very deserving pupil. His father is a clergyman near Dumfries, and has given the boy a very good education, but with other views. But the boy's inclinations are so much turned to mechanics, and his mind so much caught by anything of this kind, that we all agree that this is the line of business in which he is most likely to succeed. His constitution is healthy and strong, so that he is perfectly fitted for the hard labour by which he is to get his living. If, therefore, you can find employment for him, I shall look on him as setting out in the most favourable manner; and I will flatter myself that you will find some pleasure in being serviceable to the friend of an old acquaintance. What has made me write just now is, that the Countess of Hopetoun has written in his behalf to Mr. Boulton, and has referred to my recommendation of him to you: this will be unintelligible to you both, if my letter on the subject has miscarried.*

* Note, on a separate paper, by Mr. Watt:—"Mr. Professor Robison's letters, 1805. No letters in my possession prior to Oct. 2nd, 1781: that letter mentions two others, which I seem not to have received, and recommends Mr. Peter Ewart to our service as a millwright or engineer. The answer to it does not appear, but I believe I recommended him to learn the business as far as he could in Scotland first." For an authentic and interesting sketch of the life of Mr. P.

[200.]

MR. WATT TO MR. BOULTON.

Cosgarne, 1 Nov. 1781.

I send you enclosed three yards of the specification, and have about one yard more to send, which is the explanation of the drawings. I have written the whole over so often, and have scratched out and put in, that, in order to save the labour of writing so many sheets of paper, I have tacked the copies together, after cutting out the errata. You may perhaps think the specification long, but I can make it no shorter, to be full and complete as the law requires; and we had better pay something extra than have the patent non-effective. I submit it, however, to your correction. * *

I have thought on some other methods by which rotative motions may be made, but they are inferior to those specified, and I feared the specification would have grown four yards long.

* * * *

The Horner's engine is certainly the double cylinder, by what I have just learnt from R. Cameron, who has just brought me a model I had caused him to make of a horizontal-axled ecliptic wheel with one pulley, which performs *à merveil*, and is free from the untoward friction. My head aches. Adieu.

Ewart, afterwards so much distinguished in mechanical employments, see the Address of the learned President of the Institution of Civil Engineers (James Walker, Esq.) to the Annual General Meeting, Jan. 1843, pp. 6-9.

[201.] MR. WATT TO MR. BOULTON.

Cosgarne, 8 Nov. 1781.

* * * *

I am at a loss whether the English petition should be for certain new improvements on steam-engines, or for certain newly-invented steam-engines. Lord Coke has said that a patent must not be for a new button on an old coat, but for a new button and coat.

[202.] MR. WATT TO MR. BOULTON.

Cosgarne, 19 Nov. 1781.

* * * *

It is fourteen years since I thought of the double cylinder and expansive engine, and I think that I mentioned the double cylinder to Mr. Smeaton when I explained the expansive engine to him in your parlour some years ago. William Murdock and Mr. H [andley] can both testify my having mentioned it to them. * *

[203.] MR. WATT TO MR. BOULTON.

Cosgarne, 31 Dec. 1781.

To-day I went to Penryn and swore to a fresh petition for certain new improvements on fire or steam engines for raising water and other mechanical purposes, and certain new pieces of mechanism applicable to the same, which I have transmitted to Mr. Handley. The specification for

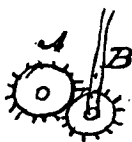
the rotative should now be completed with diligence, otherwise it may be too late. * *

[204.]

MR. WATT TO MR. BOULTON.

Cosgarne, Jan. 3d, 1782.

I wrote to you on the 31st, since which I have tried a model of one of my old plans of rotative engines, revived and executed by Mr. M [urdock], and which merits being included in the specification as a fifth method; for which purpose I shall send a drawing and description next post. It has the singular property of going twice round for each stroke of the engine, and may be made to go oftener round, if required, without additional machinery. The wheel A is fixed at the end of an axis which carries a fly; the wheel B is fixed fast to the connecting-rod from the working beam, and cannot turn on its axis, and is confined by some means, so as always to keep in contact with the wheel A; consequently, by the action of the engine it goes round it and causes it to revolve on its axis; and if the wheels are equal in the number of their teeth, A will make two revolutions while B goes once round it. * *



[205.]

MR. WATT TO MR. BOULTON.

Cosgarne, Jan. 5th, 1782.

* * * *

I send you the drawings of the 5th method, and thought to have sent you the description complete,

but was late last night before I finished so far, and to-day have a headache, therefore only send you a rough draft of part. The drawing is made to $\frac{1}{2}$ -inch scale for 6-foot stroke, but must be reduced to the $\frac{1}{4}$ -inch. * * This 5th method makes an exceeding good motion, and may in many ways be very useful, from its peculiar properties. I imagine there is no difficulty in making a short or small cylinder go 24 strokes per minute, when free from *vis inertiae*. * *

[206.]

MR. WATT TO MR. BOULTON.

Cosgarne, 7 Jan. 1782.

I wrote to you on Saturday, with drawings of the 5th method of rotatives, and enclosed I send the complete specification of that method. * *

[207.]

MR. WATT TO MR. BOULTON.

Cosgarne, 16 Jan. 1782.

* * * *

The drawings for the specification are so bad that I shall be ashamed to put my hand to them; they are much worse than my own drawings which I reprobated; therefore I fear I must draw the whole over myself, which, in my present state of health, and hurried as I am, is dreadful to me; but I fear must be done, and without delay. * * I have, some time ago, thought of a new expansive engine, a reciprocating engine, with a heavy circular fly moved by a pinion from the end of the

beam, so as to make three turns per down-stroke, and as many contrariwise per return, so that in first half of stroke it may acquire a momentum which will carry it through the last half; and if a weight equal to half the load be put upon the inner end of the beam, and the engine be made to lift it during the return, by making a vacuum above the piston, and using a rack instead of a chain, a cylinder of the present size may work to the same depth by half the steam; and I believe the engine will work very sweetly. * *

[208.]

MR. WATT TO MR. BOULTON.

Cosgarne, 21 Jan. 1782.

* * * *

I am just preparing the parchment for the specification drawings, but I tremble to begin to them, I am so molested with a pain in my back; but Playfair's are too bad to be used. * *

[209.]

MR. WATT TO MR. BOULTON.

Cosgarne, 23 Jan. 1782.

* * * *

Both my health and spirits are very bad, and I am particularly molested with a pain in my back. It is impossible for me while here to keep up any regularity in our business, or to attend to the many and different things which pour in upon me; indeed, my head grows every day less fit for it; and drawing is attended with so much increase

of the pain in my back, that, though I cannot approve of Playfair's specification drawings, I believe I must use them, from inability to make others, (although I have got one copy partly done in a much better manner). * * * My inclination and feelings would lead me to abandon both Cornwall and Wheal Virgin forthwith, and to attend to and amuse myself with these rotative machines, &c. ; but it would be dropping the substance to catch at the shadow. I have a very mean opinion of the rotative's profits, and the trouble with each of them must be at least double that of an engine which raises water. Peace of mind, and delivery from Cornwall, is my prayer. * * * Since the above was written I have done a good deal towards the fair copy of the drawings, which I hope I shall be able to finish in time. * - *

[210.]

MR. WATT TO MR. BOULTON.

Cosgarne, 26 Jan. 1782.

* * * *

I have got one copy of the specification drawing finished in an elegant manner upon vellum, being the neatest drawing I ever made ; and have improved the construction of several of the machines, and represented their stands and several other parts necessary. The double-toothed wheels admit of several different applications, one of which admits the rotative wheel to be in the middle of an axis, and that was the original one. * *

[211.]

MR. WATT TO MR. BOULTON.

Cosgarne, 28 Jan. 1782.

* * * *

Mr. Henderson was here to-day, intending to set out to-morrow; but as I hope to have the second copy of the drawing done to-morrow, I have detained him to take at least one of the copies with him. * * I have made one copy on vellum for the office, and the other on stamped parchment for want of plain. * *

[212.]

MR. WATT TO MR. BOULTON.

Cosgarne, 31 Jan. 1782.

Mr. Henderson set off this day with the vellum copy of the drawing; I have kept the parchment one, in order to annex it to the specification when it arrives. * *

[213.]

MR. WATT TO MR. BOULTON.

Cosgarne, 2 Feb. 1782.

* * * *

Last post I despatched the specification to Mr. Handley, with desire to lay it before Mr. Palmer; and if you did not send the drawing immediately, to make only such corrections as regarded form, and to proceed to engrossment, as not an hour is to be lost; and if any accident should happen to the specification, it will cost me a journey to London. * * Specification must be delivered on or before the 25th instant. * *

[214.]

MR. WATT TO MR. BOULTON.


Cosgarne, 9 Feb. 1782.

Another post is come, and no letter from you. I grow uneasy at not hearing of Mr. Henderson's arrival at Soho, where he ought to have been on Saturday night (with the specification drawing), nor any advice from Mr. Handley of his having received the specification, which was sent off on Thursday se'nnight. If I receive no satisfactory advice next week, I shall set off for London with the rough copy of the specification I have left, as it will thus be too late to remedy the business in any other way. * *

I have nothing new to advise you of, except a new method of an equalising beam, by causing the gudgeon to change its place, thus—

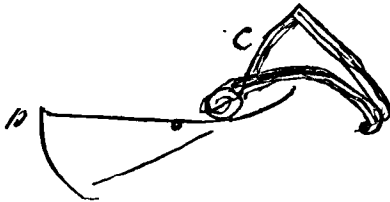


The working beam is made hollow on the under-side, and rests upon a roller which has an axis through it, and this axis has a wheel fixed upon each end of it, unconnected with the roller, but connected together by means of the axis. At beginning of the stroke the roller and beam stand

thus—  ; but as the engine-end

descends, the curve forces the roller to travel towards the pump-end, and *vice versâ*. N.B. The

wheels, and not the roller, rest upon the fulcrum or support. I have also made sketches of some equalising beams, which perform by means of a roller acting upon a curve in the nature of the working gear; the engine pulls by the arch C, and



the pump is hung to the arch P; the roller travels about the length of the stroke, and the curve permits a perfect equalisation.

I intend to put down the heads of the next specification, and send you for your perusal soon, as it will take a long time to make it out, and must be thoroughly discussed. * *

[215.]

MR. WATT TO MR. BOULTON.

Cosgarne, 11 Feb. 1782.

* * * *

I have filled one whole sheet, royal, with equalisers, and shall probably fill another before I am done. * * I have received Mr, Handley's letter to-day, advising the receipt of the specification, which shall receive all due despatch from me when it arrives. * *

[216.]

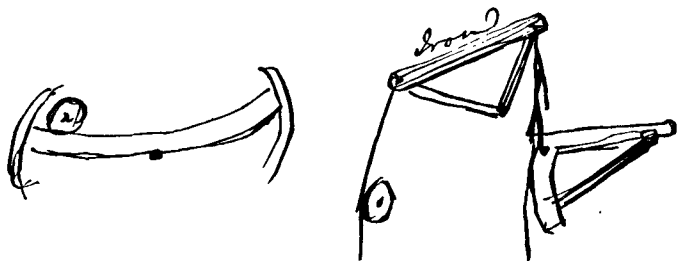
MR. WATT TO MR. BOULTON.

Cosgarne, 14 Feb. 1782.

* * * *

I hope you will spur on Mr. Handley with the patent, and at the same time inquire what new patents are now going through the office; for I do not think that we are safe a day to an end in this enterprising age. One's thoughts seem to be stolen before one speaks them. It looks as if Nature had taken an aversion to monopolies, and put the same things into several people's heads at once, to prevent them; and I begin to fear that she has given over inspiring me, as it is with the utmost difficulty I can hatch anything new.

I remark what you said in your last about equalisers, and had thought of the same; below are two new ones. But the flyer is the best of all, and will prove the true equaliser, and will



have much less friction than any other. It may, however, be combined with some of the most simple ones; and the weight raised by the back-stroke may be placed so far above the centre as in some measure to equalise itself. * *

[217.]

MR. WATT TO MR. BOULTON.

Cosgarne, Feb. 20, 1782.

* * * *

From the many opponents we are like to have, I fear that the engine business cannot be a permanent one; and I am sure it will not in any case prove so lucrative as you have flattered yourself.

[218.]

MR. JOSIAH WEDGWOOD TO MR. WATT.

London, 15th May, 1782.

* * * *

My Thermometer paper was read in the R. S. last Thursday. It underwent the examination of many chemists and philosophers here before that time, and they gave it their approbation very fully. I will send you some little account of the degrees at which various bodies changed, when I have a few moments' time.*

* * *

* Mr. Wedgwood duly fulfilled his promise, but it does not seem necessary here to recapitulate the construction and other particulars of an instrument so well known as his argillaceous pyrometer; the principle of which depended on the contraction, by high degrees of heat, of argillaceous bodies, which, being suddenly quenched in cold water, retained the exact dimensions they had when taken from the fire, and were therefore capable, by comparison of their measurement before and after they had been heated, of indicating the temperature they had undergone.

[219.]

MR. WATT TO MR. JOSEPH FRY.

Birmingham, May 22, 1782.

. * * * *

I will stick by the engine business while it sticks to me ; but we have got so many pretenders now, that I fear they will make us little people. If so, let them. * *

[220.]

MR. WATT TO MR. G. HAMILTON.

Birmingham, July 11, 1782.

* * * *

The clear income of the engine business is above 3000*l.* per annum, and has a chance of being 2000*l.* greater, but may also be less, or nothing ; [according] as we shall be able to defeat our opponents.* *

[221.] MR. WATT TO MR. COCHRANE [OF GREENOCK].

Birmingham, Sept. 1st, 1782.

DEAR SIR,—Yesterday brought me your letter of the 23rd, containing the afflicting news of the death of my worthy and kind father. When we consider his death as a removal from a state of pain and disease to a state where we must hope that he will meet the reward of a well-spent and laborious life, we cannot with reason bewail his loss ; yet there is something so afflicting in the thought of the final, solemn departure of a beloved friend and revered parent, that though I

have been, by his long illness and declining state, prepared for the event, the account of it has given me much pain. * *

It behoves me now, however, to lay aside un-availing regret, and to thank God that He has hitherto preserved me from signal misfortunes.

My wife and family are all well, and my children are promising, which circumstances I have great reason to be grateful for, however I may be otherwise afflicted. * *

[222.]

MR. WATT TO MR. BOULTON.

Birmingham, 19 Sept. 1782.

* * * *

I have drawn several rotatives since you went,* and revived a valve turning on a centre originally designed for the other wheel, which can shut the moment it passes it, and without any loss of steam; which valve is particularly suitable for those rotatives which have only one valve. I have drawn a rotative with two sliding valves or flushits, which relieve the guard, so that the action of the steam is continual, and the axis of which need not exceed 5 or 6 inches in diameter; and one-sixth of a revolution or more may be employed in opening, and as much in shutting, each valve without detriment. Also a rotative with two valves turning on centres, which has the same properties; only the axis must be larger, and there cannot

* Into Cornwall.

be quite so much time employed in opening and shutting the valves, but being in other respects abundantly more simple and compact than with sliding valves. I apprehend it to be the best of the two. As to the larger size of the axis, making the cylinder 3 inches more in 24 will make amends for that.

But both these rotative motions, and all others which have more than one valve fixed to the external cylinder, must have as many regulators, steam-pipes, &c., as the up-and-down reciprocating engine; and moreover, their steam-pipes and education-pipes must be twisted and turned in many very absurd directions, so as to cut a very ugly appearance, and, perhaps, to be inconvenient; and, in short, both of them will have as many parts as any reciprocating engine, and some of those parts much worse to execute. The engine with two valves folding down upon, or sliding into the axis, will require no regulators, and will be very simple. * *

[223.]

MR. WATT TO MR. G. HAMILTON.

Birmingham, Sept. 22d, 1782.

* * * *

I have now to trouble you on another affair, which is of importance to me. When Robert Cameron came to our service, two years ago or thereabouts, he had some confused unmechanical ideas about making a rotative motion by means

of a piston or radius fixed to the axis of a cylinder, and forced round by the power of steam acting between it and a sliding valve, which was to be withdrawn to let the piston pass it. On his mentioning this to me, I told him that such a thing could not be done without encroaching on our patent, as the piston must be pressed upon by steam, and [the steam] condensed in a separate vessel; and further, that I had had the same in contemplation many years ago, and had turned the principle in my mind in every possible shape, but found that it must be attended with so many difficulties and inconveniences in practice, that though I had made a model of it in two different manners, I had never put it to trial, nor did I choose to try it then, as the same purpose might be answered in a less exceptionable manner, by means of reciprocating engines. Matters passed off so; and as he intended to go to the West Indies as a millwright, I thought he might be useful in erecting our engines there, and therefore have been at much pains explaining every part of them to him, and have kept him in pay ever since, principally trying experiments, which we could have found others to have done fully better, for he is a very clumsy workman.

Since his return from Cornwall, this said whirligig still running in his head, and he finding that I did not pay the attention to it he wanted, he applied to Mr. Boulton to permit him to make a model of it, because, he said, otherwise the Hornblowers might light upon it and be troublesome.

Mr. B., who is always fond of new things and afraid of opponents, gave him liberty without consulting me, but in a few days after told me he had done so. It was then in vain to attempt to hinder it; accordingly, a model was made, which abounded in many very unmechanical contrivances; but, as might be foreseen, went round, though it was unable to do anything else. As the general opinion of *schemists* seemed to be that they might make any use they would of our principle, provided they did not make their engines *exactly* similar to those they had seen of ours, in order to cut off as much as might not have any such pretences, I took out a new patent for certain new improvements upon, and certain new pieces of mechanism applicable to steam or fire engines, which passed the seals in March last (long before this model was begun to). In the specification of this patent I included all the improvements on our engines which we had not publicly used and were thought worthy of notice; and among others, three methods of the said rotative engines by an axis turned round in a cylinder by the immediate action of steam; and this specification was written before the model was made, and delivered into Chancery about the time it was finished.

When R. C. returned from Glasgow, he was set to superintend the direction of an engine for a forge-mill of Mr. Wilkinson's; but he grew sulky, as I have been since told, and almost totally neglected his business when at Soho, and then

wrote a kind of insolent letter to Mr. Boulton, requiring us to go on with further improvements on the said rotative engine, in which case he would, on proper consideration, go to the West Indies and erect them; but otherwise, he conveyed a hint that he would apply to other people to assist him in it. All this time my original model was lost, but on receipt of his letter, Mr. B. searched for it, and found it in his library, where it had been six years. I showed him the model, which, as I mentioned before, is an unfinished one; however, it is sufficiently advanced to convince any candid person that I had invented such rotative motion; and, by the by, is more perfect than the thing he made, even though every part and principle of what he did was borrowed from what he had seen in our service, except one or two things, which prove useless or bad. But Robert, instead of being convinced, as I expected, wrote a still more insolent letter to Mr. Boulton, requiring a fourth of the profits of what he called his invention; and in conversation said to Mr. Boulton, at the time Mr. Boulton told him I had secured it by a fresh patent, that I certainly was not the contriver of it, because I had always discountenanced it and raised objections to it (which is fact,—and those objections are by no means removed by anything he has done). He added, he was well assured that I had never invented such a thing, because Dr. Irvine had told him that I had communicated every thought I had upon the subject

to him, and I had never mentioned this; and that he (Dr. Irvine) looked upon it as an entire new thought. I cannot bring myself to believe that Dr. Irvine ever would say so; as, in the first place, it must be evident to Dr. Irvine that this was an engine, the acting power of which was the elastic force of steam, which steam must be condensed in a separate vessel. Therefore it is entirely within my first specification; and secondly, though I communicated most of my ideas to Dr. Irvine, it does not follow that I invented nothing but what he knew of. I shall be glad, however, to know what Dr. Irvine did say.

Be that as it may, true it is and of a verity, that this model now here was made in the year 1765 or 1766 by a confidential workman of mine. I know not whether ever J. Gardiner or Murray Osborne have seen it, but will be obliged to you to ask them; and I send a small drawing of the two states of it to show them, and to ask them; as Osborne got my patterns, ten to one but he has seen the pattern of some of the parts—perhaps may have them yet.

On this conversation being told me, I was for immediately dismissing the gentleman for so flagrant a piece of insolence as doubting my veracity; but Mr. B., who always prefers peaceable methods, overruled me, and made him an offer, if he would go to the West Indies, to give him a third of the clear profits arising from such of these engines as he should erect there on our

account, or one-ninth of such as he should personally superintend the erection of in Britain, which last would probably be less than his wages would cost us if kept in our employ. But all this upon condition he should make a better rotative engine than I could. All this has not satisfied him, but he has partly agreed to it; but as I see too late that he is of a most obstinate, opinionated disposition, and resolute in carrying his point, I am now calling on all my friends to whom I have mentioned the matter, to rake up their memories as to my having invented it; and if he does not quietly agree to our proposals, I shall make Britain too hot to hold his pretended invention. Please make my compliments to Dr. Irvine; show him the drawings, and desire him to recollect himself, both whether I ever mentioned it to him, and what he said to R. C.; but it will not be necessary to show him this letter, or to say anything publicly about the matter.

The Hornblowers, who have caused us so much uneasiness by the lies they have told in Cornwall, have never been able until lately to get their engine to work at all; and now it performs as badly as we could wish it, being very much worse than a common engine, notwithstanding which they have uniformly asserted in Cornwall, that it performed beyond their most sanguine hopes (which, by the way, must have been very humble), and that it was the very best engine ever made. We had a person there last week who informs us, that

when they have got a very strong steam, it will make 21 strokes in three minutes, but then comes to rest, and must stand five minutes before it gets strength enough to make another stroke, and all the while they must fire away as hard as ever they can, otherwise it will not work at all. To add to their triumph, a Cornish gentleman, whose knowledge, candour, and abilities give him influence there, has seen it in this good order, and has borne witness in Cornwall of its performance, much to the Horners' comfort and honour, as you may suppose. Mr. Boulton is now in Cornwall, and will not fail to take proper advantage of our enemies' defeat. * * I find I must delay the sending the drawings by this post, as this letter has turned out so unconscionably long, and I am obliged to go out on business. * *

[224.]

MR. WATT TO MR. HAMILTON.

Birmingham, Sept. 24th, 1782.

Enclosed you have the drawings of the model I mentioned in mine of the 22nd. Fig. 1st was finished as far as you see, about the [year] 1765 or 1766, and is now in my possession; and the same period, the internal parts of fig. 2d and 3d, which are two views of the same thing, were cast, but very little else was done to them. I remember of seeing the patterns of these internal parts among my patterns not long before I left Glasgow; and perhaps Osborne, who got my patterns, may have

them yet, or may remember them. The model was made by Daniel M'Millan, who is not now in Britain, but is come-atable. The fig. 2d is the thing most necessary to be proved, as being in itself a continued rotative motion, which the other is not. Fig. 4th was only in idea, together with many others of its brethren; and those ideas were suffered to sleep from the hurry I have been kept in, and the obvious objections of great friction and difficulty of execution, which, though my present experience supplies me with more expedients to get the better of them, will always be *remoras* in the way of the use of such machines.

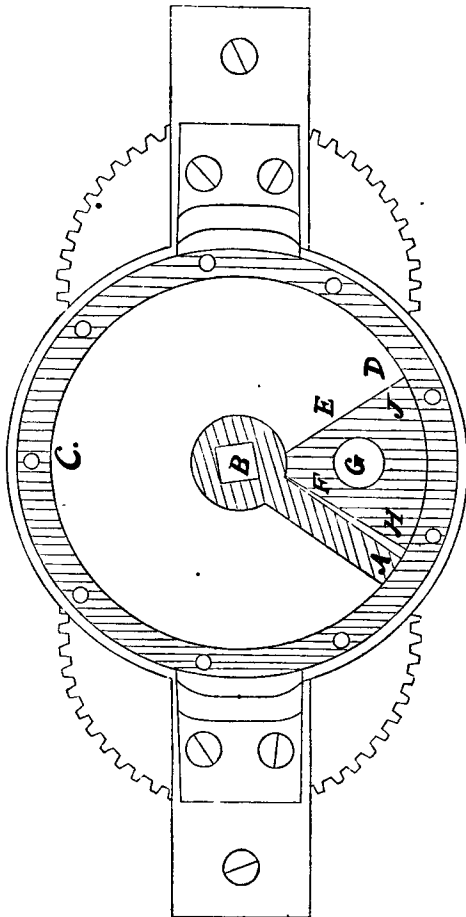
As to R. C., the model he made with us was of the nature of fig. 4th, but had a sliding valve, which from accidents must be very liable to be broken; and his model had many other unmechanical contrivances about it, which I suspect will also be the case with his second one. * *

I should have been determinate in having immediately dismissed him, but thought it might be best to do that quietly, as I doubt not his presumption will meet a check from Dame Nature, who is confoundedly obstinate with those who do not understand her ways.

The Hornblowers continued to brag away in Cornwall with redoubled velocity; but, thank God, their day of retribution is near. By calculation, their engine is three times *worse* than a common fire-engine. * *

A Model of a Semi-Rotative Steam-Engine, executed in 1765 or 1766, by J. W., at Glasgow.

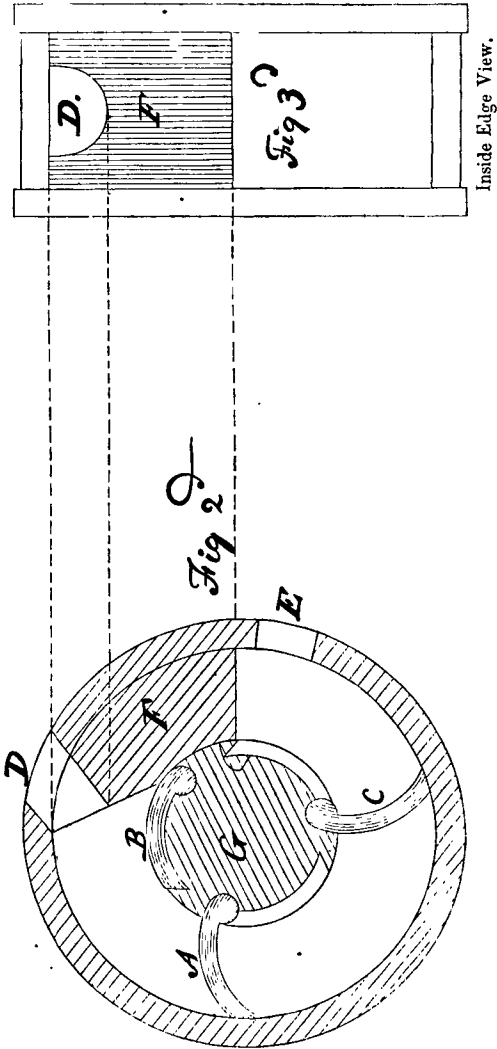
The drawing is half the real size of the model, which was made in brass, and is about 2 inches deep.



By means of the cock G the steam is admitted at the opening F, between the piston A and the first obstacle H F J; and there being vacuum in the cylinder A C D, the steam forces the piston to revolve on the axis B, until A arrives at D; then the steam is admitted by the opening E, and discharged by the opening F, and the piston revolves in the contrary direction, but by means of wheels on the other side gives a continued rotative motion to machinery, or works reciprocating pumps, as may be required.

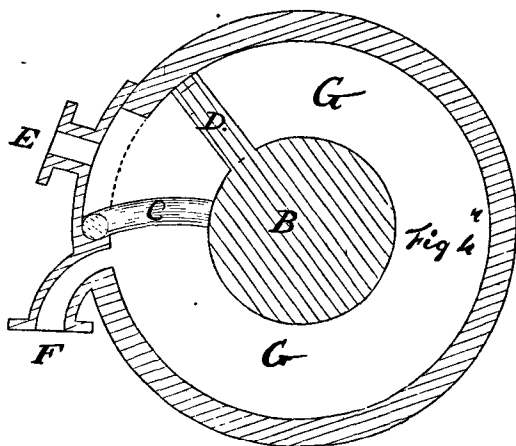
The piece F and the three valves were cast, and the piece F was fitted to the cylinder, but the other parts are still unfinished.

Fig. 2d is another way in which the same model was intended to be used to produce a continued rotative motion. A, B, and C are three crooked valves which, when folded down, form a part of the axle G, and when opened out perfectly fill the space between it and the cylinder. The steam is admitted by the passage E, and there being vacuum behind A, it (the steam) acts against the valves A and C, and causes them, and the axle to which they are fastened, to turn round; when the valves come to the place B, they are folded down by the first obstacle F, and the steam issues at D, and the motion is continued by the valves succeeding one another.



Inside Edge View.

Fig. 4th is a drawing of another method of a continued rotative motion. The steam being admitted by E, between the valve C and the piston or radius D, and there being vacuum in G G, the piston revolves towards G until it arrives at the valve C, which is then opened by proper machinery, the pipe E, which admits the steam, being first shut; when the piston passes the pipe F, the steam rushes out through that pipe into the condenser, and the piston, having passed the valve E, is opened, and the steam acts as before. The motion, during the absence of the steam, is maintained by means of a fly, or a weight.



[225.]

MR. WATT TO MR. G. HAMILTON.

Birmingham, Sept. 29th [1782].

* * Mr. B. writes me from Cornwall that the Horners, notwithstanding the real bad

performances of their engine. (which I have no reason to doubt of), have propagated reports in Cornwall of its excellences, and have actually made proposals to several of the mines where we are most interested to alter our engines to their construction at a small expense, and to serve them afterwards, and allow the mines the use of their engines for a small salary; and that the Cornish people believe them, and some of the principal are determined to support them against us, in such a manner as to render the situation of Mr. B. exceedingly disagreeable. You may conceive that we have now no choice but to enter into a lawsuit against them; and the event of that God only knows. We have right, law, and justice on our side; we are highly injured; yet who knows what the chicanery of the law may suggest, or the rage of an English jury against monopolisers do? Yet if our right cannot be supported by law or custom, it is time we knew it, before we waste more of our lives improving machines for the benefit of scoundrels. * * I do not mean, however, to give you any needless alarm, but to prepare you against the worst. We are informed by many knowing people that our cause is a very clear one, and that we cannot fail of success. We mean to apply immediately to the Chancellor to grant a rule to show cause why an injunction may not pass; and we are told that if this is well managed, an injunction will pass in course; and in that case I should not fear their being able to get it removed, that being an exceedingly difficult

matter. If we can avoid ill-informed juries, I shall have some hopes; but if the Chancellor sends us back to the courts of law, we must take our chance of them. We have also this in our favour, that the Horners' reports are downright lies, and that the truth may be brought out time enough to lessen the ardour of their Cornish friends; besides, as to the mines laying down our engines to erect theirs, that seems rank nonsense, as in all our agreements that are likely to be contested, there is a clause that they shall not employ any workmen, engine-men, or servants to work, *alter*, or repair the said engines without we approve of them, but shall, at our desire, dismiss from their service all such workmen, &c., as shall not behave to our satisfaction; and also that they shall pay us our premium so long as they shall use the said engines at the said mines; by which I conclude that they cannot get off without demolishing everything we have done, and throwing away the materials, which they will not find a profitable transaction, as some engines have cost between four and five thousand pounds; and even if we should lose our patent right, equity will in those cases make us ample redress, or I know not what equity means. The present Chancellor is a sagacious, just, and determined man, who will not be influenced or turned aside from his own notions of justice; what those may be in this present case, I cannot tell.

You see, therefore, that we have as much reason to hope as people can have who are embarking on

the stormy sea of law. Yet I cannot build upon it. My mind is gloomy, and I wait with impatience and fear for Tuesday, which is to bring me news from Cornwall, and from a friend at Bristol, who was to go to Radstock, where this confounded engine is, to get us further information. Could we overcome our enemies at law, it would secure us for ever from all insults of the like kind; for there is no law equal to an adjudged case.

* * * *

[226.]

MR. WATT TO MR. BOULTON.

Birmingham, 26 Oct. 1782.

* * * *

Mr. Smeaton was so thoroughly taken up by his canal business while he staid here, that, after his first visit, I never could get him to come, excepting on Sunday last that he came to tea, and staid to eleven at night *sans souper*; nevertheless, I could only slightly touch upon the new inventions, being wholly taken up reading and explaining the case. He grows old, and rather more talkative than he was, but retains in perfection his perspicuity of expression and good sense. He came also to the Philosophers' meeting * at this house on Monday; and we were receiving an account of his experiments on rotatives, and some new ones he has made, when, unluckily, his facts did not agree with Dr. Moyes the blind philosopher's theories, which made Moyes contradict

* The meeting of the *Lunar Society*.

S., and brought on a dispute which lost us the information we hoped for, and took away all the pleasure of the meeting, as it lasted two hours without coming half an inch nearer the point.

* * * *

[227.]

MR. WATT TO MR. BOULTON.

Birmingham, 29 Oct. 1782.

* * Yesterday Baron Reden called upon me, in company with Mr. De Luc. The Baron wanted some plated goods at Soho, and Mr. De Luc to see the manufacture, so I went out with them, showed them what I could, and as I found that Mr. De Luc understood the nature of our engines pretty well, and wished to know more, I pressed them to stay dinner, and afterwards to supper, and gave Mr. De Luc a full lecture upon steam and steam-engines, with which he professed to be much pleased, and indeed appeared to be so. He was present at Paris when Perrier called the Royal Academy to view the engine set out, when, lo! it went *two* long strokes per minute; which he said was owing to the want of the steam-case, which in haste he had omitted. This being afterwards added, the engine wrought at the rate of four strokes per minute, and he (De Luc) never saw it go any faster. He says that M. Perrier did not pretend to the Academy that it was his own invention, but that the Academy knew it to be ours;—which circumstance we did not know before, at least I did not. * * M. De Luc is a modest, ingenious man. * *

[228.]

MR. WATT TO MR. BOULTON.

Birmingham, 9 Nov. 1782.

* * I intended to have gone to Bristol on Thursday, but upon Wednesday, Wilkinson, Reden, and De Luc sent for me to the Castle after dinner, and kept me to supper. I found it then in vain to think of going away upon Thursday, so asked them to dinner; and De Luc came to breakfast, and spent the whole forenoon incensing himself with steam and steam-engines. He is making a book, and will mention us in it. Dr. Priestley came also to dinner, and we were all good company till six o'clock, and Wilkinson set off for Broseley, and they for London. * *

[229.]

MR. WATT TO MR. BOULTON.

Birmingham, 26 Nov. 1782.

* * Wilkinson has cast the up-and-down reciprocator, and it is on the road hither.

* * Joseph is on the eve of the grand projection, *i. e.*, he is to set his hammer to work to-night. Having been very bad yesterday with a headache, and much indisposed to-day, I have not been able to go out; but if they get it set to work, expect advice in time for the post.

I have just learnt that they have tried the engine; but Joseph, from a notion of making it do all he could, set both pump and hammer to work at once. It went about 18 strokes per

minute, but during the return of the engine went slower than during the descent of the piston; the frame they had laid down was not sufficiently solid; which things shall be cured, as I hope to be able to go out to-morrow. * *

[230.]

MR. WATT TO MR. BOULTON.

Birmingham, 28 Nov. 1782.

* * I wrote to you last post of the first trial of the hammer. I went out yesterday and saw it tried without the pump; the first trial it went with a lame leg, 3 strokes fast and 3 slower; but on putting about 2 cwt. on the outer end of the beam, that was corrected, and it went with all the regularity we could desire, the engine making about 25 strokes per minute. The rotative motion and mill part answered to every expectation, but the hammer-frame and anvil-block were not sufficiently secured, which, however, I have given orders for doing. And as the engine has a great overplus of power, I mean to increase the weight of the hammer to about $1\frac{1}{2}$ cwt., and to cause it to make 250 or 300 strokes per minute, by diminishing the height it rises to 9 or 10 inches. The present facts are, cylinder, 15 inches diameter, and 4 feet stroke, 25 strokes per minute; hammer makes 6 blows per stroke of the engine; fly under 5 cwt., and 7 feet diameter; hammer 120 lbs., and 18 inches wide; it strikes a good blow, and forges iron very well. The *camms* were wood, and were cut all to pieces by

the anvil-block sinking. I have ordered steel ones to be made, which I expect will stand it. I could make no guess at the quantity of steam used; only the upper regulator was shut as soon as it could be, and even when the pump was used with the hammer, and the steam was continued on almost the whole time, the boiler supplied it perfectly, which we attribute to the communication being cut off with the sleeping cylinder, which, it seems, somehow or other, destroyed much steam. * * There is now no doubt but that fire-engines will drive mills, but I entertain some doubts whether anything is to be got by them. * *

[231.]

