

vent the uncouth appearance of the open mouth of that which opens into the room over the fire-place, it may be masked by a medallion, a picture, or any other piece of ornamental furniture proper for that use, placed before it at the distance of one or two inches from the side or wall of the room.

The bottom of this *air tube* should reach to the ground, where it should communicate freely with the open air of the atmosphere, but it should not rise quite so high as the chimneys (or canals for carrying off the smoke) are carried up, but should end (by lateral openings, communicating with the air of the atmosphere) immediately above the roof of the house.

If this air tube be situated in the middle of a building, it is evident that an horizontal canal or tube of communication must be carried from its lower orifice to some open place without the building, in order to establish a free circulation of fresh air, both upwards and downwards, in the *air tube*. I say both *upwards* and *downwards*, for sometimes the current of air in the tube will be found to set upwards, and sometimes downwards. Its direction will depend on the winds that happen to prevail, or rather on the eddies they occasion in the air out of doors in the neighbourhood of the buildings, and it is no small advantage that will arise from leaving both ends of the air-tube open, that the tube will always be supplied with a sufficiency of air, whatever eddies the winds may occasion. It is easy to perceive how powerfully this must operate,

rate, to prevent those puffs of smoke which, in high winds, are frequently thrown into some rooms by the eddies, and the partial rarefactions of the air that they occasion; but this is far from being the only or the most important of the advantages that will be derived from this air tube. Those who consider what an immense quantity of air is required to supply the current that sets up the chimney of an open fire place, where there is a fire burning, must perceive what an enormous loss of heat there must be, when all this expence of air is supplied by the warmed air of the room, and that all this warmed air is necessarily and constantly replaced by the cold air from without, which finds its way into the room, by the crevices of the doors and windows. But all this waste of heat, or any part of it, at pleasure, may be prevented by the scheme proposed, for if the air necessary to the combustion of the fuel, and to the supplying of the current up the chimney, be furnished by the air-tube, the warmed air in the room will remain in its place; and as this will in a great measure prevent the cold currents from the crevices of the door and windows, the heat in the room will be the more equable, and consequently the more wholesome and agreeable on that account.

But there are, I am told, persons in this country, who are so fond of seeing what is called a great roaring fire, that even with its attendant inconveniences, of roasting and freezing opposite sides of the body at the same time, they prefer it to the genial

and equable warmth, which a smaller fire, properly managed, may be made to produce, even in an open chimney fire-place. To recommend the air-tubes to persons of that description, I would tell them, that by closing up, by means of its register, the lower branch of communication (that which ends just under the grate) and setting that situated near the top of the room wide open, they may indulge themselves with having a very large fire in the room *with little heat*, and this with much less inconvenience from currents of cold air from the doors and windows, than they now experience.

It is easy to perceive, that by a proper use of the two registers, together with a judicious management of the fire, the air in the room may either be made hotter, or colder;—or may be kept at any given temperature—or the room may be most effectually ventilated; and that this change of air may be effected, either gradually or more suddenly. And here it may perhaps be the proper place to observe, that in all our reasonings and speculations relative to the heating of rooms by means of open chimney fires, we must never forget that it is the *room that heats the air*, and not the air that heats the room.

The rays that are sent off from the burning fuel, generate heat, only *when and where* they are *stopped*, or *absorbed*, consequently they generate no heat in the air in the room, in passing through it, because they *pass through it*, and are not *stopped* by it, but, striking against the walls of the room, or against any solid

solid body in the room, these rays are *there* stopped and absorbed, and it is *there* that the heat found in the room is *generated*. The air in the room is afterwards heated by coming into contact with these solid bodies. Many capital mistakes have arisen from inattention to this most important fact.

It is really astonishing how little attention is paid to events which happen frequently, however interesting they may be as objects of curious investigation, or however they may be connected with the comforts and enjoyments of life. Things near us, and which are familiar to us, are seldom objects of our meditations. How few persons are there who ever took the trouble to bestow a thought on the subject in question, though it is, in the highest degree, curious and interesting.

END OF THE ELEVENTH ESSAY.

ESSAY XII.

OBSERVATIONS

CONCERNING THE

SALUBRITY OF WARM ROOMS

IN

COLD WEATHER.

VOL. III.

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Of the SALUBRITY of WARM ROOMS.—A distinction ought to be made between FRESH, or COLD AIR, and PURE, or WHOLESOME AIR.—Streams of cold air are always pernicious.—They cannot be avoided in cold weather in rooms heated by a large open chimney fire.—The danger from these cold currents of air is greatest when we are least sensible of their existence.—This remarkable fact is explained, by shewing that we are not capable of feeling heat and cold at the same time.—Sudden changes from hot rooms to the cold air is not dangerous to health.—This is proved by the healthfulness of the Swedes and Russians, who inhabit very warm rooms in winter.—A warm room, by promoting a free circulation of the blood, gives that health and vigour which are necessary in order to support without injury occasional exposure to intense cold.

ESSAY XII.

Of the Salubrity of Warm Rooms.

IT is a question often discussed in this country, whether living in a warm room in winter be, or be not, detrimental to health?

There is no doubt whatever of the necessity of pure air for the support of life and health, but I really do believe that erroneous opinions are entertained by many people in this island, respecting the effects of that equal, and at the same time moderate heat, which can only be obtained in rooms where strong currents of air up the chimney are not permitted. Those who have been used to living in large apartments, in which the large fires that are kept up, instead of making the rooms equally warm, do little more than increase the violence of those streams of cold air, which come whistling in through every crevice of the doors and windows; when such persons come into a room in which an equal and genial warmth prevails in every part, struck with the novelty of the sensation that this general warmth produces, they are

very apt to fancy that the air is *close*, and consequently that it must be unwholesome, and are uneasy until a door or a window be opened, in order that they may get what they call *fresh* air.

But they do not seem to make a proper distinction between *fresh* air, and *pure* air. When they call for *fresh* air, they doubtless mean *purer* air. They certainly get *colder* air, but I much doubt whether they often get air that is more wholesome to breathe; and it is most certain that the chilling streams and eddies that are occasioned in the room by the fresh air so introduced, are extremely dangerous, and often are the cause of the most fatal disorders.

It is universally allowed to be very dangerous to be exposed in a stream of cold air, especially when standing or sitting still;—but how much must the danger be increased if one side of the body be heated by the powerful rays from a large fire, while the other is chilled by these cold blasts? And there is this singular circumstance attending these chills, that they frequently produce their mischievous effects without our being sensible of them; for as the mind is incapable of attending to more than one sensation at one and the same time, if the *intensity* of the sensation produced by the heat on the one side of the body be superior to that of the cold on the other, we shall remain perfectly insensible of the cold, however severe it may really be, and if we are induced by the disagreeableness of what we do feel to turn about, or
change

change our position or situation, this movement will be occasioned, not by the cold, which we do not feel, but by the heat, which being superior in its effect upon us, engages all our attention. And hence we may account for those severe colds or catarrhs, which are so frequently gotten in hot rooms in this country by persons who are not conscious at the time of being exposed to any cold, but, on the contrary, suffer great and continual inconvenience from the heat.

I have said, that these colds are gotten in *hot rooms*, but it would have been more accurate to have said *in rooms where there is a great fire*—or where there is a *great heat*, occasioned by a great number of burning candles, or by a great number of persons crowded together,—for it is very seldom indeed that A ROOM is much heated in this country, and their being cold is the principal cause which renders partial heats that occasionally exist in them so very injurious to health.

The air of the room that comes into contact with the cold walls, and with the enormous windows, which, in open defiance of every principle of good taste, have lately come into fashion, is suddenly cooled, and being condensed, and made specifically heavier than it was before, in consequence of this loss of heat, it descends and forms cold streams, that are so much the more rapid and more dangerous as the partial heats in the room are more intense,—consequently they are the more

dangerous, as they are less liable to be observed or felt.

If to these cold currents which are generated in the room, we add those which come into it from without, to supply the enormous quantity of air that is continually going off by the chimney, when there is a great quantity of coals burning in an open grate, we shall not be surprised, that those who venture to go into such rooms without being well wrapped up in furs, or other warm cloathing, should be liable to take colds.

I never see a delicate young lady dressed in thin muslins, or gauzes, in the midst of winter, expose herself in such a perilous situation, without shuddering for the consequences. But how many young persons of both sexes do we find, of delicate habits, and particularly among the higher ranks of society?—And what vast numbers are carried off annually by consumptions!

It is well known, that this dreadful disorder is almost always brought on by colds, and that the cold of winter is commonly fatal to consumptive people; but why should the inhabitants of this island be so peculiarly subject to these colds? Is it not highly probably that it is because they do not take proper care to prevent them?—For my part I declare, in the most serious manner, that I have not the smallest doubt that this is really the case.

Much has been said of the supposed danger of keeping rooms warm in winter, on account of the
neceſſary

necessity most people are under of sometimes going into the cold air. But how many proofs are there, that these sudden transitions from heat to cold, or from cold to heat, are not attended with danger, if care be taken to be properly cloathed, and if the heats and colds are not partial?

How very hot do the Swedes and the Russians keep their houses during the long and severe frosts that prevail in winter in those countries? and yet no people are more strong and healthy than they are, nor are there any less liable to catarrhs and consumptions.

It is the very warm rooms in which this hardy race of men spend much of their time in winter, (which, by promoting a free circulation of their blood gives them health and strength) that enables them to support, without injury, exposure, *for short periods*, to the most intense cold.

In Germany, the rooms of people of rank and fashion are commonly kept, in winter, at the temperature of about 64° or 65° of Fahrenheit's thermometer (the dwellings of the peasants are kept much hotter); but though the ladies in that country are, from their infancy, brought up with the greatest care, and are as little exposed to hardships, as the women of condition in this, or in any other country, they find no inconvenience in going out of these warm rooms into the cold air. They even frequent the plays and the operas, and go on staving parties, during the severest frosts, and spend one whole month in the depth of winter (in

the season of the carnival) in one continued round of balls and masquerades. - And, what may perhaps appear to many still more incredible, they seldom fail, whatever the severity of the weather may be, to spend half an hour every morning in a cold church.

But if in Germany, where the winters are incomparably more severe than they are in this country, persons tenderly brought up, and of delicate habits, find no inconvenience whatever in living in warm rooms, and in going from them into the cold air, why should warm rooms be unwholesome in this country?

There cannot surely be any thing injurious to health in the genial warmth of 60° or 65° ; and if pure air for respiration is what is wanted, the great height of our rooms in England secures us against all danger from that quarter.

The prejudice in this country against living in warm rooms in winter, has arisen from a very natural cause; and though the prejudice is general, and very deeply rooted, as its cause is known to me, I really have hopes that I shall be able to combat it with some success. I am perfectly sure that justice will be done to the purity of my intentions in engaging in this arduous undertaking, and *that* I look upon as a circumstance of no small importance, especially when I consider that it can hardly escape the observation of my reader, that few persons can be better qualified by their own experience, to give an opinion on any subject,
than

than I happen to be to give mine on that under consideration.

I went to Germany many years ago, with as strong a prejudice against warm rooms as any body can have, but after having spent twelve winters in that country, I have learnt to know that warm rooms are very comfortable in cold weather, and that they certainly tend to the preservation of health:

Having occupied a very large house, in which there are several apartments that are furnished with open chimney fire-places, I have had an excellent opportunity of making experiments of the comparative advantages and disadvantages of warming rooms with them, and with stoves, and my opinions on these subjects have not been hastily formed, but have been the result of much patient investigation. They have been the result of conviction.

Were there any thing *new* in what I recommend, I might be suspected of being influenced by a desire to enhance the merit of my own discoveries or inventions; but as there is not, this suspicion cannot exist; and I may fairly expect to be heard with that impartiality which the purity of my intentions give me a right to expect.

It may perhaps be asked by some, what right I have to meddle at all in a business that does not concern me personally? Why not let the people of this country go on quietly in their own way, without tiring them with proposals for introducing changes

changes in their customs and manner of living, to which they evidently have a decided aversion?

To such questions and observations as these I should make no reply, but should still feel anxious to promote, by every means in my power, all such improvements as tend to increase the comforts and innocent enjoyments of life, from whatever quarter they might come.

If it be wisdom to choose what is good, it must be folly to refuse what is advantageous to us;—and if liberality be an ornament to a respectable character, it is weakness to be ashamed of adopting the useful inventions of our neighbours.

I am not without hopes, that, at some future period, houses in England will become as celebrated for warmth and comfort, as they are now for neatness, and for the richness and elegance of their furniture.