MR. WATT TO MR. BOULTON.

Birmingham, 30 Nov. 1782.

* * I wrote to you last post concerning the success of the tilt-hammer: I have not seen it since; but J. B. wrote to me yesterday that they had made it more steady, but having hammered the anvil into the anvil-block, they wanted to help that and some other things before I came out again. I propose going out this afternoon, and if I observe anything material shall add it to this letter. * *

I have been at Soho since writing the within, and saw the tilt go admirably from 16 to 24 strokes per minute, and it could have gone much faster, but our men could not work the iron under it. Joseph said that yesterday they made it go 28

strokes per minute, which is much more than the engine should do by my calculations; but in the midst of our glory, the hammer helve broke: it appears to have been rotten. The steel *camms* answer very well, and the whole will answer better when made to have a less lift and more strokes, as it will then answer for a common tilt for steel; at present the blow is so strong, that we dare not attempt to *hack* a piece of iron under $1\frac{1}{2}$ inch square, otherwise it knocks it to pieces. By the help of some more weight on the outer end of the beam, it goes so regular that you cannot tell when the engine is going out or when coming in.

* * * *

There must be a catch fixed to our fly to prevent back-turning, which it is very liable to at setting on. The revolving-wheel has a tremulous motion which I don't like. I shall try to remedy it by increasing the strength of the swan-neck part of the connecting-rod, though that is already 4 inches by $1\frac{1}{4}$, and the rod itself 6 inches square.

* * It seems to me that the outside eccentric will be the best motion for forges, and for great powers; the revolving motion does not admit of being made so strong. * *

[232.]

MR. WATT TO MR. BOULTON.

Birmingham, 3 Dec. 1782.

* * Mr. Wilkinson went away to-day. We got a new helve in yesterday, and showed him the engine at work; but as it was Mynheer Peploe's wedding-day, Joseph

was rather *wise*, and they wrought the engine badly, particularly in setting it a-going the wrong way round, which it is very apt to do, and by making it go 28 strokes per minute, which I fear has again broke the helve, at least it smoked much at the *hurst*. In other respects it pleased him, particularly the carriage; but he seems not to be satisfied about its being possible for it to turn the wrong way about, which must be prevented by a catch applied to the fly. * *

What shall we set the little new double engine to do? Joseph. thinks a rolling-mill. Please give your opinion of size of rolls, &c. * *

[233.]

MR. WATT TO MR. BOULTON.

Birmingham, 10 Dec. 1782.

* * You may remember that I have often said that if water could be heated red-hot or something more, it would probably be converted into some kind of air, because steam would in that case have lost all its latent heat, and that it would have been turned solely into sensible heat, and probably a total change of the nature of the fluid would ensue. Dr. Priestley has proved this by experiment. He took lime, and chafed out all the fixed air, and made it exceedingly caustic by long-continued and violent heat. He then added to it 2 ounces weight of water, and as expeditiously as possible subjected it again to a strong heat, and he obtained 2 ounces *weight* of air; and what is most surprising, a balloon which he inter-

posed between the retort and receiver was not sensibly moistened, nor at all heated, that could be observed. The air produced was but very little worse than common air, and contained scarce any fixed air. So here is a plain account where the atmospheric air came from, &c. &c. The Doctor does me justice as to the theory.

Mr. De Luc proposes to be here about the end of January. * *

[234.]

MR. JOSIAH WEDGWOOD TO MR. WATT.

Etruria, Dec. 10th, 1782.

DEAR SIR,—I thank you for your good letter of the 10th instant with the account you are so obliging to give me of your tilting forge. When you have quite completed the alterations you are making in it, and Mr. Boulton is returned from Cornwall, I will, if possible, take a ride to Soho to see him and you and the forge together.

You owe me no letter of thanks, though you may write *any letter* to me you please, and the oftener the better for me. With respect to the mortars, &c., I never charge such *experiment pieces* to any body,* and it would be unreasonable in you to expect in this instance to be favoured

* These expressions refer to an interchange of good offices, whereby Mr. Wedgwood occasionally supplied Mr. Watt and his friend Dr. Black with specimens of the rough materials used in his celebrated manufacture, as well as with various small articles for furnace and laboratory use; while, on the other hand, Mr. Watt was enabled, on his excursions into Cornwall, to inform Mr. Wedgwood of the localities of substances valuable for pottery.

beyond the rest of mankind. This business settled, I have to thank you for the communication of Dr. Priestley's wonderful discovery of the conversion of water into air, *weight for weight*.* The Doctor had obliged me with a short account of the discovery, but had omitted this last circumstance, which is of consequence; for there would have been nothing very extraordinary in forcing some air from a mixture of water with quicklime; as that earth might, like others in calcination, have imbibed air in that process.

The difficulty will be to say, if the Doctor proceeds in these interesting and curious experiments, what parts of the three kingdoms which naturalists have divided our world into, may not be converted into air, or by and by perhaps into water, or any other substance.

I wish you could have given me a better account of your health. I suppose it is your head that is principally indisposed, by having so many of those must-be-done matters continually passing through it. Your mind, my friend, is too active, too powerful for your body, and harasses it beyond its bearing. If this was the case with any other machine under your direction, except that in whose regulation your [friends] are most interested, you would soon find out a remedy. For the present permit me to advise a more ample use of *the oil of delegation* through your whole

* See Correspondence on the Discovery of the Composition of Water, pp. 1 to 8.

machinery, and I am persuaded you will soon find some salutary effects from this application.

Seriously, I shall conclude in saying to you what Dr. Fothergill desired me to say to Brindley : —“ Spare your machine a little, or like others under your direction it will wear out the sooner by hard and constant usage.”

I am, with great regard,

Dear Sir,

Your faithful and obedient Servant,

JOS. WEDGWOOD.

[235.]

MR. WATT TO MR. BOULTON.

Birmingham, 12 Dec. 1782.

* * I went out to Soho yesterday forenoon hoping the engine would be ready for trial, but it was not. In the evening they wrought it 2 hours, 240 blows per minute, rise of hammer 8 inches. The catch answers effectually to prevent backsliding, and is lifted up when the engine is at work, and let down when we intend to stop. They say that it used rather less steam than before. The helve which cracked (present Mr. Wilkinson) gave way almost totally last night, so that I cannot see the engine till a new one is got and made. * * I have improved the working gear of the forge by fastening the piece of wood which shuts the top regulator, to the upper end of an iron rack which comes down the plug-tree to the man's hand, and is moved by a pinion of six and a winch with a notched wheel

to fix it, whereby the man below can keep the top regulator longer or shorter open according to the exigencies of the machine, and is particularly useful in setting it a-going or in stopping it, gently; as it may be pulled down so as not to suffer that regulator to open at all.

[236.]

MR. WATT TO MR. DE LUC.

Birmingham, Dec. 13th, 1782.

* * We have tried our little tilting-forge hammer at Soho, with success. The following are some of the particulars:—cylinder 15 inches diameter, 4 feet stroke, strokes per minute 20. The hammer-head, 120 lbs. weight, rises 8 inches, strikes 240 blows per minute. The machine goes quite regular, and can be managed as easily as a water-mill. It requires a very small quantity of steam, not above half the contents of the cylinder per stroke. The power employed is not more than $\frac{1}{4}$ of what would be required to raise the quantity of water which would enable a water-wheel to work the same hammer with the same velocity. * *

[237.]

MR. WATT TO MR. BOULTON.

Birmingham, 14 Dec. 1782.

* * I have just been out at Soho, seeing the engine after the alteration. The hammer-frame is quite steady, and it does not seem disposed to break the helve; but, as this

method of working requires by calculation 50 per cent. more power than half the number of blows with double the rise, so it proves in fact; for the engine wants more weight to take it out of doors, although the fly has been made $\frac{2}{3}$ heavier. There seems also to be something a-wanting in the ready setting it to work, and the regulation of it.

* * * *

[238.] MR. WATT TO MR. MACDOWAL, CRICHEN.

Birmingham, Jan. 3d, 1783.

* * * We have altered all the engines in Cornwall but one, and many in other parts of England; but do not acquire riches so fast as might be imagined; the expenses of carrying on our business are necessarily very great, and have hitherto consumed almost all our profits: but we hope to do better by continuing our attention and exertions, and by multiplying the number of our works. We are now busy contriving to work mills of many kinds by fire engines. We have made a tilting-forge, the hammer of which is 120 lbs. weight, and makes 240 blows per minute; it is wrought by an engine with a cylinder of 15 inches diameter and 4 feet stroke, which makes 20 strokes per minute and burns about 40 lbs. of coal per hour. We are making another to work a hammer of 700 lbs., which will soon be at work.

* * * *

[239.]

MR. WATT TO MR. G. HAMILTON.

Birmingham, March 26th, 1783.

* * Affairs in Cornwall go on very prosperously. It is said Wheal Virgin will gain 3000*l.* per month, as it proves much richer than we expected, and the costs much less; but it will be some time before we can have any cash from it, or indeed get any considerable remittances from the county, as money is exceedingly scarce there. * *

We have got the forge-engine at Bradley set to work yesterday morning, which performs very well. They made it go at the rate of 240 blows per minute, though the hammer weighs 7 cwt., and lifts 2 feet 3 inches. We are in terms with some people in London to erect a corn-mill to drive 18 pair of large millstones, which will bring us 1000*l.* per annum; and another for the Victualling-office, which will bring 200*l.* per annum. These are the principal orders we have at present.

* * * *

[240.]

MR. WATT TO MR. BOULTON.

Birmingham, 14 April, 1783.

* * I think that before you engage to erect corn-mills only for one company, you should consider whether the favouring a monopoly of bread may not be an argument against our patent, and whether there is not room for many more than 20 pair of stones in London: and also,

if such a monopoly is agreed to on our part, within what limits it should be confined. The bills of mortality is an unlimited or undefined space.

[241.]

MR. WATT TO MR. DE LUC.

Birmingham, April 26th, 1783.

* * I was yesterday at Bradley with Mr. Wilkinson, to see a trial of his forge-engine, which is at last finished and works exceedingly well. The engine can work from 15 to 20 strokes per minute; and the hammer, which is $7\frac{1}{2}$ cwt. and rises 2 feet high, strikes 6 blows for each stroke of the engine; but this is to be altered, to strike only $4\frac{1}{2}$ blows for each stroke of the engine. I believe it is a thing never done before, to make a hammer of that weight make 300 blows per minute; and, in fact, it is more a matter to brag of than for any other use, as the rate wanted is from 90 to 100 blows, being as quick as the workmen can manage the iron under it.

We have also succeeded in making an engine act by the power of steam, both in the ascent and descent of the piston; and, in fact, it acts so powerfully that it has broken all its tackling repeatedly. We have now tamed it, however. * *

[242.]

MR. WATT TO MR. SMEATÓN.

Birmingham, April 27th, 1783.

* * We have had a trial of our new forge-engine at Bradley; cylinder 42 inches dia-

meter, 6 feet stroke. Makes from 15 to 50 (even 60 strokes per minute) at pleasure, works a hammer of $7\frac{1}{2}$ cwt. raised 2 feet high, which makes 6 strokes per stroke of the engine, and has struck 300 blows per minute; we are, however, going to make it strike only $4\frac{1}{2}$ blows per stroke of the engine, because we want the latter to go 20 strokes per minute, and they want only 90 blows of the hammer in that time; but will increase the weight of the hammer to 10 cwt.

N.B. The engine is to work two hammers, but is capable of working four hammers, of 7 cwt. each. We have made an engine which works equally powerfully in the ascent as in the descent of the piston, and which acts by a rack and sector instead of a chain, all of which answers well. We are now finishing an 18-inch cylinder, with 18-inch stroke, which is to turn a pair of corn-millstones $4\frac{1}{2}$ feet diameter 100 turns per minute. The engine is to make 60 strokes (acts up and down) in that time. We are also making a small engine, 1 foot diameter, 1 foot stroke, to work 100 strokes per minute, and to act up and down. These are our novelties in the engine way.

* * * *

[243.]

MR. WATT TO MR. G. HAMILTON.

Birmingham, [May or June, 1783.]

* * We are just upon finishing our steam-engine corn-mill; we have tried the engine and rotative motion without the mill, which goes

extremely swift and smooth. The first trial the engine went 120 strokes of 2 feet long per minute, but had no work to do,—only to turn the rotative motion. * *

[244.]

MR. WATT TO MR. BOULTON.

Birmingham, 18 May, 1783.

* * Chacewater Company sunk 50,000*l.* and upwards in setting that mine to work; and whether they have recovered it all yet seems uncertain, although the mine has been tolerably prosperous.

Wheal Virgin and Co. lost 28,000*l.* in ten months' unprosperous working. Poldice has sunk a very great sum, and is not now gaining nor saving. It has cost 35,000*l.* to fit up and drain Wheal Virgin in this working, and it costs above 10,000*l.* a-year to draw the water, after all that can be done for them. Pool adventurers have sunk near 14,000*l.*, and have no great prospect of recovering any part of it. Roskeere has been long languishing, and does not now pay costs. At Dolcoath Mine it is said they use 500*l.* of timber per month, and a new kibble rope of above a ton weight is worn out in a fortnight. It takes fully 15 minutes to draw a kibble of ore there, which weighs only about 3 cwt. On the average, above $\frac{2}{3}$ of the stuff drawn is barren stones. It cost three years' work, and, I believe, as many thousand pounds, to sink a new shaft in that

mine :—every fathom of an engine-shaft that is sunk under the engine costs from 50*l.* to 100*l.*

United Mines have been at death's door, and are still in a tottering state. Wheal Union adventurers, after working near three years, were glad to sit down with a loss of 7000*l.* or 8000*l.* If we had not furnished them with more effectual means of drawing the water, I believe almost all the deep mines had been abandoned before now.

* * * *

[245.]

MR. WATT TO MR. BOULTON.

Birmingham, 5 Sept. 1783.

* * Our millwrights have kept working, working, at the corn-mill ever since you went away, and it is not finished; but, my patience being exhausted, I have told them that it must be at an end to-morrow, done or undone. There is no end of millwrights once you give them leave to set about what they call machinery :—they have multiplied wheels upon wheels until it has now almost as many as an orrery. * *

J. Wyatt agrees to 4½-foot stones; 10 pairs to each engine. * *

[246.]

MR. WATT TO MR. BOULTON.

Birmingham, 14 Sept. 1783.

* * The corn-mill is now finished; and, by stopping air-leaks and mending valves, makes a much better vacuum and goes infinitely

better than ever, and that readily with one boiler ; but burns too much coal still (100 per hour). It drives the orrery work and the dressing-mill with the utmost ease, even while grinding ; and does not seem to be at all burdened thereby, only it seems to feel the sack-tackle a little. However, on the whole it is a pleasure to see it now to what it was. 100 is about double what it ought to burn ; the causes must be searched for.

* * * *

[247.]

MR. WATT TO MR. BOULTON.

Birmingham, 2 Oct. 1783.

* * Our corn-mill wrought yesterday better than ever ; and, Joseph says, does not use quite $\frac{2}{3}$ hundred per hour.

I have tried many experiments with the forge-engine, when raising water, to ascertain the consumption ; and found that with the rotative fly it used about, cwt. 0·375 per hour ; at $27\frac{1}{2}$ strokes per minute, = cwt. 0·28 for 20 strokes ; but, on being freed from the fly and rotative motion, it was only, cwt. 0·235 per hour for 20 strokes per minute. In both cases the boiler evaporated 11 feet per cwt. Without the steam-case, and with the top and bottom cold, it does not do so well, but does not fall so far short as might be expected. * *

[248.]

MR. WATT TO MR. BOULTON.

Birmingham, 22 Oct. 1783.

* * I have nearly finished the drawing of Blackfriars; but I fear the expense of each of these engines will be very great, and I do not see how to remedy it and make the machine *à toute épreuve* at the same time. * *

[249.]

• PROFESSOR ROBISON TO MR. WATT.

Edinburgh, Oct. 22, 1783.

* * I am glad of anything which may happen to bring me to your remembrance, often regretting that our different pursuits have separated me so far from a person whom I so much esteem and love. It would add greatly to the pleasure of my life could I be witness of the regard that is paid to your genius, and the success which attends the exertion of your talents. Believe me there is no one who more sincerely rejoices in your prosperity, or is more fully persuaded of your title to all the regard which is paid you. I am too far removed from you to have any interest in flattering you, and you must therefore take this as the honest effusion of very affectionate regard. * *

[250.]

MR. WATT TO MR. KIRWAN.

Birmingham, Nov. 14, 1783.

DEAR SIR,—Your obliging communication of Mr. Scheele's process of making the Prussian acid

gave me great pleasure, and, according to your desire, I communicated it to our Lunar Society last Monday, who desire me to return you their thanks.

Having lately been making some calculations from Messrs. Lavoisier and De la Place's experiments and comparing them with yours, I had a great deal of trouble in reducing the weights and measures to speak the same language; and many of the German experiments become still more difficult from their using different weights and different divisions of them in different parts of that empire. It is therefore a very desirable thing to have these difficulties removed, and to get all philosophers to use pounds divided in the same manner, and I flatter myself that may be accomplished if you, Dr. Priestley, and a few of the French experimenters will agree to it; for the utility is so evident, that every thinking person must immediately be convinced of it. My proposal is briefly this; let the

Philosophical pound	consist of	10 ounces,	or	10,000 grains.
the ounce	„	10 drachms,	or	1,000 „
the drachm	„	100 grains,	or	100 „

Let all elastic fluids be measured by the ounce measure of water, by which the valuation of different cubic inches will be avoided, and the common decimal tables of specific gravities will immediately give the weights of those elastic fluids.

If all philosophers cannot agree on one pound

or one grain; let every one take his own pound or his own grain; it will affect nothing except doses of medicines, which must be corrected as is now done; but as it would be much better that the identical pound was used by all, I would propose that the Amsterdam or Paris pound be assumed as the standard, being now the most universal in Europe: it is to our avoirdupois pound as 109 is to 100. Our avoirdupois pound contains 7000 of our grains, and the Paris pound 7630 of our grains, but it contains 9376 Paris grains, so that the division into 10,000 would very little affect the Paris grain. I prefer dividing the pound afresh to beginning with the Paris grain, because I believe the pound is very general, but the grain local.

Dr. Priestley has agreed to this proposal, and has referred it to you to fix upon the pound if you otherwise approve of it. I shall be happy to have your opinion of it as soon as convenient, and to concert with you the means of making it universal.

I remain, with much esteem,

Dear Sir,

Your obliged friend,

JAMES WATT.

I have some hopes that the foot may be fixed by the pendulum and a measure of water, and a pound derived from that; but in the interim let us at least assume a proper division, which from the nature of it must be intelligible as long as decimal arithmetic is used.

[251]

MR. WATT TO MR. DE LUC.

Birmingham, Nov. 23, 1783.

* * In making calculations from Messrs. Lavoisier and De la Place's memoir, I have been much plagued reducing French grains to English ones, to compare them with some experiments of Mr. Kirwan's; and, indeed, to compare one experiment with another, even where the weights used are the same, gives much trouble from the absurd subdivisions used by all Europe; and also, to compare cubic inches of various substances with weights is a perpetual source of unnecessary calculation:—in order to avoid which, I proposed to Dr. Priestley and Mr. Kirwan to agree on a perpetual decimal subdivision of the pound, thus:—

100 grains	1 drachm.
1,000 grains	1 ounce.
10,000 grains	1 pound.

All elastic fluids to be measured by the ounce or pound measure. The decimal tables of specific gravities will give the weights without calculation. All liquids to be weighed. Thus every philosopher may use the grain or pound he has most affection for, and yet, if he adopts this method of subdivision, the results will be comparable by persons knowing nothing about his individual grain or pound.

Mr. Kirwan answers that Mr. Whitehurst is at work on a philosophical measure from which he

means to deduce a pound divided as above; but I say, that as it may be long before that comes forth, let the expedient of the proper division take place in the mean time. Dr. Priestley will immediately adopt it; and I will be obliged to you to write to Mr. De la Place on the subject. In order to introduce uniformity as much as we can, we mean to subdivide the Paris pound into 10,000 parts. * *

[252.]

MR. WATT TO MR. KIRWAN.

Birmingham, Nov. 26th, 1783.

I am glad to hear that Mr. Whitehurst is so far advanced with the universal measure; but, as it may be some time before he brings it forth, and I want a new set of weights, and am not willing to make bad ones, I should therefore be glad to know the outlines of his plan. If he uses a seconds pendulum, and divides it into 3 feet, that cubic foot of water will weigh about $80\frac{1}{2}$ lbs. avoirdupois, which may very properly be re-divided into 80 lbs., and would thereby occasion very little confusion in the article of weights. I think it would make too small a pound to divide it into 100 lbs., without some other length of pendulum be pitched upon, but it will require much consideration to adapt it properly to all the different things such a standard is applicable to; I shall therefore speculate no more upon it until I hear Mr. Whitehurst's proposal. * *

[253.]

MR. WATT TO MR. MAGELLAN.

Birmingham, Dec. 1st, 1783.

* * Dr. Withering has shown me your paper on weights, which in general coincides with my own sentiments on that subject, on which I wish something was done, as we are at present in a most confused state in those matters, and subject to perpetual errors.

[254.]

MR. WATT TO MR. MAGELLAN.

Birmingham, Jan. 1st, 1784.

* * As to the philosophical weight and measure, I have thought very little about it. The principal thing seems to be dividing the pound, &c., decimally, and weighing liquids instead of measuring them, and measuring elastic fluids by the ounce or pound measure of water. As to the precise foot or pound, I do not look upon it to be very material, in chemistry at least. Either the common English foot may be adopted according to your proposal, which has the advantage that a cubic foot is exactly 1000 ounces, consequently the present foot and ounce would be retained; or a pendulum which vibrates 100 times a minute may be adopted for the standard, which would make the foot 14.2 of our present inches, and the cubic foot would be very exactly a bushel, and would weigh 101 of the present pounds, so that the present pound would not be much altered. But I think that by this scheme the foot would be too large, and that the inconvenience of changing

all the foot measures and things depending on them would be much greater than changing all the pounds, bushels, gallons, &c. I therefore give the preference to those plans which retain the foot and ounce. * *

[255.]

MR. WATT TO MRS. CAMPBELL.*

Birmingham, May 30th, 1784.

* * I heard some time ago of your

* This letter is selected as a specimen of the advice Mr. Watt was in the habit of giving as to the education of lads who had to make their own way in the world, and the qualifications he considered it most needful for them to possess. The young man for whose benefit it was intended, Mr. Charles Campbell, afterwards entered the medical profession, and was for several years resident at Fort Marlborough (Bencoolen), Sumatra, in the service of the East India Company, as Botanist. He was possessed of great talents and fondness for science, and devoted much time to a detailed examination and record of the natural history of the island, then but little known, which had become his home.

Mr. Marsden, the author of the 'History of Sumatra,' has mentioned Mr. Campbell with commendation in many parts of his work,* as having first determined the botanical character of the *Urceola elastica*, or caoutchouc vine of Sumatra and Pulo-Pinang; as having introduced the extensive cultivation of nutmegs and cloves from Amboina into Sumatra, as well as restored the coffee-trees (which from want of culture and care had degenerated so as to be worthless), by introducing fresh plants from Mocha; and as having exposed the fabulous accounts previously circulated regarding the Puhn upas, or poison-tree, (*Arbor toxicaria*). On the latter curious subject Mr. Campbell says—"The poison is certainly deleterious, but not in so terrific a degree as has been represented. As to the tree itself, it does no manner of injury to those around it. I have sat under its shade, and seen birds alight upon its branches; and as to the story of grass not growing beneath it, every one who has been in a forest must know that grass is not found in such situations." For his public services a gold medal was voted to Mr. Campbell, in 1802, by the Board of Agriculture; and had

* See pp. 2, 92, 110, 147, 158, 304, 364, of the 'History of Sumatra,' by William Marsden, F.R.S. Edit. 1811.

son's* dutiful and generous behaviour, which gave me great pleasure, both on your account and on his own. In relation to Charles, as your intention is to breed him an engineer, the things most necessary are drawing, geometry, algebra, arithmetic, in which he should be very expert, and the elements of mechanics, which comprehend the greatest part of what is called Natural Philosophy. As to teaching him any mechanic employment, I know not if it is necessary, but if any time is to spare from his studies, by way of exercise you may send him an hour or two in the day to a good house-carpenter or architect; cabinet-making or the nicer arts will be of little use to him.

I must observe to you, however, that there is at Woolwich a military academy, where young men intended to be engineers are taught the necessary sciences at the expense of Government; and that

he survived, there can be little doubt that he would have been the means of still further advancing the botanical and agricultural resources of our Eastern empire. But that prospect was unhappily cut off by his premature death in 1808; when he fell a victim to the climate of those countries, the condition of which he had done so much to investigate and improve. Many valuable MSS. and drawings, the results of his laborious journeys in the interior of Sumatra, which he had bequeathed to his friend Mr. Marsden, were never recovered, nor ascertained to have been brought to Europe.

* Lieut.-Col. John Campbell, H.E.I.C.S., a gallant and distinguished officer, whose active, zealous, and judicious services during the wars in which he was engaged in India, together with his strict integrity and scrupulous attention to economy in the administration of an important department of the Commissariat, were repeatedly noticed in the most public manner by the Commander-in-Chief and Governor-General in Council, as being highly honourable to Colonel Campbell, and productive of extensive benefit to the public interests. He died in 1832, having throughout his life gained the esteem and love of all who knew him.

the same interest which could get him sent out as an engineer could get him placed there as a previous step. What expense attends it, or if any, I cannot tell, having no acquaintances in that line. If you find you cannot get him placed there, above all things get him well grounded in geometry, algebra, and arithmetic, and take pains to make him write a good plain legible hand. Merchants' accounts will also be useful to him; nothing is of more consequence than method in business. And if he can attain the qualifications I have mentioned, he will be able, with the help of a little ingenuity and good sense, to find his way through the world either in Europe or Asia.

I have sent my son* to Mr. Wilkinson's iron-works, at Bersham, in Wales, where he is to study practical book-keeping, geometry, and algebra at his leisure hours; and three hours in the day he works in the carpenter's shop. I intend he should stay there a year; what I shall do with him next I know not, but I intend to fit him for some employment not so precarious as my own. He has not yet manifested anything which may be called genius, but he has abilities to learn anything, draws tolerably, and writes a letter in good style.

* * My younger children are very thriving, very amiable, and sufficiently advanced in knowledge for their years.

My situation in respect to worldly affairs is much mended since I wrote you last; but my health, though perhaps rather better than when

* The late Mr. James Watt, of Aston Hall.

you knew me, is still of the languid kind. You talk of my coming to Scotland and leaving care behind me :—I should be like the wounded stag, “ He flies, but the deadly arrow sticks in his side.” I would willingly shake off care, but I fear I must first shake off this mortal coil. * * *

Please remember me affectionately to Mr. Campbell, to your brother, and Mrs. Muirheid, and to all relations and friends who remember me. I remain, my dear cousin, with best wishes for your welfare and that of your family,

Your affectionate friend,

JAMES WATT.

[256.]

MR. WATT TO DR. BLACK.

Birmingham, June 6th, 1784.

DEAR DOCTOR,—The other day I received yours without date. I am extremely concerned to hear of your bad health and spirits, and sorry that I should have plagued you about publication; but I could not bear to see so many people adorning themselves with your feathers. And I still hope that, if you cannot perform the task yourself, you will find some man of ability, and with a greater quantity of animal spirits, who will consent to be your editor, and whom you will furnish with ideas.

In the mean time, everything should give way to your health; you should, during the recess of college, make a long excursion, and leave care behind you. It will give me the utmost pleasure to see you here, and to contribute by every way in my power to your pleasure and comfort when

here. Our situation is healthy and clear of the town, and the country about affords many objects to interest and amuse you. I hope, therefore, that you will take a sudden resolution and set out, and if you can bring Dr. Hutton with you, so much the better. If you give me a little warning, I shall endeavour to get De Luc to meet you here; you will find him one of the most amiable and entertaining of men.

Previous to your letter I had heard much of Mr. Cort's process for making bars, and have seen a great deal of his iron; though I cannot perfectly agree with you as to its goodness, yet there is much ingenuity in the idea of forming the bars in that manner, which is the only part of his process which has any pretensions to novelty. The kind of iron you describe is one of the modifications of cold-short iron, and is known here by the emphatical name of *rotten tough*. I have long known that almost any cold-short iron may be brought to that state by rolling it very hot, or by drawing it across the anvil so as to spin the crystals into threads; and, by certain mechanical processes, good iron may be rendered cold-short. Nevertheless, in neither of these cases is the quality of the iron altered: the good iron continues strong, and the cold-short is very weak. I look on Mr. Cort's iron as a cold-short whose crystals are spun out by the rolling, and which is mixed with a large quantity of half-metallised earth. It is tender to the file, and soft to the hammer, rusts very readily, and ought never to be used where it is subjected

to any strain, as it is very weak, therefore unfit for engine-work, ship-work, &c., but good for nails, because easily wrought; but then the nailers complain that it wastes more than the common cold-short, I suppose because not so well freed from its cinder. I speak only of the iron made from cold-short by his process. Good iron is hard under the hammer, and stubborn to the chisel and file, breaks white, generally granulated, but the very best is fibrous, and white like silver. I find I am getting into a dissertation on iron, which I must shorten. Mr. Cort has, as you observe, been most illiberally treated by the trade; they are ignorant brutes: but he exposed himself to it by exposing his process to them before it was perfect; and they saw his ignorance of the common operations of making iron, laughed at and despised him; yet they will contrive by some dirty evasion to use his process, or such parts as they like, without acknowledging him in it. I shall be glad to be able to be of any use to him. * * *

My health is as usual indifferent, and I feel I grow old and stupid. I have still, however, some desire for more knowledge; which, with the necessary attention to my family and business, serves to keep me awake. With best respects to Dr. Hutton and all friends,

I remain ever sincerely yours,

JAMES WATT.

I again repeat that I most sincerely wish you to come here as soon as you can. You have often

told me that amusement was one of the best things in life, and I believed you, and found it so.—Now do as you bid me do.

[257.]

MR. WATT TO MR. DE LUC.

Birmingham, June 6th, 1784.

* * I have lately received a letter from Dr. Black, by which I am sorry to find that from the badness of his health and spirits he has laid aside all thoughts of publishing. I have begged of him to come here this summer and amuse himself, but I fear he will scarcely be prevailed upon. I should be very happy if I could bring you and him together. Now we are upon that subject, when are you to come here? we have expected a visit for some time. * *

[258.]

MR. WATT TO MR. BOULTON.

Birmingham, 30 June, 1784.

* * I have started a new hare. I have got a glimpse of a method of causing a piston-rod to move up and down perpendicularly, by only fixing it to a piece of iron upon the beam, without chains, or perpendicular guides, or untowardly frictions, arch-heads, or other pieces of clumsiness; by which contrivance, if it answers fully to expectation, about five feet in the height of the [engine-]house may be saved in 8-foot strokes, which I look upon as a capital saving; and it will answer for double engines as well as for single ones.

I have only tried it in a slight model yet, so cannot build upon it, though I think it a very probable thing to succeed, and one of the most ingenious simple pieces of mechanism I have contrived, but I beg nothing may be said on it till I specify.

* * * *

[259.]

MR. WATT TO MR. BOULTON.

Birmingham, 11 July, 1784.

* * I have made a very large model of the new substitute for racks and sectors, which seems to bid fair to answer. The rod goes up and down, quite in a perpendicular line, without racks, chains, or guides. It is a perpendicular motion derived from a combination of motions about centres, very simple, has very little friction, has nothing standing higher than the back of the beam, and requires the centre of the beam to be only half the stroke of the engine higher than the top of the piston-rod when at lowest, and has no inclination to pull the piston-rod either one way or another except straight up and down. It has rather more power at beginning and end of the stroke than in the middle,—I think about one-sixth; which I believe will do no hurt in rotative motions, and little in any case. Beams mounted in this way need no arches; and the whole iron-work will not, I think, be more than chains, martingales, and their appendages, if quite so much. However, don't pride yourself on it; it is not fairly tried yet, and may have unknown faults.

Where it is used, the beams will be best above the centre of motion, which will answer double engines very well, and may in most cases be dispensed with in the others. * * The piston-rod motion at the corn-mill answers very well.

* * * *

[260.] MR. WATT TO MR. BOULTON.

Birmingham, 20 July, 1784.

* * I have invented another method of a right-lined motion from central ones, which has some advantages and some defects. However, I shall include it in the specification, which is begun to.* * *

[261.] MR. WATT TO MR. BOULTON.

Birmingham, 22 July, 1784.

* * The specification must be done immediately, and will require the whole force of my attention. * *

[262.] MR. WATT TO MR. BOULTON.

Birmingham, Aug. 17th, 1784.

* * I have now got the specification composed, but the drawings are not nearly finished. I have given such description of engines for wheel-carriages as I could do in the time and space I

* But he says, 31st July, "as soon as the specification is done, (which is not yet begun to)."

could allow myself; but it is very defective, and can only serve to keep other people from similar patents! * *

[263.]

MR. WATT TO MR. BOULTON.

Birmingham, 21 Aug. 1784.

* * The draft of the specification is gone to London, and the drawing will be done to-night. * *

[264.]

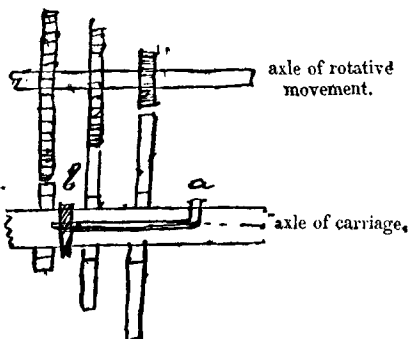
MR. WATT TO MR. BOULTON

Birmingham, Aug. 27th, 1784.

I wrote to you last night, and now sit down to give you some of my ideas on the wheel-carriage scheme, and have therefore annexed that article of the specification, by which you will see the general idea. The engine may either be connected with the rotative motion by a working beam, or may be placed directly over the secondary axle, and work the rotative motion by means of two rods coming down on each side of the cylinder from a cross-bar on the top of the piston-rod, guided perpendicularly by a sliding frame; but I am inclined to prefer a working-beam, which in this case may be short. I do not know that the organ-pipe condenser will make

* Prefixed to this letter is an extract from the Specification of the Patent of April 28th, 1784, from "My seventh new improvement is upon steam-engines which are applied to give motion to wheel carriages," down to the end.

much vacuum, but it may, by the *help of the bellows*, condense, and save most of the water. On the side you have a sketch of the two axles, and of the means I use to lock and unlock the wheels which connect them together, so as to make the carriage go faster or slower at pleasure, or, at least,



to have more or less power at will. The piece (*a b*) slides in a hollow, and two slits in axle of the carriage; when *b* is in the place drawn, the rotative motion can turn without moving the carriage; but when *b* is placed so as to be in a slit which is in one of the wheels, then the wheel will cause the axle to turn round or to break *b*; and *b* is always disengaged from one wheel before it is locked to the other. As to the size of the cylinder, boiler, &c., I calculate that, suppose the power necessary to move a post-chaise on a plain to be 80 lbs. weight, and the chaise to move at the rate of 4 miles per hour, or 6 feet per second, let the moving-wheel be 4 feet diameter, then it will make 1 revolution in 2 seconds, and if the engine makes 60 strokes per minute, it will make one revolution for 2 strokes; but as the rotative motion will make 2 revolutions per stroke, it will make 4 revolutions for each turn of the

wheel of the carriage, and 80 lbs. \times 6 feet = 480 lbs. 1 foot high per second, and supposing the stroke of the engine 1 foot long, $480 \div 2$ must be its power = 240 = 6 lbs. on inch to a 7-inch cylinder; but as going up hills it will require a power of 400 lbs. to drag the chaise up, the power in these cases must be increased 5 times, that is, *the axle* of the carriage must make only 1 turn for 20 turns of the rotative axle, and will then move only 12 feet in 10 seconds; but this inconvenience may be something lessened by letting the steam get stronger at such times.

A cylinder of 7 inches diameter and 12-inch stroke will take something more than $\frac{1}{2}$ a foot of steam per double stroke, supposing it to be working with a condenser; consequently it would take 30 cubic feet of steam per minute = 1800 feet of steam per hour, which, supposing it to be equal to 1 cubic foot of water, would require a boiler of 8 feet surface exposed to the fire to make any tolerable performance in respect of fuel; but as we can *depend* on no aid from condensation, we must suppose this steam to be at least $1\frac{1}{2}$ times as dense as the common steam, therefore there must be a surface of 12 feet exposed to the fire, if not more; let us leave the form of the boiler out of the case at present. The surface of 12 square feet which we suppose to be exposed to the fire, must be covered with a shell of water of some thickness, which, upon the average, I shall suppose to be 6 inches thick, which will make the whole quantity of water necessary = 6 cubic feet,

supposing no magazine of water to be carried. As we must suppose the copper of the boiler which is to stand such violent steam to be at least $\frac{1}{4}$ inch thick, it will weigh at least 10 lbs. per square foot; we have then 120 lbs. for the inside part of the boiler; and as there must be steam-room, and the outside case of the boiler must be 1 foot wider than the inside, supposing the inside oblong 1 foot wide, 3 feet long, and 18 inches high, then the outside must be 4 feet long, 2 feet wide, and $2\frac{1}{2}$ feet deep, which would have 35 feet surface, which at 10 lbs. would weigh 350 lbs. The boiler, then, with the included water, would weigh 830 lbs., without any allowance for a grate or wooden case; but, in relation to the latter, the copper might be made so much thinner as to allow for it, and perhaps some means may be hit upon to make the boiler cylindrical, with a number of tubes passing through, like the organ-pipe condenser, whereby it might be thinner and lighter; but I fear this would be too subject to accidents. Let us suppose, however, that it could be reduced to 300 lbs. weight, which, with the water, would make 660 lbs.

	lbs.
A post-chaise weighs about	1000
The boiler and water would weigh	660
The engine and wheels, say about	200
The fly, 3 feet diameter, containing the power of one stroke of the engine	100
The organ-pipe condenser and bellows, say	100
Three persons, including the driver	400
	<hr/>
Carried forward	2460

	lbs.
Brought forward	2460
Their luggage	200
Coals for four hours, at 15 lbs. per hour	60
And if the organ-pipe condenser is not found sufficient to condense the steam, water must be carried, say for two hours	180
	<hr/>
	2900
	<hr/>

And then, if the machinery cannot be made lighter than has been stated, the power will, I am afraid, prove insufficient, and a further augmentation of the boiler, &c., must take place. If there were no friction, the power of 80 lbs. would be sufficient to draw the carriage up an ascent of 1 in 36 on a hard smooth plain; but there would be some friction, and roads are both unequal and generally soft, which latter gives a continued resistance of the same nature as going up a steep ascent. There is another consideration, which is, that the carriage, being loaded with the weight of the engine, would require stronger wheels than usual for these machines, which would still increase its weight.

I have taken it for granted all along that 80 lbs. is a sufficient force to move a common post-chaise, loaded as I have mentioned, (but without the engine); which, however, I am by no means certain of. I rather apprehend it will require that power on a quite plain road, and more upon acclivities; for four men would be able to exert that force, and yet could not move the loaded post-chaise at the above rate; and I observe that horses labour as much in a cart as they do in a horse-mill, yet

they exert near 200 lbs. each in the latter, at the rate of $1\frac{1}{2}$ miles per hour.

31 August, 1784.

The whole matter seems to turn on an answer to the question, whether 80 lbs. be a sufficient power to move a post-chaise on a tolerably good and level road at the rate of 4 miles in an hour. 2dly. Whether any less surface than 8 feet exposed to the fire be sufficient to evaporate a cubic foot of water per hour, without much waste of fuel; which question seems partly answered by the boiler of our corn-mill, which has only about 5 feet surface exposed to the fire for each foot it evaporates per hour; and it evaporates about 8 cubic feet per cwt., so that by submitting to a waste of coals, a smaller boiler would do. 3rdly. Whether it will require steam of more than $1\frac{1}{2}$ times atmospheric density to cause the engine to exert a power = to 6 lbs. on the inch, which I fear it will. I think that the cylinder must either be made larger, or make more than 60 strokes per minute; and I do not think the latter plan very advisable, principally because the rotative motion already turns too fast for the axle of the chaise, and that it will require more wheels than two to reduce the motion to the proper velocity. As to working-gear, stopping and backing, with steering the carriage, I think these articles perfectly manageable.

The proper place for the engine will be behind the carriage, and to act upon the hind-wheels. Cokes must be used in place of coals, to prevent the

disagreeable circumstances of soot and smoke, but there will be no avoiding the sulphureous air, which, when going before a gentle wind, will prove suffocating. The shaking of the carriage will supersede the necessity of poking the fire, but will be apt to waste the coals, by making the coals fall through the grate before they are consumed. The shaking of the carriage will be apt to derange the joints of the cylinder, &c., and render them untight; but perhaps some remedy may be devised for this in construction.

My original ideas on this subject were prior to my invention of these improved engines, or before the crank or any other of the rotative motions were thought of. My plan then was to have two inverted cylinders, with toothed-racks instead of piston-rods, which were to be applied to two ratchet-wheels on the axle-tree, and to act alternately; and I am partly of opinion that this method may be applied to advantage yet, because it needs no fly, and has some other conveniences.

From what I have said, and from much more which a little reflection will suggest to you, you will see that without several circumstances turn out more favourable than has been stated, the machine will be clumsy and defective, and that it will cost much time to bring it to any tolerable degree of perfection; and that for me to interrupt the career of our business to bestow my attention on it would be imprudent. I even grudge the time I have taken to write these comments on it.

There is, however, another way in which much mechanism might be saved, if it be in itself practicable, which is, to apply to it one of the self-moving rotatives, which has no regulators, but turns like a mill-wheel by the constant influx and efflux of steam; but this would not abridge the size of the boiler, and I am not sure that such engines are practicable. * *

[The remainder of this letter is occupied with the consideration of the arrangements proper to be made with a third party, (not named, but then in the employment of Messrs. Boulton and Watt, and known to have been Mr. William Murdock), in case of his prosecuting the design, which he appears at that time to have warmly entertained, and urged, of making steam wheel-carriages for sale to the public, under a license from his employers, or in partnership with them.]

[265.]

MR. WATT TO MR. BOULTON.

Birmingham, 11 Sept. 1784.

* * You will find delineated one of the new methods of producing a right-lined motion from a combination of motions round centres. The convexities of the arches described by the ends of the working-beam, and of the regulating radius, lying in contrary directions, there is a certain point in the connecting-lever, which has very little sensible variation from a straight line. This method we are executing in Mr. Cotes' en-

gine. There is another method, which permits the house to be six feet lower than this method, and is in some respects preferable, but requires more iron-work; and there are six or seven methods [in] all specified. The friction in this method is very small, being principally on the pivots of the cross-bar of the piston-rod, and the pivots at the top of the connecting-lever; for the pivots at the bottom of the connecting-lever sustain only about one-fifteenth of the power of the engine, and that only at one point, or for a short part of the stroke. * * The thing principally in suspense now is the working-beam, which I am making some experiments to enable me to determine upon. Our beams hitherto were made to resist a force acting downwards; but this must resist in both ways, and is above the power of a single log, and, on account of its length, above the power of any reasonable quantity of logs combined, without something in the nature of an arch or ring-post be applied to it. * *

[266.]

MR. WATT TO MR. BOULTON.

Birmingham, 21 Oct. 1784.

* * The new central perpendicular motion answers beyond expectation, and does not make the shadow of a noise; but for want of some regular work for the engine to do, we have not been able to give it a fair trial. All we could do was to burthen the engine by means of a break, and to apply a pair of rolls, with which we have

rolled some copper and red-hot iron. I observed the movement while it was rolling the copper, and could not see that it was affected by it; but these operations could only last for a moment, as the rolls turn much too fast, viz., at least 80 per minute, and it was not worth while to put up machinery to turn them slower. The machines for opening the steam-regulators by means of toothed-sector and pinion, would answer very well; but when the engine is in very quick motion, we cannot set the pinion with accuracy; we have, therefore, adopted a somewhat different machine for the steam-regulator. But where motions are slower, as they will be in a pump-engine, I fancy the pinion may be used; or, in place of it, an endless screw, like that of an equatorial instrument. On the whole, the engine looks as if it would answer extremely well, and be free of most of the bad properties of the corn-mill engine, which, by the by, is much mended. * *

[267.]

MR. WATT TO MR. BOULTON.

Birmingham, March 25th, 1785.

* * I think we are in the way of getting quit of smoke in the engines. * *

[268.]

MR. WATT TO MR. BOULTON.

Birmingham, Aug. 11th, 1785.

* . * Perriers are erecting rotative engines at their foundries, and are to cast cylinders

as far as 30 inches diameter; they have got their subscription filled up for raising water to the city of Lyons. * *

[269.]

MR. WATT TO MR. BOULTON.

Birmingham, Aug. 18th, 1785.

* * We have now got Soho engine altered to an outside rotative motion, which, with the inverted valves in the nozzles, seems to answer very well; but the new furnace does not please yet, though I have hopes of mending it. * *

[270.]

MR. WATT TO MR. DE LUC.

Sept. 10th, 1785.

* * I have some hopes of being able to get quit of the abominable smoke which attends fire-engines. Some experiments which I have made promise success. It is not on Mr. Argand's principle, but on an old one of my own, which is exceedingly different. * * When I succeed I shall let you know particulars. * *

[271.]

MR. WATT TO MR. BOULTON.

Birmingham, Sept. 13th, 1785.

* * My own health is so bad that I do not think I can hold out much longer, at least as a man of business. * *

[272.]

MR. WATT TO MR. BOULTON.

Birmingham, Sept. 24th, 1785.

* * I cannot help being dispirited, because I find my head fail me much ; business an excessive burden to me, and little prospect of any speedy release from it. Were we both young and healthy, I see no reason to despair, but very much the contrary ; however, we must do the best we can, and hope for quiet in Heaven, when our weary bones are laid to rest. * *

[273.]

MR. WATT TO MRS. WATT.

Birmingham, 9th Oct. 1785.

* * We had a first trial yesterday of a large furnace to burn without smoke under the big boiler, at Soho, that used to poison Mr. B.'s garden so much, and it answered very well, as far as we could judge from a wet furnace, and without the engines being at work. Do you remember that you were to talk to your father on that head, to see if anything could be made of it in Scotland ; if it would be of any use to him ; and if it would be worth the expense of a patent, which, I believe, is about 120l. * *

[274.]

MR. WATT TO MR. BOULTON.

Birmingham, Nov. 5th, 1785.

* * On the whole, I find it now full time to cease attempting to invent new things, or

to attempt anything which is attended with any risk of not succeeding, or of creating trouble in the execution. Let us go on excepting the things we understand, and leave the rest to younger men, who have neither money nor character to lose.

* * * * * .

[275.]

MR. WATT TO M. REVEILLON.*

Birmingham, Dec. 9th, 1785.

* * I am not sure that the English paper-makers use what you call the *relevage*, but I believe they do; I have seen them performing some such operation; and I apprehend the paper never would be smooth without it.

As to the art of smooth-pressing printed papers, I apprehend that it is practised in England when books of price are required. Mr. Baskerville of this town performed that operation by interleaving the printed sheets with polished plates of thin brass, and then passing 10 or 12 of them together once or twice through between the cylinders of a rolling press. (He was the first person who introduced the use of the vellum-paper.) His rollers were of iron, like those of our copying-machines. Some years ago I heard that some persons in London smoothed the printed paper for books in that manner, instead of beating them, as is the general practice; and the pressing the paper without interleaving soon after its being printed, and

* In regard to this gentleman see the letter from M. Brunelle to Mr. Watt of the 1st of May, 1789, given below; [No. 294.] p. 226.

before it is quite dry, is frequently done; and the method of interleaving with polished pasteboard, which you mention, I have practised myself, but did not consider it as anything new.

I have not heard of anybody binding books without sewing them, though I think it extremely practicable; and perhaps it may be done in London, though I am ignorant of it. You will have observed, I doubt not, that they bind books very well in London.

I suspect that you are in a mistake concerning the Royal Society, which gives no premiums, and makes no criticisms nor observations on anything which is laid before it. If a present is made, thanks are returned by the President, but no other acknowledgment is made.

The Society of Arts, where Mr. More is Secretary, gives premiums, and passes votes of approbation or disapprobation on machines, or other matters relative to the arts, which are laid before it; and I suppose that it might be there that the person you speak of might present his book, as it was more an object of *art* than of *science*.

I intended to have mentioned, while you were here, to you and Mr. Montgolfier, that a person who understood the making of good spongy paper for letterpress-printing, and of the Columbian paper for copper-plates, might at least get a *good living* in England. If I did not hate to have any concern with the Excise laws, I should have made some attempts in that way myself; but on this subject, if you please, we shall have some future

correspondence, when I have informed myself more fully as to the matters of fact. In the meantime I should be glad to receive by some friend who may be coming from Paris, samples of your different papers, and their wholesale prices.

I beg you will believe that I feel myself much honoured by your favourable opinion, and that anything I can serve you in here you may freely command.

I beg my best respects may be presented to Mr. Montgolfier; and praying for my friend Argand's success in his lawsuit, and your and Mr. Montgolfier's safe return to France, and happy meeting with your friends, I remain, with much esteem, &c.

* * * *

[276.]

MR. WATT TO MR. DE LUC.

Birmingham, Dec. 11th, 1785.

* * I have accomplished the engine-fire without smoke, and I hope soon to show you it in practice at the Albion mill; it is too long to describe in a letter.

I have been turning some of my idle thoughts lately upon an arithmetical machine; how I shall succeed I know not, not having made it yet. Its properties are to be, that when you want to multiply, you first turn up one figure of the multiplier, you then turn up in their order all the figures of the multiplicand, and the machine will show the product by that multiplier; you then turn up the second figure of the multiplier, and, beginning one place towards the left hand, you turn up

again all the figures of the multiplicand, and the machine shows the product by these two figures ready added, and so on for any number of figures; and it will perform division nearly as easily, without the least calculation or burthen to the memory, other than to take the figures in their order, beginning at either end you like. I intend to make an attempt at making it;—I say an attempt, for though the machine is exceedingly simple, yet I have learnt by experience that in mechanics many things fall out between the cup and the mouth.

* * * *

[277.]

MR. WATT TO MR. BOULTON.

Birmingham, April 27th, 1786.

* * In the anguish of my mind amid the vexations occasioned by new and unsuccessful schemes, like Lovelace, I “curse my inventions,” and almost wish, if we could gather our money together, that somebody else should succeed in getting our trade from us. However, all may yet be well. Nature can be conquered, if we find out her weak side.

* *

[278.]

MR. WATT TO MR. HAMILTON.

Birmingham, June 18th, 1786.

I should have written to you long ago, but have really been in a worse situation in some respects this spring than I have ever been in my life. The illness I was seized with in London in the

spring greatly weakened me both in body and mind; and, I believe, was brought on by over-exertions, endeavouring to get home as soon as possible. The bodily disease has in great measure subsided; but an unusual quantity of business, which by Mr. Boulton's frequent and long absences has fallen wholly on me, and several vexations, with the consequent anxious thoughts, have hitherto prevented my mind from recovering its energy. I have been quite effete and listless, neither daring to face business, nor capable of it; my head and memory failing me much; my stable of hobby-horses pulled down, and the horses given to the dogs for carrion. In such a situation it requires something very pressing, or very animating, to make one put pen to paper. I have had serious thoughts of throwing down the burthen I find myself unable to carry, and perhaps, if other sentiments had not been stronger, should have thought of throwing off the mortal coil; but, if matters do not grow worse, I may perhaps stagger on. Solomon said that in the increase of knowledge there is increase of sorrow: if he had substituted *business* for knowledge, it would have been perfectly true. * *

[279.]

MR. WATT TO MR. BOULTON.

Birmingham, Sept. 12th, 1786.

* * I am extremely sorry that W[illiam] M[urdock] still busies himself with the steam-carriage. In one of my specifications I

have secured it as well as words could do it according to my ideas of it; and if to that you add Symington's and Sadler's patents, it can scarcely be patentable, even if free of the general specification in the Act of Parliament; for even granting that what I have done cannot secure it, yet it can act as prior invention against anybody else, and if it cannot be secured by patent, to what purpose should anybody labour at it? I have still the same opinions concerning it that I had; but to prevent as much as possible more fruitless argument about it, I have one of some size under hand, and am resolved to try if God will work a miracle in favour of these carriages. I shall in some future letter send you the words of my specification on that subject. In the meantime I wish W[illiam] could be brought to do as we do, to mind the business in hand, and let such as Symington and Sadler throw away their time and money, hunting shadows. * *

[280.]

MR. WATT TO MR. BOULTON.

Birmingham, Sept. 23d, 1786.

* * You are certainly wrong in your computation of 18 lbs. of water serving your steam-carriage an hour. At present, where engines are wrought by condensation, to exert the force of one horse requires 10 lbs. of coals and 1 cubic foot of water per hour; but if steam of double density is used, as must be the case where there is no condensation, it will take 20 lbs. of

coals and 2 cubic feet of water for each horse power. These are the present facts, and I suspect the age of miracles is past. I am glad, however, that William applies to his business. * * *

[281.]

MR. WATT TO MR. BOULTON.

Birmingham, Oct. 3d, 1786.

ON Sunday last I received the following letter :—

“ Messieurs,—J’ai l’ordre de ma Cour d’avoir l’honneur de vous faire savoir que si vos affaires pourroient vous permettre de vous rendre à Paris, elle pourvoiroit aux frais de votre voyage ; et de vous assurer, que vous recevriez d’ailleurs de la part du Gouvernement tout l’accueil que vous pourriez, Messieurs, désirer, et auquel doivent s’attendre des personnes de votre mérite et votre célébrité. J’ai d’autant plus de plaisir, Messieurs, à exécuter auprès de vous cet ordre de ma Cour, que j’y trouve l’avantage particulier de vous renouveler les assurances de tous les sentiments de considération et de dévouement avec lesquels j’ai l’honneur d’être, &c. “ BARTHELEMY.”

I have acknowledged the receipt of the letter ; informed him that you were in Cornwall, and that I would communicate it to you ; that though our engagements in this country multiplied every day, yet we were so sensible of the distinction they had shown us, that we should use our best endeavours to arrange matters so that *one* of us at least should

be able to obey the summons, but deferred our determination till I had heard from you:—(and I returned his flummery in kind.)

I am perfectly sensible of the honour which may be acquired by such a job as Marly, but I am also sensible that it would be attended with much labour and vexation, and am by no means so sure of the profits. I have no great confidence in their promises. * * In relation to which of us shall go, I think that is easily settled; once every other matter is so, perhaps we may both go. I must own I have a great desire to see Paris, but then I have no stomach for entering into treaties with artful statesmen, and my desire for going is not so strong as to make me wish to hinder our business here from being kept in good train.

* * I think if either of us go to France, we should first wait upon Mr. Pitt, and let him know our errand thither, that the tongue of slander may be silenced, all undue suspicion removed, and ourselves rendered more valuable in his eyes, because others desire to have us! * *

[282.]

MR. WATT TO DR. BLACK.

Birmingham, Oct. 5th, 1786.

* * You know I have long had plans of moving wheel-carriages by steam, and I have even described them in one of my patents some years ago. I believe I shall make some experiments on them soon, but have small hopes of their ever becoming useful. * *

[283.]

MR. WATT TO MR. DE LUC.

Birmingham, Oct. 8th, 1786.

* * The French Ministry have sent us an invitation to give our opinion on the machine of Marly, but this *entre nous*. I have not an atom of philosophical news; our business increases in making mill-engines, but my cares increase in the same ratio; our profits from these machines are not great in proportion to the trouble, but there is some pleasure in success. * *

[284.]

MR. WATT TO MR. JAMES WATT, JUN.

Birmingham, Feb. 1st, 1787.

* * We have had a very agreeable journey in France, and a most flattering reception from the Ministry, who seem much disposed to employ us in the line of our business there; but we have absolutely refused to engage in any manufactures, as contrary to the interest of our country. * *

[285.]

MR. WATT TO DR. ROEBUCK.

Birmingham, Feb. 3d, 1787.

* * Considering the season of the year, Mr. Boulton and I made an agreeable journey in France; we were sent for by the Ministry there to give our opinions on the best way of renewing the venerable machine of Marly, which they now consider as much the disgrace as it once was the honour of the nation. We have contented ourselves with giving a general opinion, until we

come to closer terms, which cannot be before summer, when the Academy shall have given their decision on the merits of the 400 proposals which are laid before them on the subject. The field being then clear, the minister can make a bargain with us if he shall then choose. We have been treated with much respect, civility, and attention, and they have paid the expenses of our journey. We have also vindicated the honour we were robbed of by M. Perrier's assuming the merit of my invention; he said our coming was *un coup de soufflet diabolique pour lui*. He has succeeded, however, in having erected a most magnificent and commodious manufactory for steam-engines, where he executes all the parts most exceedingly well. He is a man of abilities, and would be very estimable if he were a little more just, (or more honest). * *

[286.]

MR. WATT TO MR. MACGREGOR.

Birmingham, April 8th, 1787.

I most sincerely sympathise with you on the late afflicting event.* None of the many trying calamities to which human nature is subjected bears harder or longer on a thinking mind than that grief which arises from the loss of our dear friends; but, like other evils, it must be endured with patience until the lenient hand of Time shall gradually soften the keenest sensations caused by it, which it always does, though we still retain the

* The death of Mrs. Macgregor, Mr. Watt's mother-in law.

remembrance of the lost friend. To a person of your calm and energetic mind it would be presumptuous in me to urge the common topics of consolation. I know by experience they are all futile. I shall only venture to urge one thing, and that I believe to be the most powerful remedy for grief, which is, that the sooner and the more you can apply to business, or amusements, which can call your mind from its sorrows and prevent it from preying upon itself, so much the better. In the fullness of our grief we are apt to think that allowing ourselves to pursue objects which may turn our minds from the object it is but too much occupied with, is like a kind of insult or want of affection for the deceased; but we do not then argue fairly;—our duty to the departed has come to a period, but our duty to our living family, to ourselves, and to the world, still subsists, and the sooner we can bring ourselves to attend to it, the more meritorious.

That God may grant you consolation and bless the remainder of your life is my sincere prayer!

* * * *

[287.]

MR. WATT TO MR. MACGREGOR.

Birmingham, April 27th, 1787.

* * In relation to the inventor,* he is a man of science, a member of the Academy of

* Of bleaching by chlorine, then recently invented by Berthollet; whose acquaintance Mr. Watt had made on occasion of his visit to Paris in 1786-7, and with whom he afterwards maintained a frequent and most friendly correspondence.

Sciences at Paris, and a physician, not very rich, a very modest and worthy man, and an excellent chemist. My sole motives in meddling with it were, to procure such reward as I could to a man of merit who had made an extensively useful discovery in the arts, and secondly, I had an immediate view to your interest; as to myself, I had no lucrative views whatsoever, it being a thing out of my way, which both my business and my health prevented me from pursuing further than it might serve for amusement when unfit for more serious business. Lately, by a letter from the inventor, he informs me that he gives up all intentions of pursuing it with lucrative views, as he says he will not compromise his quiet and happiness by engaging in business; in which, perhaps, he is right: but if the discovery has real merit, as I apprehend, he is certainly entitled to a generous reward, which I would wish, for the honour of Britain, to procure for him; but I much fear, in the way you state it, that nothing could be got worth his acceptance. * *

[288.]

MR. WATT TO MR. JAMES WATT, JUN.

Birmingham, May 7th, 1787.

* * I am glad to hear you are making such progress in your mathematics. As to Mr. Werner's classification of minerals, though it may be proper for you to know it, yet I cannot conceive it to be of much consequence to you, as the che-

mical analysis is the *only sure method* of discriminating fossils, and is abundantly more simple than any other, and must be reverted to in the long run, at least for all fossils which admit of it. That of the external characters has a few partisans in France, but none that I know of here.

* * * *

[289.] MR. WATT TO MR. JAMES WATT, JUN.

Birmingham, July 1st, 1787.

* * I had lately the honour of explaining one of our steam-engines to the King at Mr. Whitbread's brew-house. His Majesty was much pleased with the brew-house, which is immense; brews this year 165,000 barrels of porter, each barrel 36 gallons (or 6 cubic feet), and pays 52,000*l.* of excise. The engine does the work for which 30 strong horses were kept, grinds 800 quintals of malt in 8 hours, besides pumping all the water and worts used in the brew-house, and consumes only $\frac{8}{10}$ of a bushel of coals (or about 66 pounds weight) per hour. The King and Queen behaved to me with the utmost civility and affability.*

* In July, 1805, a visit of his Majesty George III. to Soho was arranged; and, notwithstanding the King's blindness, he "persisted in his intention because he would not disappoint the Queen and Princesses;" but at last, in consequence of medical advice, it was given up. The great engineer's intercourse with crowned heads did not, however, terminate here; for in 1814 he spent two hours in company with the Emperor of Russia and his sister at Messrs. Huddart and Co.'s celebrated rope-work, and found them, as he expresses it, "very pleasant, affable people."

Our great mill, called the Albion Mill, at Blackfriars Bridge, goes on very well in point of performing its business ; it has at present one steam-engine, which turns 8 pair of millstones always, and sometimes 10 pair, and grinds about 25 quintals of wheat per hour, besides turning the machinery which dresses it into flour, and hoists up the sacks to the top of the building. When finished, it is to have three engines, and 30 pair of millstones. It has cost a prodigious sum of money, and the miller trade having been very bad ever since we began to work, it is not hitherto a profitable concern. * *

[290.]

MR. WATT TO MR. ARGAND.

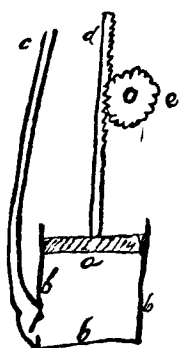
Birmingham, Aug. 8th, 1787.

* * I have just seen some of Keir's lamps, but have not seen them tried ; in my opinion, they will be found troublesome, and subject to be out of order ; for the quality of the saline liquor must be adjusted to a drachm, otherwise they will not answer : besides, I should suspect that said liquor will have bad effects upon the oil, or upon the vessels containing it. I am sure they are clumsy, logger-headed things, top-heavy, and liable to be overset.

I have four plans for making lamps with the reservoir below, and the stem as tall as you please. The first is, by means of a watch fixed above the reservoir, which shall work a small forcing-pump, about the size of a quill, at proper intervals, and

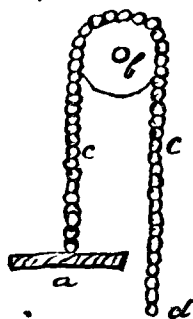
keep the burner always supplied ; and it may be so contrived as to stop the water while the oil is within certain limits in height of the feeder of the burner.

Second, by means of a pump about 3 inches diameter and 3 inches stroke, with a *light* piston fixed to it, garnished with a pliable leather, made to go easy, and perfectly oil-tight. The stem of this piston, which guides it perpendicularly, to be pressed down by a clock or time-piece spring in a barrel, acting on the stem by a wheel and rack-teeth on the stem ; but as the spring will grow weaker as it unbends, and the pillar of oil will grow heavier as the piston descends, to regulate these inequalities I attach to the piston one end of two heavyish chains, which lie over two pulleys, at some considerable height above ; so that, as the piston descends, more weight of the chains will come to that side, and assist it in the descent.



a Piston.
bb Pump.
c Feeding-tube.
d Stem and rack.
e Wheel on spring barrel.

View of Chains and Pulley.



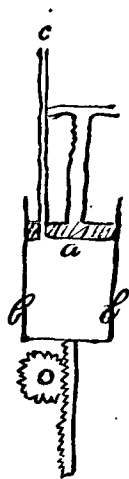
a Piston.
b Pulley.
c Chain.

The end (*d*) of the chain must be always heavier than the other, so that it may keep it tight.

Third, instead of making the piston moveable as in the last, make it fixed; carry the feeding pipe out of its upper surface; let the pump be moveable upwards by means of a spring and barrel; then, as the spring grows weaker by unwinding itself, the height of the column of oil and the weight in the pump will both grow less, in a ratio to which it is possible to adjust a spring.

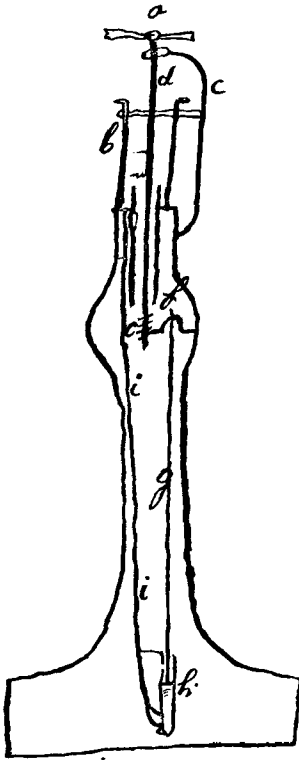
In order to avoid too much height, the pump may be pulled up by two racks, fixed to the upper edge, and acted upon by two wheels on the axis of the spring barrel.

Fourth, last, and best. Let there be placed, about 2 inches above the upper end of the glass cylinder, a small fly like that of a smoke-jack, which will turn round very swiftly by the current of air, and pretty forcibly. Let this fly have a stem coming down in the inside of the inner cylinder; at its lower end let there be an endless screw of one thread, working into a wheel of 60 or 100 teeth, which will make one turn for every 60 or 100 revolutions of the fly; on the axis of this wheel let there be a crank, (*manivelle*), to which attach the piston of a small pump about the size of a goosequill, and $\frac{1}{2}$ an inch or $\frac{3}{8}$ inch stroke, which



a The piston fixed.
 bb The pump moveable.
 c The feed-pipe.
 d Wheel on spring barrel.

will always keep the lamp abundantly supplied with oil, and a waste-pipe may convey back the superfluity. I once thought of making it work a rope-pump, but the crank will be better, and amadou will make an excellent piston; *expertus sum* the amadou.

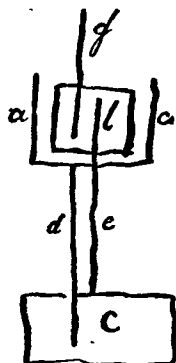


- a Fly.
- b Glass.
- c Glass-holder.
- d Spindle.
- e Endless screw.
- f Crank.
- g Pump-rod.
- h Pump.
- i i Feed-pipe.

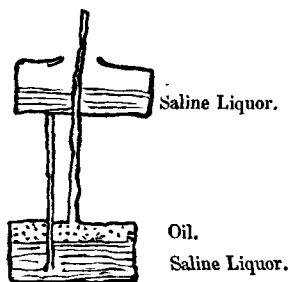
Now, if this will answer, it will be the *TO KALON*, the *TO TO MEIZOTON*, because it will perform its office by its own *vis insita*. The fly, indeed, will darken a small space above it; but it will serve to amuse people, and consequently will sell if well made. In short, I like it so well, that if you will try it, and find it answers, I will go half with you in a patent for England, if you choose it; otherwise, it is entirely at your service to make what use of it you please.

Keir's lamp has, however, one good property which this will not have, viz., as his pillar of saline liquor grows shorter, the pillar of oil grows

shorter too. Keir's lamp may be improved in this way:—let *aa* be an open vessel containing



Keir's Lamp.



oil, and *bb* be a close vessel containing the same fluid, *c a* vessel containing air; then the oil in *aa* will descend into the vessel *c*, by *d*, and the air will ascend by the pipe *e* into the upper part of *b*, and will force the oil in it to ascend by the pipe *f* as much above *b* as the surface of oil in *c* is below the surface in *aa*. By this means you will be quit of the saline liquor and all its embarrassments, and you may carry the burner higher than he can; and if you use a saline liquor in *aa*, you may carry it twice as high as he does. Q. E. D. *Sat verbum sapienti. Valeant quantum valere possunt, &c. &c. &c.*

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[291.]

MR. WATT TO DR. BLACK.

Birmingham, June 8th, 1788.

* . * I have lately improved upon a hint I saw, and made an instrument for measuring

specific gravities of liquids. It consists of a syphon of two equal legs, with a tube joined to the bend of it, and a little water in that tube. One leg being immersed in water, and the other in the liquid to be examined, by sucking at the pipe the liquors will both rise to columns proportioned to their specific gravities; and, if it is about 13 inches long in the legs, you can easily judge within $\frac{1}{400}$ part of the specific gravity, or, rather, of the longest column suspended. * *



[292.]

M. BERTHOLLET TO MR. WATT.

Paris, Rue de Bourbon, F.S.G.,*
6 Aoust, 1788.

* * Les dernières expériences de votre célèbre ami M. Priestley offrent sans doute des objets intéressans, comme tout ce qui vient de lui; mais elles ne me paraissent apporter aucun changement dans les idées que nous nous sommes formées. Il est incontestable qu'il se forme de l'acide nitreux dans la combustion du gaz inflammable et du gaz oxigène; mais il me paraît aussi incontestable par les expériences de M. Cavendish et par celles de MM. Monge et Landriani, que si le gaz oxigène est parfaitement pur, il ne se forme point d'acide; ainsi, dans deux expériences, M. Monge a obtenu sept onces d'eau qui était si peu acide, qu'à peine elle causait quelque changement sur un papier très sensible, teint avec le tournesol;—peut-on dire

* Faubourg St. Germain.

que dans cette expérience un acide ait été le résultat de la combinaison des deux gaz ?

Dans ses expériences, M. Priestley a-t-il pu exclure quelques molécules d'air atmosphérique, dont le gaz azotique aura produit par sa combinaison avec l'air vital la très petite portion d'acide nitreux ? D'ailleurs, nous savons que quelques oxides métalliques contiennent un peu d'azote : tel est l'oxide de manganèse ; peut-être la plupart des autres, peut-être même tous en contiennent-ils une très petite quantité. Au reste, j'attends avec impatience ce que vous avez à nous donner sur ces objets ; car je mets le plus grand prix à tout ce qui peut venir de vous, et je désirerais bien que la chimie pût vous distraire un peu plus de vos autres occupations. * * *

L'on a fait ici une grande expérience sur la formation de l'eau ; M. Lefèvre, Professeur au Collège Royal, a fait deux livres trois onces d'eau, ce qui a représenté, à moins d'un gros près, le poids total des gaz employés ; mais, comme son gaz oxigène n'était pas bien pur, l'eau contient une quantité assez considérable d'acide nitreux. L'expérience sera publiée avec ses détails. * *

[293.]

M. BERTHOLLET TO MR. WATT.

Paris, Rue de Bourbon, F.S.G.
9 Novembre, 1788.

* * * Nous sommes bien flattés du jugement que vous portez de la nomenclature que nous avons proposée : un suffrage tel que le vôtre

compense bien les plaisanteries et les mauvaises discussions qu'elle nous a attirées, quoique nous n'avons pu avoir en vuë que de faciliter l'étude de la chimie, et de porter plus d'exactitude dans les idées par celle du langage. Les caractères dont vous vous servez sont réellement plus commodes que les nôtres. Que n'avons nous pu vous consulter! Nous l'aurions fait avec autant de confiance que d'empressement. * *

Tous mes confrères qui ont eu le bonheur de vous connaître à Paris, principalement Messrs. Monge, Vandermonde, Lavoisier, me chargent de vous présenter leurs complimens, et de les rappeler à votre souvenir. * *

[294.]

M. BRUNELLE TO MR. WATT.

Paris, le 1^{er} Mai, 1789.