However habit may have reconciled us to it, or rendered us insensible to its effects, *cold* is undoubtedly a very great physical evil. It may be, and no doubt is, productive of good in some way or other, but that is not a sufficient reason why we should not endeavour to guard ourselves against its painful and disagreeable effects. Their being painful is a proof of their being hurtful, and it is moreover a kind intimation to us of the presence of an enemy, to be avoided.

We may, no doubt, by habit, inure ourselves to cold in such a manner as to render our bodies in some degree insensible to it; but does it necessarily

fairly follow that by these means its pernicious effects on us are prevented, or even diminished? I see no reason for supposing this to be the case.

If inuring to cold were a sufficient preservative against its bad effects, this method (which, certainly, would be the most economical) would, we have reason to think, have been adopted by Providence in respect to brute animals; but beasts and birds which pass the winter in cold climates, are all furnished with warm winter garments.

What provident nature furnishes to brute animals, man is left to provide for himself, or to supply the want of it by his ingenuity.

If living in cold rooms really tended to give strength and vigour to the constitution, and to enable men to support without injury the piercing cold of winter, we might expect that the dwellings of the inhabitants of the Polar regions would be kept at a very low temperature; but this is so far from being the case in fact, that we always find the hottest rooms in the coldest climates.

If the transition from a hot room to the cold air were so dangerous as it is represented, how does it happen that Swedes and Laplanders, who live in rooms that are kept excessively hot, do not take cold when they expose themselves to the intense cold of their winters?

Swedes and Russians, who pass the winter in England, never fail to complain of the uncomfortable coldness of our houses, and seldom escape catarrhs, and other disorders occasioned by cold. And the
sickness

sickness and mortality which prevailed among the Russian soldiers and sailors, who wintered in this country in the years 1798 and 1799, were generally, and no doubt justly ascribed to their being unable to support the cold to which they were exposed in our barracks, and in our hospitals; a degree of cold to which they never had been accustomed, *within doors*, and which to them appeared to be quite insupportable.

These are strong facts; and the evidence they afford in the case under consideration, is pointed, and appears to me to be incontrovertible. There are many other similar facts that might be adduced in support of the position we are endeavouring to establish.

It has often been objected to warm rooms, that the air in them is always confined, and consequently unwholesome; but no argument more perfectly groundless and nugatory was ever adduced in support of a bad cause.

When, in cold weather, a room is kept warm, the air in it, so far from being confined, is continually changing. Being specifically lighter (in consequence of its being warm) than the air without, it is impossible to open and shut a door without vast quantities of it being forced out of the room by the colder air from without, which rushes in; and if at any time it be required to ventilate the room in so complete a manner that not a particle of the air in it, shall remain in it, this may be done in less time than one minute, merely by letting

ting down the top of one of the windows, and at the same time opening a door which will admit the external colder, and heavier air. And it must not be imagined that the room will be much cooled in consequence of this complete ventilation.—So far from it, a person returning into it, three or four minutes after it had been ventilated, and the air in it totally changed, would not find its temperature sensibly altered.

The *walls of the room* would still be nearly as warm as before, and the radiant heat from those walls, passing through the transparent air of the room, without any sensible diminution of their calorific powers, would produce the same sensation of warmth as they did before. And even the cold air admitted into the room would in a few minutes become really warm. And as the specific gravity of air is so very small, compared with that of the dense solid materials of which the walls, floor, and ceiling of the room are constructed, the warming of this air will not sensibly cool the room.

Hence we see how easy it is to ventilate warm rooms, in cold weather, and also how impossible it would be to live in such a room, without the air in it being perpetually changed, and replaced with fresh and pure air from without.

It is those who inhabit cold rooms who are exposed to the danger of breathing confined air; for it would be in vain to open the doors and windows

dows of such an apartment; if the air in it is as cold, and consequently just as heavy, as that without, there is no physical reason why it should move out of its place. Part of it may indeed be blown out by a wind, or, without opening the doors and windows, a *part of it* may be forced up the chimney, if there be a fire burning in it; but this kind of ventilation is not only dangerous in a very high degree, to the health of those who are in the room, but it is also partial, and very incomplete. As the currents of cold air which supply the draught of an open chimney fire are confined to the bottom of the room, below the level of the mantel of the fire-place, the same air may remain for weeks in the upper parts of the room, and perhaps for a much longer time in some remote corner, far from the fire.

I think enough has now been said to prove to the satisfaction of every reasonable person who is disposed to listen, and willing to be convinced, that the air in rooms properly and equally warmed in cold weather cannot be confined and contaminated;—and that inhabiting warm rooms in winter, so far from rendering persons weak and unable to bear the cold on going abroad, is the best preservative against the bad effects of occasional exposure to cold.

If there are any persons who like cold rooms, and partial chilling streams of cold air, and prefer them to the genial warmth of a mild and equal tempe-

temperature, that choice must be considered as a matter of *taste*, about which there is no disputing.

There is a simple experiment, easily made, and no wise dangerous, which shews, in a sensible and convincing manner, that warmth prepares the body to bear occasional cold without pain and without injury: let a person in health, rising from a warm bed, after a good night's rest, in cold weather, put on a dry warm shirt, and dressing himself merely in his drawers, stockings, and slippers; let him go into a room in which there is no fire, and walk leisurely about the room for half an hour, or let him sit down, and write or read during that time, he will find himself able to support this trial without the smallest inconvenience; the cold to which he exposes himself will hardly be felt; and no bad consequences to his health will result from the experiment. Let him now repeat this experiment under different circumstances. In the evening of a chilly day, and when he is shivering with cold, let him undress himself to his shirt, and see how long he will be able to support exposure to the air in a cold room in that light dress.

There is another remarkable fact, with which I was made acquainted by an eminent Physician of London, Dr. BLANE, which can hardly be accounted for but on a supposition that heat prepares and enables the body to support cold. Those persons who, after having remained several years in the hot climates of India, return to reside
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in this country, do not feel near so much inconvenience from the cold of our climate the first year after their return, as they do the second.— If they would be persuaded to live in warm rooms, *when they are within doors*; and make a free use of the warm bath, they *never* would feel any inconvenience from it; and they might with safety take much more exercise in the open air than they now do.

Occasional exposure to cold, when the body is prepared to support it, so far from being dangerous, or injurious to health, is salubrious in a high degree.

It is in order that people may be enabled to go abroad frequently, and enjoy the fine bracing cold of winter, that I am so anxious that they should inhabit warm comfortable rooms, when they are within doors. But if, during the time when they are sitting still, without exercise, the circulation of the blood is gradually and insensibly diminished by the cold which surrounds them, and above all, by the cold currents of air in which they are exposed, it is not possible that they should be able to support an additional degree of cold without sinking under it.

They are like water, which, by long exposure to moderate cold, in a state of rest, has been slowly cooled down below the freezing point; the smallest additional cold, or the small agitation, changes it to ice in an instant; but water at a higher temperature, and full of latent heat, will support the
6 same

same degree of severe frost, for a considerable time, without appearing to be at all affected by it.—The more attentively this comparison is considered, the more just will it be found; and the more conclusive will be the inferences that are derived from it.

If man has been less kindly used than brute animals by being sent naked into the world, without a garment to cover and defend from the inclemency of the seasons, the power which has been given him over FIRE has made the most ample amends for that natural deficiency; and it would be wise in us to derive all possible advantages from the exercise of the high prerogative we enjoy.

END OF THE TWELFTH ESSAY.

ESSAY XIII.

OBSERVATIONS
CONCERNING THE
SALUBRITY OF WARM BATHING,
AND
THE PRINCIPLES
ON WHICH
WARM-BATHS
SHOULD BE CONSTRUCTED.

CONTENTS OF THIS ESSAY.

The salubrity of warm bathing has been universally acknowledged in all ages.—It has been practised in all climates.—An account of a circumstance by which the author was accidentally induced to turn his attention to this subject.—Good effects experienced by him from a very free use of the warm bath.—It is found that the use of the warm bath, so far from rendering persons peculiarly liable to take cold on going into the cold air, actually strengthens the constitution, and diminishes the danger attending occasional exposure to cold.—Exclusive of the salutary effects of warm bathing, the practice is well deserving of being recommended on account of the delightful enjoyment which it affords.—Probability that the best method of sitting up and using warm baths is not known in this country.—Water in large quantities is not so necessary in a warm bath, as is generally supposed.—Probability that it is the warmth, and not the water, to which the salutary effects resulting from warm bathing ought to be ascribed.—Danger attending the use of tepid and temperate baths.—An account is given of the result of an interesting experiment.—Great ingenuity displayed in the construction of the hot baths of the Russians.—A sketch of a plan for an elegant bath.—Plan of a bath on a more economical scale.—Description (from M. Savary) of the manner in which the warm bath is used in Egypt, and of the pleasurable sensations which result from the use of it.

ESSAY XIII.

Of the Salubrity of Warm Bathing.

HAD I any hopes of being able, by any thing I could say, to prevail on the inhabitants of this island, to adopt more generally a practice which so many nations have considered as a most rational luxury, and which, no doubt, is as conducive to health, as it is essential to personal cleanliness, I should think my time well employed were I to write a volume in recommendation of warm bathing: but I am sensible, that after all that has already been said on that subject, by ancient and modern writers;—by historians, and by medical men;—what I could add would be of little avail. The subject is, however, so intimately connected with that treated in the preceding Essay (XII.) that I may, perhaps, without any impropriety, take the liberty to make a few observations concerning it.

If a perfectly free circulation of the blood, brought on and kept up for a certain time, without any violent muscular exertion, and consequently without any expence of strength, be conducive to health, in that case warm bathing must be wholesome; and so far from weakening the constitution, must tend very powerfully to strengthen it.

Among those nations where warm bathing has been most generally practised, and where the effects of it have of course been best known, no doubts have ever been entertained of its being very beneficial to health; and nobody can doubt of its being pleasant and agreeable in a high degree.

Had warm bathing never prevailed but in certain climates, doubts might be entertained of its *general* usefulness; but so many nations,—remote from each other,—and inhabiting countries extremely different, not only in respect to climate, but also in respect to situation and produce, and where manners and customs have been extremely different in all other respects, have practised it,—that we may safely venture to pronounce warm bathing to be useful to man.

It was by accident I was led, about two years ago, to consider this subject with that attention which it appears to me to deserve; and I then made an experiment on myself, the result of which I really think very interesting, and of sufficient importance to deserve being made known to the public.

The waters of Harrowgate, in Yorkshire, having been recommended to me by my physician, I went there in the month of July 1800, and remained there two months. I began with drinking the waters, at the well, every morning, and with bathing in them, warmed to about 96° of Fahrenheit's thermometer, every third day, at my lodgings.

At first, I went into the bath at about ten o'clock

o'clock in the evening, and remained in it from ten to fifteen minutes; and immediately on coming out of it, went to bed, my bed having been well warmed, with a view to preventing my *taking cold*.

Having pursued this method some time, and finding myself frequently feverish and restless after bathing, I accidentally, in conversation, mentioned the circumstance to an intelligent gentleman, who happened to lodge in the house, and who had long been in a habit of visiting Harrowgate every year. He advised me to change my hour of bathing; and to stay longer in the bath; and, above all, to avoid going into a warmed bed on coming out of it. I followed his advice, and shall have reason, all my life, to thank him for it.

I now went into the bath regularly every third day, about two hours before dinner, and staid in it half an hour, and on coming out of it, instead of going into a warmed bed, I merely had myself wiped perfectly dry with warmed cloths, in a warmed room, adjoining to the bath; and dressing myself in a bed-gown, which was moderately warm, I retired to my room, where I remained till dinner time, amusing myself with walking about the room, and with reading, or writing, till it was time to dress for dinner.

The good effects produced by this change of method were too striking not to be remarked, and remembered. I was no longer troubled with any of those feverish heats after bathing, which I experienced

rienced before; and so far from feeling *chilly*, or being particularly sensible to cold on coming out of the bath, I always found myself less sensible to cold after bathing than before. I even observed repeatedly and invariably, that the glow of health, and pleasing flow of spirits, which resulted from the full and free circulation of the blood, which bathing had brought on, continued for many hours; and never was followed by any thing like that distressing languor which always succeeds to an artificial increase of circulation, and momentary flow of spirits, which are produced by stimulating medicines.

I regularly found that I had a better appetite for my dinner on those days when I bathed, than on those when I did not bathe,—and also, that I had a better digestion, and better spirits; and was stronger to endure fatigue; and less sensible to cold in the afternoon and evening.

As these favourable results appeared to be quite regular and constant, I was induced to proceed to a more decisive experiment. I now began to bathe every *second day*; and finding that all the advantageous effects which I had before experienced from warm bathing still continued, I was encouraged to go one step further; and I now began to bathe *every day*.