* * Nous venons d'avoir ici une action abominable exécutée par la plus vile canaille de Paris, soudoyée probablement par des personnes mal intentionnées. Voici un abrégé très succinct de cette malheureuse histoire M. Reveillon,* très honnête homme, homme de probité et industriel, qui avoit dans le faubourg St. Antoine une manufacture de papiers peints où il employoit plus de 500 ouvriers par jours, et qui cet hiver, pour nourrir les malheureux, avoit fait pour plus de 30,000 livres de charités, a été accusé par des scélérats d'avoir dit, dans une assemblée où il étoit comme électeur, qu'il falloit mettre les journées des ouvriers à 15

* See above, No. [275.] p. 206.

sous au lieu de 30 qu'on leur payoit, et qu'ils pouvoient vivre avec 15 sous malgré la cherté du pain ! Pure calomnie : il est incapable de tenir un pareil propos. La canaille s'est attroupée autour de sa maison, qu'on a voulu forcer pour le prendre ; elle a fait une forte potence, qu'ils ont traînée par toute la ville et en Place de Grève, où ils l'ont pendu en effigies avec toutes les cérémonies d'usage ; et tout cela s'est passé sans qu'on ait osé les arrêter. De retour chez M. Reveillon, ne pouvant point y entrer, ils ont enfoncé la maison du voisin salpêtrier de son état, où tout [étoit] pillé et brûlé, meuble, montre, argenterie, or, argent, et au moins 20 billets de caisse d'escompte de 1000 livres chaque. On a gardé la maison de M. R. toute la nuit, et le lendemain toutes les troupes de garde se sont retirés, espérant que tout étoit appaisé. On s'est trompé ; l'attroupement a recommencé ; on a forcé la porte de M. R., qui heureusement avoit pris la fuite pour échapper à leur fureur ; ils ont généralement tout brûlé, et vouloient mettre le feu à la maison ; ils ont cassé toutes les bouteilles de vin et liqueur, et quand ils n'ont plus pu boire ils ont enfoncé tous les tonneaux ; ils y en a même qui sont morts pour avoir bu de l'eau forte par méprise. On a enfin fait feu dessus pour les dissiper ; les hommes et les femmes, grimpés sur les toits, jetoient les tuiles et les briques des cheminées sur les troupes ; on tiroit sur eux, et on les jetoit bas. Des troupes d'infanterie et de cavalerie qui étoient autour de Paris sont accourus promptement ; on a conduit du canon

dans les rues, et on est parvenu à les maîtriser. L'alarme étoit grande, et le carnage pouvoit être épouvantable; on assure qu'il y en a 300 à 400 de tués ou blessés. Deux ont été pendus le lendemain prévôtalement comme à la guerre, et probablement qu'on exécutera de même tous ceux qu'on tient encore. On craint que cette révolte, qu'on avoit annoncé depuis quelque tems pour le 27, ne soit point finie. Dieu veuille que si ! * *

[295.]

M. BERTHOLLET TO MR. WATT.

Paris, 9 Août, 1789.

MONSIEUR,—Pendant que vous vous occupez tranquillement des sciences et des arts, qui vous ont de si grandes obligations, nous avons été obligés de les perdre de vue. La férocité des grands, l'insurrection des citoyens, la fureur du peuple, le fléau de la famine, ont absorbé toute notre attention: cependant il faut revenir aux occupations paisibles, et l'on peut commencer à jouir des douceurs de l'étude. Je reprends mes expériences. * *

[296.]

MR. WATT TO MR. BOULTON.

Birmingham, 27 Aug. 1789.

* * I wish my head and mind to be at rest, though that should be in the grave,—and I fear they will not rest sooner. * *

[297.]

DR. PATRICK WILSON TO DR. LIND.

Glasgow College, Nov. 3, 1789..

* * The brilliant successes of the excellent Herschel have formed an æra in the history of philosophy, and hold out to mankind a lesson of infinite importance. In so illustrious a career we behold the certain triumph of genius when actuated by high aims, and when allying itself, meekly and humbly, with invincible labour. In his passion for knowledge, in that ardour which marks his character, there has always appeared to me something very peculiar;—something so pure, and unmixed with anything of an earthly basis, that I have sometimes, when present at Herschel's, pleased myself by imagining his mind to be one of Plato's celestial sparks, recently from the heavens, and perpetually tending homeward by an irresistible affinity, originating in some remaining consciousness of its former estate. For who before him ever directed their lyncean sight to the utmost verge of the Milky Way, and contemplated the remotest of those everlasting fires as only lighting up the threshold of the universe? Who before him, in exploring the bosom of Night, ever led the human thought to the knowledge of that Table, upon which THE ALMIGHTY has multiplied His works of creation?

In this short eulogy you see that I rest principally the sublimity of Herschel's genius upon

what he has devised, and is attempting, by means of *large apertures*; though no person admires more than I do the discoveries he has made within our own system. These, however, he has taught me to consider as almost microscopical objects, yet abounding in manifestations of beauty and order. But to find out the DEITY more fully, we must follow Him into the infinite abysses of space; for wherever light dwelleth, there we may trace the power of His Almighty arm! * *

[298.]

DR. DARWIN TO MR. WATT.

Derby, Nov. 20, 1789.

DEAR SIR,—As the Loves of the Plants *pays* me well, and as I write for pay, not for fame, I intend to publish the Economy of Vegetation in the spring:—now in this work I shall in a note mention something about steam-engines, which may occupy 2 or 3 pages. The historical part, as far as relates to the Marquis of Worcester, Capt. Savery, Messrs. Newcomen and Cawley, I think to abstract from Harris's Lexicon and Chambers's Dictionary. But what must I add about Messrs. Watt and Boulton? This is the question. Now, if you will at a leisure hour tell me what the world may know about your *improvements* of the steam-engine, or anything about your experiments, or calculated facts about the power of your engines, or any other *ingenious stuff* for a note, I shall with

pleasure insert it, *either with or without your name*, as you please.

If you do not take this trouble, I must make worse work of it myself; and celebrate your engines as well as I can. I wish the whole not to exceed 2 or 3 quarto pages, and to consist of such facts, or things, as may be rather *agreeable*; I mean, *gentlemanlike facts*, not abstruse calculations, only fit for philosophers.

I hope you use the warm bath, and enjoy better health, and ride some furious hobby-horse. I am sorry I cannot see you oftener; it is a great loss to my understanding, and to my happiness. The Lord keep you! Adieu!

From yours affectionately,

E. DARWIN.

[299.]

M. BERTHOLLET TO MR. WATT.

Paris, Rue du Faubourg St. Denis, Hôtel du Désir,
23 Novembre, 1789.

MONSIEUR,—J'ai reçu avec bien de la sensibilité les témoignages d'amitié que vous me donnez dans votre dernière lettre, mais j'ai apperçu avec chagrin que vous vous livrez à une mélancolie qui vous empêche de jouir des avantages que vous avez acquis, et de la vénération de tous ceux qui cultivent les sciences et qui aiment les arts. Vous vous défier de votre tête! Elle sera long-tems faite pour des combinaisons profondes; mais je crois bien que vous avez besoin de modérer votre activité, de vous donner du repos, et de plus chercher à vous dissiper qu'à vous occuper.

Les personnes qui n'ont point eu de prétentions à défendre contre l'opinion publique n'ont couru aucun danger dans ce pays-ci. Pour moi, j'ai été fort tranquille dans une petite campagne où je me suis retiré, et si ce que je tiens du gouvernement entre dans les réformes, que l'on étend sur toutes les parties de l'administration, j'y pourrai vivre dans une médiocrité qui, quoiqu'étroite, ne me donnera pas des regrets. Puisse ma patrie se délivrer des entraves du despotisme sous lequel elle a languï si long-tems, et jouir des avantages d'une constitution libre, et je ne regretterai point ce qu'il pourra m'en coûter! * *

Je conserve toujours le désir d'aller contempler les arts et toutes les parties de la philosophie chez vous : mais je remets à un tems indéfini l'exécution de ce projet. * *

[300.]

MR. WATT TO DR. DARWIN.

Birmingham, Nov. 24th, 1789.

I know not how steam-engines come among the plants; I cannot find them in the *Systema Naturæ*, by which I should conclude that they are neither plants, animals, nor fossils, otherwise they could not have escaped the notice of Linnæus. However, if they belong to *your* system, no matter about the Swede; and your kind attention to us will certainly make me furnish you with all the necessary materials for poetic readers, with a wish that something else in the author way would pay

you better than poetry, though no man possesses a more amiable Muse, and you are a happy man that still find yourself equal to the embraces of such a frolicsome damsel!

The accounts in Harris's *Lexicon* are not quite right. If I remember, it is better in Desaguliers, though he tells some lies. Chambers's *Dictionary* I have not read upon the subject.

The first writer on steam-engines was Hero Alexandrinus, who describes two of them,—rotative ones too; (see his *Spiritalia*). The first idea of a partial vacuum by steam was by a Frenchman, name forgotten, about 1630, or sooner. The Marquis of Worcester knew the expansive force of steam, but I doubt whether he knew the injection and condensation. Papin was nearly contemporary, and the most ingenious man of them all; he knew the injection, at least I believe so (see Desaguliers). If he knew it, he was the first inventor,* being prior to Savery, who, if Papin has

* This, however, is now well known not to have been the case. Papin proposed to carry out his ingenious idea of forming a vacuum by the condensation of steam, by the clumsy, tedious, and unprofitable expedient of removing the fire from beneath the cylinder previous to each stroke, or descent, of the piston. As to the invention of condensation by the application of cold water, whether in the way of affusion or of injection, which is now universally admitted to have been of English origin, see the Translation of Arago's 'Eloge of Watt,' pp. 56-58, ed. 1839.

Desaguliers, to whom Mr. Watt refers, clearly and positively ascribes the important discovery of the advantages of the injection, and the consequent adoption of the *rose-head*, to Newcomen and Cawley.—(Desaguliers, vol. ii. p. 533.)

Dr. Darwin's note will be found at p. 287 of the first volume of his 'Botanic Garden.' The lines of that poem which refer to the steam-

no claim to the injection, certainly was the inventor of it, and a beautiful invention it was. Savery

engine, affording no unfavourable specimen of his usual poetic style, are the following:—

“ Nymphs! you erewhile on simmering caldrons play’d,
 And call’d delighted SAVERY to your aid ;
 Bade round the youth explosive STEAM aspire
 In gathering clouds, and wing’d the wave with fire ;
 Bade with cold streams the quick expansion stop,
 And sunk the immense of vapour to a drop.
 Press’d by the ponderous air the piston falls
 Resistless, sliding through its iron walls ;
 Quick moves the balanced beam, of giant birth,
 Wields his large limbs, and nodding shakes the earth.

“ The giant-power from earth’s remotest caves
 Lifts with strong arm her dark reluctant waves ;
 Each cavern’d rock and hidden den explores,
 Drags her dark coals, and digs her shining ores.
 Next, in close cells of ribbed oak confined,
 Gale after gale, He crowds the struggling wind ;
 The imprison’d storms through brazen nostrils roar,
 Fan the white flame, and fuse the sparkling ore.
 Here high in air the rising stream He pours
 To clay-built cisterns, or to lead-lined towers ;
 Fresh through a thousand pipes the wave distils,
 And thirsty cities drink the exuberant rills.
 There the vast mill-stone with inebriate whirl
 On trembling floors His forceful fingers twirl,
 Whose flinty teeth the golden harvests grind,
 Feast without blood! and nourish human-kind.

“ Now His hard hands on Mona’s rifted crest,
 Bosom’d in rock, her azure ores arrest ;
 With iron lips His rapid rollers seize
 The lengthening bars, in thin expansion squeeze ;
 Descending screws with ponderous fly-wheels wound
 The tawny plates, the new medallions round ;
 Hard dies of steel the cupreous circles cramp,
 And with quick fall His massy hammers stamp.
 The harp, the lily, and the lion join,
 And GEORGE and BRITAIN guard the sterling coin.

also appears to have been a man of merit, though stigmatised for a plagiary. It does not appear that Worcester went further than theory, and Savery's was practice, and improved practice, and theory too.

Newcomen applied Savery's vacuum to act upon a piston, and thereby made the machine safe and tractable; but he had hints from Savery's engine, and, possibly, from Papin. His machine was so great and so powerful, that scarce anybody thought it could be much improved; until your humble servant, being dissatisfied always both with other people's works and his own, was vain enough, or rather rash enough, to attempt it. *Cætera desunt.*

In what I mean to send you, fear not that I shall enter into calculations or geometry: my soul abhors them both, and all other abstract sciences. I shall give you a few matters of fact, of whys and wherefores, but I hope not to occupy your two quarto pages. To say the truth, although I will not say that all vain-glory is dead with me, yet the desire of fame is nearly satiated;—nothing

“ Soon shall thy arm, UNCONQUER'D STEAM! afar
 Drag the slow barge, or drive the rapid car;
 Or on wide-waving wings expanded bear
 The flying-chariot through the fields of air.
 Fair crews triumphant, leaning from above,
 Shall wave their fluttering kerchiefs as they move;
 Or warrior-bands alarm the gaping crowd,
 And armies shrink beneath the shadowy cloud.”

Darwin's 'Botanic Garden,' canto i. l. 253-296,
 vol. i. p. 30-35, ed. 1799.

now remains but the desire of money ; which, however, I cannot take much pains to get, as I find it can neither buy health nor happiness. Therefore on my own account I would not take the pains to write what you desire, but I cannot refuse to comply with so obliging a request. But I only promise to do it upon condition that you bestow no immoderate praise, as you did the last time you were so kind as to mention the engine in print. Without affecting any maidenly coyness, you really made me appear contemptible in my own eyes by considering how far short my pretensions, or those of the invention, were of the climax of human invention,—I, that know myself to be inferior to the greatest part of enlightened men in most things! If I have excelled, I think now it has been by chance, and by the neglects of others.

Preserve the dignity of a philosopher and historian ; relate the facts, and leave posterity to judge. If I merit it, some of my countrymen, inspired by the *Amor Patriæ*, may say, “Hoc a Scoto factum fuit.”—I shall, as soon as my necessities permit me, send you what I wish to be said ; if too much, you have a pen to dash out, but let the recital be yours, not mine. I use no baths, I ride no hobby-horses ; but other men ride mine, and beat and drive the poor creatures unmercifully. I join in your wish that we could meet oftener ; I should be the greatest gainer of the two : as it is, I am one day tolerably well, and another have some troublesome headache or

asthma, and am as stupid as a bat, and cannot add three figures together without error. Of all the evils of age, the loss of the few mental faculties one possessed in youth is the most grievous. Adieu! excuse bad English, and accept my thanks for your remembrance of

Yours affectionately,
JAMES WATT.

Steam is only 1800 times the bulk of water; Bighton knew nothing of it.

[301.]

M. MONGE TO MR. WATT.*

Paris, le 10 Décembre, 1789.

* * Notre révolution occupe toutes les têtes, chacune à sa manière; et les sciences y perdent. Dieu veuille qu'elle finisse bientôt, car nous perdrons l'habitude du travail, et l'amour des sciences.

La décomposition de l'eau par l'étincelle électrique, et dont vous avez sûrement connoissance par le Journal de Physique, ferme ici la bouche au petit nombre d'incrédules que nous avons encore; et il n'est plus douteux que ce liquide soit composé de l'oxygène et de l'hydrogène, comme l'acide nitrique est composé d'oxygène et d'azot, et comme l'ammoniaque est composé d'hydrogène et d'azot.

Je vous prie, Monsieur, d'être bien persuadé de

* Introducing M. Schurer, Professor of Natural Philosophy and Chemistry at Strasbourg.

la profonde vénération que j'ai pour vos talens et pour vos vertus, et de compter sur l'inviolable attachement avec lequel j'ai l'honneur d'être,

Monsieur,

Votre très humble et très obéissant serviteur,

MONGE,

de l'Académie des Sciences.

[302.] MR. WATT TO THE CHEVALIER LANDRIANI.

Birmingham, Dec. 12th, 1789.

* * I have found out a method of making tubes of the elastic resin, without dissolving it,* which you shall have if you please.

• * * * *

[303.] MR. JAMES WATT, JUN., TO MR. WATT.

Manchester, July 11th, 1790.

• * * It is astonishing what an impression the smoke-consuming power of the engine has made upon the minds of everybody hereabouts; nobody would believe it until the engine was set a-going, and even then they scarcely trusted to the evidence of their senses. You would be diverted to hear the strange hypotheses which have

* We have not found this method described in any subsequent letter of Mr. Watt of which a copy has been preserved; but the subject of it was one which excited considerable interest at that time. See an account of Cavallo's method of dissolving caoutchouc in sulphuric æther, and forming tubes of it by dipping cylindrical clay moulds into the solution, in the 'Travels of Faujas de St. Fond in England,' vol. i. p. 28-34.

been started to account for it. However, it has answered one extremely good end,—it has made your engines general topics of conversation, and consequently universally known; which they were by no means before in this country. * *

[304.]

MR. WATT TO MR. BOULTON.

Birmingham, 23 July, 1790.

* * I have a letter from Mr. Le-
vêque of July 4th. He has seen Perrier's engine,
which he does not like; says Mr. De Betancourt
instructed him how to make double engines, and
has sent a model of them to Spain, as he does of
everything he sees; and has written a memoir
upon the effects of steam, which will be published
in Prony's *Hydraulogie*.* We must be more and
more careful in respect to foreigners. * *

* M. de Prony, (who usually spells the name of Watt either *Wats* or *Wast*), has an article in his "*Nouvelle Architecture Hydraulique*" (No. 1345, tome i., published in 1790)—"*Comment M. le Chevalier de Bettancourt a deviné le principe d'une machine à feu postérieurement construite par MM. Wats et Bolton:*"—on perusing which, it turns out that the engine alluded to was the double-engine; that the method M. de Bettancourt took to "divine the principle" was to visit and inspect the engine itself at work at Soho; to observe the piston impelled both upwards and downwards by an equal force of steam; and then, having made a model, to get MM. Perrier to make an engine on the same construction as that which he had thus visited, inspected, and observed at work. A truly original, and doubtless an accurate, method, "*deviner le principe.*"

M. de Prony's book is curious under another point of view. It contains a table of its own errata, in which there are enumerated no fewer than two hundred and seventy-eight; consisting of four great classes, viz., errata of the text, errata of the notes, errata of the tables, and errata of the "*éclaircissements.*" But in all that catalogue, such errors

[305.]

MR. JAMES WATT, JUN., TO MR. WATT.

[Manchester], 30th September, 1790.

* *

The gross sum which your engines cost at first, startles all the lesser manufacturers here, and it is scarcely possible to make them comprehend the advantages to be derived from a regular motion, from a machine liable to few repairs, and from an annual saving of fuel, when weighed against 200*l.* or 300*l.* more of ready cash. * *

as Wats and Wast for Watt, and Darmouth for Dartmouth, Durhan for Durham, &c. &c., are not noticed, and pass "pour absolument rien." Therefore, to what the grand total of errata in the whole work might amount, we cannot even guess; and if to such as we have named were to be added the errata of the corrections of the errata,—(or errata *squared*),—and errata raised, as it were, to the third, or some even higher power, probably the work of Prony, like the machine of Marly as described by Belidor, might be found to be without a rival, "dans ce monde."

But it is satisfactory to be able to add, that, on a personal acquaintance with M. de Prony, Mr. Watt found that he was a very estimable person; and that in any mistakes he had made as to the steam-engine, he had proceeded on erroneous information, and was anxious to correct them. "I acquit him," writes Mr. W., in 1808, "of all blame or envious intention; he was merely the chronicler of what was related to him; and with such relators as Perrier and Bettancourt at his ear, what better could be expected? He knew nothing of me or my works but what they pleased to relate. He is himself a most ingenious, modest, and candid man, and regrets much his having published what he has done; and he offered to insert in his next publication whatever I pleased to communicate on the subject." (Mr. Watt to Mr. James Watt, jun., 10th Nov. 1808.) In 1816 Mr. W. signed M. de P.'s certificate for the Royal Society; and, in returning it to Mr. Rennie, observed that he was glad to have had an opportunity of giving this testimony of his esteem for him. (To Mr. Rennie, 5th December, 1816.) See also Mr. Watt's letter to Professor Robison, No. [343.] p. 284, *infra*.

[306.]

MR. WATT TO MR. DE LUC.

Birmingham, July 19th, 1791.

DEAR SIR,—It seems at present necessary to inform you that we are *safe*, and have not been injured by the truly dreadful mob we have had in this neighbourhood. The affair originated from some gentlemen very foolishly celebrating the French revolution by a dinner on the 14th. They were warned that some tumult might ensue, and advised against it; however, some of them met, were insulted as they went in, and, therefore, dispersed by five o'clock. About eight o'clock a mob assembled, broke the windows of the hotel where the company met, pulled down two dissenting meeting-houses, then Dr. Priestley's house, which they razed to the ground, (he and family made their escape in time); they then destroyed a very good house in town, and from that proceeded to destroy some others in town, and some of the best houses in the country, mostly belonging to dissenters, they say to the number of ten or fifteen, and to the amount of above 100,000*l*. Then was the sovereignty of the people established in full authority for three days and nights! Quiet subjects were panic-struck; and, after some feeble efforts to establish peace, people submitted quietly to their fate. We, on our part, finding there was no likelihood of any other protection, applied to our workmen, convinced them of the criminality as well as imprudence of joining

the mob, and kept them all at home, procured some arms, and had their promise of defending us and themselves against all invaders.

Though our principles, which are well known, as friends to the established government, and enemies to republican principles, should have been our protection from a mob whose watchword was *Church and King*, yet our safety was principally owing to most of the dissenters living on the south of the town; for after the first moments they did not seem over nice in their discriminations of religion or principles. I, among others, was pointed out as a Presbyterian, though I never was in a meeting-house in Birmingham, and Mr. B. is well known as a Churchman. We had everything most portable packed up, fearing the worst; however, all is well with us. It must be observed to their credit, that they neither killed nor maltreated any of the sufferers, except such as opposed them by violence, among whom they dealt some civil knocks by bludgeons. Some military arrived on Sunday night, since which there has been no rioting in the town, and we hope they are dispersed.

The matter has been too serious to be passed over in silence; but I fear, from the principles of many in Birmingham, that, if Government do not interfere, no justice will be done upon the miscreants. The post waits; I wish you, and all with you, health and happiness, and remain affectionately yours,

J. WATT.

[307.]

MR. WATT TO DR. PRIESTLEY.

Heathfield, Oct. 21st, 1791.

* * I should have written to you long before now, had I felt less reluctance to enter upon a subject that has been a cause of lamentation to all your friends, or had I had anything to communicate which could have been of use to you. At one time, on hearing that you intended to revisit Birmingham, I intended to have written to you expressing my fears for your personal safety, from the brutal rage with which the blackguards of the town and neighbourhood were filled; but I then learnt from good authority that you had laid that design aside, which made it unnecessary to add to the disagreeable emotions the intelligence you had received of that matter must have excited. Since that time I have been happy to hear that you are fixed in a situation where you are secure from the malevolence, which, to the disgrace of this town, I yet believe would have continued to persecute you here.

To express my abhorrence of the motives which instigated the perpetration of these atrocious insults to all laws, both divine and human, seems unnecessary, especially as I had reason to believe that myself, among your other friends, was included in the proscription; yet I cannot help lamenting that I live in a country where such things have been done, and, what is worse, have passed in a manner unpunished, which, in my

opinion, is more degrading to the country than even the commission of the crimes.

I have been informed that you intend to come here soon, to take leave of your congregation. There is no saying how the populace may act. That they have not forgiven the man they have injured is to be presumed from the general conduct of bad men. I, therefore, have some fears for you ; at the same time it is certain that a cool courage frequently overawes those most determined to do mischief. Let me, however, recommend caution, and a proper regard to your own safety : if, therefore, you should find, upon coming to Birmingham, that ill-minded people are likely to excite a tumult, a public meeting with your congregation had better be deferred.

I know that you despise all mean attentions to your own safety, where you think your duty calls upon you ; but there are duties you owe to your family, to your friends, and to humanity in general, that should direct you not to risk a life so valuable to them all ; especially as the public meeting with your congregation can be deferred, until time has softened the antipathy with which the ignorant and brutal now behold you. * *

[308.]

DR. PRIESTLEY TO MR. WATT.

Nov. 2, 1791.

I intended to defer answering your friendly letter only till the arrival of the *copying-machine*, which you and Mr. Boulton are so obliging as to

send me; but it is not yet arrived, and of *this* it may be proper to inform you. It is an instrument I always greatly valued, and made much use of, as, if I live, I hope to do again. - This, and many other things, will ever remind me of the obligations I am under to you, and the pleasing intercourse I have had with you, and all my friends of the Lunar Society. Such another I can never expect to see. Indeed London cannot furnish it. I shall always think of you at the usual times of your meeting. * *

[309.]

MR. WATT TO DR. BLACK.

Heathfield, Birmingham, Nov. 23d, 1791.

* * I have heard that there is somebody at Edinburgh who makes artificial marble. If you have heard of it, I shall be obliged to you when you write to mention whether it is a real stone, or an imitation by varnish or enamel; if a stony composition resembling marble, whether vitreous, gypseous, or calcareous; all this, only if you have seen or been informed of the thing, for I do not wish you to have the trouble of inquiring.

The reason of my inquiries is, that I have been employed some time upon an artificial alabaster, which I have brought nearly to the hardness and transparency of marble—very much harder than any natural alabaster.*

* Mr. W. does not mention how this artificial alabaster was made; but when he afterwards invented and used his machine for copying sculpture, many of the specimens of its performance were made of a somewhat similar material; perhaps natural alabaster hardened by alum. See No. [379], p. 334, *infra*.

[310.]

DR. PRIESTLEY TO MR. WATT.

Clapton, March 16, 1792.

I thank you for your very valuable present of the *Digester*, which is come safe, and promises to be very useful, being in a much better condition than my former ones, on which account I did not make so much use of the instrument as I should otherwise have done. Mr. Boulton was so good as to promise me a *chymical lamp*, and such of his collection of *minerals* as he could most conveniently spare. Other friends have also contributed to set up a broken philosopher; so that in a short time I hope to be at work, and as busy as I have generally been. * *

[311.]

MR. WATT TO DR. DARWIN.

Birmingham, June 30th, 1794.

Mrs. Watt and I can but thank you and Mrs. Darwin for your kind sympathy in our late loss,* and pray that we may never have occasion to condole with you on a similar event. Mrs. W. continues to be much affected whenever anything recalls to her mind the amiable child we have parted with; and these remembrances occur but too frequently:—her little works of ingenuity, her books, and other objects of study serve as mementos of her who was always to the best of her power usefully employed, even to the last day of her life. With me, whom age has rendered incapable of the

* That of Mr. Watt's daughter by his second marriage.

passion of grief, the feeling is a deep regret; and, did nature permit, my tears would flow as fast as her mother's. I feel that one of the strongest ties which bound me to life is broken, and that the acquisition of riches avails not when we cannot give them to those whom we love.

I have long found that, when an evil is irreparable, the best consolation is to turn the mind to any other subject that can occupy it for the moment. This is not always possible, but we must make the best of our imperfect nature, and do what lies in our power. I told you, that I had turned my contemplations to the subject of medicinal airs; not from any idea that I understood the subject, but because nobody else does, and therefore that my hints might by chance be as good as another man's. Where the regular physician professes his ignorance, the quack may safely be called in, and Dame-Fortune suffered to throw the dice. I have made an apparatus for extracting, washing, and collecting of poisonous and medicinal airs. * *

I mean to send you an apparatus, with which you may try the whole round of poisonous and salutiferous airs; and, I hope, in your hands, not without success. * * I have written a short list of my hints for Dr. Beddoes, and am sending him an apparatus, a description of which he means to insert in his next publication. I should object to this, because it is in a manner untried; but, as it is *likely* to answer, I cannot withhold anything which may be of use in prompting others to do better.

* * * *

[312.] PROFESSOR ROBISON TO MR. WATT.

[London], Monday, Dec. 1796.

The rambling materials for evidence which occurred to me have turned out such a prolix mass, that I fear that neither yourself nor your counsel will have patience to separate the few grains from the chaff. I know that the things which I have to narrate, when taken alone, are frivolous in the extreme; and it has often been matter of regret to me that I have put you, and must yet put you, to so much expense for a trifle that I now think you might have easily spared. * * * Yet I still think that, if the time can allow me to tie these trifling particulars together, somewhat in the manner I have done here,* they will have considerable weight with a jury of men of liberal minds; and that it will not hurt your cause should I in this manner give vent to that affection which is naturally excited by the recollection of our careless days and gay scenes, in a mind not hackneyed in the bustle of life, and softened by suffering.

* * * * *

[313.] MR. WATT TO DR. BLACK.

Heathfield, Jan. 15th, 1797.

MY DEAR FRIEND,—You have been informed by Mrs. W. of the fortunate issue of our new trial at

* Referring to the interesting document from which long extracts have been made in the first volume of this work; and the substance of which, as given in evidence by Professor Robison, was of signal service to Mr. Watt's cause.

law, and she received your kind congratulations upon the event. I did not write to you myself sooner, because I was much indisposed, partly with a bad cold, but much more by the anxiety and attention such an affair required, which, though I neither gave way in the least to despair, nor had such acute feelings as I have been used to on less serious occasions, took great effect upon me; so that even after the trial I remained nearly as much depressed as if we had lost it. The stimulus to action was gone; and, but for the attentions of my friends, I ran some risk of falling into stupidity. The getting away at last from the unwholesome air of London, and the journey home, have greatly reinstated me. * *

In the whole affair, nothing was so grateful to me as the zeal of our friends, and the activity of our young men, which were unremitting. Our friend Mr. Robison exerted himself much; and, considering his situation, did wonders. When we had got through a few of our witnesses, our opponents thought it wise to give up their allegations against the priority of invention, and also acknowledged their infringement; the Judge also complained of bad health, and requested the trial might be shortened, upon which we thought it unnecessary to call Mr. Robison and Mr. Roebuck. Our opponents, however, thought proper to call the former, but had reason to repent it, and we were obliged to them for calling him, as he gave clear and decided evidence against them; and a sketch he produced, made by Mr. *Model* at Petersburg, had

considerable effect in convincing the Judge and the jury how few hints were necessary to enable a man of mechanical knowledge to execute the invention. I believe this was not strictly legal evidence, but the Court permitted it, and the force of truth is great, even when against law. Our opponents have not yet given us up; they mean to move in arrest of judgment, and, if they cannot prevail in that, to bring a writ of error to take it to the King's Bench; but, it seems, that writ is of slow progress, and they probably cannot get it brought to an argument in less than a year and a half, and in the meantime they are tied fast by injunctions from Chancery, nor, at any rate, have we reason to fear the event after two decisive verdicts in our favour. . * *

[314.]

PROFESSOR ROBISON TO MR. WATT.

Edinburgh, Feb. 3, 1797.

* * I was received by my class with a plaudit. I gave my pupils a short account of what I had been about, and of the simple turn which the cause took at last, which made it not more the cause of Watt versus Hornblower, than of Science against Ignorance. When I finished, I got another plaudit that Mrs. Siddons would have relished. You must take your share of it. And now that the thing is over, give me leave to say that few things in my life have given me more sincere pleasure; and you oblige me greatly when you allow me the satisfaction of thinking that my

appearance was of essential service. I have but few opportunities of feeling myself of any use, and it would have greatly mortified me had Brother Le Blanc not called upon me, and I had returned without opening my mouth, in return for so much expense to you, and so long a journey to myself.

* * * *

[315.]

MR. WATT TO MR. J. ROEBUCK, JUN.

Heathfield, Feb. 18th, 1797.

* *

Our opponents had the four first days of term to move in arrest of judgment, or for a new trial. They made their motion on the latter point upon the feeble plea of the quicksilver. An argument has been had on Tuesday last, when their plea was rejected by all the three Judges present as too trivial. The new trial was, consequently, refused; and all they obtained was the insertion of the specification in the record, and a choice given them to change the verdict from the 5th to the 2nd count of the declaration. The 5th charges them with having infringed upon my *invention*, and the 2nd with having infringed upon the *method*, &c., invented by me. We are told that judgment now follows of course, as they cannot now move in arrest. But they mean to proceed with their writ of error, which, barring hindrances, may come on to be argued by Michaelmas term, November next. In the mean time we are proceeding with our Bill in Chancery against them, to perpetuate the injunction, and to recover the

Chancery costs. The law costs are taxed, and they must find security to pay them before they can proceed with their writ of error. We shall not recover from them much above one-half of what we have expended on the trial. * *

[316.] PROFESSOR ROBISON TO MR. WATT.

Edinburgh, April 7, 1797.

* * Dr. Black's health is better than when I formerly spoke of it. But he feels very strongly the loss of his amiable and worthy friend and companion Dr. Hutton. Dr. Black has not had spirits enough to be able to see Dr. Hutton these several months, till within a few days of his decease. He left us without a struggle, in less than half a minute after speaking with the utmost clearness. He was busy with another large volume, and had engaged the engraver to come and get his orders the day after that on which he die^d

* * * *

[317.] PROFESSOR ROBISON TO MR. WATT.

Edinburgh, May 3rd, 1797.

* * I believe I told you that I had been on the hunt to find documents of Sir Isaac Newton's Scotch extraction, and that he himself firmly believed that his grandfather was a younger son of Sir ——— Newton, of that Ilk in East Lothian, and wrote to the last man of the family requesting information whether some of the younger

sons did not attend James VI. when he succeeded to the Crown of England. I am still in hopes of finding that letter. Should I be able to render this descent probable, I will lodge an account of my labours in the University Library. * *

Think also of a new Doctorate that I am scheming with some hopes of success, if we can find a proper name for it,—Doctor of Arts,—a Collegium or Corporation of Scientific Engineers, with three degrees of Bachelor, Master, and Doctor:—not merely academical honours, of no more value than the offices of a Mason Lodge, but to have civil consequences. As a man must have a diploma to entitle him to a consulting fee, so should an engineer; &c. &c. * *

[318.]

MR. WATT TO MR. T. PARKER.

Heathfield, Birmingham, June 2d, 1797.

* * Bramah's impudent pamphlet excited little emotion in our minds, as in its bombast and evident malice it carried its own antidotes.

* * The pamphlet has sunk into oblivion, after suffering contempt from all those who understood the case. * * One fact, however, I must inform you of is, that prior to the Act of Parliament we had sold no engines; though we had made some, they were merely to satisfy ourselves,—and, had the Act not passed, the invention had fallen to the ground;—so much did we foresee the moral difficulties before us, and the great necessary expenditure. * *

[319.]

MR. WATT TO MR. R. MUIRHEID.

Heathfield, Dec. 1st, 1797.

* . * We have got a fresh crop of engine pirates, but, having become used to them, do not lay them so much to heart as formerly. Mr. Bull, our great opponent, has committed a great *faux pas* in Cornwall, and we have been entreated to make his engine go, on our own terms, at a mine which had set us at defiance. Our law matters, however, still remain suspended:—I believe the lawyers on both sides have agreed not to let them be terminated too soon. * *

[320.]

MR. WATT TO MR. S. LYSONS.

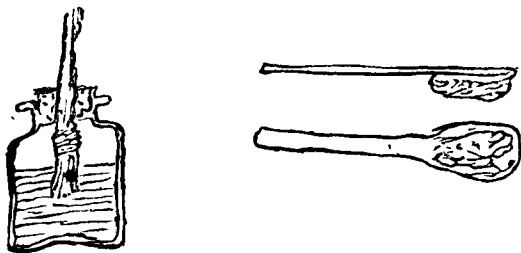
Heathfield, Dec. 1st, 1797.

* * The best white copal *oil* varnish does not readily crack unless much bent, or exposed to the sun, but is apt to grow somewhat yellow, though regularly so. There are several kinds of it, called cabinet varnish, chaise or coach varnish, &c.

* * I have also seen a spirit copal varnish called *balsam* copal varnish, which is well spoken of. There is a *beautifully* white spirit copal varnish made by my friend Mr. Henry, of Manchester, and sold in London, though I know not where; probably by those who sell his calcined magnesia. It is almost colourless, not much disposed to grow yellow, and possesses considerable ductility, though probably not so much as the oil varnishes. * *

All of these varnishes require that the paper should be first prepared with isinglass size, or fine clear starch, to prevent the varnish sinking into the paper. I prefer the isinglass, as more pliable and more clear. It must be laid on hot, and care taken not to spread the colour in laying it on: practice is necessary for this. Probably going over the drawing with a dilute solution of sandarac in sp. wine may secure the colours from spreading with the size, but this wash should be thin, as sandarac makes a brittle varnish if thick. The spirit varnishes should be used warm, say about 90° ; and the room should be of the same warmth, otherwise they will chill, and look opaque. Camel's-hair tools are commonly used for laying them on with; each coat should be thoroughly dry before another is laid on, and, to make varnish beautiful, very little should be laid on at a time; that is, each coat should be very thin. The same rule holds good with the oil varnishes, which, when you buy them, are generally too thick, and should be diluted with about their own bulk of best sp. of turpentine, say fresh-distilled oil of turpentine. I have commonly used a *ground hog's-hair tool* for laying them on. I bore a hole through a large cork with a hot iron, through which I put the handle of the brush tight; then fit the cork to a wide-mouthed phial in which there is a quantity of varnish, and by this means the brush is always in the varnish, which keeps it in order and saves washing it. I have also, with much advantage, used a piece of fine sponge glued to a piece of wood, for the spirit

varnishes, which lays on the varnish more evenly and less at a time than the brushes, and leaves no hairs behind it.



If your friends are not practised varnishers; I advise them to begin by trying their hand upon such things as they have not much regard for, as probably they may not succeed at once, there being many little attentions necessary which practice only can teach. Meanwhile, I shall be glad if what I have said can be of any use to you, or to your friends.

Having been out of the world this long time, I have heard nothing of your Dorsetshire antiquities, which, when I come to London, I shall be happy to see; but, if this should not happen before you set out on your travels, it will give Mrs. W. and myself much pleasure to see you here, where we have a bed at your service. * *

[321.]

PROFESSOR ROBISON TO MR. WATT.

Edinburgh, May 4, 1798.

* * I have been searching for your last kind letter, but can't find it. You spoke of a

new hydraulic machine. It seems to me that one on the same principle (announced near forty years ago by Dan. Bernouilli in his *Hydrodynamica*) was erected somewhere in Cheshire, (I think at Oulton), by a clergyman, with success. I think that the Zurich machine with a spiral pipe, taking in air and water alternately, when constructed with attention to principle, is an excellent one. A cylindric, instead of a flat spiral, gradually diminishing, so that the compressed air may always occupy one-half of each spire, will produce the greatest effect; and, if the motion be slow, will raise more water than anything I know. The construction is very delicate, and quite unfit for common hands. I made one, just when I was growing ill, which gave me great satisfaction.

* * * *

Dr. Black is now very feeble indeed. I have not been able to see him this long while, for I cannot go in upon him when my countenance betrays my own suffering. * *

[322.]

MR. WATT TO DR. BLACK.

Heathfield, 21 May, 1798.

* * In regard to the engine business, I now take little part in it, but it goes on successfully. We are still engaged in law; but it gives us little trouble, and we contrive to make it pay itself. The vexation it gave us for a long time contributed much to impair my faculties of mind, and to destroy that cheerfulness so necessary to

happiness in this life. I have learnt, however, to content myself with my present negative state, and to thank Providence for having placed me in the situation I enjoy. * *

[323.]

PROFESSOR ROBISON TO MR. WATT.

Edinburgh, Dec. 15, 1798.

* * Dr. Black has continued pretty much in the same trim you saw him in. I have seen him but seldom, but have always found him cheerful and pleasant, though very feeble indeed; but free from anything that alarms him.

* * * *

Something always made me forget to tell you that I have, several years ago, observed some most curious optical properties of Iceland crystal, that are more puzzling than even its double refractions. I had proceeded a good length in classing them, and have nearly reduced them to general laws; but my observations were but rough, so that I was not in a condition to subject them to public view. I got an apparatus made for repeating them with the precision that was necessary for ensuring me that my laws were exact: but this cruel disorder totally prevents me. I have begun them several times, and the stirring that was necessary always brought on such paroxysms of pain as not only stopped my proceeding, but made me ill for a day or two. I am uneasy at the thoughts that they should be lost, for some of the facts are extremely curious and amusing.

I inform you of this, in hopes that you may know some person of optical curiosity and mathematical taste, who would take up the affair where I have left it, and prosecute the experiments with zeal. I would send him a variety of fine specimens, possessing that singular property, and an abstract of my leading observations. I am no longer anxious to be the author, and only wish the theory to be prosecuted. If I am not mistaken, I once showed you one of the most remarkable facts. For I first observed it in Canada, among a parcel of specimens found in a parson's drawer plundered by our sailors; when I came to London, I went to Ben Martin's lectures, and, to curry favour with him, I gave him my specimens; he added some observations to what I showed him, and made a pamphlet of it; I found the same property, or at least one connected with it, in crystals found in the freestone at Castle-Semple, and I think I showed it to you. But it was not till 1788 that I was able to see their connection, by getting some beautiful specimens from Mr. Stanley, just returned from Iceland. I will send you some, with a note of a general observation, which comprehends most of the facts. Now, my good friend, if you can find any person who will engage in this research with interest and ability, you will greatly oblige me. Farewell, my dear Sir, and believe me, with affectionate regard, yours,

JOHN ROBISON.

[324.]

MR. WATT TO MR. BOULTON.

London, 25 Jan. 1799.

We have WON THE CAUSE hollow. All the Judges have given their opinions very fully in our favour, and have passed judgment. Some of them made better arguments in our favour than our own counsel, for Rous' speech was too long, and too divergent. *I most sincerely give you joy*; but in our joy let us remember that a question of almost equal importance is still pending in Chancery. To that also I hope a happy termination, but in the meantime we should be quiet. * *

[325.]

MR. JAMES WATT, JUN., TO MR. WATT.

Soho, 7 October, 1799.

DEAR FATHER,—I am sorry to have to announce to you the loss of your valuable friend Dr. Withering, though you must long have been prepared for such an event. I understand that his health had been for some time more precarious than usual, and perhaps the exertion necessary for removing to his new house may have somewhat accelerated what could not long have been deferred. He is said to have had some attack of a liver complaint in addition to that upon his lungs, which reduced him still more in flesh than he had been before,—and, after a short interval of delirium, carried him off at ten o'clock last night. * *

[326.]

PROFESSOR ROBISON TO MR. WATT.

Edinburgh, Dec. 11, 1799.

MY DEAR SIR,—Colonel Burnet has devolved on me the mournful task of informing you of the loss of your dear friend Dr. Black, who died last Friday. Knowing how severely you must feel this long-expected stroke, I should hardly have accepted of the unpleasant office, were it not in my power to tell you that his end was such as his most affectionate friend would wish;—without a groan, and without warning. The servant had set down his little dinner before him, while he was busy with a tinman about a pan for warming his mess. Some time after, a gentleman called; the servant opened the door, and announced him, the Doctor sitting as usual on the end of the sofa, with his back to the door, and his legs lying along the sofa. He made no answer, and John told the gentleman that his master was asleep, and desired him to call again; and then went down stairs. But, recollecting that the Doctor had scarcely had time to prepare and eat his little mess, and that he never had observed him fall asleep at dinner before, he went up again, opened the door, and went forward till he could see his master's face. He saw him with his eyes shut, and having his basin of milk standing between his thighs, supported by his right hand. Thinking him asleep, and the milk in no danger of spilling, he went back again, and shut the door.

But, as he was going down stairs, his heart mis-

gave him, and he returned, and came forward, and called him by name pretty loud :—got no answer. He then took hold of his hand, and felt all cold ;—in short, “found,” as he said, “that his poor master *had given over living.*” The basin was not fully supported by its position, and was really kept up by Dr. Black’s hand.

What an enviable close of life to every man ! and to our dear friend it was inestimable. You know that his mind was elegance itself. He sometimes hinted his uneasiness at the thought of becoming silly, or slovenly, or squalid, and even of the last struggle of life ; and could not bear the thought of any indecency of conduct or appearance. His wish was completely gratified, for life must have ceased without a pang. The servant told me that for an hour there was not any change observable on his countenance. Had skilful people been about him, that sweet countenance might have been preserved. When I saw him next morning, the lips had been allowed to contract.

Dr. Black had been in remarkably good spirits ever since the beginning of autumn, and was as busy as a man hanging by his slender thread could be. He was scheming a new laboratory, to be built by subscription, of which he was to be the contriver and the architect ; and he never was without some gentle occupation. Elegance and propriety modelled every thought, and his every sketch has a beauty which would be highly prized if found at Herculaneum. *Quando ullum inveniemus parem ?*

I think that you, my dear friend, and Mr. Geddes

of Leith,* had the greatest share of Dr. Black's esteem and affection. I am now proud of having had some of his attentions. You know well that he was both a sagacious and a delicate judge of character, and that Dr. Black's favourable opinion was an honour to any man. I owe to him my first introduction to the notice and acquaintance of men of science and worth, and his countenance gave me more confidence in myself. When I returned from London, at the account which I gave him of your triumph over Hornblower and Co. he was delighted, even to tears. He said, "It is very foolish, but I can't help it, when I hear of anything good to Jamie Watt."

I think our excellent friend well away from a world that is no longer worth living in; and I envy his situation,—not tied to it by those whom he has brought into it, and must leave in it. * *

[327.]

MR. WATT TO PROFESSOR ROBISON.

Heathfield, Dec. 16th, 1799.

MY DEAR SIR,—Your letter of the 11th, containing the afflicting intelligence of Dr. Black's death, I received yesterday. I had written to him on the 8th in answer to one of his of the 2nd; but little did I think that it was our last correspondence, or that my friend no longer existed amongst the living! In that letter he had mentioned his having had a cold, from which, he said, he was considerably

* At that time manager of the glass-works at Leith.

recovered, and hoped by his usual prudent management to be soon well!

His death was certainly often expected by us all, but of late we had been flattered by the accounts he gave of his improved health; so that when it happened, it was totally unexpected. In respect to himself, life has not for many years been very desirable; yet he had his enjoyments in his own schemes, and in the welfare of his friends, which no man enjoyed more, and with all his infirmities he was still an useful member of society, whose loss will be much felt.

Like you, I may say, to him I owe in great measure my being what I am; he taught me to reason and experiment in natural philosophy, and was always a true friend and adviser, whose loss will always be lamented while I live. We may all pray that our latter end may be like his; he has, truly, gone to sleep in the arms of his Creator, and been spared all the regrets attendant on a more lingering exit.

I could dwell longer on this subject, but regrets are unavailing, and only tend to enfeeble our own minds and make them less able to bear those ills we cannot avoid. Let us cherish the friends we have left, and do as much good as we can in our day! * *

[328.]

PROFESSOR ROBISON TO MR. WATT.

Edinburgh, Dec. 18, 1799.

* * None of the faculty can say anything distinctly on the immediate cause of our

dear friend's death. I was mistaken in saying that he was sitting with his legs up on the sofa;—he was in his chair, with his basin of milk on his knees, supported by one hand, the other leaning on the arm of the chair, and his chin resting on his breast, as he usually slept after dinner. Any extravasation in the lungs must have provoked a cough, or a wry face, or caused some movement. Mr. Geo. Bell, who saw him within five minutes after his death (for the servant had seen him alive about that time before), tells me that there was not the smallest appearance of his having had an uneasy sensation. He thinks that it was a paralytic affection of the diaphragm, of which the Doctor twice before complained to his father, saying, that “he had caught himself forgetting to breathe.” The heart, beating but feebly, ceased at the first omission of a stimulus from the pulmonic vein (I think it is called). I have heard that Col. Townshend died in one of his exhibitions of stopping his heart, and that it was without the least struggle. So departed our friend.

My first acquaintance with Dr. Black began in your rooms, when you were rubbing up M'Farlane's instruments. Dr. Black used to come in, and, standing with his back to us, amuse himself with Bird's quadrant, whistling softly to himself, in a manner that thrilled me to the heart. * *
In the end of 1758, when I went to sea, and had a favour to ask of the professors, Dr. Black spoke very handsomely of me. This I learned at my return; but we had no further acquaintance till

then, or rather till 1764; and his marked attention to me (as he told me not long ago) was owing to my saying distinctly, and giving reasons for it, that Dr. Dick, my professor, had infinitely more knowledge than his successor, who was much more popular. Indeed Dr. Black has often said to me, that Dick was one of the most sensible and manly fellows he ever knew. * *

Dec. 29.

* * You frequently wrote to Dr. Black on scientific subjects, and communicated to him your experiments; and I have been told that his sentiments were much influenced by what he had on your authority respecting the new doctrines. As you had the start of every person in the decomposition of water, I imagine, therefore, that some valuable information may be had from this correspondence. • * *

His fortune, in February last, amounted to 18,700*l.*, and must now considerably exceed 20,000*l.* It is divided into 10,000 shares, and is parcelled out among a great number of nephews and nieces. Several annuities revert to Mr. Geo. Black,* besides the largest share in the present partition. * * I do not hear any exceptions made to the distribution that Dr. Black has made. Mr. Geddes of Leith knows the situation of all his relations, and thinks the partition made with great judgment,—with particular attention to the need which each individual has for his assist-

* Son of Mr. George Black, of Belfast.

ance, and even to the chance of his making a good use of it. * *

[329.]

PROFESSOR ROBISON TO MR. WATT.

Edinburgh, Feb. 25, 1800.

* * Mr. Black also gave me a scroll of a letter from Dr. Black to you, which points out the very thing I wish to be informed about. It is dated [*] and alludes to some pressing instances from you to publish his peculiar doctrines, and some proffers by Mr. De Luc and yourself to be his editors. The Doctor then says, that he has already done a part of what you had pressed on him, and that it was his fixed resolution to finish next summer. He also undertakes to add *your extensions of his doctrines, if agreeable to you, and some particular discoveries which were wholly your own*; the words have a stroke below them by way of emphasis. I presume that this relates to your notions as to the composition of water, which were published in the Transactions for 1784. I have a very imperfect remembrance of a *tracasserie* which took place in the Society about the reading or printing of your paper;—some partiality to Mr. Cavendish. But I forget the circumstances. With-

* Blank in the original. The draft letter in question we have not found among Mr. Watt's papers, although his letters to Dr. Black were returned to him after the Doctor's death, and have been carefully preserved. It would appear, therefore, to have remained in Professor Robison's possession, and probably may have been the draft of that letter to Mr. Watt, of 30 Jan. 1783, which has already been printed in the 'Correspondence on the Discovery of the Composition of Water,' pp. 9, 10, and 11.

out committing you in the smallest degree, I must surely give these things with the most accurate arrangement of dates that I can procure. Pray give me the necessary information on this point.

* * * *

Surely there is a fair field of speculation laid open to a philosophic mind like Dr. Black's, by the facts which these new doctrines have brought together. The connection between the particles of tangible matter and the cause of heat and light is now seen in many new situations—in a sort of gradation, from the arithmetical expansion of a solid to the formation of a permanent gas. The important truth, that the immediate cause of chemical union is a moving force, like gravity, or any other pressure, is made evident by its being counteracted by pressure, and, therefore, being of the same kind. The seemingly general law, that the differences of temperature indicated by equal expansions of the thermometer produce equal *multiplications* of the bulk of vapours and gases, promises much instruction as to the manner in which the expanding cause is connected with the tangible matter. But, alas! like our departed friend, I am only fretted by finding myself no longer able to make those exertions of mind and body that these objects and hopes invite me to. I have been obliged to drop some very interesting subjects in my own line, and must not think of trying any cruises on the chemical coasts. * * I don't know whether I told you that I have gotten an addition to my family,—a fine little boy, born

in July, healthy and cheerful, and now beginning to amuse me, and to be amused by me. I find this a great acquisition, notwithstanding a serious thought sometimes stealing into my mind. I am infinitely delighted with observing the growth of its little soul, and particularly with the numberless instincts which formerly passed unheeded. I thank the French theorists for more forcibly directing my attention to the finger of God, which I discover in every awkward movement, and every wayward whim. They are all guardians of his life, and growth, and powers. I regret that I have not time to make infancy, and the development of our powers, my sole study. But I must recollect that he must be fed and clothed, and I must think of more profitable subjects, contenting myself with amusement with my pretty plaything. * * *

[330.]

MR. WATT TO PROFESSOR ROBISON.

Heathfield, March 7th, 1800.

* * My paper on the constituent parts of water was first written in a letter to Dr. Priestley, dated April 26th, 1783, and sent to him in London, with a request he would lay it before the Royal Society. The notions it contained were scouted by those members to whom it [was] shown; and I thought it proper to desire it might not be read then, but lie in the President's hands, which it did till April 1784, when it was read, but was never printed, being superseded by a letter to Mr. De Luc upon the same subject, dated November

26th, 1783, which was read before the Society in April of 1784, and printed in the Transactions for that year, with a note * in part explaining the delay; which see. * *

[331.] MR. WATT' TO MR. WILLIAM MITCHELL, EDINBURGH.

Heathfield, Birmingham, March 12th, 1800.

SIR,—I am favoured with your letter of the 5th, and am obliged to you for the intimations it contains, none of which, however, are new to me, or useful in their present form. To give my reasons would make a longer letter than I have time or health for at present. Rotative motions, on the principles of the first and second you describe, have been tried and abandoned many years ago. The third (the spiral) is not practicable as you have drawn it, and would be attended with considerable disadvantages in any way; (it can only make half a revolution for each stroke of the engine). A more perfect application of that principle is contained in the specification of my patent in the year 1781. In respect of the fourth invention, we use no racks or toothed sectors now; they are bad things: the method we use is much preferable, (which you may see at any of our engines). In general, no rotative motion will answer well that requires the piston to move with equal velocity in every part of the stroke, and a common

* See the 'Philosophical Transactions' for 1784, vol. lxxiv. p. 330; and 'Correspondence of Watt on his Discovery of the Composition of Water,' 1846, p. 78.

crank is nearly the best which has been yet contrived, or, perhaps, may ever be.

I do not by what I have said mean to discourage you from paying particular attention to the subject; your ideas are ingenious, and by further experience you may think upon better things.

I thank you for your attention to me, and the deference you express to my opinion, and think it my duty to set you right in a matter which might lead you into fruitless and expensive experiments.* I remain, &c.

[332.]

PROFESSOR ROBISON TO MR. WATT.

Edinburgh, Sept. 9, 1800.

* * These are wonderful steps which are every day making in chemical analysis; the analysis of the alkalis and alkaline earths by Guyton, by Henry, and others, will presently lead, I think, to [the doctrine] of a reciprocal convertibility of all things into all. It brings to mind a minister lecturing on the first chapter of one of the Gospels, where, after reading, "Adam begat Abel,

* This letter has been selected as one of the many instances that might be cited, of the sort of counsel, at once kind and judicious, that Mr. Watt was in the habit of giving when consulted by those who aspired to success in his own favourite field of mechanical invention. To many, his experience and sagacity were the means of saving much waste of time, the disappointment of their hopes, and even the misery and ruin which too often attend the failure of ingenious but unprofitable projects. In this respect, emphatically, "the alert, kind, benevolent old man," as Sir Walter Scott has so well said of him, "had his attention alive to every one's question, his information at every one's command." See also Mr. Watt's letter to the Rev. W. J. Rees, Sept. 20, 1810. No. [368] p. 315, *infra*.

and Abel begat," &c., to save himself the trouble of so many cramp names, he said, "and so they all begat one another to the 15th verse."* I expect to see alchymy revive, and be as universally studied as ever. * *

[333.]

MR. WATT TO MR. R. MUIRHEAD.

Heathfield, Jan. 9th, 1801.

* * You will have heard of our exploit with the robbers. We had been informed of their intention by the watchman, whom they had endeavoured to corrupt, and watched for them three nights, on which they only tried keys and examined the premises, which by our wise law is no felony; and had we apprehended them, they would soon have been let loose upon the public, and we could not have rested in safety. We were, therefore, obliged to let them commit the robbery; and, on their coming out, fell upon them with guns, pistols, bayonets, and cutlasses. Some of them resisted, and were badly wounded; others fled; one was caught on the top of a house; one fell from a house-eaves, fifteen feet high; another got clean over and off; with, as it is said, a broken arm,

* From this passage it would appear that the worthy Professor was more conversant with the evidences of natural than of revealed religion; as in the first chapter of the Gospel according to St. Matthew, the genealogical descent of our Lord commences with Abraham; and in that according to St. Luke, the genealogical ascent is given neither in the first chapter, nor before the fifteenth verse, nor through Abel (who may be supposed to have died *sine prole*),—but through Seth, "another seed instead of Abel, whom Cain slew." (Gen. iv. 25.) Perhaps Dr. R. was not altogether unlike the reverend gentleman whom he commemorates, in his desire "to save himself *the trouble of so many cramp names.*"

and some shots in him. We took four out of the five; but the little devil made his escape. Our young men were commanders-in-chief, and laid their plans very well; but one of our guards came not soon enough to their station, by which the escape took place, though by a way deemed impracticable.* * *

[334.]

MR. WATT TO MR. A. FERGUSON.

Heathfield, Birmingham, Feb. 8th, 1801.

DEAR SIR,—Yesterday I was favoured with your obliging letter of the 2nd inst. In respect to the question you put, whether Mr. De Luc's ideas on latent heat were prior to Dr. Black's, I cannot answer it. Mr. De Luc, in some part of his essay on the modifications of the atmosphere (see § 968, and the rest of that chapter, and, I believe, some other parts of that work, which I cannot now quote), seems to have had some ideas on the subject, nearly similar to Dr. B.'s; but they were only ideas, and not distinct ones. What was the date of that work, I do not know; I saw it first in 1772; but as a proof of Dr. B.'s priority of invention, see Mr. De Luc's *Idées sur la Météorologie*, § 210 and 249, where he positively ascribes the priority of invention to Dr. Black, and you can have no better authority. As to the

* See this story, (not, however, told with strict accuracy), in Allan Cunningham's *Memoranda of Sir Walter Scott*, given in 'Lockhart's Life,' chap. lii. "I like Boulton," continued Sir Walter, "he is a brave man," &c. &c. (p. 457, ed. 1842).

dates of Dr. B.'s invention ;—in 1780, a person of the name of Magellan having very absurdly attributed the invention of latent heat to Mr. Wilcke, a Swedish professor (who, I am persuaded, learnt it from Dr. B. through a Mr. Gahn), I wrote to the Doctor requesting the dates of that discovery, which, in consequence, he furnished me with ; but, unfortunately, his letter is mislaid,* yet I have copy of what I wrote to Magellan from it as follows :—

“ Dr. Black gave the doctrine of latent heat in his lectures at Glasgow, immediately on his being made Professor there, which was in the year 1757–8, or at latest in 1758–9, and taught it every winter at Glasgow until 1766–7, when he began to lecture at Edinburgh. In 1760–1 the Hon. Mr. Fitzmaurice, brother to Lord Shelburne, and a Dr. Menish (now settled near London as a practical chemist), attended his lectures, and took notes. In the same year, Mr. Geo. Farquhar, now a surgeon in London, attended these lectures, and went to Paris the next winter to finish his education, where, no doubt, he mentioned the new doctrines. In 1761–2 Dr. Irvine (afterwards lecturer on chemistry at Glasgow), and Mr. Patrick Wilson, now (1801) living in London, attended the lectures. In 1764–5 Messrs. Desnitzky and Tretia-

* See the letter in question, No. [179.], printed at pp. 118–120 of this volume. An extract from it was also printed in the Introductory Remarks to the ‘ Correspondence of Watt on the Discovery of the Composition of Water,’ p. xxiii. ; where, however, its date was given as of May, instead of March, 1780. The latter is the correct date.

koff (afterwards professors in Russia) attended them. Dr. Crell of Brunswick was his scholar in 1769; and, in Nov. 1772, Dr. Henry Gahn from Sweden. A Mr. Williamson, a Dane, attended them about 1769." I myself never attended his lectures; but the Doctor explained his doctrines to me about the year 1763. A pretty full account of this theory is, as I am told by a friend, contained in the Abbé Rozier's *Journal de Physique*, at the time it was published in duodecimo, (prior to the year 1774).

Dr. Crawford seems not to have been much disposed to do either Dr. Black or Dr. Irvine justice, and consequently was willing to deprive either of them of the honour of discoveries which were the foundation, and indeed the only valuable parts, of his own voluminous writings on the subject. His own theories and experiments are, in my opinion, of little value, although they serve as one of the props to the French theories.

Like you, I have no end to serve in detracting from Mr. De Luc, who is my intimate friend. I have given my authorities, and, if I am wrong, shall be glad to be set right; but I think his own avowal supersedes all inquiries, though a man may be deceived even as to his own inventions.

* * * *

[335.] DR. PRIESTLEY TO MESSRS. BOULTON AND WATT.

Northumberland [America], Oct. 17, 1801.

GENTLEMEN,—I cannot express how much I think myself obliged to you for the noble present

you have made me of a *furnace*, and other *apparatus for making large quantities of air*. I have had it only a few days, and I find it, in all respects, to exceed my expectations. The furnace alone is invaluable. I never had anything so convenient for many purposes before, nor had I ever so excellent a *lute* as I find your Cornish clay to be. I admire the ingenuity with which every part of the apparatus is fitted to each other, and only wish that *earthen tubes* could be used instead of *iron vessels*, as the air would be much purer.

* * * *

I have lately sent to Mr. Nicholson an account of some experiments that I have made with the *pile of Volta*, which appear to me to be decisive in favour of the doctrine of phlogiston, and absolutely inconsistent with that of the decomposition of water. I have also sent an answer to *Mr. Cruikshank's paper* in Mr. Nicholson's Journal. He supposes fixed air to be formed in circumstances in which it is impossible that, according to known laws of chemistry, the elements can possibly combine; and that it is, after this, decomposed by a substance which has no such power.

In this state of exile from my native country, and the friends that I most value, I am happy to have the means of prosecuting my experiments; but everything that I make use of, substances as well as instruments, must be had from England, for all our druggists are supplied from thence, and consequently at a great expense. I am truly thankful to my friends for lessening this expense.

In return, I can only say that they may depend upon my gratitude, and my assiduity in making the best use that I can of the assistance they are so kind as to afford me.

With much gratitude, and every good wish to yourselves and all the other members of the Lunar Society, the advantages of which I most feelingly find the want of,

I am, Gentlemen, yours sincerely,

J. PRIESTLEY.

[336.]

MR. WATT TO MR. HAMILTON.

Heathfield, March 1st, 1802.

* * Our engine trade thrives; the profits per cent. are, however, very moderate; it is by the great capital and expensive establishment of engineers, &c., that we keep it up: without our tools and men very little could be done, as we have many competitors, and some of them men of abilities.

* * * *

[337.]

DR. R. W. DARWIN TO MR. WATT.

Priory; near Derby, April 21, 1802.

DEAR SIR,—You will probably have heard of the death of my excellent and honoured father, which took place before your letter could reach him.

* *

My poor father on the 10th of this month had a severe attack of fever, which was removed by the loss of about 25 ounces of blood during the

day; he seemed to recover perfectly. On Saturday, the 17th, Mrs. Darwin remarked to him, while they were walking out in the evening, his good looks and good spirits:—he answered, “I generally look well before I become ill.”

On Sunday morning (18th) he came down stairs at six o'clock and wrote some letters; after seven he went to the kitchen-fire and drank some butter-milk,—ordered a fire to be made in his study, where he went and lay down on a sofa. He complained to the servant that he was cold and a little sick; Mrs. Darwin came to him,—he was raised up and placed in a chair; he desired to have less air (which shows he was not much oppressed), became faint, and died before nine o'clock.

It seems to have been the cold fit of inflammatory fever. He always dreaded pain, but not death,—he died without pain.

It was my intention to write to Mr. Keir and Mr. Boulton, but, as I could only repeat these particulars, perhaps you will have the goodness to communicate them for me. My father had great friendship and esteem for each of you, and I therefore think you would be interested in knowing the particulars attending his last moments.

Mrs. Darwin is in heavy affliction.

I have the honour of being,

Dear Sir,

Your faithful servant,

R. W. DARWIN.

[338.]

MR. WATT TO DR. R. W. DARWIN.

Heathfield, April 24th, 1802.

DEAR SIR,—It was with extreme concern that on Thursday last I heard of the loss of my much respected and valued friend your late father; and yesterday I received your kind letter informing me of the circumstances of his illness, for which attention I thank you. I communicated the contents to Mr. Keir by letter, and to Mr. Boulton verbally. Mr. Boulton, as well as Mrs. Watt and myself, is much afflicted. The final dissolution of a friendship of so long standing as ours with your father has been, and that so unexpectedly, produces sensations of the most disagreeable kind upon people of our age, who feel themselves as it were in danger of being left alone in the world.

To offer consolation to your afflicted family would be vain; time is the only consoler, with the consideration that your lamented parent has lived a life of utility to his family and to the public, by whom he has been highly respected and will be much regretted; to which may be added, that he has not been the victim of a tedious and painful malady. For my part, it will be my pride, while I live, that I have enjoyed the friendship of such a man.*

*

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*

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* "He was almost my most ancient acquaintance and friend in England, I having been intimate with him for thirty-four years, and on many occasions much indebted to his good offices."—Mr. Watt to Mr. R. Muirheid, May 3, 1802.

[339.]

MR. WATT TO MR. GREGORY WATT.

Heathfield, April 28th, 1802.

* * I had the misfortune on the 18th to lose my much-valued friend Dr. Darwin. He had a violent attack of pleurisy about a year ago, which was removed by profuse bleeding. On the 10th instant he had an attack of inflammatory fever, for which he lost 25 ounces of blood in one day, and seemingly recovered; on the 17th he seemed to be in unusually good health; on the 18th, in the morning, he got up about six o'clock and wrote some letters; about seven o'clock came to the kitchen-fire, complained of being chilly, drank some buttermilk, lay down on a sofa in his study, said he was a little sick, and about nine o'clock expired, seemingly without pain. His son, Dr. R. W., thinks it was the cold fit of an inflammatory fever. He has died in the height of his reputation, and has left few, if any, equals in the scientific part of his profession. He had at Lady-day removed from Derby to a very pleasant place, Breadsall Priory, about five miles from Derby, which he had fitted up and took great pleasure in.

* * * *

[340.]

MR. TELFORD TO MR. WATT.

London, 3 May, 1802.

* * I this day paid my respects to you in the Exhibition room. I think Beechey has succeeded admirably well. I have just received from a young poet of very uncommon talents, (a

schoolfellow of one of your sons, Mr. Campbell, *author of the 'Pleasures of Hope'*), some beautiful verses to Painting. After having spoken of the powers of Song, he says :—

“ But thou, serenely silent Art,
By Heaven and Love wast taught to lend
A milder solace to the heart,—
The sacred image of a friend.

“ No spectre forms of pleasure fled
Thy soft'ning, sweet'ning tints restore ;
For thou canst give us back the dead,
Even in the loveliest looks they wore.”

He is about publishing a quarto edition of his works by subscription. Have you any people guilty of a taste for fine poetry in your quarter? If so, I stand ready to abet them in their transgression by adding their names to the list I am trying to procure for this young Scot. I am afraid he has a poor trade. Fame is thin, meagre food for living authors; the booksellers generally contrive to eat up all the substantial profits.

I am always, with much respect and esteem,

Yours very sincerely,

THOMAS TELFORD.*

* Mr. Telford was himself always a warm admirer, and, in early life, even a modest suitor of the Muse; and the poem of “ESKDALE” (printed at p. 655 of the Appendix to his Life, written by himself, and edited by Mr. Rickman, 1838) bears record that, in the words of the great “rustic bard” of his country, he

—“ by himsel' had learn'd to wander
Adown some trotting burn's meander,
An' no think lang :
O sweet, to stray an' pensive ponder
A heart-felt sang ! ”

Indeed,

[341.]

MR. WATT TO MR. BOULTON.

London, 23 Nov. 1802.

* * As to ourselves, we cannot help feeling, with deep regret, the circle of our old friends gradually diminishing, while our ability to increase it by new ones is equally diminished; but perhaps it is a wise dispensation of Providence so to diminish our enjoyments in this world, that when our turn comes we may leave it without regret.

[342.] MADAME LA ROCHE TO "MISTER JAMES WATT, NEAR BIRMINGHAM."*

Offenbach, near Francfort, the 4 of March, 1803.

MUCH HONORED WORTHY SIR,—would your Genius have read in my Soul, the very moment I

Indeed, in a collection of verses written in honour of Burns, and published by Allan Cunningham ("Life and Works of Robert Burns," p. 154—156, 1840), which includes the names of Roscoe, Campbell, Wordsworth, Coleridge, James Montgomery, and the Ettrick Shepherd, the first that occurs is "A Poem addressed to Robert Burns by Mr. Telford."

That eminent engineer's "secret liberality," (see Appendix to his Life, p. 659),—a distinguishing feature of his discerning and benevolent mind—was always exercised with great readiness towards those who, though poor in purse, were rich in talent; and a poet, who could boast of uniting in his own person both of those qualifications, possessed a threefold facility of access to his heart. He was constant in his friendship to Campbell; and among the legatees named in his last will, (he died in 1834), are "Robert Southey, poet-laureate," and "Thomas Campbell, poet."

* This quaint epistle is given exactly as it was sent, unaltered in one jot or tittle of its charming *naïveté*. The good old lady who penned it, was the authoress of the "History of Lady Sophia Sternheim,"

perused the obliging letter with which you honored the old mother of Sophy Sternheim, be sure I remembered with blessing the hour I saw in my little abode *Sir James Watt*, the great benefactor of all Centuries to come,—having proved the power of a mind, Who surly and steadily aply'd his faculties, for the improvements of Science and Art—the more useful, for his fellow creatures—Physik and Mekanik—will for ever bless your name—I was happy to behold you with a New Conviction, *that the very great man is a very good man to*—I admire you for the first, but bless and love you for the second.—May your Sons partake, of your Spirit, and character, with wath feelings, should I have seen the worthy mother of your Childs—and I will ever regret her sickness—and my old age who has deprived me of the advantage to become acquainted to her.—I have thanked my god, to shaked the hand, who has traced the perfection of Steam Engine—and I pray god, to conserve you Mistriss Watt and family—in all happiness, far more, then 73 years of mine. When Dear Sir! you recall Germany, say that you have there an old friend and well-wisher in

SOPHY LA ROCHE.

(translated by J. Collyer, 2 vols., 1776); and also of a Journal of Travels in Holland and England (“Tagebuch einer Reise durch Holland u. England, von Sophie Wittwe von La Roche;” Offenbach am Main, 1791. We trust that God “conserved” in all peace to the end of her days her honest, ardent, German heart; which united to such admiration of intellectual greatness, the emotions of humble, pious goodness.

excuse Dear Worthy sir! all the faults, of the broken English, I was bold enough to write you. Mister Trapp, has my everlasting thank for the blessing hour, in wick He conducted you to my cottage.—*God bless you.*

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MR. WATT TO PROFESSOR ROBISON.

Heathfield, April 26, 1803.

* * I am glad you have completed your task,* which I am sorry has proved so grievous. You judged right in thinking I should not have consented to your own friendly intention of dedicating it to me, I am not a proper patron for Dr. B.'s Lectures: not enough known in the world, nor a sufficient adept in chemical science for my name to recommend the book; and, as Dr. B.'s friend, there were many with whom he was more intimate and more connected. Besides all this, I have a great aversion to standing in the front rank on any occasion. I can only regard it as a proof of your friendship, which, though grateful to me as such, I wish you could still turn aside and inscribe the book to some more appropriate person. I shall feel equally obliged by the intention. * *

We were very kindly received by my old friends at Paris, M. Berthollet, M. Monge, and M. De la Place, now become Senators. M. Prony and M. Hassenfratz were also exceedingly attentive;

* That, viz., of editing Dr. Black's Lectures, published in 2 vols. 4to.

the former especially, and seems an exceeding good sort of a man, as well as a very able mathematician. He appeared to be sorry that he had not taken more notice of me in his book on the steam-engine, and has offered to publish, in a succeeding volume, anything I please to furnish him with on the subject. Many others were very kind. We passed five weeks there, and, had the weather been warmer, I should have wished to prolong my stay. * *

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MR. WATT TO MR. A. WESTON.

Heathfield, Nov. 15th, 1803.

DEAR SIR,—Being informed that my name is in the list of those nominated as Sheriff of Staffordshire, I must request your advice and assistance in averting so serious a misfortune as serving that office would be to me.