This experiment was thought to be very hazardous, by many persons at Harrowgate, and even by the physician, who did not much approve of my proceedings; but as no inconvenience of
any

any kind appeared to result from it, and as I found myself growing stronger every day, and gaining fresh health, activity, and spirits, I continued the practice, and actually bathed *every day*, at two o'clock in the afternoon, for half an hour, in a bath at the temperature of 96° and 97 degrees of Fahrenheit's scale, during *thirty-five days*.

The salutary effects of this experiment were perfectly evident to all those who were present and saw the progress of it, and the advantages I received from it have been permanent. The good state of health, which I have since enjoyed, I ascribe to it intirely.—But it is not merely on account of the advantages which I happened to derive from warm bathing, which renders me so warm an advocate for the practice.—Exclusive of the wholesomeness of the warm bath, the luxury of bathing is so great, and the tranquil state of mind and body which follows it, is so exquisitely delightful, that I think it quite impossible to recommend it too strongly, if we consider it merely as a rational and elegant refinement.

I am persuaded, however, that we are very far, in this country, from understanding the best method of fitting up warm baths, and of using them in the most comfortable and advantageous manner. It appears to me to be quite evident that it is not the water, but the *warmth* to which most, if not all the good effects experienced from warm bathing, ought to be ascribed.

Among those nations where warm bathing has
been

been most generally practised, water has seldom been employed, except occasionally, and merely for washing and cleaning the skin: and though washing in warm water is pleasant, and is, no doubt, very wholesome; yet, remaining with the whole body, except the head, plunged and immersed in that liquid for so great a length of time as is necessary, in order that a warm bath may produce its proper salutary effects, is not very agreeable, nor is it probably either necessary or salutary.

The manner in which a warm bath operates, in producing the pleasant and salutary effects which are found to be derived from it, appears to me to be so evident as to admit of no doubt or difference of opinion on that subject.

The genial warmth which is applied to the skin, in the place of the cold air of the atmosphere, by which we are commonly surrounded, expands all those very small vessels where the extremities of the arteries and veins unite, and by gently stimulating the whole frame produces a free and full circulation, which, if continued for a certain time, removes all obstructions in the vascular system, and puts all the organs into that state of regular, free, and full motion, which is essential to health, and also to that delightful repose, accompanied by a consciousness of the power of exertion, which constitutes the highest animal enjoyment of which we are capable.

If this statement be accurate, it cannot be difficult to explain, in a manner perfectly satisfactory,
why

why a warm bath is often found to produce effects when first used, and especially by those who stay in the bath for too short a time, which are very different from those which it ought to produce, and which it cannot fail to produce when properly managed. We shall likewise be enabled to account for the feverish symptoms, which result from going out of a warm bath into a warmed bed.

The beginning of that strong circulation, which is occasioned on first going into a warm bath, is an effort of nature to remove obstructions; and if time be not given to her to complete her work, and if she be checked in the midst of it, the consequences must necessarily be very different from those which would result from a more scientific and prudent management. Hence we see how necessary it is to remain in a warm bath a sufficient time;—and above all, how essential it is that the bath should be *really warm*, and not tepid, or what has been called *temperate*.

When we consider the rapidity with which water carries off heat from any body hotter than it, which is immersed in it, we shall find reason for astonishment that any person, even the strongest man in a state of the highest health, is able to support the loss of heat which must necessarily result from lying for half an hour quite motionless in a tub of water, at the temperature of 55 or 60 degrees; and yet, if I am rightly informed, baths at that temperature have sometimes been ordered
by

by physicians, and even for persons of delicate constitutions.

Because we are able to support that degree of cold, without injury, *in air*, that is very far indeed from being a good reason for concluding that *water* at that temperature would not be hurtful; for water is 800 times more dense than air, and consequently when it is cold, must deprive our bodies of heat, when we are immersed in it, with infinitely greater rapidity than air, at the same temperature, can do.

Having reason to think that physicians in general are not sufficiently aware of the very great difference there is in the powers of these two fluids to *carry off* heat when they are both at the same temperature;—and having myself been a witness, more than once, to very alarming consequences which have resulted from the use of what was called a *tepid bath*, I cannot resist the inclination I feel to avail myself of this opportunity of calling the attention of medical men to a circumstance which is, most undoubtedly, of very serious importance.

When we go into a bath at the temperature of about 96 degrees (which is blood heat) though the water at first may seem warm to us, and even hot, yet it is not capable of communicating much heat to us, for our bodies being at the same temperature, except it be perhaps at the very surface of the skin (where the nerves of feeling are most plentifully distributed) there is no reason why heat should pass out of the water into us; but if the
water

water be only a few degrees below the temperature of the blood, though it may feel warm when we first go into the bath, yet that sensation will soon be followed by one of a very different nature; and the water will carry off heat very rapidly from the surface of the body.

A rapid cooling of the body, by carrying off, by a mechanical process, the heat generated in the body by the action of the vital powers, may, or may not, be adviseable in certain cases. That is a question of nice discrimination, and one upon which I am perfectly sensible that I am not qualified to decide: but I may be allowed to point out physical consequences, not very obvious, and consequently not likely to be subjects of meditation and investigation, which ought certainly to be rightly understood.

There is one observation more respecting tepid and temperate baths, which appears to me to be deserving of particular attention, and that is, the state of *inaction* in which a person commonly remains in such a bath, and the probable consequences of inaction under such circumstances. Swimming is universally allowed to be an wholesome exercise, and there are few instances, I believe, of harm arising from it, even when the water has been at a much lower temperature than that of the blood; but I am far from being of opinion that remaining in the water, without any muscular exertion, would be found to be equally conducive to health.

Cold

Cold baths are perfectly different from hot baths, and tepid baths, and the intention of the physician in ordering them is also different. I am not prepared to explain the physical effects produced by a momentary plunge into cold water; and much less to give an opinion respecting the salubrity of the practice of cold bathing, or of its usefulness as a remedy for certain diseases.

But to return from these speculations to more interesting details—to the results of actual experiments.—During the thirty-five days that I continued to make daily use of a warm bath, I made a number of experiments on myself, in order fully to satisfy my own mind on several important points, respecting which I still had doubts remaining. Some of those experiments were certainly too hazardous to be reconciled to sober good sense, and to that prudent attention to the preservation of health, which every wise man would be ashamed of neglecting. But though I may be blameable for my temerity, and may even expose myself to ridicule by making a discovery of my rashness; yet I am so deeply impressed with the importance of the results of some of my experiments, that I cannot refrain from laying them before the public.

Having long entertained an opinion, that the most effectual means that can be used to prepare the body to support, without inconvenience, and without injury, those occasional exposures to cold, to which every person is liable who inhabits a cold country, is, by a proper application of warmth, and

without the fatigue of violent muscular exertion, to bring on, and keep up for a certain time, at certain intervals, such a full, strong, and free circulation and perspiration, as shall effectually remove, from time to time, all those gradual contractions and obstructions which chilling cold naturally produces, and give a new impulse to those actions in which life, health, and strength consist; I imagined that, if this opinion was well founded, the use of the warm bath, instead of rendering my habit more delicate, and making me more liable to take cold on exposing myself in the cold air, I should certainly find myself strengthened by it, and my constitution rendered more robust.

The first direct proofs I had, that this advantageous change had actually taken place in me, were accidental; and it was probably that discovery which induced and encouraged me to expose myself voluntarily to more severe trials.

I had, from the time of my first arrival at Harrowgate, been in a habit of retiring to my room towards evening every day, where I commonly spent an hour or more in reading or writing, and as I never had any fire in my room, I frequently felt myself quite chilled by the cold of the evening. At this time I bathed only once in three days; but after I had begun to go into the bath before dinner, I soon found that I was much less sensible to the cold of the evening on those days when I bathed, than on those when I did not bathe.

It

It was the discovery of this interesting fact which contributed much, and perhaps more than any thing else, to induce me to take the resolution, (which was considered as very violent and unadvised) of going into the bath every second day, and afterwards every day.

After I had continued to bathe every day for some time, I no longer felt the smallest inconvenience from the cold of the evening, though I frequently sat in my room with the windows open, when the weather was very cold and chilly, 'till it was so dark that I could neither see to read nor to write; and when I joined the company below, I felt myself in high spirits, and never wanted an excellent appetite to my supper. My sleep was undisturbed and refreshing; and every thing indicated the return of perfect health.

All these favourable appearances having continued for some time, and finding my strength to increase daily, I became more venturous, and frequently went out after it was dark, when the evening was cold and raw, and walked alone more than half an hour on the bleak dreary common, which lies before the house where I lodged (the Ganby Inn) to see if my constitution was really so much changed as to enable me to support that trial without taking cold.

I even returned on foot from the play-house, across the common, several times, in the evening, lightly dressed, when a cold wind blew over the common, and after I had suffered much from heat
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in the theatre: but in none of these severe trials did I receive the smallest injury: I never too cold, nor did I experience any feverish heats, or restlessness, on going to bed after them. I call them *severe* trials; and as such they will doubtless be considered, when it is recollected, that when I arrived at Harrogate, I was far from being in a good state of health, (having never recovered from the dangerous illness I had brought on myself six or seven years before in Bavaria, by excessive application to public business) and when it is remembered that at the time when I was exposing myself in this manner to the danger of taking cold, I was using the warm bath every day.

But I am firmly persuaded that it was to the *warm bath*, that I was indebted for my escape; and it is that persuasion which has induced me to publish this account of my experiment.

I am very far indeed from wishing that my example should be followed in all points.—All the unadvised and imprudent details of the experiment may, and ought to be omitted. It would indeed be more than imprudent; it would be foolish to repeat them. But I do really believe that all those who will be persuaded to adopt the practice of warm bathing, in health and in sickness, will find the greatest and most permanent advantages from it.

Were the general and constant use of the warm bath, by persons in health, a new thing, I should have many scruples in recommending it to the

public, whatever my private opinion of its salubrity might be. But so many nations have practised it for ages ; and there are so many who now practise it, and—what is very remarkable—one (the Russian) which inhabits the coldest parts of the globe, that there cannot possibly be the smallest reason to doubt of its beneficial effects.

With regard to the *pleasant* effects that result from the use of the warm bath, there never has been any difference of opinion. But still, I am quite certain that the true luxury of warm bathing is not understood in this country ; and till the construction of our baths is totally changed, and a different manner of using them adopted, we never can enjoy a warm bath as it ought to be enjoyed.

As we must allow, that in most cases, and particularly in a matter of this kind, it is much more wise and prudent to adopt those arrangements and improvements which have been the result of the experience of ages, than to set down and attempt to invent any thing new ; I think we cannot do better than to rebuild some of the baths which were left us by the Romans. *They* most certainly understood warm bathing, as well as any nation ever did ; and if there be any thing in our climate which renders any deviations necessary from the manner commonly practised in constructing baths in warmer countries, there is no doubt but those luxurious foreigners, who had possession of this island for so many years, must have found them out. The

plans they have left us may therefore be adopted with safety as models for our imitation.

I am far from wishing to see the baths of Dioclesian and Caracalla rise up, in all their splendour, in the neighbourhood of London, for I am well aware that the magnificent and ostentatious exhibitions of a nation of conquerors, and slaves, would but ill accord with the manners of a free, enlightened, and industrious people ; but still I cannot help wishing that the inhabitants of this island, and all mankind, might enjoy all the innocent luxuries and comforts that are within their reach.

I am even jealous of the poor Russian peasant ; and when I see him enjoying the highest degree of delight and satisfaction in the rude cave which he calls a warm bath—without wishing to diminish his pleasure—I greatly lament that so useful and so delightful an enjoyment should be totally unknown to so great a portion of the human species.

Who knows but that the poor Russian, in the midst of his snows—with his warm room, and warm bath—may not on the whole, enjoy quite as much happiness as the inhabitant of any other country ? And if this be really the case, what an addition would it be to the enjoyments of the inhabitants of other, more favoured countries, to add the warm room, and warm bath of the Russian, to all their local advantages ! When I meditate profoundly on these subjects, it is quite impossible for me not to feel my bosom warmed with the most enthusiastic zeal for the diffusion of that know-

ledge which contributes to the comforts and enjoyments of life.

There is nothing more interesting than the results of the ingenuity of man in the infancy of society, before the light of science has extended his views, and increased the number of the objects of his pursuit. Ever intent upon a few simple mechanical contrivances, the usefulness of which he continually experiences, all his thoughts remain concentrated on them, and all his ingenuity and address are employed in rendering them perfect, and using them with agility and effect. When we examine the implements which savage nations have contrived to provide for themselves, almost without tools, we shall see one of the most striking proofs to be found, of the effects of persevering industry, and long experience.

No person of any feeling can contemplate the canoes, snow-shoes, and hunting and fishing-tackle of the North American savages, without experiencing emotions which it would be very difficult to describe: and the ingenuity displayed by the Russian peasant, in the construction and management of his warm bath, is not less striking.