I am nearly seventy years old ; my health, always precarious, generally confines me to the house for the greatest part of the winter and spring. I never was endowed with the speedy decision, firmness of character, and intrepidity necessary for a public station, and these qualities have not been augmented by my declining years. You, as well as any man, know the anxiety and vexation which I endured for many years from the harassing lawsuit in which we were unfortunately engaged, and which have had the effect of making me very unfit for business of any kind ; the powers of my mind are worn out, as well as those of my

body. I have laboured very hard for the public during the greater part of my life, and hope I have been of some use. Though I cannot bring forward to the public mind the “labores, sudores, vigiliæ,” yet the “instrumenta artis nostræ” are in everybody’s hands. I have been useful to the State in the way Nature intended, and hope I shall not have a duty imposed upon me I am totally unfit for, nor have my grey hairs weighed down by a load of vexatious cares. You know that from my inability to support the cares of business I have retired from it with a very moderate fortune, in order to enjoy that quiet for which alone I am now fitted, and which I pray may be undisturbed. My property in the county is very small,—only a house and forty acres of poor land, which has *any* value only from its vicinity to Birmingham.

The present juncture of affairs seems to require a Sheriff in the prime of life, possessed of activity and decision, and not a timid old man. It is not my part to say who is equal to the office; but I am fully impressed with a sense of my own unfitness, and hope I have not deserved so ill of the nation as to be placed in a situation that might expose my weakness, or perhaps have worse consequences.*

* *

* Although every exertion was used by those to whom Mr. Watt communicated his wishes on this occasion, there was at first a great deal of difficulty in getting him excused from serving in the office to which he had been nominated, but to the labour, publicity, and responsibility of which he felt so strong a repugnance; one of the other two names on the list being that of a gentleman who had previously

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MR. WATT TO THE HON. C. F. GREVILLE.

Heathfield, Nov. 19th, 1804.

* * Previous to my setting out on our unfortunate journey to Bath, Mr. Rennie communicated a printed copy of my Report on the Caledonian Canal, which he had found in the Reports of the Committee of the House of Commons on the British Fishery, which appears to be correct, and from which we have made a fair copy.

* * I have also found among my papers the first draught of the map of the Canal, of which, as soon as I can get it done, I mean to send you a copy; at the same time I return that which Lord Cathcart was so obliging as to send me, and for which I beg you will return his Lordship my thanks. * *

served, and the other that of a baronet who was a half-pay officer, and pleaded his liability to be called into military service. But Mr. W.'s scientific friends, Sir Joseph Banks and the Hon. C. Greville, having used their influence with his Grace the Duke of Portland, then President of the Council, that nobleman, in the most kind and handsome terms, expressed his opinion that Mr. Watt's disposition to preserve that quiet to which he was so well entitled would induce the members of the Council to direct his name to be removed from the list of persons nominated as sheriff. Ultimately a "pocket-sheriff," *i. e.*, a gentleman who was willing to serve, though not nominated, was found by the Lord-Lieutenant. An argument in support of Mr. Watt's claim for release, at that period more valid than any of those at first suggested, (although one that now-a-days would have been of little avail), was that he was a member, not of the Established Church of England, but of the Presbyterian Church of Scotland.

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MR. WATT TO MRS. CAMPBELL.

Heathfield, Dec. 1st, 1804.

MY DEAR COUSIN,—I duly received your kind letter of the 20th November. In circumstances like ours, it is, as you observe, our duty to submit with patience to the will of Providence, which we have endeavoured to do, though we can never cease to feel the deepest regret for our loss,* which was not of an ordinary kind; for there are very few young men that possess the power of mind, the genius, which could adapt itself to any science, and—what occurs still more rarely—the activity and industry that could and did proceed in his studies and exertions, even while labouring under the disease which terminated his earthly career.

We have lost a son, and you a relation, that would have done honour to any family or any country! I cannot weep; but I must ever lament his early fate. We must, however, console ourselves as well as we can, and remember that we still have duties to fulfil in the world, and that we still have a son† affectionately attached to us, whose abilities do not fall short of his brother's, though differently directed. * * *

* That of Mr. Watt's youngest son, Gregory, who died on the 16th of October, 1804, at the age of twenty-seven. His brilliant, though brief career, would here have received some further notice, had it not been that, with his literary remains, it may form the subject of a future publication.

† The late Mr. James Watt, of Aston Hall, at that time actively engaged in the management and direction of the steam-engine manufactory at Soho.

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MR. WATT TO MR. R. MUIRHEID.

Heathfield, Jan. 26th, 1805.

* * I, perhaps, have said too much to you and Mrs. Campbell on the state of my mind. I therefore think it necessary to say that *I am not low-spirited*, and, were you here, you would find me as cheerful in the company of my friends as usual. My feelings for the loss of poor Gregory are not passion, but a deep regret that such was his and my lot.

I know that all men must die, and I submit to the decrees of Nature; I hope, with due reverence to the Disposer of events. Yet one stimulus to exertion is taken away, and, somehow or other, I have lost my relish for my usual avocations. Perhaps time may remedy that, in some measure; meanwhile, I do not neglect the means of amusement which are in my power. * *

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MR. WATT TO MR. C. K. ROBISON.

Heathfield, Feb. 5th, 1805.

DEAR SIR,—It was with great concern that I received yesterday your advice of the loss of my dear and much esteemed friend your father. It adds to my sorrow, that from the afflicting circumstances in my own family for this last twelve-month, I have not corresponded with him as I ought to have done had my mind been more at ease.

The loss you have sustained is a very great one,

yet it must be some consolation that he is relieved from the state of suffering in which he has so long continued; that he will be sincerely regretted by all who had the happiness to know him; and that he has lived long enough to have by his writings raised monuments to himself that will long outlive the date of frail mortality. I shall, while I live, warmly remember his friendship to me, his virtues, the clearness of his head, and the uncommon extent of his knowledge and science, as well as the unwearied application with which he pursued it under the pressure of a painful disease. I shall not at present intrude further upon your sorrows, being sensible that time alone can alleviate the feelings of his family, and enable them to bear this affliction. * *

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MR. WATT TO MR. R. MUIRHEID.

Heathfield, Feb. 7th, 1805.

* * It was with great concern that I learned the other day the death of my worthy friend Professor Robison. He was a man of the clearest head and the most science of anybody I have known, and his friendship to me ended only with his life, after having continued nearly half a century. * *

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MR. WATT TO DR. P. WILSON.

Heathfield, March 12th, 1805.

* * I understand Mr. De Luc, who is lately returned to England, is writing an answer

to Dr. Robison's censures upon him, which he feels most severely. I wish Dr. R. had not said so much; it is hard at fourscore for a man to be obliged to write in self-defence. I do not enter into the matter in dispute, but I know Mr. De Luc to be a very worthy man, and I do not conceive that he had the intentions Dr. R. attributes to him.*

* * *

[351.]

MRS. ROBISON TO MR. WATT.

Edinburgh, 17th March, 1805.

* * * His [Professor Robison's] talents were great, and his knowledge most extensive; but, as perfection is forbid to this state, there was a kind of mist, I was sensible, that often obscured his amiable, bright character from those that did not often see him. It was much produced by his wonderful *sensibility* and *delicacy*, which naturally caused him to be hurt with many things not felt by common minds, and even by minds of refinement who mixed with the world. *They* were accustomed to allow for and overlook what can neither be prevented nor approved. This irritability made him often appear unlike the benevo-

* This answer by Mr. De Luc was published in the 'Edinburgh Review' for July, 1805, the reviewers at the same time expressing their opinion, that in it "he exculpates himself completely from the imputation which was rather rashly thrown upon him in Dr. Robison's edition of Dr. Black's Lectures, and repeated by us in our review of that publication." Edin. Rev., vol. vi., p. 501. See Correspondence of Mr. Watt on his discovery of the Composition of Water, p. 10.

So ample an expression of the deliberate opinion of the reviewers seems fully to exonerate us from the necessity of giving any further extracts from the correspondence of Mr. Watt on this subject.

lent, gentle man he was in so eminent a degree, and kept the world at a distance.

As to his talents and acquirements, I have less anxiety. They are in part known [to], and will be much easier understood by the world; but his religion and piety, which made him patiently submit, without even a fretful or repining word in nineteen years of *unremitting* pain; his humility, in his modest opinion of himself; his kindness, in labouring with such industry for his family during all this affliction; his moderation for himself, to indulge an *unbounded generosity* to all around him; joined to his talents, form a character so uncommon and so noble, as won't be easily conceived by those who have not, like me, had the contemplation of it. * * I wish I could convey his wondrous worth, but I am much mortified that the chief knowledge of it rests in so inefficient [an] agent. * *

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MR. WATT TO MR. R. MUIRHEID.

Heathfield, April 8th, 1805.

* * It is rather mortifying to see how easily the want of even the best of us is dispensed with in the world, but it is very well it should be so. We here, however, cannot help feeling a terrible blank in our family. When I look at my son's books, his writings, and drawings, I always say to myself, Where are the mind that conceived these things, and the hands that executed them? In the course of nature he should have said so of mine; but it was otherwise ordered, and our sorrow is unavailing. As Catullus says—

“ Nunc it per iter tenebricosum
 Illuc, unde negant redire quemquam.
 At vobis male sit, malae tenebrae
 Orci, quæ omnia bella devoratis ! ”

But Catullus was a heathen: let us hope that he (G.) is now rejoicing in another and a better world, free from our cares, griefs, and infirmities. Some one has said, “ I shall not wholly die,” and Gregory’s name, his merits, and virtues will live at least as long as those do who knew him. You are not from this to conceive that we give way to grief; on the contrary, you will find us as cheerful as we ought to be, and as much disposed to enjoy the friends we have left as ever; but we should approach to brutes if we had *no* regrets. * *

[353.] J. WATT’S RECOLLECTIONS OF HIS FRIEND DR. J. ROBISON.

April, 1805.

* * Our acquaintance began in 1756 or 57, when I was employed by the University of Glasgow to repair and put in order some astronomical instruments, bequeathed to the University by Dr. Macfarlane, of Jamaica. Mr. Robison was then a very handsome young man, and rather younger than I. He introduced himself to me, and I was happy to find in him a person who was so much better informed on mathematical and philosophical subjects than I was, and who, while he was extremely communicative, possessed a very clear method of explaining his ideas. Between two young men of ardent minds, and engaged in

similar pursuits, a friendship was soon formed, which has continued until death has deprived me of my friend ; and has suffered no other interruption than what has been caused by our absences from each other, and the necessary attentions to our respective duties in life. Soon after this, I settled as mathematical-instrument-maker in the College of Glasgow, and was frequently favoured by Mr. R.'s company, until he left the College about the end of 1758, and went to sea, I believe, in one of his Majesty's ships. During this period he turned my attention to the steam-engine, a machine of which I was then very ignorant, and suggested that it might be applied to giving motion to wheel-carriages, and that for that purpose it would be most convenient to place the cylinder with its open end downwards, to avoid the necessity of using a working-beam. The latter idea he had published some time before in the 'Universal Magazine.'* In consequence, I began a model,

* "The Universal Magazine of Knowledge and Pleasure, containing News, Letters, Debates, Poetry, Musick, Biography, History, Geography, Voyages, Criticism, Translations, Philosophy, Mathematicks, Husbandry, Gardening, Cookery, Chemistry, Mechanics, Trade, Navigation, Architecture, and other Arts and Sciences, which may render it Instructive and Entertaining to Gentry, Merchants, Farmers, and Tradesmen ; to which occasionally will be added An impartial account of books in several languages, and of the state of learning in Europe ; Also of the Stage, New Operas, Plays, and Oratorios." This now obsolete periodical, a curious relic of the literature of the last century, was published monthly for a number of years, commencing in 1747 ; and it must be admitted that the variety of its contents appears to have justified its somewhat ambitious title. Robison's communication, with a rough woodcut of the inverted cylinder, will be found in vol. xxi., p. 229—231, for Nov. 1757.

with two cylinders of tin plate, to act alternately, by means of rack motions, upon two pinions attached to the axis of the wheels of the carriage; but the model, being slightly and inaccurately made, did not answer expectation. New difficulties presented themselves. Both Mr. R. and myself had other avocations which were necessary to be attended to; and, neither of us having then any idea of the true principles of the machine, the scheme was dropped.

I, however, went on with some detached experiments on steam until 1763, when I set about the matter more seriously, and discovered the principles upon which my improvements on the steam-engine are founded. Mr. R. returned to Glasgow in 1763 or 64. Among other places, he had been in the West Indies, and I remember his mentioning to me his feelings upon his landing in Jamaica, and his admiration of the vegetables there, especially the trees—so extremely unlike those of Europe—as well as some of the phenomena of the climate. He mentioned that, for the purpose of astronomical observation, he had gone up among the mountains there; and that though at 7 o'clock in the morning he had found the sun intolerably hot on the S.E. side of the mountain, he had found it so cold at 9 o'clock of the same morning on the N.W. side, that he found a large wood-fire exceedingly agreeable while he breakfasted. He mentioned many other circumstances that—though they interested me much then—are now obliterated from my memory.

After his return to Glasgow, I think it was, that he became tutor to Mr. Macdowal, of Garthland, and his brother; and during that time I recollect his mentioning that, during a very intense frost, the window of his room, being very badly fitted, admitted rather more cold air than was agreeable, which he remedied by applying water with a brush to the bad joints, and, in proportion as it froze, applying more until the joints were stopped.* I do not recollect his being present or assisting me in any of my experiments on steam, or of the improvements upon the steam-engine; but on this head I send a copy of his evidence in B. and W.'s trial with Maberly, in the Court of Common Pleas, at Guildhall, in 1796. I remember also that in 1765, on seeing a perspective machine, with a double sliding motion at right angles to each other, which Dr. Lind had brought from India, and had made some improvements upon, Mr. R. suggested that the same thing might be better accomplished by a double parallelogram (as some parallel rulers were then made),—an idea which I pursued, and, by some improvements and additions of my own, made a useful instrument.

From the period of Mr. R.'s return to Glasgow, our interviews were rare: he had his duties to attend to, and I, having become the father of a family, and loaded with cares of many kinds, had less time for mere philosophical conversations;

* For an account of a somewhat similar practice among the Esquimaux, see Sir John Richardson's "Journal of an Arctic Searching Expedition," vol. i. p. 349.

our friendship, however, subsisted, and we were happy when we met upon any occasion. I cannot recollect the date when he went to Russia, nor do I know much of his transactions there, only in general that he was much esteemed, as was testified to me by Sir Charles Knowles, to whom he had recommended me. I remember also the receiving a letter from Mr. R., in or about 1773, proposing to me to come to Russia, where he had recommended me to fill some station I did not conceive myself equal to, and which I respectfully declined.* In 1774 I left Scotland to settle in Birmingham, where I have resided ever since, and have had very few opportunities of meeting with Mr. R. But in 1796, when Boulton and Watt were assailed by a combination of pirates, who wished to rob them of the fruits of their industry, and disputed my claim to the invention of the improvements upon the steam-engine, Mr. Robison, notwithstanding the painful disease under which he laboured, and his necessary attention to the duties of his class, procured leave of absence, and made a journey to London to appear as witness in our cause, where his testimony had very great effect both upon the judge and jury; but be the latter circumstance as it may, the zeal with which he espoused my cause, and the disregard to his own personal inconveniences when they came in competition with it, can never be forgotten by me while I remember anything.

* See note on p. 82, *suprà*.

To give Dr. R.'s character is beyond my power, but some things I may mention as hints to those who are more capable. He had the quickest and clearest comprehension of every question in science of any person I ever knew, and added to that a very pleasing manner of explaining it to others, though he was rather impatient if he found he was not attended to or comprehended. He used to complain of his own want of industry, but it was without cause, for nobody was more studious than himself; though, perhaps, he was sooner tired than duller men, with those studies which presented little upon which he could exercise those inventive powers he possessed in so eminent a degree. Yet, if this was so, his intense application in more mature life, and his productions even when labouring under an excessively severe malady, show that his complaints of himself were more imputable to the impatience of youth, and to the despondency and doubts of his own powers, to which he was unfortunately subject, than to any other defects in his character or disposition. He was kind and affectionate, constant in his friendships, and would take more trouble for his friends than he would for himself. Naturally diffident, he was reserved in his conversation with strangers,—at least with those whose characters he was not well informed of; but with his friends, nobody was ever more open and communicative, though he was always more ready to listen than to offer his opinion.

He had a high sense of honour and propriety, and nothing could offend him more than a breach

of them in others. He entertained a high respect for the constitution of his country, and detested the novel doctrines of Jacobinism, which made him pass censures too severe upon several of the French philosophers (otherwise extremely estimable men, and to whom science is much indebted), without, perhaps, duly weighing the circumstances in which they were placed. His displeasure with some of them was probably augmented by his thinking them deficient in giving that praise and honour to Dr. Black which his discoveries merited: and, however any person might think himself unjustly censured by Dr. R., I can safely say that I am sure he was actuated by no selfish, envious, or malignant motive in anything he has written.

His errors must be attributed to the failings of human nature, and to the painful malady under which he laboured; which, however, he bore with the utmost patience.

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MR. WATT TO MR. J. CRAIG.

Heathfield, April 30th, 1805.

MY DEAR SIR,—It would give me much pleasure were I able to answer your queries concerning my respected friend Professor Millar,* but the

* John Millar, Esq., advocate, Professor of Law in the University of Glasgow, and the learned author of (among other works) "Observations concerning the origin and distinction of Ranks in Society"—a well-known treatise, of which a fourth edition was published at Edinburgh in 1806, with a life of the author by Mr. Craig. For a copious and lively description of Professor Millar's intellectual powers, attainments, and habits, see Dr. Beattie's *Life of Thomas Campbell*, vol. i., p. 157.

length of time which has elapsed since the transactions you inquire after, the diversity of my avocations, the anxieties and vexatious occurrences of my life, and the natural decline of memory at my years, have all concurred to obliterate most matters of that period from my recollection.

I was first acquainted with Mr. Millar about the year 1752 or 53, and frequently met him at your grandmother's house, as well as at an irregular club a few of us had at Mr. Shed's,* as I think: the members of which were, William Morehead, of Herbertshire; John Allan, of the Row; your father; Mr. Millar, and myself. I am not sure whether Mr. Archibald Hamilton of London, and Mr. R. Carrick were not also of the number, at least occasionally. I remember Mr. Millar was always looked up to as the oracle of the company; his attainments were greater than those of the others; he had more wit, and much greater argumentative powers, of which he was not sparing, as those who engaged with him felt to their cost; at the same time he was perfectly good-humoured, though he had an air of firmness which was apt to dismay his antagonist. In short, such as you knew him in age he was in youth, allowing for his more matured judgment in advanced life. Our conversations, besides the usual subjects with young men, turned principally upon literary subjects, religion, morality, belles-lettres, &c.; and to those conversations my mind owed its first bias to such subjects,

* This name is indistinct in the MS.

in which they were all much my superiors, I never having attended a College, and being then a mechanic.

I never was so intimate with Mr. Millar as I was with most of the others, our pursuits being exceedingly different. In 1754 I went to London, where I stayed a year; and, when I returned, settled for some time at Greenock. When I settled at Glasgow, I think in 1756 or 57, Mr. Millar was no longer at college. I remember calling on him at Edinburgh, and I think he had then a pupil, but of this I am not certain; but I am sure it was not in Lord Kaim's house. I do not remember that he had any particular mathematical or physical acquirements, but he was quick at everything.

I think I remember his first opening at the bar much praised, and that he was getting into considerable reputation when he accepted the Professorship,* which latter circumstance many of his friends regretted; but I never heard him speak in public, nor do I recollect his style in our meetings, otherwise than its being argumentative and impressive, being always quick in perceiving everything which made for his purpose, and concise rather than verbose. I do not know whether he was soon eminent as a lecturer, but I think he was, for he had a great reputation when he became a Professor; and I know the powers of his mind were then fully expanded, and he was not the

* This was in 1761.

man to hide his candle under a bushel. I know not who was his fellow-student with Mr. Lindsay.

I have already generally answered the latter part of your letter, but I shall be more particular. He was always remarkable for his vivacity in conversation, fond of argument, and quick in seizing his ground. His pleasantry and his other qualifications were natural to him, and never appeared the effects of study, though few had studied so much, or to such good purpose. He had, however, always a degree of stiffness that might have been mistaken for pedantry or affectation, but which perhaps arose from a conscious superiority or confidence in the rectitude of his own opinion, and which soon wore off upon a more close acquaintance. No man, however, was more affable, or less liable to exult over his weaker brethren. In short, he was a *man* when I was a *boy*, though in years he was little my senior. We might say of him what has been applied to another person dear to me :*—"Puer, adolescentium æmulus ; adolescens, virorum." This, together with the diversity of our pursuits, the decrease of our intimacy after he became a Professor, and the disagreeable circumstances in which I was then placed, make me know less of him than I should otherwise have done ; for we always remained attached friends, and I consider myself indebted to him for much useful

* Mr. Watt's much beloved and lamented son Gregory, who had died about six months previous to the date of this letter. See above, pp. 288 and 292.

knowledge. I wish I could have given you more information; but I beg you will excuse my deficiencies, and accept what I have written, as a tribute to my affectionate memory of him and of your family. Mrs. Watt and my son join in best wishes and kind remembrances to you, your sisters, and family, and I remain very affectionately yours, &c.,

J. WATT.

[355.]

MR. WATT TO MR. BOULTON.

Glasgow, 12 Nov. 1805.

* * The new lights* are much in vogue here; many have attempted them, and some have succeeded tolerably in lighting their shops with them. I also hear that a cotton-mill in this neighbourhood is lighted up with them. A long account of them was published in the newspaper some time ago, in which they had the candour to ascribe the invention to Mr. Murdock. From what I have heard respecting these attempts, I think there is full room for the Soho improvements, though when once they see one properly executed, it will have numerous imitators.

* * * *

* The gas from coal, then recently applied to economical purposes by Mr. Murdock, at Soho; where Mr. Boulton's manufactory was illuminated by "the new light," on occasion of the announcement of the Peace of Amiens. For this most valuable invention—one of the many fruits of his ingenious and practical labours—Mr. Murdock received from the Royal Society their large Rumford gold medal. See his paper in the Philosophical Transactions for 1808, pp. 124—132, and Mr. Watt's letter to Mr. Browne, 26th April, 1809; No. [355.] p. 312, *infra*.

[356.] MR. WATT TO THE RIGHT HON. THE EARL OF
BREADALBANE.*

Heathfield, Birmingham, May 12th, 1806.

* * I never made a *survey* from the Tay to Crieff and Loch Earn ; but, at the desire of some gentlemen of that neighbourhood, I rode over the ground from the Linn of Campsie to Crieff, when I was making a survey from Perth to Forfar, (I think at the expense of the Trustees for Fisheries and Manufactures), and found that a canal in that line was apparently very practicable ; but it has occurred to me since that the proper line of canal would be up the valley of Strathearn, from near the confluence of the Earn with the Tay ; as it would by that means extend its influence over a greater tract of fertile country, and avoid the banks of the Tay, which, as far as I remember, are in many places very steep between Perth and the Linn of Campsie. But, as this view was taken so long ago as the year 1770, my memory upon the subject cannot be much depended upon. * *

* In answer to a letter from the Earl, who was then chairman of a Committee for making a navigable communication between the Tay and Loch Earn ; and had applied to Government for part of the balances remaining from the forfeited estates, on the ground that such a grant had been in contemplation by the Board of Annexed Estates, and was prevented from being carried into effect only by the dissolution of the board on the restoration of those estates.

[357.]

MR. J. F. TUFFEN TO MR. WATT.

London, 9th July, 1806.

* * Have you, my dear Sir, seen or heard anything of a book written by one Olinthus Gregory? I am told it contains a slanderous misrepresentation of your immortal improvements of the steam-engine, but perhaps you will not condescend to notice so unworthy an antagonist.

* * * *

Everything yields to city aristocracy; its baneful influence has already deeply injured the London Institution, and now pervades the Royal Society, so as to justify Sir Joseph Banks' remark to a friend of mine, who presented him a poem with some curious Greek notes,—that he ought in his next edition to translate the notes, for the benefit of the ladies, and the Fellows of the Royal Society.

* * * *

[358.]

DR. BEDDOES TO MR. WATT.

10 Sept., 1806.

* * Nobody need be surprised if some day, sooner or later, I take my departure suddenly, for that country where neither the myrmidons of France nor the tax-gatherers of England are to be dreaded. Yet I expect to outlive poor Mr. Fox.

* * * *

[359.]

DR. BEDDOES TO MR. WATT.

20 June, 1807.

* * You have no doubt seen Davy's paper. It seems to me almost the greatest thing done in chemistry since Dr. Black's discovery of fixed air. As there were many previous indications of electrical action in animated bodies, so this gives shape to conjecture on the mode of its operation. Davies Giddy says ores are carried into veins on the back of positive and negative electricity. So on we go, deciphering the world.

* * * *

[360.]

DR. BEDDOES TO MR. WATT.

22 Nov., 1807.

* * I suppose you know that Davy has decomposed the alkalis, with circumstances as extraordinary as ever took place in any chemical discovery,—the production of new bodies, which may, I think, be named ethereal metals.

* * * *

[361.]

MR. WATT TO THE REV. DR. WILLIAM TAYLOR,
PRINCIPAL OF THE COLLEGE OF GLASGOW.

Heathfield, Birmingham, June 3rd, 1808.

REVEREND SIR,—I take the liberty of requesting you, in your official capacity, to communicate the following proposition to the Faculty of your University, and, on my part, to request their favourable acceptance of it.

Entertaining a due sense of the many favours

conferred upon me by the University of Glasgow, I wish to leave them some memorial of my gratitude, and, at the same time, to excite a spirit of inquiry and exertion among the students of Natural Philosophy and Chemistry attending the College; which appears to me the more useful, as the very existence of Britain, as a nation, seems to me, in great measure, to depend upon her exertions in science and in the arts. I therefore propose to settle 300*l.* upon the College, in Trust, to be laid out at the best interest, upon landed security, 10*l.* of which to be given annually as a premium for the best essay on some subject in one of the branches of Natural Philosophy hereinafter mentioned, which shall be appointed by a majority of the Principal, Professors, and Lecturers of the University, and which shall be composed by any *actual* student of the University who shall have gone through a regular course of Languages and Philosophy, either at Glasgow or in any other Scottish University. The prize to be adjudged by the majority above mentioned, in conjunction with Gilbert Hamilton, Esq., my brother-in-law, so long as he shall live; and [it] shall be subjected to the same rules and regulations, as to the time and manner of giving it in, as the other prize-essays appointed by the University. If in any year no essay shall be judged worthy of the prize, the same subject shall be re-appointed for the following year, and the premium reserved for it to be adjudged at the same time with the premium for such other subject as shall be regularly appointed for such year; and

if then no adequate essay shall appear, the said premium to be added to the principal sum.

I know not whether the interest will be subject to the property-tax; but, in any case, the surplus, whatever it may be, after paying the premiums, and 10s. 6d. to the clerk of the meeting, is to be added to the principal annuity; until it shall accumulate so that the interest shall be able to afford two premiums on two subjects, to be appointed as aforesaid.

I had at first intended that the subjects for the prize-essay should be taken from any branch of Natural Philosophy or Chemistry; and now think it proper to restrict them to the following branches, and in the following rotation:—

First Year, to any branch of Mechanics or its dependent Arts.

Second Year, to Statics, and the Machines and Arts dependent.

Third Year, to Pneumatics, Statical or Chemical Machines and Arts.

Fourth Year, to Hydraulics, Hydrostatics, their Machines and Arts.

Fifth Year, to Chemistry, its Arts and Apparatus.

The Sixth Year, the rotation to begin with Mechanics, as before, and so on by five years' rotations.

I should request a copy of the successful essay to be sent me annually, and, after my decease, to my male representative; and I request that no public mention may be made of this donation, by

paragraphs in the newspapers, or otherwise, until a prize come to be adjudged; [I] not being, as far as I know, actuated by vanity, but by a desire to stimulate others to do as I have done.

I reserve to myself, at any time during my life, by any writing under my hand, to change either the rotation or the subjects of the essays, as well as the other regulations concerning them.

Should what I now propose meet the approbation of the Faculty, I shall immediately direct a proper deed to be drawn, and the money to be paid to their order.

Requesting you, Sir, to accept my most respectful compliments, and to present them to all the other members of the Faculty, I have the honour to remain,

Reverend Sir,

Your most obliged,

And most obedient humble Servant,

JAMES WATT.*

* This letter has been already printed in a volume prepared for private circulation, entitled "Deeds instituting Bursaries, Scholarships, and other Foundations, in the College and University of Glasgow," 4to., 1850, pp. 216—218. It is there stated, that "the Faculty having gratefully accepted this donation, on the terms proposed by Dr. Watt himself, no further Deed of Foundation seems to have been considered requisite."

We have, however, ascertained, on examining Mr. Watt's correspondence, that, on the 1st of July, 1808, he enclosed to Mr. G. Hamilton, to be put into proper form by Mr. Reddie, one of the town-clerks of Glasgow, the draft of a contract, in which the principles set forth in his letter of 3rd June to the Principal of the College were carried out on the one part, and on the other part the Principal and Professors of the said College bound themselves to perform all the conditions of the

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MR. WATT TO SIR JOSEPH BANKS, BART.

Heathfield, Aug. 8th, 1808.

MY DEAR SIR,—On my return from Wales lately, I received a letter from Mr. Delambre, announcing my nomination as a Correspondent of the class of Physics and Mathematics of the National Institute. Being at a loss how to transmit my answer to him, and knowing that most scientific foreigners wait upon you, I have taken the liberty of troubling you with it, requesting you will do me the favour of sending it by any person who you may think will deliver it to Mr. Delambre.

* * As to myself, I am as well as my

contract, under penalty of forfeiture of the said sum of 300*l.*, with all accumulations of interest. On the 14th of July, Mr. Reddie had received the draft, and promised to do what was required as speedily as he could. On the 15th of August, Mr. Watt sends to Mr. Hamilton the “Deed of Gift,” which he had executed, desiring that Mr. Reddie might get a proper receipt written on it, and direct who should sign it (on the part of the College); “and when signed,” adds Mr. W., “you will please to get it registered.” On the 23rd October he writes to Mr. H. —“I am glad that the business with the College is at last settled. * * When you are more recovered I shall be glad to have an extract of the deed from the Town books.” And on the 11th Nov. he thanks Mr. Hamilton for his attention “in procuring” the extract of the trust-deed to the College.

This was not very many days before the death of Mr. Hamilton, “than whom,” writes Mr. Watt, on the 4th Dec., “I never knew a more friendly or worthy man, nor one more useful to society;” and on the 24th of the same month he writes to his cousin, Mr. Robert Muirheid, “I had named Mr. Hamilton as one of the judges, in deciding the merits of the prize-essays to be given [in] consequence of my donation to the College; but he having vacated the place unfortunately, I shall appoint you, if you please to do me the honour of accepting it.”

advanced life and a naturally infirm constitution could give any room to hope, but have very little ability or inclination for anything which requires thought. * *

[363.]

DR. BEDDOES TO MR. WATT.

Nov., 1808.*

* * There is another very important point on which you can furnish instruction, if anybody at all can. Among the hardships incident to married poor women who have a family, I have noticed one as peculiarly severe. Nothing can support their health against it; and, in consequence of it, a very slight cold shall render them sickly for years, and at length destroy them. This is neither more nor less than their frequent dabbling in water to wash. Could no good Genius invent a machine, by which opulent neighbours, attentive to the welfare of these hard-fated human creatures, shall be able to redeem some of them from this destructive drudgery? * *

[364.]

MR. WATT TO PROFESSOR PLAYFAIR, EDINBURGH.

Heathfield, Feb. 27th, 1809.

MY DEAR SIR,—I cannot sufficiently thank you, and the authors of the Edinburgh Review, for the pains you have taken to vindicate my fame from

* This was the last letter which Mr. Watt received from his old correspondent and friend Dr. Beddoes, whose manifold humane exertions on behalf of the poorer classes were terminated by his death in the month of December following.

the aspersions of Mr. O. Gregory and his coadjutor. Setting aside its falsity, never was anything more unmerited than this attack from Gregory, a man whom I never knew, nor perhaps heard of, before this explosion. As to the other,* there was some cause; he had been turned out of Boulton and Watt's service for ignorance, pride, and idleness: moreover, *they had saved him from starving.*

Perhaps I ought to have saved you the trouble by taking up the pen in my own defence, but I have always had a great repugnance to be the trumpeter of my own fame; and I considered that "*Magna est veritas,*" &c., and that the *æqua posteritas* would do me the justice, which my adversaries were disposed to deny me at present. I am far from being insensible to just praise, but the conviction that I had in some cases deserved it has always been with me a superior sensation.

* * * *

[365.]

MR. WATT TO MR. J. H. BROWNE, M.P.

Heathfield, April 26th, 1809.

DEAR SIR,—I am favoured with your obliging letter of Monday last. As the Gas-light Bill confers no exclusive privilege, it cannot do any injury to other artists in the same line; but, in my opinion, may prove injurious to the public, by encouraging people to buy shares in a concern which cannot pay them, under the probable manage-

* One of the Hornblowers, whose lucubrations were severely handled in the *Olympic* article in the "Edinburgh Review," here referred to.

ment it is like to have. I should, perhaps, speak more strongly, but to you it is unnecessary.

* * * *

The original inventor of this application of the gases is Mr. Wm. Murdock, a most ingenious man, now at Soho here, under whose directions several very large manufactories have been lighted at Manchester and elsewhere, by Boulton, Watt, and Company. Mr. M.'s invention is of fifteen or twenty years' standing. I saw it employed at Soho in the fireworks for the celebration of the last peace. * *

My years, and state of health, render me unable at present to appear as a witness; but there are others younger and better qualified by their knowledge of the subject, who might not have the same objections.

* * * * * Meanwhile I refer you to a late volume of the Philosophical Transactions, where you will find an account of the matter by Mr. Murdock, to whom the Royal Society granted Count Rumford's 50*l.* gold medal for that paper. I remain, with great respect,

Dear Sir, your obedient Servant,

JAMES WATT.

[366.] MR. WATT TO M. LEVÊQUE, DE L'INSTITUT DE FRANCE. *

Heathfield, near Birmingham, Mar. 14th, 1810.

* * * * * If I had any philosophical news, I should trouble you with them on this occasion,

* The earlier part of this letter relates to the captivity of a son of M. Levêque, as a French prisoner of war, at Lichfield; concerning whom

but, having none, permit me to present to you and my other friends my most grateful thanks for the honour you procured me of being elected a Corresponding Member of the Institute of France, (for which I immediately returned my thanks to M. Delambre, which letter I hope he duly received). I am sorry that my age,—now above seventy-four,—and the necessary businesses of life, rendered more irksome by bad health, have prevented me from having the honour of making them any communication hitherto; what I may be able to do in future depends upon circumstances not in my power to control.

I believe you know that I have long ago entirely relinquished business in favour of my son James, now my only child, for I lost my son Gregory in 1804, and the world lost a very promising young man.

My health does not permit me to make chemical experiments, but I still do a little in mechanics: a part of which, if I live to complete it, I shall have the honour of communicating to my friends in France. * *

his father had written to Mr. Watt, on the 12th Dec., 1809; but the letter having been detained, (a very common occurrence during that time of war), in its passage through the post and transport offices, was not delivered till the 4th of March. On its receipt, Mr. Watt immediately wrote to M. Levéque, at Lichfield; but, receiving no answer, and making further inquiries, he learned that the young man had been exchanged, and had returned to France about six weeks previously. The allusion in the latter part of the letter is to the machine for copying statuary, &c.

[367.] MR. WATT TO MR. JOHN LOVE, PAISLEY.

Heathfield, July 12th, 1810.

*. * I, in particular, have reason to thank God that he has preserved me so well as I am, to so late a period, while the greater part of my contemporaries, healthier and younger men, have passed "the bourne from which no traveller returns." It is, however, a painful contemplation to see so many who were dear to us pass away before us; and our consolation should be, that as Providence has pleased to prolong our life, we should render ourselves as useful to society as we can while we live. * *

[368.] MR. WATT TO THE REV. W. J. REES,
CASCOB, NEAR PRESTEIGN.*

Heathfield, Birmingham, Sept. 20th, 1810.

SIR,—I am favoured with your letter of the 15th instant. I have several years ago entirely withdrawn from business, and am now a very old man, so that I can be of no use to your friend as an associate or patron. The manufactory of steam-engines, which Mr. Boulton and myself carried on, is continued by his son and mine under the firm of Boulton, Watt, and Co.; but they do not engage

* In answer to an announcement of "a machine, or rather engine, lately discovered by a friend, an ingenious clergyman of this county, that gives motion to itself, and can communicate motion with immense power to any machinery to which it may be applied; or which may be described as an engine generating perpetual motion, with as great a quantity of power as to supersede the necessity of all other expedients." (!)

in any concern which requires other partners, nor do they manufacture any machines the utility of which has not been fully proved by experience.

I hope yourself and your friend will excuse my incredulity, but I have very long been satisfied that there can be no such thing on earth as a perpetual motion, generated in the machine itself, without the expenditure of some external power or cause of motion. All the known elements have, as I believe, been already applied to machinery, and you do not infer that your friend has discovered any new one.

It is possible that he may be deceiving himself, and I would therefore recommend to him, before he proceeds further, to make a *working* model of his machine, on as large a scale as he can, and from it to calculate the power and the probable expense of exciting it, and not to take any other steps in the business until he is satisfied he is in no mistake.

The taking a patent would be the next step, but I suppose you know that is expensive,—now, I believe, above []00l.*

I should have very great reluctance to be made the depository of the secret of any invention which is not secured by patent. Should the invention not meet my approbation, it would lay me under the disagreeable necessity of speaking my sentiments upon it, which might be construed as dictated by interested motives; or, if the secret got abroad by other means, I might be blamed for it.

* The sum is indistinct in the MS.

Yet, on the other hand, the inventor might be benefited by my advice, the fruit of fifty years' experience in mechanics. On the whole, I wish to decline the confidence; but if I can give any useful advice, without a full confidence, I shall be glad to be of use to any ingenious man.

If your friend will answer me by letter the following questions, it may save him the coming here, should he, after what I have said, think that proper.

Is there no expenditure of any power or agent extraneous to the machine itself? and, if so, what may be the expense in money to enable the machine to raise 30,000 cubic feet of water 1 foot high? Is that extraneous agent any of the known powers or elements which have been employed to raise water, or give motion to machines, such as fire, water, steam, air, or animal force? Is the machine itself complicated or expensive?

I feel myself very much obliged by the confidence which you have been pleased to repose in me, and shall endeavour always to merit your good opinion.

I remain respectfully, Sir,

Your obedient,

JAMES WATT.

[369.] MR. WATT TO M. LE COMTE BERTHOLLET.

Heathfield, near Birmingham, Dec. 26th, 1811.

MY DEAR SIR,—There is nothing more grateful to an old man like me, than to find himself re-

membered by his old friends, and to be esteemed. worthy of notice by such a person as you are.

* . * * *

Two years ago I was favoured with M. Delambre's letter, announcing the honour which the National Institute had done me, in appointing me one of their Corresponding Members,—an honour of which I am proud, and for which I feel truly grateful.

I am uncertain whether M. Delambre received the letter of thanks which I wrote to him on that occasion, and which I sent to Sir Joseph Banks to be forwarded by some safe hand.

Permit me now, my dear Sir, to return you my thanks for the part you were so kind as to take on that occasion, and to communicate them to my other friends who were so kind as to assist. I am sorry that I have not been able to avail myself of that honour by making any communication; but my advanced stage of life, and the recluse life I lead of late years, have put it out of my power to send them anything which I could have deemed worthy their acceptance.

I also regret that I can send you no philosophical news by this opportunity:* the state of my health has for several years disabled me from chemical pursuits. I have therefore turned my attention to mechanics whenever my health per-

* The return to Paris of some gentlemen who had brought a letter of introduction from M. Berthollet to Mr. Watt.

mited, and have, as I hope, nearly completed a machine which promises to be of use in the imitative arts, and of which, if I am enabled to complete it, I shall send you a description; but at present I do not like to say much upon a matter *in prospectu*—I wish to speak *de facto*. Whatever may be its success, it has at least had the good effect of making me avoid many hours of ennui, by employing my hands when I could not employ my head, and [has] given me some exercise when I could not go out.

You would hear that we lost our friend Mr. Boulton last year, after a long period of acute suffering. Though his age was eighty-one, yet his constitution was good; and he might have lived many [more] years if he had not been visited by his malady.

The steam-engine business has been carried on for several years solely by Mr. Boulton, Jun., and my son. I retired long ago to live upon a very moderate fortune, which the increasing expenses of the times threaten to render small enough to keep up my station in the world; but my wants are now few, and I have no *goût pour le grand monde*.

Mrs. Watt and my son desire to unite with me in presenting our kind remembrances and best wishes to you and Madame Berthollet, and in begging you will have the goodness to communicate them to Monsieur and Madame La Place, Monsieur and Madame Prony, and to our other friends at Paris, of whose kindness we entertain a

grateful remembrance; and I have the honour to remain, with the highest esteem, my dear Sir,

Your affectionate friend,

JAMES WATT.

I beg to be particularly remembered to Monsieur and Madame Monge, and Monsieur L'Abbé Haüy.

[370.]

MR. KEIR TO MR. WATT.

Tivendale, Dec. 30th, 1810.

DEAR SIR,—My friend Mr. Sneyd Edgeworth is desirous of paying his respects to you, and I have a pleasure in introducing him to your acquaintance. His father, our old friend, rides his hobby-horse (mechanics, &c.) with the same spirit that he did forty years ago; and this young gentleman will give you a proof of it, by acquainting you of a project of his father to make a cast-iron tunnel across the ferry at Bangor, instead of the intended bridge; two schemes for which, Mr. Rennie has proposed to the House of Commons.*

I am, with best wishes and compliments of the season to you and Mrs. Watt,

Dear Sir,

Yours, sincerely,

JAMES KEIR.

* Mr. Rennie designed the bridge to be of cast-iron; but as at that time (1801—1808) large grants of the public money were required for the packet-stations at Holyhead and Howth, the estimated expense of this great additional work prevented his project being carried out.—See the 'Life of Telford,' p. 205; 1838.

[371.]

MR. R. L. EDGEWORTH TO MR. WATT.

Edgeworthstown, Ireland, 6 Jan. 1811.

MY DEAR SIR,—As I have long known you to be the first engineer in the world, you must pardon me for having given you the trouble of a visit from my son. He is not the young engineer, and therefore he could not give you a full notion of my *cast-iron tunnel*.*

In the first place, Mr. Rennie's scheme has, I believe, been laid aside; but let that be as it may, I had no thoughts of opposing him; he is my associate in the Society of Civil Engineers, and I would not thwart him if I could, and I know that his credit is so deservedly established, that I could not if I would. But, so far from wishing it, I some time since wrote to Mr. Rennie, to propose to him means of obviating the great objection to his plan of a bridge, which arose from the bulk of the piers, which he proposed to build on two rocks in the Menai. These were to be seventy feet in diameter, and all the seamen in those parts

* In the days of the magnificent "Britannia Bridge," the description, contained in these letters, of Mr. Edgeworth's ingenious project will be perused with interest. But the idea can be viewed as, at most, only a very remote step towards the gigantic undertaking so admirably carried out by Stephenson; to whom, in all probability, Mr. Edgeworth's suggestion was quite unknown.

The construction of the Menai Bridge, which forms so conspicuous a monument to the intrepid genius and industry of Telford, was commenced in 1818; and on the 30th of January, 1826, the bridge was formally opened to the public. Its length is 1710 feet, or nearly one-third of a mile; and the total weight of iron-work employed in it is above 2186 tons.—See the '*Life of Telford*,' pp. 220—229.

agreed in stating that such large piers, equal in diameter to the length of their vessels, would cause baffling winds, which would endanger ships passing between them. I mentioned to him the idea of having eight cast-iron hollow columns of three feet diameter, connected by proper *diaphragms* and braces, so as to form an open or *transparent* pier, that would obstruct the wind but little. At the same time, I spoke to him of my cast-iron tunnel.

Your objections to this are,—That it must have flexible joints; that perhaps it would not leave a sufficient draught of water for ships to pass over it; and lastly, that it would be exposed to imminent danger from the shock of loose rocks that might be dashed against it by the tides or storms. As to the necessity of flexible joints, did it exist, the project must be totally abandoned: the formation of these, so as to be secure, would be scarcely practicable, and would be enormously expensive.

My scheme is to join the parts of my fourteen-foot cast-iron cylinders in one curve, in a dry dock opening into the Menai; when the joints were sufficiently secured, the whole—let the length be what it might—would float when both its mouths were above water. When properly ballasted, I would open the flood-gates of the dock, tow the tunnel into the river near the junction of the opposing tides, and sink it upon a bed, previously constructed, by large stones thrown into the water, so as to form two walls 16 feet asunder, filled with sand thrown between them,

and supported by a talus of large stones extending to a considerable distance on each side of the walls. I do not suppose that these walls would, at an average, exceed 5 feet high.

Secondly;—There is sufficient depth for vessels to pass over such a tunnel during neap-tides.

Lastly;—I do not believe that rocks or large stones are driven by the junction of the tides. If they *are*, it is a serious objection, and most certainly I would not propose anything till I was master of this part of the subject.

As to the expense, I suppose that it is not difficult to make a tolerable estimate. The tunnel would cost, at 30*l.* per foot, *running*, for 1000 feet, only 30,000*l.* Say 50,000*l.* :—it would bear but a small proportion to the expense of a bridge, which is stated at 250,000*l.* No scaffolding or centres will be wanting; and if it were determined that rocks are not carried by tides or storms through the channel, and if, as appears by Mr. Rennie's report, there is still-water, at times, where the east and west tides meet, I do not see any great difficulty that could prevent this vast buoyant mass from floating gently to the place of its destination, nor in its being gradually sunk upon its bed in security.

The length of the machine will [not] exceed three times the length of [a first-rate] man-of-war.

Your very sincere and very old friend,

RICHARD LOVELL EDGEWORTH.

Mrs. E. and Maria send their respects to you.

[372.]

MR. WATT TO MR. R. L. EDGEWORTH.

Heathfield, Jan. 30th, 1811.

MY DEAR SIR,—I should sooner have answered your obliging letter of the 6th instant, received some time ago, but that the state of health I am in makes me very unwilling to write, and indeed not very able to do any more in that way than is absolutely necessary; besides, my engineering faculties are so rusted for want of use, that I cannot place much dependence on my opinions in that line. I retain, moreover, a salutary dread of untried schemes, which even mathematical demonstration does not suffice entirely to remove.

The opinion I gave to your son was necessarily a very hasty one, and more intended to put you on your guard than to condemn the scheme; but since you seem to have laid more stress upon it than it deserved, I have reconsidered the subject, and shall now state what appear to me to be the objections, leaving it to your discretion to make such use of them as they may deserve.

Leaving Mr. Rennie and his bridge out of the question, (of the bridge I know nothing beyond what your son and yourself have informed me, consequently can be no advocate for it), I admire your scheme of putting the tunnel together in a dry dock, and floating it into its place; but would not the construction of such a dock prove very expensive? and would not there be great risk of breaking some of the joints or pipes in floating

it out, or in laying it upon its bed of sand? which latter would be with difficulty made of the same form as the tunnel.

I believe no pipe or cylinder of 14 feet diameter has ever been cast of any considerable length, such as 9 feet, nor have I heard of any, even of 3 feet long, beyond 8 feet diameter. They must therefore, as I apprehend, be made in panels, 6 or 8 in the circumference, which infers many joints, flanches, and screws, besides fitting, which is very expensive. Should any part or joint fail after it is under water, repairs seem to me nearly impracticable, except by fishing up the whole. Cast-iron is not perfectly impervious to water when under considerable pressure. B., W. and Co. lined a coal-pit 20 fathoms deep with cast-iron cylinders, $1\frac{1}{2}$ inch thick, in panels, I believe, and the water in many places sprang through the iron where it was apparently solid. Sea-water acts upon cast-iron without dissolving it, so as to change its nature, and to make it more resembling a brittle stone than iron. Bullets fished up out of the Spanish Armada ship, (sunk at the island of Mull), at the beginning of the last century, were so soft as to be cut with a knife; and I have seen pumps at Wheal Virgin mine, in Cornwall, that by the vitriolic water had, in six years, been reduced to that state. In fresh water it lasts long.

The expense of such a tunnel I cannot compute, though I believe there are ingenious founders in England who could, so far as the castings were

concerned; but that, I should fear, would be the least part of it.

The tunnel should be laid so low, that vessels, such as frequent that Strait, could pass over it at low water, or at least at any time of the tide that would serve them to come to it, otherwise some unlucky vessel might make a hole in it.

I could not hope that the tunnel could be made so tight but that it would take in some water; therefore pipes should be laid within it, and an engine prepared to take out that water as it came in.

There are other objections, some of which must have occurred to you, and I would trust to your ingenuity being able to obviate them. On the whole, my opinion remains unchanged, that if such a work is not impracticable, it would be extremely hazardous, and what I could not wish any friend of mine to engage in.

I trust in your candour to pardon the freedom with which I criticise the scheme. I should consider myself unpardonable, holding the opinions I do, if I disguised them to *you*. Should you think them not valid, you must place them to the caution of age and my regard for you. I can have no other interest in dissuading you from it.

I have now got pretty well quit of the very [* *]* when I had the pleasure of seeing your son, but [not of the debility] it occasioned.

* * Mrs. Watt joins in best wishes to

* Two or three words illegible.

you, Mrs. Edgeworth, Miss Maria, and all your family, and I remain, my dear Sir,

Your sincere friend,

JAMES WATT.

[373.]

MR. R. L. EDGEWORTH TO MR. WATT.

Edgeworthtown, Ireland, 15 February, 1811.

MY DEAR SIR,—I am glad that the scheme of an iron tunnel came into my head, as it has been the cause of my being gratified by your kind attentions.

At the close of a long life it is delightful to find that we have preserved the esteem of the best and wisest men of our time, and to learn that distance of time and place has not erased us from the remembrance of those with whom we were associated in early life.

I am truly thankful for the trouble you have taken in detailing your opinion, and I do not wish now to draw you into any further communications on the subject, but to assure you that I am in no danger of being hurried into any serious difficulties in any pursuit of any sort. Though I have been an inventor all my life, I have never yet injured my fortune, nor, so far as I can tell, hurt my reputation, by any scheme, either of a public or private nature.

Our excellent friend Dr. Small early convinced me that I might easily lessen my happiness by •risking any material part of my income, and that

I could not, by increasing it sevenfold, add anything to my real enjoyment.

I cannot, however, spare you the result of my reflections on your very solid objections to my tunnel. If, by building a number of furnaces upon the spot, the casting of cylinders of 14 or 12 feet diameter [cannot be effected], the whole project must be abandoned. A frame in panels never entered into my thoughts. As to the effect of sea-water, I think that casing the iron with terras would prevent injury. Perhaps the tunnel might be also covered with sand, for there is sufficient depth below the surface to carry any vessels that navigate the Straits above the tunnel.

I would try each piece separately, under a sufficient depth of water, to ascertain its soundness. If the separate pieces are staunch, I do not know why the joints may not also be considered water-tight. The expense of the dry-dock would not be enormous. And lastly, iron-masters can determine as to the possibility of casting such cylinders as I propose, and it is easy to calculate the expense of excavating a dock, of forming the approaches, and of laying a proper bed for the machine.

Mrs. and Miss E. send their kind remembrances to their Parisian friend Mrs. Watt, and I, my dear Sir, renew to you most sincerely my acknowledgments.

Your obliged Servant,

RICHARD LOVELL EDGEWORTH.

[374.]

MR. WATT TO DR. P. WILSON.

Heathfield, March 7th, 1811.

* * I well remember your most excellent father's and your kindness to me at a period when I did not consider myself as meriting them, and I hope I shall always remember them with gratitude while I live. It is, as you observe, a long time since—more than half a century. Let us be thankful we are spared to tell the tale.

* * * *

We were much gratified by Dr. and Mrs. Herschel's call upon us; our regret was that they could not stay longer. It gives us much pleasure to hear that they have got over the winter so well, and that the Doctor's ardour of research continues. Long may it do so;—without a hobby-horse, what is life? * *

Dr. Leslie's combination of principles to produce ice is ingenious, and may in some cases be useful; though, I think, not generally so. I agree with you that much may be done by the application of known principles. Indeed, in mechanics we have little else left to work upon.

For want of other news I must now say a little upon my late invention,* with which Dr. H [erschel] seemed much pleased. It continues to succeed, and I have realised some more of my ideas on the subject. I have executed several small busts in alabaster, not being strong enough to work

* The machine for copying statuary.

marble. I had a difficulty in getting the several segments which form the surface of the bust to meet, but have now accomplished it. It requires a very accurate construction of the machine, and a very accurate adjustment of the tools, so that their axes may be always equally distant from each other, as the axes of the pattern and that of the stone to be cut are. I have also made some improvements in the tools for cutting marble and other hard stones.—The things you saw, were done by the tool and the guide-point, moving in parallel lines, straight or circular, and very near one another; (an illustration of Euclid's position, that the motion of a point generates a line, and the motion of a line generates a surface). I have now contrived, though not executed, that the two points, the guide and the cutting-point, may move in any line, straight or crooked, square or diagonal, so that an inscription might be cut in stone from a drawing on paper. * *

[475.]

MR. DENNY TO MR. WATT.

Glasgow Water-Works, 2 May, 1811.

SIR,—I beg leave to transmit you an extract from the Minutes of the Annual General Meeting of the Company of Proprietors of the Glasgow Waterworks, which was held yesterday.

I am, with great respect, Sir,

Your most obedient Servant,

DAVID DENNY.

Extract referred to.

“It was proposed, and unanimously agreed to, that the Committee, in name of the Company, should present a piece of plate, value one hundred guineas, to James Watt, Esq., of Birmingham, in testimony of the high opinion they entertain of his abilities, and for essential services rendered by him to the Glasgow Waterworks; particularly for the very ingenious plan furnished to the Company, through his recommendation, by the house of Messrs. Boulton, Watt, and Co., for conducting the water from the peninsula across the Clyde to the Company's engines at Dalmarnock.*

“DAVID DENNY, Sec.”

[376.] MR. WATT TO MR. DAVID DENNY, GLASGOW.

Heathfield, Birmingham, May 6th, 1811.

SIR,—I am this moment favoured with your obliging letter of the 2nd inst., and request that you will have the goodness to present my grateful thanks to the Glasgow Waterworks Company for the honour they have done me by their notice of my attention to their business, and for the valuable token of their satisfaction with which they have resolved to present me. I beg of you to assure them that the services they are pleased to set so high a value on were induced solely by a

* For an account of the ingenious suggestion here referred to, see the ‘Edinburgh Philosophical Journal’ for 1820, vol. iii. p. 60, and the Translation of Arago's Eloge of Watt, p. 124.

desire to be of use in procuring good water to the city of Glasgow, and to promote the prosperity of a Company which had risked so much for the public good: to which I entreat you will further add, that it gives me sincere pleasure that the success of the plan answers their expectations, which I hope it will continue to do.

I request you will accept my thanks for the obliging manner in which you have communicated the resolutions of the Company, and for the ability and zeal you have manifested in the execution of the plan; and I remain, with respectful compliments to the Company,

Sir,

Your obedient humble servant,

JAMES WATT.

[377.

MR. WATT TO MR. P. EWART.

Heathfield, May 9th, 1811.

* * It would give me great pleasure to show you my machines, though you may not perhaps think them the best possible. Mr. Lee can give you some account of them. The principle is the making a drill, or, in some cases, a sharp point, walk over the work to be done, in some given ratio to the motions of a blunt point upon the pattern; but there is some art in making a drill, while continually varying its situation, turn round regularly with any desired velocity; and, on the whole, there is some art required in the use and application of the tools, which experience only has taught me. * *

[378.]

DR. PATRICK WILSON TO MR. WATT.

29, Kensington Square, Kensington, 11th May, 1811.

* * I was much gratified by the particulars you mentioned concerning your NEW INVENTION, as to which my lips were ever sealed till lately, that I perceived you had imparted it to the excellent Dr. Herschel, when with you at Heathfield last summer. We then, under your patent, talked about it confidentially, when I was pleased to find your contrivances had been admired by that friend, who certainly is an excellent judge.

The first thought of making a cutting or gnawing point *eat its way*, according to three dimensions, with next to mathematical precision too, by the turning of a winch, so as to search for *beautiful forms* into the heart of marbles, and bring them out into full daylight, is no mean instance of human sagacity, when *by hook and by crook* the thing has been so accomplished.

In all matters of this sort, nine-tenths of the whole achievement consist in setting before the mind the desideratum, though disrobed of the means: I mean in the *factum, puta*, which lies remote from ordinary or common analogies or associations, and which is the creation of *genius* alone. The precious germ afterwards requires but the fostering care of its parent, to expand till it arrives at fulness of stature. So have prospered with you, my good friend, many important inventions; and so, I doubt not, the present one will attain to maturity, to reward your patient thought.

Have you attended to the controversy carried on in Nicholson's Phil. Journal for February, March, April, and in last [number], between Mr. John Davy and Mr. Murray of Edinburgh, about Professor Davy's theory of the oxymuriatic acid? This theory looks towards another revolution of chemistry; but is opposed by Murray, who writes well. Professor Davy has certainly high merit, but he may soar *too* high, and melt the wax of his pinions. By-the-bye, the ground-work of the present fabric of chemical science is partly your own freehold. * *

[379.]

MR. WATT TO MR. R. SHORT.

Heathfield, Birmingham, July 7th, 1811.

* * I am afraid what I can say, respecting the use of alum in hardening plaster figures, may not be of much use. I think it was about four or five years ago that I used it for small medallions. I made a strong solution of alum, and boiled them in it, and let them dry, and then repeated the immersion; but I found that it hurt the sharpness of the impression, therefore I did not follow it up. I have never tried it on a bust or figure, because what I wanted it for was quite another purpose. Though what I have mentioned was the earliest I applied it by boiling the things in it, I have very long known the property of alum in hardening plaster, by mixing up the plaster with a solution of alum before I cast it; at least twenty-eight years.

I apprehend, however, that no *private* practice will invalidate a patent; it is the *public* practice for sale, or its being used by several people.

* * * *

[380.]

MR. WATT TO MR. DAVIES GIDDY.

Heathfield, Birmingham, Aug. 8th, 1811.

DEAR SIR,—The following is the receipt you desire. Mr. Vauquelin having examined a liquor for making cloth water-proof, found that it contained glue, soap, and alum, but did not mention the proportions. After several trials I found the following to answer :—

Dissolve 30 grains of isinglass-glue in 4 oz. of water, and separate the insoluble skins; then add 80 grains of alum in powder, and keep the liquor hot: dissolve 50 grains of shavings of Castille soap in 4 oz. of water by boiling; mix the two liquors together, both hot, and use it in that state by applying it to the cloth by a brush or sponge, or by immersing the cloth in it. Stretch the cloth, and let it dry in a cool place.

Mr. Vauquelin found also a little vitriolic acid disengaged in the liquor; but I found it answer without it, and omitted it, as it might do hurt if in excess. I have only tried it, as far as I recollect, upon linen and silk, but in both cases it proved effectual. On woollen I suspect it might give too much stiffness; perhaps the vitriolic acid might be added to remedy that.

As I have made the liquor only once, I cannot

answer that these are the best proportions; but they are what I had recorded; and, it being ten years ago, I have no very clear memory of the affair, only of having used it on some umbrellas, which, for the most part, still retain the property.

* * * If the cloth is immersed, it will be necessary to wring it out of the liquor. I fancy the process is the same as was practised some years ago by Messrs. Duke and Co., in London: the cloth was said to be perfectly water-tight while new, but when worn was said to lose the property in a great degree.

[381.]

MR. WATT TO MR. ANDREW WILSON.*

Jan., 1812.

It was with extreme concern I heard of my dear friend your brother's death. * * *

* This much-respected person, son of Dr. Alexander Wilson and the elder brother of Dr. Patrick Wilson, both Professors of Astronomy in Glasgow College, (see above, pp. 106 and 107), was, in general cultivation of mind, and in every charitable and humane disposition, not inferior to his father and brother, although both of the latter were more publicly known by their scientific works. Mr. Andrew Wilson followed the business of a type-founder in Scotland, which his father had the merit of first bringing to the rare perfection exemplified in the publications of the Glasgow press in the time of the brothers Robert and Andrew Foulis. It is curious to observe an eminent astronomer devoting himself to the care of the practical, and even the mechanical, portions of the art of typography; but Dr. Alexander Wilson deserved the praise bestowed on him by the learned editors of the Glasgow Homer of 1756, of being not only "egregius ille typorum artifex," but also "vir ad varias ingenuas artes augendas natus."—(Pref. ad Iliad., p. viii.) He revived, in truth, in our own days, the spirit of the Stephani; and in the manufacture of types, his son, here referred to, maintained the high reputation of his parent.

On these subjects I can offer no other consolations than what are derived from religion : they have only gone before us a little while, in that path we all must tread, and we should be thankful they were spared so long to their friends and the world.

[382.]

THE REV. DR. TOWNSEND TO MR. WATT.

29, Pulteney Street, Bath, 31 March, 1812.

* * We have here Mrs. Drummond, lately returned from Canada, who speaks in high terms of a steam packet-boat in which she travelled to New York: I take it for granted that you made this steam-engine.

I shall esteem it, therefore, as the greatest favour, if you will have the goodness to give me some information on this subject.

We have finished our canal from Bath to Newbury, and from thence have a good navigation by the river Kennet to Reading. But from London to Reading our navigation is much interrupted by floods, by which our barges are frequently detained near London for days and weeks. We should willingly extend a canal to London, were it not for the insurmountable opposition of the Thames Commissioners. Should we, however, be able to adopt the steam-engine as a moving power for our barges, our navigation would be perfect.

Our barges are 70 feet in length ; and, with 60 tons, draw 3 feet 6 inches water. * *

[383.] MR. WATT TO THE REV. DR. TOWNSEND, BATH.

Heathfield, Birmingham, April 13th, 1812.

DEAR SIR,—Not being a partner in the engine business for many years past, I was unable to answer your queries until I made the necessary inquiries, which has obliged me to delay writing to you till now.

It is a Mr. Fulton who has constructed the steam-boats in America: two of the engines have been made by Boulton, Watt, and Company, but the machinery has been made entirely in America under his own direction. The following is his account of his boat (Sept. 15th, 1810):—“ The first engine thus in use was 24-inch cylinder, 4-feet stroke, which drove a boat 166 feet long and 18 feet wide, drawing $2\frac{1}{2}$ feet of water, at the rate of 5 miles an hour on the Hudson river; that is, taking the tide for and against the boat, the average velocity is 5 miles an hour.” The boats go regularly between New York and Albany, distant 160 miles, and he is forming similar establishments on other rivers, and has had a second engine of 28-inch cylinder, 4 feet stroke; and one of the latter size has been made to navigate a boat between Montreal and Quebec.

I am informed by a friend who has seen the steam-boat, that the engine and boilers occupy about one-third of the length of the boat, and that the engine operates by communicating motion to a water-wheel on each side of the boat, which he said were about 6 feet diameter and 3 feet wide in

the sole; but I think they must be of a larger diameter.

You will readily see that a machine of this kind could not pass bridges and locks, which all our navigations are full of; but might navigate in the tide-way of the Thames or Severn, or other rivers clear of bridges, &c., and sufficiently wide.

Peter Miller, Esq., of Dalswinton, in Scotland, tried many experiments, ten or more years ago, with a boat of this construction, and might have succeeded if he had had a better engineer. He is now a *very* old man. On the whole, as far as it is at present known to me, I think it would not answer the purpose you want. I believe Mr. Rennie is engineer to your canal: nobody is more able to advise you on this head. * *

[384.]

MR. WATT TO MR. R. MUIRHEID.

Heathfield, Oct. 14th, 1812.

* * I am prone to see the black side of everything which depends upon chance, and the idea of being about to be deprived of so dear a connection * would have sat heavy upon me; especially as, by one friend's withdrawing after another, I feel myself in danger of standing alone among strangers, the sons of later times. But a truce with moralising: let it suffice that I most

* Mrs. Campbell, Mr. R. Muirheid's sister, and cousin-german to Mr. Watt. See pp. 185 and 288 *supra*. Lord Brougham has called Mrs. C. a *female* cousin of Mr. Watt, meaning a cousin by the mother's side:—the mothers of Mrs. Campbell and of Mr. Watt having been sisters. (See 'Lives of Men of Science and Letters,' vol. i. p. 361. 1845.)

sincerely sympathize with you and all her family, praying this evil may be averted from us as long as it pleases Providence. * * * The hopes of her recovery I pray may be verified, and that she may long live to enjoy the attentions of her very dutiful family and friends, of whom nobody has more sincere ones. * *

[385.]

MR. WATT TO MR. MURDOCK.

Heathfield, Dec. 7th, 1812.

MY DEAR SIR,—The band-guide fully answers expectation, and even follows the motions of the frame faster than I hoped. The axis bends a little, but not injuriously: it would have been better a hollow tube. The turned-up edged tool makes very smooth work on an Egyptian head I am cutting in mahogany. I cannot manage the twisted tools on wood; they will occasionally set in their claws and split off pieces; but the four-toothed tool is more manageable, and works faster. * *

[386.]

MR. WATT TO MR. MURDOCK.

Heathfield, Jan. 17th, 1813.

* * I have done a little figure of a boy lying down and holding one arm, very successfully; and another boy, about 6 inches high, naked, and holding out both his hands, his legs also being separate. But I have been principally employed in making drawings for a complete ma-

chine, all in iron, which has been a very serious job, as invention goes on very slowly with me now. When you come home, I shall thank you for your criticisms and assistance. * *

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[387.]

MR. R. L. EDGEWORTH TO MR. WATT.

7 August, 1813.

* * I have always thought that steam would become the universal lord, and that we should in time scorn post-horses. An iron railroad would be a cheaper thing than a road on the common construction.

I do not know how your steam-engine acts against the water; the common method is to employ circulating oars or paddles. An ingenious workman in my neighbourhood constructed a reacting pump to force the boat forward, as in the manner of Barker's mill. It acts well, and he proposed it for a steam-boat, but here nobody would listen to him.

The principal advantage for a canal boat would be the avoiding the embarrassment of the external wheels in passing locks. * *

[388.]

MR. WATT TO MR. H. T. ELLICOMB.

Heathfield, Birmingham, Nov. 16, 1813.

SIR,—My absence from home prevented me from answering your obliging letter of the 12th ult. sooner. The necessity of reading Professor

•

Robison's account of the steam-engine with attention also contributed considerably to the delay.

I am unable to supply you with any documents or drawings relative to the steam-engine much posterior to Dr. Robison's account of it, as I have had no share in the business since 1800, when all papers relative to it were transferred to the new Company, of which the principal partners are Mr. Boulton's son and my own son, who manufacture engines under the firm of Boulton, Watt, and Company; and I cannot ask them, as manufacturers, for that kind of information in a business they carry on for profit; but this I can say, that *no improvement whatever has been made in the principles of the invention, nor, as far as I recollect, has any more advantageous method of employing the fuel and steam been devised, either by them or others.* In point of construction, some alterations have been made; ideas have been reduced to practice which had been long floating in B. and W.'s counting-house, and, by longer practice, superior workmanship has been attained; good workmen have been multiplied; iron has been substituted for wood in almost every case where it was applicable, and superior machinery and tools have been devised and made for executing all the parts of the engine. The alterations in point of form are visible to all who have access to inspect the engines of their construction, and are varied according to the uses to which the engines are destined to be applied.

In respect to the account of the engines in the Encyclopædia, I find in it many errors and mis-

statements, the most material of which are corrected in the Supplement; and the remainder will, I expect, be corrected in a new edition of all Dr. Robison's works, which is now preparing at Edinburgh by Dr. Brewster, and will shortly be published.

The best account of my inventions on this subject which has been published, is contained in a criticism upon Mr. O[linthus] Gregory's *Mechanics*, in the *Edinburgh Review*; Jan. 1809, No. 26; but in that there are errors, either of some transcriber or of the printer, which obscure the sense, especially in the account of the Parallel Motion, pp. 329 and 331, which render the passages where they occur difficult to be understood, but which any person who understands the nature of the parallel motion can readily rectify.

As to myself, I have published little in respect to the engine; that part of my life when I was most able to have done it was painfully occupied in carrying my inventions into practice, and in repelling unjust aggressions, and attempts to deprive me both of the credit and profit due to my labours;—and since I retired from business my advanced years have forbid my engaging in so laborious a task.

I beg my best respects may be presented to Mr. Brunel, whom I highly esteem, and that you will accept my thanks for the honour you have done me in consulting me on this subject. I remain, &c.,

JAMES WATT.

[389.]

MR. WATT TO MR. R. MUIRHEAD.

Heathfield, Nov. 16th, 1813.

* * I do not hear that trade has received as much in Birmingham as it has done in Glasgow and Manchester. Our engine Company is, however, very well supplied with orders: among the rest, some engines for Sheerness Dock-yard, which is improving upon the plan I was concerned in, with some additions by Mr. Rennie. They are also making engines for two Glasgow steam-boats, and for a very large one in Canada, 145 feet long and 30 feet beam, (which, however, you need not mention until you hear of it from other quarters). * * *

[390.]

DR. BREWSTER TO MR. WATT.

Edinburgh, 13, Hope Street, December 5th, 1813.

* * There are many points in the history of an invention which the inventor himself is apt to overlook as trifling, but in which posterity never fail to take a deep interest. The progress of the human mind is never traced with such a lively interest as through the steps by which it perfects a great invention; and there is certainly no invention respecting which this minute information will be more eagerly sought after than in the case of the steam-engine.

* * * *

You were so good as to say that you would favour me with a sketch of your instrument for drawing in perspective. I believe I mentioned

to you that I wished to insert it in the article *Drawing-Instruments*, in the Edinburgh Encyclopædia, which I am solicitous to make as interesting as possible.* If I recollect rightly, you mentioned to me that the optigraph, which was first made by Ramsden, was invented either by yourself or by Dr. Darwin. * *

[391.]

SIR JOSEPH BANKS TO MR. WATT.

Soho Square, Feb. 23, 1814.

MY DEAR SIR,—I wish I could give you any satisfactory information on the subject of your letter, but as I had never heard of Mr. K. Fitzgerald's invention till I received it, I have nothing in my power that can answer your purpose.

It does not appear from your letter that you have seen the 50th volume of the *Philosophical Transactions*; if you have not, I will send it the moment I know that it is wanted, as your letter directs.

The machine is,—as you describe it,—a method of changing a reciprocating motion into a circular one, by an arrangement of wheel and pinion, neither new nor interesting. The only crank that appears on it is turned by the train of wheels, and is meant to work the ventilators.

Keen Fitzgerald I knew; he was an Irish

* The description in question will be found, not in the Edinburgh Encyclopædia, but in the Edinburgh *Philosophical Journal*, vol. ii. (for 1820), pp. 259-262; where Sir David Brewster has added a note,—“The Editor is in possession of one of these machines, presented to him by Mr. Watt, and constructed by himself;” (*i.e.* constructed by Mr. Watt).

Mr. Watt's description of his Perspective-machine has also been printed in the first volume of this work.

gentleman of fortune, who did not, when I knew him, pretend to any mechanical knowledge. The paper was communicated to Dr. Birch, the Secretary, with this remark: "As I have not met with anything of the kind described, I request you to lay it before the Royal Society, and I hope it may be made some way useful to the public." This is dated June 7th, 1758. Now, if Mr. Keen had not at this time taken out a patent, he never could do it afterwards, on account of the disclosure he had made; if he had, he must have abominably ill-used the Society.

I conclude that the publishers of the Encyclopædia must have a person as their agent in London who knows how to search the Patent Office, and has frequent occasion to do it. Such a person only can find out whether any patent was granted for this or any other invention of Keen Fitzgerald. I see that he was admitted into the Royal Society March 25th, 1756, and died June 20th, 1782.