Without any knowledge of the principles of pneumatics, hydrostatics, and chemistry, he has proceeded in the same manner, precisely, as he would have done, had he understood all those sciences; and without money, or the means of purchasing any thing of value, he has contrived,
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with the rude materials, of no value, which he finds lying about him, to construct an edifice in which he enjoys, in the most complete manner possible, all the delightful sensations which result from one of the most rational pleasures, of the most refined and luxurious nations. And if security in the possession of an advantage adds value to it, how much greater is the security of the Russian peasant in the enjoyment of his luxuries, than the rich and effeminate in the possession of theirs?—Nothing is more calculated to fill us with wonder and admiration than to see how the different situations of man, on this globe, have been equalized by compensations!

The warm baths of the Russian peasants have so often been described, that I dare not take up the reader's time unnecessarily by giving a particular account of them. They are, as is well known, what are called vapour baths; and as those who build them are much too poor to afford the expence either of boilers, or bathing tubs, they are heated in a manner which is equally ingenious and economical. A parcel of stones are heated upon a wood fire made on the ground, and when these stones are hot, water or snow is thrown on them, and the steam which is produced, rises up and occupies the inside of the arched roof of the cave which constitutes the bath.

Those who enjoy the bath, place themselves, extended at full length, on a bed composed of the small twigs and leaves of trees, on hurdles in the

form of shelves, placed round the cave, under its vaulted roof, and above the level of the top of the door way.

From this short description it is evident, that the air occupying the top of the cave, and which is heated by the steam, being rendered specifically lighter than the cold air without, by the heat it has acquired, will remain in its place, even though the entrance into the cave should not be provided with a door. A few branches of trees placed against the door-way would break the force of the wind, if any were stirring, and the bath would remain as warm as should be required, for any length of time, even in the most severe frost of a Russian winter, with the expence of a very small quantity of fuel.

Were I asked to give a plan for a warm bath, by a friend who had full confidence in my abilities to execute such an undertaking with intelligence, I should adopt, with little deviation, all the principles of the Russian baths.

The bath room should be built of bricks; and should be covered above by a gothic or pointed dome; and the entrance into it should not be through the side walls, but through the pavement, by a flight of steps from below. The walls should be double, the inner wall being made as thin as possible, and the room should be lighted by three or four very small double windows of single panes of glass situated just below the spring
of

of the dome, which might be at the height of seven or eight feet above the pavement.

As the (double) walls of the building would be of some considerable thickness, and as the windows ought to be small, and double, it would be very easy to construct them in such a manner that a person from without should not be able to see any person in the bath, even though they were to get a ladder, and attempt to look in at the window. One of the windows should be made to open, in order to ventilate the bath.

The inside of the walls, and dome of the bath room should be plaistered, and afterward well painted in oil;—or, (what would have a neater and more elegant appearance), they might be lined with Dutch tile.

The pavement might be made of any kind of flat stones, or of bricks, or tiles; or it might be constructed of stucco, well painted in oil, and it might be covered with matting.

If ornament were required, I would place a figure of *Vesta*, holding an *Argand's* lamp, on a pedestal, on one side of the room. This pedestal, which should be large in proportion to the figure, should be made of sheet copper, and painted of a bronze colour on the outside. The cavity within it should be accurately closed on every side, in order that it might occasionally be filled with steam from a boiler situated without, and used as a stove for warming the room.

The important object had in view in making the entrance into this bath from below (the preservation of the warm air in the room) might be attained equally well with the door placed on one side of the room, provided the door were made to open immediately into a narrow descending vaulted gallery, furnished with a good door at the lower end of it.

The top of the door at the lower end of this gallery should be two or three feet below the level of the bottom of the door at the top of it, which opens into the bath,

By setting both these doors open; and at the same time opening one of the windows of the bath, all the warm air in it, below the level of the window, will be forced out, in a very few moments, and the room will be completely ventilated.

If the entrance be made through the side of the room, in the manner just described, this will render the form of the room more simple, and more elegant, than if the passage into it were from below, through the pavement.

If the pavement of the bath be on a level, or nearly on a level, with the surface of the ground, the entrance into it must, nevertheless, come from a lower place. If the door leading into the bath be situated at one side of the room, the vaulted gallery, with which it communicates, must descend below the level of the surface of the ground, and a passage must be opened from without, in order

order to arrive at the door which must close this gallery at its lower extremity.

A steam boiler should be placed under the bath, in a vaulted room, and the smoke from the closed fire-place of the boiler should be made to circulate in flues under the pavement of the bath, near the walls of the room, in which part the pavement should not be covered with matting.

A bathing tub should stand on one side of the room, and opposite to it should be placed a bamboo or caned sofa, covered, first with a soft thick blanket, and then with a clean sheet, thrown over it.

The bathing tub, which might be of the usual dimensions, should be placed on a platform of wood, covered with sheet lead, about seven or eight feet square, and raised six or seven inches above the pavement. This platform should be flat, and nearly horizontal, with a border all round it, about two or three inches high, and a leaden pipe at the lowest part of it, to carry off the water that happens to fall on it.

The lead should be covered by thin boards, or by a loose piece of matting; and a caned chair, or a stool, should be placed on the platform, by the side of the bathing tub. A pipe should be prepared for admitting cold water into the bathing tub from a reservoir situated without the bath; and another for bringing steam into it, to heat it, from the steam boiler. There should likewise be a waste

waste pipe for carrying off the water when the bathing tub is emptied.

The bathing tub should not be set down immediately upon the lead which covers the platform on which the tub is placed, but should be raised eight or ten inches above it, in order that the air may pass freely under the bottom of the tub; and that there may be room to come at the lead, to wash it, and clean it, in every part.

A bath constructed in the manner here described might be kept constantly warm, all the year round, at a very small expence for fuel; and in that case, it would always be ready for use.

It is equally well calculated to serve as a warm air-bath;—as a vapour-bath;—or as a warm water-bath;—and when it is used as a water-bath, the air in the room may be made either warm, or temperate, at pleasure.

This last circumstance I take to be a matter of the greatest importance; for nothing surely can be more disagreeable than the sensations of a person on getting out of a tub of warm water, and standing shivering with cold, till he is wiped dry, and dressed; and I cannot help suspecting, that such a situation is as dangerous as it is unpleasant.

I am much inclined to think that the warm *air-bath*, with occasional washing with warm water, will be found to be not only the most pleasant, but also the most wholesome of any; and if that should be the case, no building could answer for that

that purpose in this country—(where the temperature of the atmosphere is always so much below that which would be wanted) unless it were constructed on principles similar to those, on which the plan above described is founded.

Hot air may at any time be procured in any climate, but a large mass of air moderately and *equally* warm cannot be *preserved* in a cold country, by any other means than by preventing its being cooled, and preventing its being driven away by the denser surrounding medium.

The double walls, and small double windows of the bath, which I have recommended, will prevent the *cooling* of the air in it; and the form of the room renders it absolutely impossible for the cold air of the atmosphere, either to mix with that warm air, or to *force it out of its place*.

If it be required to mix steam with the air of the room to render it moist, that may be done by laying a steam tube for that purpose from the boiler, into the room; or it may be done in a manner still more refined and luxurious, by having a small portable boiler for that purpose, heated by a spirit lamp, or a common tea urn, heated, or rather kept boiling, by an iron heater; or a common tea-kettle heated by a spirit lamp, might be made use of. The water might be brought in, already boiling hot, and if a quantity of cloves, or other spices were mixed with it, the room would be filled with the most grateful, and most salutary perfumes. By burning sweet scented woods or
aromatic

aromatic gums and resins in the room, in a small chafing dish filled with live coals, the air in the room would be perfumed with the most pleasant aromatic odours,

Those who are disposed to smile at this display of eastern luxury, would do well to reflect on the sums they expend on what *they* consider as luxuries; and then compare the real and *harmless* enjoyments derived from them, with the rational and innocent pleasures here recommended. I would ask them, if a statesman, or a soldier, going from the refreshing enjoyment of a bath such as I have described, to the senate or to the field, would, in their opinion, be less likely to do his duty, than a person whose head is filled, and whose faculties are deranged, by the fumes of wine.

Effeminacy is no doubt very despicable, especially in a person who aspires to the character and virtues of a man; but I see no cause for calling any thing *effeminate*, which has no tendency to diminish either the strength of the body;—the dignity of sentiment;—or the energy of the mind. I see no good reason for considering those grateful aromatic perfumes, which in all ages have been held in such high estimation, as a less elegant, or less rational luxury than smoking tobacco; or stuffing the nose with snuff.

Having given a slight sketch of a bath on a scale of magnificence and refinement, which will not suit every person's circumstance; and may not accord with every person's taste, I will now give

another on a less expensive, and more modest plan.

Let a small building be erected, 14 feet 5 inches long, and 9 feet wide, measured within, and 7 feet high; and let it be divided into equal rooms of 9 feet long, and 7 feet wide each, by a partition wall of brick $4\frac{1}{2}$ wide, or equal in thickness to the width of a brick. Let the outside walls of this little edifice be double, the two walls being each the width of brick in thickness, and the void space between them, being likewise of the same thickness, viz. about $4\frac{1}{2}$ inches. In order to strengthen these double walls, they may be braced and supported one against the other, by uniting them, in different parts, by single bricks, laid across, with their two ends fixed in the two walls.

Instead of a floor of boards, these two little rooms should be paved with 12 inch tiles, or flat stones, laid in such a manner, on thin parallel walls, ($4\frac{1}{2}$ inches in thickness) as to form horizontal flues under every part of the pavement.

There should be no door of communication between these rooms, but each should have its separate entrance from without, by a door opening directly into a separate narrow descending covered gallery. These two doors should be placed on the same side of the building, and their two separate descending galleries may be parallel to each other, and may indeed be covered by the same roof.

They may together, form one gallery, divided
into

into two narrow passages by a thin partition wall, constructed with bricks.

A small porch at the bottom of the gallery should be common to both passages, but each passage should, nevertheless, have its separate door, at its lower extremity, where it communicates with the porch.

The top of the door-way of this descending passage, at its lower extremity, must be at least one foot below the level of the pavement of the rooms.

This passage may be furnished with a flight of steps; or its descent may be made so easy as to render steps unnecessary.

If there should be no natural elevation of ground at hand, on which this bath can conveniently be situated, a mound of earth must be raised for that purpose; otherwise it will be necessary that the porch at the end of the gallery should be situated 7 or 8 feet below the surface of the ground; for it is indispensably necessary that the entrance into the bath should be by an *ascent*, and in a *covered gallery*.*

The building may be covered with a thick thatched roof, which will, on some accounts, be better than any other; but any other kind of roof will answer very well, provided it be tight; and that a quantity of straw, or of chaff, or of dry leaves

* If the entrance into the houses of poor cottagers were constructed on the same principles, this simple contrivance would save them more than half their expences for fuel, in cold weather.

leaves be laid over the ceiling of the two small rooms, under the roof, to confine the heat. The ceiling of the rooms should be lathed and plastered, and the walls of the room should be plastered and white-washed.

At the end of one of the rooms opposite to the door, a bathing tub should be placed; and in the other a caned sofa.

The bathing tub should be placed on a platform 7 feet square, covered with sheet lead, and raised about nine inches above the level of the pavement. This platform should have a rim all round it, and a pipe for carrying off out of the room, the water that accidentally falls on it.

The bathing tub should be supplied with cold water from a reservoir (a common cask will answer perfectly well for that use) which should stand without the house.

The water should be admitted cold into the bathing tub, and should be warmed in it, by means of steam, which may come from a small steam-boiler, which should be situated without the building, and near to the reservoir of cold water. A small open shed, made against one side of the building—that side of it which is opposite to the entrance gallery—may cover both the boiler and the reservoir. The boiler, which need not be made to contain more than six or eight gallons, should be well set in brick-work, and well covered over with bricks, to prevent the loss of heat which would result from any part of the boiler

boiler being exposed naked to the cold air of the atmosphere.

This boiler should be so fitted up, by means of a ball-cock, as to feed itself regularly with water from the neighbouring reservoir.

The boiler should be furnished with a safety valve, opening into the open air, and with a tube for conveying steam into the bathing-tub. This tube, which may be a common leaden pipe, about half an inch in diameter, should be wound round with the lift of coarse cloth, or with any warm covering of that sort, to confine the heat.

This steam tube should rise up perpendicularly from the boiler to the height of eight or ten inches above the level of the ceiling of the bath-room, and should then be bent towards the building, and made to enter the roof of it, and then to descend perpendicularly through the ceiling of the bath-room, and enter the bathing-tub. Its open end should reach to within an inch of the bottom of the tub; and a little above the level of the top of the tub there should be a steam-cock, by means of which the passage of the steam through the steam-tube, and into the water in the bathing-tub, may be regulated, or prevented entirely, as the occasion may require.

There may be a short branch, six or eight inches long, inserted into the steam-tube just described, which branch will serve for admitting steam into the room when it is designed to be used as a steam, or vapour-bath.—This short
branch

branch must of course be furnished with its own separate steam-cock.

The smoke from the (closed) fire-place of the boiler must be made to circulate under the pavement of the two rooms of the bath, in the flues constructed for that purpose, before it is suffered to pass off into the chimney.

The chimney should stand on the outside of the building, and be made to lean against, and be supported by the wall of the building. There should be a damper in this chimney.

Each of the small rooms should be furnished with a small double window; each window consisting of one large pane of glass, and being made to open by means of a hinge, placed on one side of it.

These windows should be placed as near the ceiling of the room as possible, in order to facilitate the perfect and speedy ventilation of the bath. The inside windows may be placed level with the inside of the wall of the house; and the outside window level, or flush, with the outside wall. Either the inside windows or the outside windows should be made of ground or of wavy glass, in order that a person in the bath may not be exposed to being seen through the windows.

The two small rooms may be distinguished by calling one of them the *bath-room*, and the other the *dressing-room*.

If it be required to heat the two rooms in a very short time, the one with vapour, and the

other with dry air, equally warmed, and perfectly free from all disagreeable smells, this may be done by the following simple contrivance. Let a cylinder of very thin copper, about eight inches in diameter, and five feet in length, be placed horizontally under the sofa in the dressing-room, and let a steam-pipe from the boiler be laid into it, with another pipe for carrying off the water resulting from the condensation of the steam in it. By admitting steam into this tube, the air in the room will soon be warmed, without any watery vapour being mixed with it;—and by admitting steam into the bath-room, and allowing it to mix with the air of that room, a vapour-bath will be formed, and in a very few minutes will be ready for use.

A small quantity of cold water may then be admitted into the bathing-tub, and the steam being turned into it, it will soon be made warm enough to be used for washing, after the steam-bath has been used.

The passage from the bath-room into the dressing-room will be attended with no danger from cold; and it will be found very pleasant to dress and repose in a warm room, where the air is pure, and not charged with vapour, after coming out of the water, or out of a vapour-bath.

If there should be any apprehension that either the bath-room, or the dressing-room, might be too much heated by the smoke from the boiler passing continually through the flues under the pavement,

pavement, a canal, furnished with a damper, leading from the closed fire-place of the boiler immediately into the chimney, might be made; and whenever the pavement should become too hot, by opening this canal the smoke would pass off immediately into the chimney by the shortest road, and the pavement would receive no more heat from it. I think it would in all cases be advisable to take this precaution, in constructing a bath on the principles here recommended.

But I must hasten to finish this long dissertation; and I shall conclude it with a few passages from a modern traveller (M. SAVARY) who may be considered as being well qualified to give an opinion on the subject in question.

Speaking of the manner of using the warm bath in Egypt, he says, "The bathers here are not imprisoned, as they are in Europe, in a kind of tub, where one is never at one's ease. Extended on a cloth spread out, with the head supported by a small cushion, they can stretch themselves freely in every posture, whilst they lie quite at their ease, enveloped in a cloud of odoriferous vapours, which penetrates all their pores. In this situation they repose for some time, till a gentle moisture upon the skin appears, and by degrees diffuses itself over the whole body. A servant then comes and *masses* them (as it is called, from a word in the Arabic language, which signifies *to touch in a delicate manner*.) He

“ seems to knead the flesh, but without causing
“ the smallest pain; and when that operation is
“ ended, he puts on a glove, made of woollen stuff,
“ and rubs the skin for a considerable time.

“ During the whole of this time the sweat continues to be most profuse; and a considerable quantity of scaly matter, and other impurities, which obstructed the pores of the skin, are removed, and the skin becomes quite soft, and as smooth as satin.

“ When this operation is ended, the bather is conducted into a closet, in which there is a cistern, supplied with hot, and with cold water, which comes into it through two separate pipes, each furnished with a brass cock. Here a lather of perfumed soap is poured over him.

“ After being well washed and wiped, a warm sheet is wrapped round him, and he follows the attendant through a long winding passage into an external and more spacious apartment. This transition from heat to cold produces no disagreeable sensations, nor any bad consequences.

“ In this airy apartment a bed of repose is found prepared, and fresh and dry linen is brought. A pipe is also brought, and coffee is served.

“ Coming out of a hot bath, where one was surrounded by a cloud of warm vapours till the sweat gushed from every pore, and being transported into the free air of a spacious apartment, the breast dilates, and one breathes with voluptuousness. The pores of the body being perfectly

“fectly cleaned, and all obstructions removed, one
 “feels as it were regenerated; and one experiences
 “an universal comfort. The blood circulates with
 “freedom, and one feels as if disengaged from an
 “enormous weight, with a sense of supleness and
 “lightness, which is as new as it is delightful. A
 “lively sentiment of existence diffuses itself over
 “the whole frame, and the soul, sympathizing in
 “these delicate sensations, enjoys the most agree-
 “able ideas. The imagination, wandering over the
 “universe, which it embellishes, sees on every side
 “the most enchanting pictures—every where the
 “image of happiness!

“If the succession of our ideas be the real mea-
 “sure of life, the rapidity with which they then
 “recur to the memory, and the vigour with which
 “the mind runs over the extended chain of them,
 “would induce a belief, that in the two hours of
 “delicious calm that succeeds the bath, one has
 “lived a number of years!”

END OF THE THIRTEENTH ESSAY.

ESSAY XIV.

SUPPLEMENTARY OBSERVATIONS
RELATING TO
THE MANAGEMENT
OF
FIRES IN CLOSED FIRE-PLACES.

CONTENTS OF THIS ESSAY.

Necessity of keeping the doors of closed Fire-places well closed; and of regulating the air that is admitted into them.—Account of some experiments, which shewed, in a striking manner, the very great importance of those precautions.—A method is proposed for preventing the passage of cold air into the large fire-places of Brewhouse Boilers, Distillers Coppers, Steam-Engine Boilers, &c. while they are feeding with coals.—Bad consequences which result from overloading closed Fire-places with fuel.—Computations, which shew, in a striking manner, the vast advantages that that will be derived from the use of proper care and attention in the management of fire, and in the direction and economy of the heat which results from the combustion of fuel.

ESSAY XIV.

Of the Management of Fires in closed Fire-places.

THOUGH I have already mentioned, more than once, the necessity of preventing the entrance of air into a closed fire-place, by any other passage than by the register of the ash-pit door, and have strongly recommended the keeping of the door of the fire-place constantly closed; yet, as I have since found that those precautions are even of more importance than I had imagined, I conceived that it might be useful to mention the subject again, and give an account of the series of experiments, from the results of which I have acquired new light in respect to it.

In fitting up a large shallow circular kitchen boiler (one of those I put up in the kitchen of the house formerly occupied by the Board of Agriculture) I made an experiment, which, though it appeared to me at the time to have succeeded perfectly, led me into an error, that afterwards caused me a great deal of embarrassment. I constructed the fire-place of the boiler, of a peculiar form, for the express purpose of *burning the smoke*; imagining, that if I could succeed in that attempt, I should not only get more heat from any given quantity of coals, but also, that the narrow horizontal canal that carried off the smoke from the fire-place to the chimney, would be much less liable to be choaked

choaked up by soot or dust. The fire-place was made rather longer than usual; and near the farther end of it there was a thin piece of fire-stone, placed edge-wise, which run quite across it, from side to side, a space being left about $2\frac{1}{2}$ inches wide, between the lower edge of this stone and the bars of the grate, while the bottom of the boiler rested on its upper edge.

From this description it is evident, that the flame of the burning fuel, after rising up and striking against that part of the bottom of the boiler which was situated over the hither part of the fire-place, must necessarily pass under the lower edge of the stone just mentioned, in order to get into the canal leading to the chimney; and I fancied, that by taking care to keep that *narrow passage* constantly occupied by red-hot coals, the smoke, being forced to pass through between them, would necessarily take fire, and burn. This actually happened; and when I left a small opening in the door of the fire-place, to give admittance to a little fresh air to facilitate and excite the combustion, the flame became so exceedingly vivid and clear, that I promised myself great advantages from this new arrangement.

Being soon after engaged in putting up a large square boiler in the kitchen of the Foundling Hospital, I there introduced the same contrivance;—but how great was my surprise on finding, that notwithstanding the extreme vivacity of the fire, the contents of the boiler could not be brought to boil in less time than five hours! The fire-place,

it is true, was small, and the brick-work was new and wet; but I found that the quantity of coals consumed was such, that had there been no essential fault in the construction of the fire-place, nor in the management of the fire, the contents of the boiler ought, notwithstanding these unfavourable circumstances, to have boiled in less than one-third part of the time that had been found necessary to bring it into a state of ebullition.

Having wasted two or three days in attempting to remedy the defects of this fire-place, without changing entirely the principles of its construction;—concealing my disappointment from those who it was necessary should have confidence in my skill, by representing to them all that had been done as being a mere experiment, I pulled down the work to the foundation, and caused it to be rebuilt on principles which I knew could not fail to succeed, and which did succeed to the utmost of my expectations.

Though I ruminated often on this disappointment, I did not find out the real cause of my ill success for some months. This discovery was, however, at length made, and in such a manner as to leave no room for doubt.

Having, as an experiment, constructed in the kitchen of the Military Academy at Munich, an apparatus for the performance of all the different processes of cookery, and to serve occasionally for warming a room, with one and the same fire, thinking that the principles of the invention might be employed with advantage in the construction of
cottage

cottage fire-places, on my return to this country I made the experiment at my lodgings in Brompton-row, Knightsbridge; and, desirous of accommodating the contrivance to what I think may be called a prejudice of Englishmen, I contrived the machinery in such a manner as to render the fire *visible*.

A small low grate was fixed in the middle of a large open kitchen fire-place, and on each side of it were fixed in brick-work two Dutch ovens, one above the other; the bottom of the lower oven, on each side, being nearly on a level with the top of the grate; and as each of the ovens was surrounded by flues, I had hopes, that by causing the flame and smoke of the open fire to incline downwards, and enter an horizontal canal, situated just behind the fire, and there to separate to the right and left, and circulate under the iron bottoms of the ovens, they would, by that means, be sufficiently heated to bake or to boil; and even if the two upper ovens should not be found to be sufficiently heated to perform those processes of cookery, I thought, by leaving their doors open, they might at least be very useful, occasionally, for warming the room, acting in the manner of a German stove: but the experiment was far from succeeding as I expected.

The current of flame and smoke which arose from the open fire, was, without difficulty, made to bend its course downwards into the canal destined to receive it, and to circulate in the flues of the ovens; but, to my astonishment, I found that the ovens, instead of being heated, were barely warmed; an

accident, however, very fortunately for me, discovered to me the real cause of the ill success of the experiment.—Throwing a piece of paper on the top of the coals that were burning in the grate, in order to see if *the whole* of the large flame which I knew the paper must produce, would be drawn downwards into the horizontal opening of the canal, situated behind the back of the grate, I was surprized to find that this flame was not only drawn into this opening, but that it appeared to be violently *driven downwards*, to the very bottom of the canal.

In short, every appearance indicated that there was a very strong vertical *wind* that was continually blowing *directly downwards* into the opening of the canal: and it immediately occurred to me, that as this wind consisted of a stream of cold air, this air must necessarily cool the ovens almost as fast as the flame heated them; and I was no longer surprized at the ill success of my experiment.

On considering the subject with attention, I saw how impossible it must be for the current of hot vapour, flame, and smoke, that rises from burning fuel, to be made to pass off *horizontally*, or to deflect considerably from its direct ascension, *in contact with the cold air of the atmosphere*, without drawing after it a great deal of that cold air: and I now saw plainly why so much time and fuel were required to heat the boiler in the kitchen of the Foundling Hospital, in the experiments that were made with its first fire-place.

The cold air which entered the fire-place at its door,

door, and passing *over* the surface of the burning fuel, entered the flues of the boiler with the flame, cooled the bottom of the boiler almost as fast as the flame heated it.

The waste of heat that is occasioned *precisely in this manner* in the fire-places of steam-engines, brewers coppers, distillers coppers, &c. must be very great indeed. To be convinced of this fact, nothing more is necessary than to see how very imperfectly the entrance into one of these fire-places is closed by its single door, ill fitted to its frame—what a length of time the door is left *wide open* while the fire is stirring, or fresh coals are putting into the fire-place—and what an impetuous torrent of cold air rushes into the fire-place on those occasions.