I rejoice to hear of you still well and hearty, and that this unseasonable weather has not molested you. Thank God, I am as well as I could expect to be, and able to do my business, though not yet to walk. Adieu, my dear Sir. Always faithfully yours,

JOS. BANKS.

[392.]

MR. WATT TO MR. P. EWART.

Heathfield, Feb. 27th, 1814.

* * I have done nothing of consequence with the machine this winter, the place

having been too cold for me ; and, besides, I have been painfully occupied in correcting my friend Dr. Robison's Article on the Steam-Engine in the Encyclopædia Britannica, which I have now nearly accomplished ; but you would have done it much better. * *

[393.]

MR. WATT TO MR. P. EWART.

Heathfield, March 11th, 1814.

* * I have succeeded tolerably now in making drills for working marble, which has been a matter of difficulty. But, on the whole, I see so much still to be done, that I fear I shall never accomplish it ; or, that when done, it will not be worth the trouble, otherwise than as a mental and bodily exercise. * *

[394.]

MR. WATT TO DR. BREWSTER.*

Heathfield, May, 1814.

DEAR SIR,—At your request, I have carefully perused my late excellent friend Dr. Robison's

* This interesting letter was printed, as many of our readers may be aware, in the collective edition of Dr. Robison's essays on various subjects of "Mechanical Philosophy," published, after many years of preparation, in 1822, in four vols. 8vo., under the editorship of Dr., now Sir David Brewster. Some years previous to the date of that publication, Mr. Watt presented several of his friends with copies of the Treatises on "Steam" and "Steam-engines," with notes and additions by himself ; and reserved his right to reprint his own portions of that work, agreeing that it should not be done for a period of three years after the publication of the "Mechanical Philosophy." As, however, that time has long since elapsed, and Robison's valuable work is not in every one's hand, we need offer no apology for now including Mr. Watt's letter in a collection which would have been incomplete without it.

articles "Steam" and "Steam-engines" in the Encyclopædia Britannica, and have made remarks upon them in such places where, either from the want of proper information, or from too great a reliance on the powers of his extraordinary memory, at a period when it probably had been weakened by a long state of acute pain, and by the remedies to which he was obliged to have recourse, he had been led into mistakes in regard to facts; and also in some places where his deductions have appeared to me to be erroneous.

There had been but very little interchange of letters between us for some years previous to his writing those articles, and our opportunities of meeting had been rare and of short duration, and not occupied by philosophical discussions. Had I been apprized of his design, I might at least have prevented the errors respecting the facts in which I was concerned; but, upon the whole, it is more surprising to me that his recollection should have served him so well in narrating transactions of 30 years' standing, than that it should sometimes have led him astray. If I had not retained some memorandums made at the time of, or soon after, their occurrence, I should myself have felt great difficulty in recalling to mind the particulars at the period when I first perused those articles, which was some time after their publication. I had about that period an opportunity of personally stating to Dr. Robison some remarks upon them, of which he availed himself to a small extent in the Supplement to the Encyclopædia Britannica, and pro-

bably would have done so still more, had he been called upon to remould those articles.

I have endeavoured to throw most of my corrections into the form of notes; but in some places I judged it necessary to alter the text, which alterations I have marked to be printed in italics, that they may be readily distinguished from the original. In a few places, I have cancelled part of the text without any substitution, none appearing to me to be required. In others, I have left part of the reasoning unaltered which I did not concur in; as in mere matters of opinion, where no manifest error was involved, I did not conceive it proper to introduce my own speculations.

As the subjects of steam and steam-engines had been almost dismissed from my mind for many years previous to my undertaking this revision, I have called in the aid of my friend Mr. John Southern, and of my son, whose daily avocations in the manufacture of steam-engines render them more conversant with some points, to direct my attention to them; and of the former, to examine such of the algebraic formulæ as appeared essential,—an office for which he is much better qualified than myself; and he has accordingly marked those formulæ with his initials.

I have not attempted to render Dr. Robison's memoir a complete history of the steam-engine, nor have I even given a *detailed* account of my own improvements upon it. The former would have been an undertaking beyond my present powers, and the latter must much have exceeded

the limits of a commentary upon my friend's work. I have, therefore, confined myself to correcting such parts as appeared necessary, and to adding such matter as he had not an opportunity of knowing.

Here it was my intention to have closed this letter, but the representations of friends whose opinions I highly value, induce me to avail myself of this opportunity of noticing an error into which not only Dr. Robison, but apparently also Dr. Black has fallen, in relation to *the origin* of my improvements upon the steam-engine; and which, not having been publicly controverted by me, has, I am informed, been adopted by almost every subsequent writer upon the subject of Latent Heat.

Dr. Robison, in the article "Steam-engine," after passing an encomium upon me, dictated by the partiality of friendship, qualifies me as the "*pupil* and intimate friend of Dr. Black;" a description which, not being there accompanied with any inference, did not particularly strike me at the time of its first perusal. He afterwards, in the dedication to me of his edition of Dr. Black's Lectures upon Chemistry, goes the length of supposing me to have professed to owe my improvements upon the steam-engine to the instructions and information I had received from that gentleman, which certainly was a misapprehension; as, although I have always felt and acknowledged my obligations to him for the information I had received from his conversation, and particularly for the knowledge of the doctrine of latent heat, I never did,

nor *could*, consider my improvements as originating in those communications. He is also mistaken in his assertion, (p. 8 of the Preface to the above work), that "I had attended two courses of the Doctor's lectures;"* for, unfortunately for me, the necessary avocations of my business prevented me from attending his or any other lectures at College; and as Dr. Robison was himself absent from Scotland for four years at the period referred to, he must have been misled by erroneous information. In page 184 of the Lectures, Dr. Black says, "I have the pleasure of thinking that the knowledge we have acquired concerning the nature of elastic vapours, in consequence of my fortunate observation of what happens in its formation and condensation, has contributed in no inconsiderable degree to the public good, by *suggesting* to my friend, Mr. Watt of Birmingham, then of Glasgow, his improvement on this useful engine," (meaning the steam-engine, of which he is then speaking). There can be no doubt, from what follows in his description of the engine, and from the very honourable mention which he has made of me in various parts of his lectures, that he did not mean to lessen any merit that might attach to me, as an inventor; but, on the contrary, he always was disposed to give me fully as much praise as I deserved. And were that otherwise doubtful, it would, I think, be evident from the following quotation from a letter of his to me,

* Repeated more in detail, with the same erroneous inferences, in his Note, vol. i. p. 504.—(J. W.)

dated 13th February, 1783, where, speaking of an intended publication by a friend of mine on subjects connected with the history of steam, he says, "I think it is very proper for you to give him a short account of your discoveries and speculations, and *particularly to assert clearly and fully your sole right to the honour of the steam-engine.*"* And in a written testimonial which he very kindly gave on the occasion of a trial at law against a piracy of my invention in 1796-7, after giving a short account of the invention, he adds, "*Mr. Watt was the sole inventor of the capital improvement and contrivance above-mentioned.*"

Under this conviction of his candour and friendship, it is very painful to me to controvert any assertion or opinion of my revered friend; yet in the present case I find it necessary to say, that he appears to me to have fallen into an error; and I hope, in addition to my assertion, to make that appear by the short history I have given of my invention in my notes upon Dr. Robison's essay, as well as by the following account of the state of my knowledge previous to my receiving any

* See a more full extract from the letter in question printed at p. 15 of Mr. Watt's Correspondence on his Discovery of the Composition of Water, 1846. It is the same letter in which Dr. Black, speaking of Mr. Watt's discoveries, says, "were you to be the first publisher of them yourself, you would do it in such a cold and modest manner, that blockheads would conclude there was nothing in it, and rogues would afterwards, by making trifling variations, vamp off the greater part of it as their own, and assume the whole merit to themselves." Those prophetic sayings were, singularly enough, almost immediately followed by what Robison calls the "*trousseur*" of Cavendish and Blagden.

explanation of the doctrine of Latent Heat, and also from that of the facts which principally guided me in the invention.

It was known very long before my time, that steam was condensed by coming into contact with cold bodies, and that it communicated heat to them. Witness the common still, &c. &c.

It was known by some experiments of Dr. Cullen and others, that water and other liquids boiled *in vacuo* at very low heats:—water [at] below 100°.

It was known to some philosophers, that the capacity, or *equilibrium* of heat, as we then called it, was much smaller in mercury and tin than in water.

It was also known, that evaporation caused the cooling of the evaporating liquid, and [of] bodies in contact with it.

I had myself made experiments to determine the following facts:—

1st. The capacities for heat of iron, copper, and some sorts of wood, comparatively with water. Similar experiments had also subsequently been made by Dr. Irvine on these and other metals.

•2nd. The bulk of steam, as compared with that of water.

3rd. The quantity of water which could be evaporated in a certain boiler by a pound of coals.

4th. The elasticities of steam at various temperatures greater than that of boiling water, and an approximation to the law which it followed at other temperatures.

5th. How much water, in the form of steam, was required every stroke by a small Newcomen's

engine, with a wooden cylinder 6 inches diameter, and 12 inches long in the stroke.

6th. I had measured the quantity of cold water required in every stroke to condense the steam in that cylinder, so as to give it a working power of about 7 lbs. on the inch.

Here I was at a loss to understand how so much cold water could be heated so much by so small a quantity in the form of steam, and [I] applied to Dr. Black, as is related in the short history, p. 116, note; and then first understood what was called Latent Heat.

But this theory, though useful in determining the quantity of injection necessary where the quantity of water evaporated by the boiler, and used by the cylinder, was known, and in determining, by the quantity and heat of the hot water emitted by Newcomen's engines, the quantity of steam required to work them, did not lead to the improvements I afterwards made in the engine. These improvements proceeded upon the old-established fact, that steam was condensed by the contact of cold bodies, and the later known one, that water boiled *in vacuo* at heats below 100° , and, consequently, that a vacuum could not be obtained unless the cylinder and its contents were cooled, [at] every stroke, to below that heat.

These, and the degree of knowledge I possessed of the elasticities of steam at various heats, were the principal things it was *necessary* for me to consider in contriving the new engine. They pointed out that, to avoid useless condensation,

the vessel in which the steam acted upon the piston ought always to be as hot as the steam itself:—that, to obtain a proper degree of exhaustion, the steam must be condensed in a separate vessel, which might be cooled to as low a degree as was necessary, without affecting the cylinder; and that, as the air and condensed water could not be blown out by the steam, as in Newcomen's, they must be extracted by a pump, or some other contrivance:—that, in order to prevent the necessity of using water to keep the piston air-tight, and also to prevent the air from cooling the cylinder during the descent of the piston, it was necessary to employ steam, to act upon the piston, in place of the atmosphere. Lastly, to prevent the cylinder from being cooled by the external air, it was proper to enclose it in a case containing steam, and again to enclose that in a case of wood, or of some other substance which transmitted heat slowly.

Although Dr. Black's theory of latent heat did not *suggest* my improvements on the steam-engine, yet the knowledge, upon various subjects, which he was pleased to communicate to me, and the correct modes of reasoning and of making experiments, of which he set me the example, certainly conducted very much to facilitate the progress of my inventions; and I still remember, with respect and gratitude, the notice he was pleased to take of me when I very little merited it, and which continued throughout his life.

To Dr. Robison I am also bound to acknowledge

my obligations for very much information and occasional assistance in my pursuits, and, above all, for his friendship, which ended only with his life; a friendship which induced him, when I was beset with an host of foes, to come to London in the depth of winter, and appear as a witness for me in a court of justice, whilst labouring under an excessively painful disorder, which ultimately deprived him of life. To the remembrance of that friendship is principally owing my taking upon myself the office of his commentator at my advanced age.

May I request, Sir, that you and the public will permit that age to be my excuse for any errors I may have committed, and for any deficiencies in the performance of an office which at no period would have been congenial to my habits; and allow me to remain, with esteem,

Dear Sir,

Your most obedient humble servant,
JAMES WATT.

[395.]

MR. WATT TO DR. BREWSTER.*

Heathfield, June 7th, 1814.

* * In rummaging among papers on the subject of steam, I have found the original

* Announcing the completion of his Commentary on Dr. Robison's Articles "Steam and Steam-engines," and promising to send with it a copy of a description of his perspective-machine, and also of some of his micrometers, written by himself in 1808 or 1809, and which Mr. Playfair had seen. In the same letter he mentions that he had looked out all the parts of a perspective-machine, which he would send to Dr. Brewster.

drawing of an apparatus for drying muslin by steam, which I contrived in the year 1781, and which my father-in-law, Mr. James Macgregor, had executed at Glasgow; which I apprehend to be the original from which such machines were made, and which, I believe, is claimed by somebody else. If you think it worth publication, I shall cause a copy [to be made], and send it you: it possesses some merit.* Perhaps by this time you may think I have claimed too much already; none, however, that to my knowledge was not due to me.

Another imputation I cannot, however, repel;—with so many new ideas, why did I not complete more of them? *The spirit was willing, but the flesh was weak.* I was always averse to labour, and never was a mathematician. * *

[396.]

M. BENJAMIN DELESSERT† TO MR. WATT.

Paris, 9 Août, 1814.

MONSIEUR,—J'ai bien du plaisir à recevoir les deux lettres que vous m'avez fait l'amitié de

* See Brewster's Edinburgh Encyclopædia, vol. xviii. p. 384*, and Plate DXI., figs. 7, 8, 9, and 10.

† Of Benjamin Delessert,—a name sacred to the cause of science, of art, and of philanthropy,—see the interesting Eloge Historique by M. Flourens ('Hist. de l'Acad. des Sciences,' tome xxii. p. cxix.—cxliii.); where it is said—"Benjamin Delessert passa à Birmingham. * * Le génie de la mécanique y soumettait à l'homme l'une des forces les plus puissantes et les plus terribles de la nature. Benjamin Delessert fut témoin des essais de Watt. * * Chacun de ces hommes célèbres, comme ces Fées bienfaisantes qu'avait rêvées l'imagination de nos pères, doua Benjamin Delessert d'un talent particulier. * * Watt le doua de l'intelligence supérieure des arts mécaniques."

In the pursuits of learning and taste, M. Delessert possessed, as all his friends will long remember, multiplied endowments of no less value

m'adresser. * * Quoique les circonstances malheureuses dans lesquelles s'est trouvé ce pays depuis quelques années m'ayant empêché de correspondre avec vous, je n'en ai pas moins toujours pris beaucoup d'intérêt à tout ce qui vous regarde ; je conserverai toujours le souvenir des bontés que vous et Madamè Watt avez bien voulu avoir pour moi pendant mon séjour à Birmingham, il y a bien des années ; et je serai bien heureux de trouver des occasions de vous en témoigner ma reconnoissance. Je souhaite que ce que — vous dira de son voyage en France puisse vous engager à venir nous faire une visite ; je vous assure qu'on y voyage facilement et avec quelques agréments. Vous y verrez bien des personnes charmées de vous y voir : j'espère que vous me mettrez à leur tête. J'ai le bonheur d'avoir auprès de moi mon père et ma mère, jouissans d'une très bonne santé, et qui désirent être rappelés à votre souvenir. Ma sœur Madame Gautier, et mes trois frères qui sont associés avec moi, seroient heureux de faire votre connoissance.

Nous n'avons, Dieu merci, point ou peu souffert des événements, que par le douleur de voir depuis plusieurs années tant de gens malheureux ; à pré-

than that which he thus received. But it is still more worthy of notice, that his path was that of the just, and his death that of the righteous. The secret of his virtuous life was, at its close in 1847, revealed in these words, made public with his last testament,—(one full of charitable forethought, and munificent care for his fellow-men),—
 “Après une bonne action, on éprouve un sentiment de bonheur qui est au-dessus de toute idée : on dort d'un sommeil paisible, et tous les songes sont agréables !”

sent on se console par un avenir plus riant; on a la perspective d'une longue paix et d'une union durable entre les deux pays, et [pas] d'autre rivalité que celle des arts et de l'industrie. C'est un genre de guerre où vous personnellement avez remporté tous les genres de gloire.

Veillez me rappeler au bon souvenir de Madame Watt, et agréer l'assurance de mon bien sincère dévouement.

B. DELESSERT.

[397.]

COUNT BERTHOLLET TO MR. WATT.

Arcueil, 13 Août, 1814.

MONSIEUR,—Parmi les avantages du rétablissement de nos communications avec les pays étrangers, rien ne pouvait m'être plus agréable que de recevoir de vos nouvelles; car je conserve un souvenir bien vif de votre haut mérite et de la bienveillance dont vous m'honorez depuis si long tems. * *

Dans les premiers tems qui ont suivi la paix, nous avons beaucoup de dérangement dans l'intérieur de nos maisons, et nous ne pouvions donner aux étrangers les marques d'intérêt que nous aurions désiré; mais le calme où nous vivons actuellement nous permet de nous livrer aux impressions agréables. Soyez persuadé que je serai toujours empressé d'accueillir les personnes que vous voudrez bien m'adresser, et qui pourront me donner de vos nouvelles.

Nous avons eu le plaisir de voir à Paris plusieurs de vos illustres savans. * * Je désirerais

bien qu'il vous prit envie d'accroître le nombre : Paris pourrait offrir beaucoup d'objets à votre curiosité, et j'éprouverais une grande satisfaction à vous embrasser.

Pour moi, je me suis entièrement retiré à la campagne, et je ne vais à Paris que lorsque j'y suis appelé pour des affaires indispensables. Je commence à reprendre mes occupations, que la prévoyance des événemens avait interrompue depuis long tems.

Agréez, Monsieur, la plus haute considération et le plus sincère attachement avec lesquels j'ai l'honneur d'être, Monsieur, votre très humble et très obéissant serviteur,

BERTHOLLET.

[398.]

MR. WATT TO MR. JAMES WATT, JUN.

Heathfield, 14 Dec. 1814.

* * We were very much caressed at Edinburgh by our friends there, especially by my old acquaintance Lord Buchan, whom I had not seen for fifty-six years; by Mr. Jeffrey, Mr. Russell, Mr. Thomas Thomson, Mr. Playfair; Dr. Hope, Mr. William Erskine, who introduced me to Mr. Walter Scott,* Mr. Robison, Mr. John Craig, and others; but, from bad weather and my inability to walk, I saw little of the town besides two beautiful Gothic chapels. * *

* It is to this visit of Mr. Watt to Edinburgh that Sir Walter refers in his graphic and animated description of "a delightful evening," given in the Introduction to 'The Monastery.'—(Abbotsford Edition, vol. v. pp. 29, 30.)

[399.]

COUNT BERTHOLLET TO MR. WATT.

Arcueil, 18 Février, 1815.

MONSIEUR, — Vous avez eu la bonté de m'adresser quelques uns de vos amis, et j'ai eu le regret de ne les voir, pour aussi dire, qu'en passant, et de ne pouvoir leur témoigner les sentiments dont je suis pénétré pour vous. C'était un tems où mon habitation de ville, et surtout celle de campagne, étaient encore occupées par les troupes alliées, et où mon esprit n'avait point encore repris le calme. Je regrette particulièrement de n'avoir pas pû jouir de la société de M. Lee,* qui m'eût été bien agréable sous plusieurs rapports. S'il revient à Paris, je le prie de ne pas m'oublier.

J'ai cependant eu le plaisir d'apprendre que votre santé était excellente, et j'ai fait une acquisition bien agréable, celle de votre portrait.

Pour moi, j'ai fait entièrement ma retraite à ma campagne, et je ne vais à Paris que pour affaire. J'ai réuni près de moi les objets de mes goûts, et j'ai redonné de l'activité à mon laboratoire, qui languissait depuis long tems.

Nous ayons eu le plaisir à l'Institut de vous

* "Such," says M. Arago,—in describing Mr. Watt's application to the steam-engine of the "*governor*," or "*regulator by centrifugal force*,"—"was its efficacy, that there was to be seen at Manchester a few years ago, in the cotton-mill of Mr. Lee, a man of great mechanical talents, a clock which was set in motion by the steam-engine used in the work, and which marked time very well, even beside a common pendulum clock."—Translation of the Eloge of Watt, p. 87, ed. 1839.

Mr. Lee was a brother of Sophia and Harriet Lee, the well-known authoresses of the '*Canterbury Tales*' (1797-1805), and of several other works.

donner un témoignage de la haute considération que nous avons pour vous, en vous choisissant pour l'un des huit Associés Étrangers.

Je suis bien sensible au souvenir de Monsieur votre fils : je le prie d'agréer mes sincères compliments. Lorsque vous aurez l'occasion de m'adresser quelqu'un, je m'empresserai de faire pour lui tout ce qui dépendra de moi, et je compte sur vos bontés pour ceux que je pourrai vous présenter.

J'ai l'honneur d'être, avec une haute considération, votre ancien et dévoué ami,

BERTHOLLET.

[400.]

MR. JOHN CORRIE TO MR. WATT.*

MY DEAR SIR,—Knowing the interest you will feel in what relates to a man eminent in science, I send you an account we received last night of the death of Mr. Tennant. He had been, as I believe you knew, for some months in France ; he reached Calais the beginning of last week on his return to England, and sailed either on Tuesday night or Wednesday morning for Dover, but was driven back by contrary winds and bad weather into Boulogne. When there, on Wednesday morning, he set out on horseback with Count Bulow, (so the name is spelt in our letter), to see the pillar erected by Napoleon in that neighbourhood. The road led them over a deep trench, which they were to pass by means of a swivel bridge to which there were no side-rails. When on the bridge, the

* Without date, but indorsed by Mr. Watt, 'March, 1815.'

Count's horse took fright and threw him into the trench : he was not materially hurt, but when he got up he found Mr. Tennant lying in the trench, with one arm shattered, his head hurt, and speechless. He was immediately carried to the hospital at Boulogne, where he died in about an hour.

[401.]

SIR JOSEPH BANKS TO MR. WATT.

Soho Square, March 31, 1815.

MY DEAR SIR,—I should have long ago answered your favour, and thanked you for it, had I been able to pick up from the medical men of my acquaintance anything like common sense on the subject of the places to which persons requiring a change of climate can most properly be sent ; in fact, when a man consults a doctor without putting his hand into his pocket, the answer he gets is feeble and unsatisfactory.

As far as I can learn, it is not a matter of much importance to which of the better climates a patient removes who finds his own too cold for him, provided he does not encounter the intertropical regions, which are found to be too hot. Madeira is an excellent climate, but it is scarcely possible to obtain lodgings or shelter of any kind there, it not being the custom to let either lodgings or houses.

The Western Islands, I fear, are under the same predicament, as they are inhabited by Portuguese, but I do not hear of their having been tried.

The Cape of Good Hope is excellent in all its

points; the climate is never too hot, and never too cold,—the people in the habit of receiving strangers and showing them all manner of kindness. When I was there, the place was very cheap: I paid a dollar a-day each for myself and Dr. Solander, and half a dollar each for servants, for everything, bed and board, lived well, and was tenderly treated. My landlady was on the point of producing, and when she did, she named me godfather: my godson is still there, and has provided me with a great-godson.

A new plan has been lately thought of, and one of my friends is pursuing it: he goes with a wife in ill health to Jamaica, intending to fix his residence on the side of the Blue Mountains, where the climate will best suit him. At the bottom, at Kingston, the heat is, as we know, intolerable even to persons in health: at a certain elevation it becomes necessary to light fires in the evening and to use blankets on the beds. In this climate a friend, or rather a correspondent of mine lived many years at a place called the Cold Spring; where he planted English strawberries, which have thriven so well that the woods and wilds now abound with them.

I am sorry to have given you so unsatisfactory an account, and shall be happy if I can be of any other service when the place to which your interesting patient* is to emigrate has been determined.

* James Miller, the only grandson of Mr. Watt, who soon afterwards died (at Madeira) of consumption.

Adieu, my dear Sir. Believe me always faithfully yours,

JOSEPH BANKS.

[402.]

COUNT BERTHOLLET TO MR. WATT.

Paris, 5 Mars, 1816.

MON ANCIEN ET VÉNÉRABLE AMI,—Quoique j'aye si rarement l'occasion de m'entretenir avec vous, les anciens sentimens que vous m'avez inspirés ont conservé toute leur vérité, et j'aime à jouir du plaisir de vous les renouveler. J'ai eu bien des occasions de me rappeler ce que votre prévoiance m'a annoncé dès les premiers jours de notre malheureuse révolution, qui peut-être n'est pas à son dernier terme.

Je vous serai particulièrement obligé des bontés que vous aurez pour celui qui vous remettra cette lettre, et qui me rapportera de vos nouvelles. C'est M. Dupin, capitaine du génie maritime : il s'est fait connaître par plusieurs mémoires intéressans relativement aux constructions navales; qui l'ont fait nommer Correspondant de l'Institut ; et il s'occupe d'un grand ouvrage qui embrasse toute l'architecture maritime. C'est pour donner plus de perfection à ce vaste ouvrage qu'il va passer quelques mois en Angleterre, où il peut trouver tant d'instruction.* Ayez la bonté de

* The results of M. Dupin's laborious researches are favourably known to the public by his valuable work, 'Voyages dans la Grande-Bretagne, entrepris relativement aux services publics de la Guerre, de la Marine, et des Ponts et Chaussées, en 1816, 1817, 1818 et 1819,' of

favoriser son noble projet, et de l'aider de vos conseils et de votre protection. Agréez de sentimens qui ne cesseront qu'avec ma vie, et avec lesquels j'ai l'honneur d'être,

Votre très humble et très obéissant serviteur,

BERTHOLLET.

[403.]

MR. RENNIE TO MR. WATT.

London, July 29th, 1816.

* * I have had several calls from Mr. Skirvin since you left this, and yesterday went to see a few pictures he brought with him, and some profiles he has made since he came to London. There is one of Burns, the poet, in crayons, the most beautiful thing I ever saw. The profiles are striking beyond imagination, and he seems to possess the art of catching the favourable moment for taking the likeness and delineating the character beyond any painter I have seen. I am convinced he is the artist of all others that would do justice to you.

It unfortunately happens he has none of his crayons with him; and he will use none that are to be purchased here. He makes what he uses himself, and says he can get no others fit to use. He proposes to set out for Scotland in about a

which the first part (*Force Militaire*) was published at Paris in 1820, the second (*Force Navale*) in 1821, and the third (*Force Commerciale*) in 1824. See also an interesting collection of M. Dupin's '*Discours et Leçons sur l'Industrie, le Commerce, la Marine, et sur les Sciences appliquées aux Arts,*' in two vols., 1825; particularly the discourses at pp. 142, 174, and 285, of vol. i.

fortnight or three weeks hence, and will take your place in his way, if you are likely to be at home about either of these periods, but his drawing will only be in chalk. He, you know, is a singular character, and must have all his own way, both as to his portraits and pay. Will you try a profile in chalk? and, if you are to be in Scotland next year, will you, if you like his profile, sit for me in crayons? * *

[404.]

MR. WATT TO MR. RENNIE.

Heathfield, July 31st, 1816.

In reply to your kind letter of the 29th, I shall be at home for a fortnight, and shall be happy to sit to Mr. Skirvin, either for profile or front view, as he shall please to honour me by taking. As to my proceedings next year, they must be deferred till that time, should I live to see it. Meanwhile, please to thank Mr. Skirvin for the honour he does me by proposing to paint my portrait. The terms shall be of his own making. * *

[405.]

MR. WATT TO MR. R. MUIRHEAD.

Heathfield, 23 Nov. 1816.

* * My reasons against serving * are, that I have nearly completed my 81st year, have precarious health, and am generally confined to the house all the winter and spring; that I have spent a long life in improving the arts and manu-

* As Sheriff of Radnorshire.

factures of the nation ; my inventions at present, or lately, giving employment to [the] best part of a million of people, and having added many millions to the national riches, and therefore I have a natural right to rest in my extreme age ; that I have no domicile in the country, nor ever had, and have not been in it more than two years, and probably never shall ; that for these reasons I was excused serving for the county of Stafford, in which I live, twelve years ago,* and some of them should weigh more now. Eighty-one is not a period of active life, and, as far as my personal qualities are concerned, I esteem myself perfectly unfit ; and the consequences of serving would probably be the sending me a year or two sooner to the grave. * *

[406.]

DR. BREWSTER TO MR. WATT.

Edinburgh, 10, Hope Street, March 22d, 1817.

* * I am very anxious to have your advice and assistance respecting an invention which I have lately made, and for which I intend to take out a patent.

* * The instrument which I have invented is called the *kaleidoscope*, from the property which it possesses of exhibiting in succession the most beautiful forms. It is to the eye what a musical instrument is to the ear, and seems to do more even than realise the apparently chimerical project of an ocular harpsichord. The forms

* See above, No. [344.] p. 285-7.

created by the instrument out of absolute disorder, succeed each other in varieties which are literally infinite; and any form can be fixed and transferred to paper by the use of the camera lucida, or merely by the eye of the painter. The instrument has excited the most universal admiration among all classes in Edinburgh, and is as much admired by philosophers as it is by the mob.

I speak thus strongly of the effect of the invention, because it is so excessively simple that I can scarcely expect any credit for the contrivance.*

The instrument will be of great use to carpet-manufacturers, calico-printers, ornamental painters, architects, jewellers, manufacturers of china, and, in short, all professions where fine patterns are required; but it will probably have the greatest sale as a toy for all ages and degrees of intelligence.

It has occurred to me that the best way to bring the instrument before the public would be to make an arrangement with some active and intelligent house in Birmingham that is engaged in a similar kind of work, such as the manufacture of telescopes, or instruments of brass of any kind, for no glass-grinding is required. * *

You would oblige me very much by your advice with respect to the proper method of proceeding in this business. . * *

* Such is the language which the greatest inventors, whose humility of mind is usually commensurate with their genius, can afford to hold concerning their own inventions. But others can discern, that of such works the very simplicity here so modestly spoken of, is one of the very highest and most noble characteristics.

[407.]

MR. WATT TO MR. DUGALD BANNATYNE.

Heathfield, April 30th, 1817.

* * I had early thought of applying the steam-engine to rotative motions, but was so much occupied with reciprocating engines, that it was only in 1782 I applied for a patent for the application; but prior to that, some had been made by others, upon the atmospherical engines, and on a very imperfect plan; and the treachery of a workman had betrayed an invention of mine on that head to other persons, who took a patent for it in 1781. I had recourse, therefore, to other means, and erected a forge-engine in 1782 at Bradley Iron-works, and another engine for our own manufactory; in 1783, an engine for winding ores out of a mine in Cornwall; in 1784, an oil-mill at Hull, and the first engine of the Albion corn-mill at London, (a very splendid establishment); and an engine at Messrs. Goodwyn and Company's at London, (a brewery); another at Whitbread's, of the same kind, and several others; in all, seven engines that year. In 1785 we erected several engines, and among them one for Messrs. Robinson at Papplewick for cotton-spinning. If we had erected any engine for them in 1778, it must have been for pumping water. This engine, I suppose, was the first of our's which was applied to spinning cotton. In the following year we continued to erect rotative engines for various purposes; and in 1787, one for Messrs. Peel at

Warrington, *for cotton-spinning*; and at Nottingham, *three engines for the same purpose*; but it was only in 1789 that we erected the first cotton-spinning engine *at Manchester*, for Mr. Peter Drinkwater. In 1790, a cotton-spinning engine at Nottingham for Sir R. Arkwright; an engine at Darlington for spinning flax; a cotton-engine at Manchester for Mr. Simpson; and another at Papplewick for Messrs. Robinson. It is to be observed, however, that Sir R. Arkwright and others had atmospherical, or Newcomen's engines, with rotative motions applied to them for spinning, for some time before this, which were persevered in by several long after their date, from an ill-judged economy in the first cost. However, at last the cotton-spinners saw their own interest, and Boulton and Watt's engines came into general use among them as well as in other businesses. It is, therefore, needless to pursue this part of the subject any further.

Of the advantage of the engines to that manufacture, you can speak as well as I; and if other facts are wanted, there are no persons more able to give you correct information than our friends Mr. G. A. Lee and Mr. Peter Ewart, at Manchester, if you can prevail upon them to enter into your views.

The same principle of economy which actuated the cotton-spinners still prevails; and many, rather than give B., W., and Co. the prices which their superior work well merits, suffer themselves to be led away by ignorant pretenders, especially

the steam-boat owners, of whose blunders in that way we have lately had some melancholy proofs.

* * * *

Mr. John Kennedy, of Manchester, can also give good information about the cotton trade.

[408.]

MR. WATT TO MR. MURDOCK.

Heathfield, Aug. 3d, 1817.

* * I have been very languid and unfit for exertion of any kind since my return home; and my men and *horses* have been so closely occupied with a dilatory hay harvest, that I have not been able to get over to the foundry to see the progress of the diminishing-machine, and, I fear, I cannot at present, as we set out for Scotland on Tuesday. It must, therefore, remain, except what you find it convenient for you to do to it, until we return home. Perhaps the journey may make me more alert than I am at present, and more able to avail myself of your kind assistance. But be that as it may, I shall always retain a due sense of the zealous friendship with which you have furthered my views, and the invaluable assistance I have derived from you. * *

●

[409.]

MR. WATT TO MR. CHANTREY.

Heathfield, Dec. 8th, 1817.

* * The diminishing-machine is made ready for the trial. The short bust intended for a trial must not be coloured, but sent white, that

I may apply the proper hardening :* you were to try one of Roman cement, as likely to be harder.

* * * *

[410.] * MR. CHANTREY TO MR. WATT.

Belgrave Place, 12 March, 1818.

* * I am glad to find the instrument continues to occupy your attention. Mr. Rennie, (whose bust I have just completed), has excited my curiosity so highly as to induce me to threaten

* We have found, in Mr. Watt's handwriting, the following recipes for a "Cement for hardening plaster patterns for the carving-machine," of date Nov. 1st, 1810 :—

" 1. Wax $\frac{3}{4}$ oz., black rosin 2 oz. ; melt together by a gentle heat.

" 2. Wax 1 oz., red-lead or litharge 1 drachm, rosin 2 oz. ; dissolve the red-lead in the wax by boiling them till effervescence ceases, then add the rosin, and, when melted, withdraw from the fire.

" Wax 1 oz., sulphur 1 drachm ; unite them by a strong heat, and then add 2 oz. rosin at a lower heat.

" The cement No. 1 melts very fluid at a low heat, and will do very well for subjects where small guide-points are not necessary.

" Where small points are necessary, No. 2 or No. 3 should be used ; but they do not run so thin, and require more heat to melt them, especially No. 2.

" To use these cements, let the plaster pattern be made sufficiently hot, by placing it before the fire, or in an oven or stove ; then anoint it with the cement by a brush, and expose it before the fire, or in a stove, until it absorbs the cement. Give it in the same manner a second, third, or even fourth coat, until it has penetrated at least $\frac{1}{4}$ inch into the plaster ; remove it from the fire before it has totally absorbed the last coat, which it will take in while it cools ; and any which does not seem likely to be absorbed must be wiped off by a rag or some tow, and the pattern laid in a cool place."

This is followed by a "Cement to fasten the patterns to be cut, to the tablet of the machine. Wax and rosin equal parts, say 2 oz. of each, and, to prevent it cracking in cold weather, add $\frac{1}{2}$ oz. of a mixture of 3 parts linseed oil and 1 part of wax, boiled together until when cold they become solid."

you with a visit about the month of June, if you will be kind enough to encourage me with a promise that I shall then see it. You will smile when I tell you that I have very much improved upon the bungling instrument which we have been in the habit of using, and which you have seen: though I have not diminished the labour, the accuracy is much greater. * *

[411.]

M. DE PRONY TO MR. WATT.*

Paris, 22 Mars, 1819.

J'ai reçu l'ouvrage sur les *machines à feu* que vous avez eu la complaisance de m'envoyer, et je vous prie d'en agréer tous mes remerciements; les savans et les artistes verront avec beaucoup d'intérêt les grandes et belles découvertes qui vous ont acquis des droits immortels à la reconnaissance des hommes, exposées par vous-même. * *

* Introducing M. Hachette, of the Academy of Sciences, well known by his learned 'Traité des Machines,' of which the first edition appeared in 1811; as well as by his compendious and useful 'Histoire des Machines à Vapeur, depuis leur origine jusqu'à nos jours,' published at Paris in 1830.

END OF VOL. II.

AND OF

THE EXTRACTS FROM MR. WATT'S CORRESPONDENCE.



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