As the cold air that comes into the fire-place in this manner, and passes *over* the burning coals, has very little to do in promoting the combustion of the fuel, and must necessarily be heated very hot in passing through the fire-place, and through the whole length of the flues of the boiler, it is easy to see what an immense quantity of heat this air must steal, and carry off into the atmosphere in its escape up the chimney.

To remedy this evil, the doors of all closed fire-places should be double, and they should be fitted to their frames with the greatest nicety, which may easily be done by making them shut against the front edge of their frames, instead of being fitted *into them*, or into grooves made to receive them; and when the fire is burning, these doors
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should

should be opened as seldom as possible, and for as short a time as possible. I have already mentioned the necessity of these precautions in my sixth Essay, but they are of so much importance that they can hardly be too often recommended, nor can too much pains be taken to shew why they are so necessary.

In all cases where a fire-place is very large, and where, in consequence of the large quantity of coals consumed in it, the fire-place door is necessarily kept open a great deal, I would earnestly recommend the adoption of a contrivance, which I think could not fail to turn out a complete remedy for the evil we have been describing—viz. the entrance of a torrent of cold air into the fire-place through its door-way.

The contrivance is this—to construct the floor or pavement of the area before the fire-place door in such a manner as to cut off all direct communication, without the fire-place, in front of it, between the ash-pit and the fire-place door-way; and when this is done, to build a porch, well closed above, and on every side, immediately before the fire-place door, and in such a manner that the fire-place door may open into it.

This porch must have a door belonging to it, situated on the side opposite to the fire-place door, which door (that belonging to the porch) must open outwards, and must fit its door-frame with considerable nicety. There must also be a glass window, either in this door, or over it, or on one side of it, or in one of the side walls of the porch;
and

and there must be sufficient room in the porch to allow of a certain provision of coals being lodged there, and kept ready for use.

When fresh coals are to be thrown into the fire-place, (as also when the door of the fire-place is to be opened for the purpose of stirring the fire, or for any other purpose) the person who is charged with the care of the fire enters the porch, and then, carefully shutting the door of the porch after him, he opens the fire-place door.

As no air can get into the porch from without, its door being closed, none can pass through it into the fire-place, and the fire-place door may be left open without the smallest inconvenience; and the person who tends the fire may take up as much time as he pleases in stirring it, or feeding it with fresh fuel, for little or no derangement of the fire, or loss of heat, will result from these operations. The fire will continue to burn nearly in the same manner as it did before the fire-place door was opened; and those immense clouds of dense smoke, which, to the annoyance of the whole neighbourhood, are now thrown out of the chimnies of all great breweries, distilleries, steam-engines, &c. as often as they are fed with fresh coals, will no longer make their appearance.

When these operations are finished, and the fire-place door is again closed, the door of the porch may be opened, and the provision of coals kept in the porch for immediate use may be again completed.

If the flame from the fire-place should be found to have any tendency to come into the porch, this
may

may be easily checked, by leaving a very small hole in the door of the porch for the admission of a small quantity of air, just enough to prevent this accident. This small hole might be furnished with a register.

But it is not merely through the opening by which the fuel is introduced, that cold air furtively finds its way into closed fire-places : it frequently enters in much too large quantities by the ash-pit door-way, and rushing up between the bars of the grate, and mixing with the flame, serves to diminish instead of increasing the heat applied to the bottom of the boiler ; and this never fails to happen when a *small fire is made in a large fire-place* ; or when a part of the grate happens not to be covered with burning fuel, especially when there is no register to the ash-pit door.

It should be remembered, that whenever more air enters a closed fire-place than is actually *decomposed* by the burning fuel, all that super-abundant air, not only is of no service whatever, but being itself heated at the expence of the fire, and going off hot by the chimney, occasions the loss of a quantity of heat that might have been usefully employed.

Ash-pit doors should always be furnished with registers, of whatever size the fire-place may be, for they are always indispensably necessary to the good management of a fire ;—and where small fires are occasionally made in large closed fire-places, the ascent of air through that part of the grate that is not covered with burning fuel should

be prevented, by sliding an iron-plate under the bars of the grate, or by some other contrivance equally effectual.

If the closed fire-places of boilers, great and small, were properly constructed, and if due care were taken to introduce in a proper manner, and to regulate the quantity of the air that is necessary to the perfect combustion of the fuel, their grates might be made considerably narrower than they now are, and the bottoms of their boilers might be placed at a greater height above them; from which arrangement several advantages would be derived: but as long as so little care is taken to keep the door of the fire-place well closed, and to prevent too much air from coming up through the grate, by the openings between its bars, the bottom of the boiler must be placed very near the surface of the burning coals, otherwise so much more cold air than is wanted will find its way into the fire-place, and mix with the flame, that the bottom of the boiler cannot fail to be sensibly cooled by it.

When a boiler is properly set, if a fire, of a moderate size, that burns well, does not heat it in a reasonable time, the fault must necessarily lie in the bad management of the doors and registers of the fire-place: for as the heat required to heat the boiler is *a certain quantity*, which cannot vary, if the boiler is not found to be heated as fast as it ought to be, by the quantity of fuel consumed, a part of the heat generated must necessarily go to heat something else; and there is nothing at hand that
can

can take it, except it be the cold air of the atmosphere; which, whenever it is permitted to enter a fire-place in an improper manner, or in too large quantities, never fails to rob it of a great deal of heat, which it takes with it up the chimney, as has already been observed.

If the door by which the fuel is introduced into the closed fire-place of a kitchen boiler is not kept constantly closed, it is quite impossible that a well-constructed fire-place can answer.—With such neglectful management *a bad fire-place* is certainly *preferable* to a good one; for when an enormous quantity of fuel is consumed under a boiler, some part of it must necessarily find its way into it, even if, instead of being set in brick-work, it were suspended over the fire, in the open air; but when a fire-place is made no larger than is necessary in order to heat the boiler in a proper time, when the door of the fire-place is kept closed, it is not surprising that the boiler should be much slower in acquiring heat, when a stream of cold air is permitted to strike against its bottom, and blow all the flame and hot smoke out of its flues into the chimney.

It would be just as unreasonable to object to the fire-places I have recommended on account of the *trouble of keeping them closed*, as it would be to object to a scheme for warming a dwelling-house merely because it required that the street-door should not be left open.—The cases are exactly similar; and if insisting on the attention of servants in the one case is not unreasonable; it cannot be so in the other.

There was a time, no doubt, (when the doors of rooms first came in fashion) that the trouble they occasioned to servants was considered as an hardship, and severity in exacting attention to the proper management of them as a grievance; but all improvements are progressive, and we may hope that a time will come when it will be considered as careless and slovenly to leave open the door of a closed fire-place. In the mean time it is my duty to declare, in the *most serious and public manner*, that those who have not influence enough with their servants to secure due attention being paid to this important point, would do wisely not to attempt to introduce the improvements in closed fire-places which I have recommended. And it is not sufficient merely to be attentive to the shutting of the fire-place door; care must be taken also to manage properly the register of the ash-pit door, otherwise, if it be left too much opened, a great deal too much cold air will find its way into the fire-place between the bars of the grate.

When a closed fire-place is properly constructed, it is hardly to be believed how small a passage is sufficient to admit as much air as is necessary or useful to maintain the combustion of the fuel.

A fault, which is often committed in the management of the closed fire-places I have recommended, is the *over-loading them with fuel*. This mistake has several bad consequences, and among them there is one which would not naturally be expected; it prolongs the kindling of the fire, and
very

very frequently so much so as to prolong the heating of the boiler, notwithstanding the fierceness of the fire when the fuel is all inflamed.

Great care should at all times be taken not to overcharge a fire-place with fuel, but more especially when the fire is first kindled, and the fire-place, and every thing about it, is cold. It should be remembered that a great deal of heat is necessary to warm the fuel itself, and bring it to that degree of heat which it must have in order to its being capable of taking fire; and as long as there remains any cold fuel in the fire-place to be heated, very little heat will reach the bottom of the boiler.

All the money that is expended in the purchase of wood to kindle coal fires, is money well laid out; and it is by no means good economy to be sparing of wood in kindling such fires. In many cases it would, I am convinced, be cheaper to burn wood than coals, even in London, especially in the closed fire-places of small kitchen boilers and stewpans, where a fire is wanted but for a short time. This proposal to burn wood instead of coals, or charcoal, has already been made more than once; and the more I have considered the subject, the more I am convinced that the former would turn out to be the cheapest fuel.

A great deal of fuel is consumed in this country for boiling water to make tea. I was curious to know how low it would be possible to reduce that

expencc, and afcertaincd that point by the following experiments and computations .

I fuppoſed a ſmall family, conſiſting of two perſons, to drink tea twice every day (morning and evening) during one whole year, and that 2 pints of water, at the temperature of 55° (the mean annual temperature of the atmofphere in Great Britain) was heated, and made to boil every time tea was made.

I found on enquiry that the moſt coſtly firewood that is fold in London, dry beech in billets, at the higheſt price it is ever fold at, coſt one farthing per lb. avoirdupois weight ; that is, at the rate of *two-pence* per billet, weighing, at an average 8lbs. By wholeſale theſe billets are fold in London at *one-penny-half-penny* each.

I had ſome of theſe billets ſawed into lengths of about 5 inches, and then ſplit into ſmall pieces (about the ſize of the end of one's little finger) and bound up with a packthread into little ſmall bundles, weighing about 4 or 5 ounces each. In the middle of each bundle there were a few ſmaller ſplinters, and a very ſmall piece of paper, that the bundle might eaſily be ſet on fire with a candle, or with a common match.

On uſing the ſmall portable furnace repreſented in the figure 63, and deſcribed in chap. XI. of the Tenth Eſſay, page 293, and the ſmall tin tea-kettles repreſented in the figure 68, in that Eſſay, I found, by an experiment, which was repeated ſeveral times, that I could boil 2 pints
of

of water with a bundle of wood, weighing 4 ounces.

Hence it appears that the daily consumption of wood in boiling water for tea for two persons would be 8 ounces, or half a pound weight; consequently for one year, or 365 days, $182\frac{1}{2}$ lbs. would be required; and that quantity, at 1 farthing the pound, would cost $182\frac{1}{2}$ farthings = $45\frac{1}{4}$ pence, or *three shillings and nine-pence-halfpenny and half a farthing.*

Were it possible to heat so small a quantity of water, with the consumption of the same proportion of fire-wood, as was found to be sufficient for heating water in some of the experiments, of which an account is given in the Sixth Essay, the annual expence for fire-wood for boiling water for making tea for two persons twice a day, would amount to no more than 57 lbs. weight, which, at the London price of this wood, one farthing in the pound, would cost 57 farthings, or *one shilling and two-pence-farthing.*

It is by computations of this sort, founded on the results of unexceptionable experiments, that we are enabled to appreciate the vast saving to individuals, and to the public, that would result from proper attention being paid to the management of fire, and to the economy of heat.

END OF THE FOURTEENTH ESSAY.

ESSAY XV.

OF THE USE OF STEAM,

AS A

VEHICLE FOR TRANSPORTING HEAT

FROM

ONE PLACE TO ANOTHER,

CONTENTS OF THIS ESSAY.

Many unsuccessful attempts have been made, at different times, to heat liquids by means of steam—Reason why these attempts failed—When steam is used for heating a liquid, it must be introduced into it far below its surface, otherwise, as heat does not descend in fluids, the liquid cannot be uniformly heated—Detailed account of an apparatus, by means of which liquid may be heated, and made to boil, by steam coming from a boiler at a distance, and introduced into them—This plan has been adopted with the most complete success—Description of the DYEING-HOUSE of Messrs. Gott and Co. at Leeds, in which all the Coppers are heated by steam—Description of the CULINARY STEAM APPARATUS in the kitchen at the house of the Royal Institution—Proposals for employing hot, or strong steam, in ALLUM WORKS, and in DISTILLERIES—Of the use that may be made of steam in DRYING-HOUSES.

E S S A Y XV.

Of the Use of Steam, as a Vehicle for transporting Heat.

MANY attempts have been made, at different periods, to heat liquids by means of steam introduced into them; but most of these have failed: and, indeed, until it was known that fluids are non-conductors of heat, and, consequently, that heat cannot be made to *descend* in them—(which is a recent discovery)—these attempts could hardly succeed; for, in order to their being successful, it is absolutely necessary that the tube, which conveys the hot steam, should open into the *lowest part* of the vessel which contains the liquid to be heated, or nearly on a level with its bottom; but as long as the erroneous opinion obtained, that heat could pass in fluids *in all directions*, there did not appear to be any reason for placing the opening of the steam tube *at the bottom of the vessel*, while many were at hand which pointed out other places as being more convenient for it.

But to succeed in heating liquids by steam, it is necessary, not only that the steam should enter the liquid at the bottom of the vessel which contains it, but also that it should enter it *coming from above*.

The

The steam-tube should be in a vertical position, and the steam should *descend* through it, previous to its entering the vessel, and mixing with the liquid which it is to heat; otherwise this liquid will be in danger of being forced back by this opening into the steam-boiler; for as the hot steam is suddenly condensed on coming into contact with the cold liquid, a vacuum is necessarily formed in the end of the tube; into which vacuum the liquid in the vessel—pressed by the whole weight of the incumbent atmosphere—will rush with great force, and with a loud noise; but if this tube be placed in a vertical position, and if it be made to rise to the height of six or seven feet above the level of the surface of the liquid which is to be heated, the portion of the liquid, which is thus forced into the lower end of the tube, will not have time to rise to that height before it will be met by steam, and obliged to return back into the vessel.

There will be no difficulty in arranging the apparatus in such a manner, as effectually to prevent the liquid to be heated from being forced backwards into the steam boiler; and, when this is done, and some other necessary precautions to prevent accidents are taken, steam may be employed, with great advantage, for heating liquids; and for keeping them hot, in a variety of cases, in which fire, applied immediately to the bottoms of the containing vessels, is now used.

In dying, for instance, in bleaching, and in brewing, and in the processes of many other

arts and manufactures, the adoption of this method of applying heat would be attended, not only with a great saving of labour, and of fuel, but also of a considerable saving of expence in the purchase and repairs of boilers, and of other expensive machinery: for, when steam is used instead of fire, for heating their contents, boilers may be made extremely thin and light; and, as they may easily be supported and strengthened by hoops and braces of iron, and other cheap materials, they will cost but little, and seldom stand in need of repairs.

To these advantages we may add others of still greater importance: Boilers intended to be heated in this manner may, without the smallest difficulty, be placed in any part of a room—at any distance from the fire;—and in situations in which they may be approached freely on every side. They may moreover easily be so surrounded with wood, or with other cheap substances, which form warm covering, as most completely to confine the heat within them, and prevent its escape. The tubes by which the steam is brought from the principal boiler (which tubes may conveniently be suspended just below the ceiling of the room) may, in like manner, be covered, so as almost entirely to prevent all loss of heat by the surfaces of them; and this, to whatever distances they may be made to extend.

In suspending these steam-tubes, care must, however, be taken, to lay them in a situation, *not perfectly*

feetly horizontal, under the ceiling, but to incline them at a small angle, making them rise gradually from their junction with the top of a large vertical steam-tube, which connects them with the steam-boiler, quite to their farthest extremities: for, when these tubes are so placed, it is evident that all the water formed in them, in consequence of the condensation of the steam in its passage through them, will run backwards, and fall into the boiler, instead of accumulating in them, and obstructing the passage of the steam, (which it would not fail to do were there any considerable bends or wavings, upwards and downwards, in these tubes) or, of running forward, and descending with the steam into the vessels containing the liquids to be heated;—which would happen if these tubes inclined *downwards*, instead of inclining upwards, as they recede from the boiler.

In order that clear and distinct ideas may be formed of the various parts of this apparatus,—even without figures,—I shall distinguish each part of it by a specific name: The vessel in which water is boiled in order to generate steam—and which, in its construction, may be made to resemble the boiler of a steam engine—I shall call the *steam-boiler*:—The vertical tube, which, rising up from the top of the boiler, conveys the steam into the tubes (nearly horizontal), which are suspended from the ceiling of the room, I shall call the *steam-reservoir*:—To the horizontal tubes I shall give the name of *conductors of steam*:—and to the (smaller)

tubes, which, descending perpendicularly from these *horizontal conductors*, convey the steam to the liquids which are to be heated, I shall, exclusively, appropriate the appellation of *steam-tubes*.

The vessels in which the liquids that are to be heated are put, I shall call the *containing vessels*.—These vessels may be made of any form; and, in many cases, they may, without any inconvenience, be constructed of wood, or of other cheap materials, instead of being made of costly metals, by which means a very heavy expence may be avoided: or they may be merely pits sunk in the ground, and lined with stone, or with bricks.

Each *steam-tube* must descend *perpendicularly* from the *horizontal conductor* with which it is connected, to the level of the bottom of the *containing vessel* to which it belongs; and, moreover, must be furnished with a good cock, perfectly steam-tight; which may best be placed at the height of about six feet above the level of the floor of the room.

This *steam-tube* may either descend *within the vessel* to which it belongs, or *on the outside of it*, as shall be found most convenient. If it comes down on the outside of the vessel, it must enter it at its bottom, by a short horizontal bend: and its junction with the bottom of the vessel must be well secured, to prevent leakage. If it comes down into the vessel, on the inside of it, it must descend to the bottom of it, or at least to within a very few inches of the bottom of it; otherwise the
liquid

liquid in the vessel will not be uniformly, or equally heated.

When the steam-tube is brought down on the inside of the containing vessel, it may either come down perpendicularly, and without touching the sides of it, or it may come down on one side of the vessel, and in contact with it.

When several steam-tubes, belonging to different containing vessels, are connected with one and the same horizontal steam conductor, the upper end of each of these tubes, instead of being simply attached by solder or by rivets to the under side of the conductor, must *enter*, at least one inch, *within the cavity of it*; otherwise the water resulting from a condensation of a part of the steam in the conductor, by the cold air which surrounds it, instead of finding its way back into the steam-boiler, will descend through the steam-tubes, and mix with the liquids in the vessels below; but when the open ends of these tubes *project upwards within the steam conductor*, though it be but to a small height above the level of its under side, it is evident that this accident cannot happen.

It is not necessary to observe here, that, in order that the ends of the steam-tubes may project *within the horizontal conductor*, the diameters of the former must be considerably less than the diameter of the latter.

To prevent the loss of heat arising from the cooling of the different tubes through which the
steam

steam must pass in coming from the boiler, all those tubes should be well defended from the cold air of the atmosphere, by means of warm covering; but this may easily be done, and at a very trifling expence. The horizontal conductors may be enclosed within square wooden tubes, and surrounded on every side by charcoal dust,—fine sawdust,—or even by wool;—and the steam tubes, as well as the reservoir of steam, may be surrounded, first by three or four coatings of strong paper, firmly attached to them by paste, or glue, and covered with a coating of varnish; and then by a covering of thick coarse cloth. It will likewise be advisable to cover the horizontal conductors with several coatings of paper; for if the paper be put on to them while it is wet with the paste or glue, and if care be taken to put it on in long slips, or bands, wound regularly round the tube in a spiral line, from one end of it to the other, this covering will be useful, not only by confining more effectually the heat, but also, by adding very much to the strength of the tube, and rendering it unnecessary to employ thick and strong sheets of metal in the construction of it.

However extraordinary and incredible it may appear, I can assert it as a fact, which I have proved by repeated experiments, that if a hollow tube, constructed of sheet copper $\frac{1}{16}$ of an inch in thickness, be covered by a coating only twice as thick, or $\frac{1}{8}$ of an inch in thickness, formed of layers of strong paper, firmly attached to it by good glue,

the strength of the tube will be *more than doubled* by this covering.

I found by experiments, the most unexceptionable and decisive—of which I intend at some future period to give to the public a full and detailed account,—that the strength of paper is such, when several sheets of it are firmly attached together with glue, that a solid cylinder of this substance, the transverse section of which should amount to only one superficial inch, would sustain a weight of 30,000 lbs. avoirdupois, or above 13 tons, suspended to it, without being pulled asunder or broken.

The strength of hemp is still much greater, when it is pulled equally, in the direction of the length of its fibres. I found, from the results of my experiments with this substance, that a cylinder of the size above mentioned, composed of the straight fibres of hemp, glued together, would sustain 92,000 lbs. without being pulled asunder.

A cylinder, of equal dimensions, composed of the strongest iron I could ever meet with, would not sustain more than 66,000 lbs. weight; and the iron must be very good not to be pulled asunder with a weight equal to 55,000 lbs. avoirdupois.

I shall not, in this place, enlarge on the many advantages that may be derived from a knowledge of these curious facts. I have mentioned them now, in order that they may be known to the public; and that ingenious men, who have leisure for these researches, may be induced to turn their attention

tention to a subject, not only very interesting, on many accounts, but which promises to lead to most important improvements in mechanics.

I cannot return from this digression without just mentioning one or two results of my experimental investigations relative to the force of cohesion, or strength of bodies, which, certainly, are well calculated to excite the curiosity of men of science.

The strength of bodies of different sizes, *similar in form*, and composed of the *same substance*,—or the forces by which they resist being pulled asunder by weight suspended to them, and acting in the direction of their lengths—are *not in the simple ratio of the areas of their transverse sections*, or of their *fractures*;—but in a higher ratio—and this ratio is different in different substances.

The *form* of a body has a considerable influence on its strength, *even when it is pulled in the direction of its length*.

All bodies, even the most brittle, appear to be *torn asunder*, or their particles separated, or fibres broken, *one after the other*; and hence it is evident, that that *form* must be most favourable to the strength of any given body, pulled in the direction of its length, which enables the greatest number of its particles, or longitudinal fibres, to be separated to the greatest possible distance—short of that at which the force of cohesion is overcome,—before *any of them* have been forced *beyond* that limit.

It is more than probable that the apparent strength of different substances depends much more on the number of their particles that come into action before any of them are forced beyond the limits of the attraction of cohesion, than on any specific difference in the intensity of that force in those substances.

But to return to the subject more immediately under consideration.—As it is essential that the steam employed in heating liquids, in the manner before described, should enter the containing vessel at, or very near, its bottom, it is evident that this steam must be sufficiently strong, or elastic, to overcome, not only the pressure of the atmosphere, but also the additional pressure of the superincumbent liquid in the vessel; the steam boiler must, therefore, be made strong enough to confine the steam, when its elasticity is so much increased by means of additional heat, as to enable it to overcome that resistance. This increase of the elastic force of the steam need not, however, in any case, exceed a pressure of five or six pounds upon a square inch of the boiler, or *one third part*, or *one half*, of an atmosphere.

It is not necessary for me to observe here, that in this, and also in all other cases, where steam is used as a vehicle for conveying heat from one place to another, it is indispensably necessary to provide *safety-valves* of two kinds;—the one for letting a part of the steam escape, when, on the fire being suddenly increased, the steam becomes

so

so strong as to expose the boiler to the danger of being burst by it * ;—the other for admitting air into the boiler, when, in consequence of the diminution of the heat, the steam in the boiler is condensed, and a vacuum is formed in it ; and when, without this valve, there would be danger, either of the sides of the boiler being crushed, and forced inwards by the pressure of the atmosphere from without ; or of the liquid in the containing vessels being forced upwards into the horizontal steam-conductors, and from thence into the steam-boiler. The last-mentioned accident, however, cannot happen, unless the cocks in some of the steam tubes are left open.—The two valves effectually prevent all accidents.

The reader will, no doubt, be more disposed to pay attention to what has here been advanced on this interesting subject, when he is informed that the proposed scheme has already been executed on a very large scale, and with complete success ; and that the above details are little more than exact descriptions of what actually exists.

A great mercantile and manufacturing house at Leeds, that of Messrs. Gott, and Co. had the courage, notwithstanding the mortifying prediction of all their neighbours, and the ridicule with

* The steam which escapes out of the boiler through the safety-valve may very easily be made to pass into the reservoir of water which feeds the boiler, and be condensed there ; which will warm that water, and by that mean: save a quantity of heat, which otherwise would escape into the atmosphere, and be lost.

which the scheme was attempted to be treated, to erect a *dying-house*, on a very large scale indeed, on the principles here described and recommended.

On my visit to Leeds in the summer of the year 1800, I waited on Mr. Gott, who was then mayor of the town, and who received me with great politeness, and showed me the cloth-halls, and other curiosities of the place: but nothing he showed me interested me half so much as his own truly noble manufactory of superfine woollen cloths.

I had seen few manufactories so extensive, and none so complete in all its parts. It was burnt to the ground the year before, and had just been rebuilt, on a larger scale; and with great improvements in almost every one of its details.

The reader may easily conceive that I felt no small degree of satisfaction, on going into the *dying-house*, to find it fitted up on principles which I had some share in bringing into repute, and which Mr. Gott told me he had adopted in consequence of the information he had acquired in the perusal of my *Seventh Essay*.

He assured me that the experiment had answered, even far beyond his most sanguine expectations; and, as a strong proof of the utility of the plan, he informed me, that his next door neighbour, who is a dyer by profession, and who, at first, was strongly prejudiced against these innovations, had adopted them, and is now convinced that they are real improvements.

Mr. Gott assured me, that he had no doubt but they would be adopted by every dyer in Great Britain in the course of a very few years.

The dying-house of Messrs. Gott and Co. which is situated on the ground floor of the principal building of the manufactory, is very spacious, and contains a great number of coppers, of different sizes; and as these vessels, some of which are very large, are distributed about promiscuously, and apparently without any order in their arrangement, in two spacious rooms,—each copper appearing to be insulated, and to have no connection whatever with the others,—all of them together form a very singular appearance.

The rooms are paved with flat stones, and the the brims of all the coppers—great and small—are placed at the same height (about three feet) above the pavement. Some of these coppers contain upwards of 1800 gallons; and they are all heated by steam from *one steam-boiler*, which is situated in a corner of one of the rooms, almost out of sight.

The horizontal tubes, which serve to conduct the steam from the boiler to the coppers, are suspended just below the ceiling of the rooms: they are made—some of lead—and some of cast-iron; and are from four to five inches in diameter; but when I saw them, they were naked, or without any covering to confine the heat. On my observing to Mr. Gott that coverings for them would be useful, he told me that it was intended

that they should be covered, and that coverings would be provided for them.

The vertical *steam-tubes*, by which the steam passes down from the horizontal *steam-conductors* into the coppers, are all constructed of lead; and are from $\frac{1}{4}$ of an inch to $2\frac{1}{2}$ inches in diameter; being made larger or smaller according to the sizes of the coppers to which they belong. These steam-tubes all pass down on the *outsides* of their coppers, and enter them horizontal at the level of their bottoms. Each copper is furnished with a brass cock, for letting off its contents; and it is filled with water from a cistern at a distance, which is brought to it by a leaden pipe. The coppers are all surrounded by thin circular brick-walls, which serve not only to support the coppers, but also to confine the heat.

The rapidity with which these coppers are heated, by means of steam, is truly astonishing. Mr. Gott assured me, that one of the largest of them, containing upwards 1800 gallons, when filled with cold water from the cistern, requires no more than *half an hour* to heat it till it actually boils!—By the greatest fire that could be made under such a copper, it would hardly be possible make it boil in less than an hour.

It is easy to perceive that the *saving of time*, which will result from the adoption of this new mode of applying heat, will be very great;—and it is likewise evident that it may be increased, almost without limitation, merely by augmenting the

the diameter of the steam-tube: Care must, however, be taken, that the boiler be sufficiently large to furnish the quantities of steam required.—The *saving of fuel* will also be very considerable: Mr. Gott informed me, that, from the best calculation he had been able to make, it would amount to near two-thirds of the quantity formerly expended, when each copper was heated by a separate fire.

But these savings are far from being the only advantages that will be derived from the introduction of these improvements in the management of heat: There is one, of great importance indeed—not yet mentioned—which alone would be sufficient to recommend the very general adoption of them.—As the heat communicated by steam can never exceed the mean temperature of boiling water by more than a very few degrees, the substances exposed to it can never be injured by it.

In many arts and manufactures this circumstance will be productive of great advantages, but in none will its utility be more *apparent* than in cookery; and especially in public kitchens,—where great quantities of food are prepared in large boilers;—for, when the heat is conveyed in this manner, all the labour now employed in stirring about the contents of those boilers, to prevent the victuals from being spoiled by burning to the bottoms of them, will be unnecessary; and the loss of heat occasioned by this stirring, prevented;—and, instead of expensive coppers, or metallic boilers, which

which are sometimes unwholesome, and always difficult to be kept clean, and often stand in need of repairs,—common wooden tubs may, with great advantage, be used as culinary vessels; and their contents may be heated by *portable fire-places*, by means of steam-boilers attached to them.

As these portable fireplaces and their steam, boilers may, without the smallest inconvenience, be made of such weight, form, and dimensions, as to be easily transported from one place to another, by two men; and be carried through a door-way of the common width;—with this machinery, and the steam-tubes belonging to it, and a few wooden tubs, a complete public kitchen, for supplying the poor, and others, with soups, and also with puddings, vegetables, meat, and all other kinds of food prepared by *boiling*, might be established in half an hour, in any room, in which there is a chimney (by which the smoke from the portable fire-place can be carried off); and, when the room should be no longer wanted as a kitchen, it might, in a few minutes, be cleared of all this culinary apparatus, and made ready to be used for any other purpose.

This method of conveying heat is peculiarly well adapted for heating baths: It is likewise highly probable that it would be found useful in the bleaching business, and in washing linen. It would also be very useful in all cases where it is required to keep any liquid at about the boiling point for a long time without making it boil; for the quantity
of

of heat admitted may be very nicely regulated by means of the brass cock belonging to the steam-tube. Mr. Gott showed me a boiler in which shreds of skins were digesting in order to make glue, which was heated in this manner; and in which the heat was so regulated, that, although the liquid never actually boiled, it always appeared to be upon the very point of beginning to boil.

This temperature had been found to be best calculated for making good glue. Had any other *lower* temperature been found to answer better, it might have been kept up with the same ease, and with equal precision, by regulating properly the quantity of steam admitted.

I need not say how much this country is obliged to Mr. Gott, and his worthy colleagues.—To the spirited exertions of such men—who abound in no other country—we owe one of the proudest distinctions of our national character;—that of being *an enlightened and an enterprising people.*

In fitting up the great kitchen at the house of the Royal Institution, I availed myself of that opportunity to show, in a variety of different ways, how steam may be usefully employed in heating liquids.

On one side of the room, opposite to the fire-place, and where there is no appearance of any chimney, I fitted up a steam-boiler, of cast-iron, which, to confine the heat, is so compleatly covered up by the brick-work in which it is set, that no part of it is seen. This boiler is supplied with
water

water from a reservoir at a distance (which is not seen) and by means of a cock, which is regulated by an hollow floating ball of thin copper, the water in the boiler always stands at the same height, or level.

The steam from this boiler rises up perpendicularly in a tin tube, which is concealed in a square wooden tube, by the side of the wall of the room, and enters an horizontal tin tube (concealed in the same manner) which lies against the wall, and just under the ceiling.

From this horizontal steam *conductor* three tubes descend, perpendicularly (concealed in three square wooden tubes) and enter three different kitchen boilers (on a level with their bottoms) which are set in brick work, against the same side of the room where the steam boiler is situated.

As each of these boilers has its separate fire-place, properly furnished with a good double door, and register ash-pit door; and also with a canal, furnished with a damper, for carrying off the smoke; either of these three boilers may be used for cooking, either with a fire made under it, or with steam brought into it, from the neighbouring steam-boiler.

The object I had principally in view in this arrangement was to shew, in the most striking and convincing manner, that all the different processes of cookery, which are performed by boiling, such as boiling meat and vegetables *in boiling water*—making soups—stewing, &c. may, in all cases, be performed

performed quite as well, and in many much better, by heating the liquid which is to be boiled, and keeping it boiling, by admitting hot steam *into it*, than by making a fire *under it*.

By using one of these boilers *alternately* in these two ways, on different days, in preparing the same kind of food, I concluded that all doubts on this subject would be most effectually removed.

To exhibit in a manner still more striking the application of steam to the boiling of liquids for culinary purposes, the following arrangement has been made, and completed.—An horizontal steam-conductor (concealed in a square wooden tube) communicating, at right angles, with the steam conductor before described, passes, just below the ceiling, from the middle of one side of the room, to the middle of the ceiling; and ends in a vessel, in the form of a flat drum, about ten inches in diameter, and five inches high, which is attached to the ceiling, perpendicularly over the center of a large table, which is placed in the middle of the room.

On the outside of this drum, or short hollow cylinder (which is made of tin, and covered with wood, to confine the heat) there are, at equal distances, four projecting horizontal tubes, each about one inch in diameter, and two inches long, which communicate with the inside of the drum. These tubes all point to the same center, namely, to the center of the drum.

To each of these short horizontal tubes, there is
fixed

fixed one end of a steam tube composed of three pieces, fixed to each other, and moveable, by means of joints, which are all steam-tight.

The end of this compound flexible steam-tube is united to the end of the short tube, which projects from the side of the drum, by means of a steam-joint, in such a manner, that the steam-tube, attached to the drum, and communicating with it, may either be folded up, in joints, or lengths, just under the ceiling, or it may be made to hang down from the end of the short tube to which it is attached.—The lower joint, or rather division of this flexible steam-tube, which reaches nearly to the top of the table, is furnished with a brass cock, by which it is occasionally closed; or rather, by which it is always kept closed when it is not in actual use.

I might perhaps spare myself the trouble of describing the manner in which this culinary steam apparatus is used, as the imagination of the reader will most probably have run before me. I shall, however, just mention a very striking and pleasing manner of making the experiment, in which the action of this machinery will be exhibited to great advantage.

If the cold water, which is to be heated, and made to boil by the steam, is put into a large glass bowl, or jar; on plunging the lower end of one of the flexible steam-tubes into the water, and then opening the steam-cock, the agitation into which the water in the glass vessel will be thrown will be visible

visible through the glass; and the passage of the steam, in its elastic form, upwards, through the water into the air, *after the water has become boiling hot*, and not before, will be an instructive, as well as an amusing experiment.

Those of the flexible steam-tubes which are not in actual use, are kept so folded up, (in order to their being out of the way) that their two upper divisions, lying by the side of each other, in an horizontal position, are just under the ceiling of the room; while their lower divisions hang vertically downwards, pointing towards the table.

In order that the kitchen may not be filled with steam when any of the boilers on the side of the room are used, their covers are all furnished with steam-tubes, which, communicating by a particular contrivance, with an horizontal steam-tube, which lies immediately over these boilers just under the ceiling, and which, by passing through the wall of the building, opens into the external air, all the waste steam from these boilers is carried out of the kitchen.

Before I conclude this Essay, I shall add a few observations concerning an application of steam, which has not yet, to my knowledge, been made, but which there is much reason to think would turn out to be of very great importance indeed in many cases.—This is the employing of it for communicating *degrees of heat above that of boiling water*.

I was led to meditate on this subject by an account I received, not long ago, of some very surprising

prizing effects which were produced in bleaching, by using the steam of a very strong solution of potash for boiling the linen, instead of water; as I was confident that no part of the alkali could possibly be evaporated in this process, I could not account in any other way for the effects produced, but by supposing them to have been owing to the *high temperature* of the steam which rose from this strong lixivium: and, as steam, at a high temperature, might easily be procured, and applied to the linen, without the use of the alkali, I thought it would be worth while to try the experiment with hot steam, produced from pure water. I mentioned this idea to Mr. Duffin, secretary of the Linen Board in Ireland, who is himself concerned, in an extensive way, in the bleaching business, who has promised to make some experiments on this subject, which I took the liberty to point out, and to recommend to him, as being likely to lead to interesting results.

Meditating on the various uses to which *hot*, or (which is the same thing) *strong steam* might be applied, it occurred to me that it would probably be found to be extremely useful in *allum works*, for concentrating the liquor from which allum is crystalized. There are, as is well known, many difficulties attending the evaporation and concentration of that liquid; and it is never done without occasioning a very considerable expence, as well for fuel, of which large quantities are consumed, as
also

also on account of the frequent repairs of the pans, which are found to be necessary.

Most, if not all these difficulties, might, I think, be avoided, by introducing strong steam into this liquor, instead of concentrating it over a fire. This concentration might certainly be effected as well, and probably better, and more expeditiously, by using hot steam, than by the immediate use of the heat of a fire; and the expence occasioned by the wear and tear of the apparatus would, no doubt, be much less in the former case than in the latter: and, if it should be found (which is not unlikely) that *some certain temperature* is more advantageous in this process than any other, *that temperature*, when once discovered, may be preserved, with very little variation, when steam is used (by placing a valve, loaded with a proper weight, in the steam-tube, and obliging the steam to lift that valve, in order to pass through the tube); but there is no possibility of regulating, with any precision, the degrees of heat employed, when liquids are evaporated in boilers over a fire.

I would just point out one more application of steam, which, if I am not much mistaken, will turn out to be very advantageous indeed, in many respects;—it may be employed in heating the fermented liquor from which ardent spirits are distilled.

A proposal for introducing watery vapour into a liquor from which pure ardent spirits are to be distilled, or forced away by heat, will, no doubt, be thought very extraordinary by those who have

never meditated on the subject ; but when they shall have considered it with attention, they will find reason to conclude that this method of distilling bids fair to be very useful. The saving of expence for coppers, and other costly utensils and machinery, would be very considerable ; and the danger of the flavour of the spirits being injured by the burning of the liquor to the sides of the copper, would be entirely removed.

Steam has already been introduced, in several great manufactories in this country, into *drying-houses*, and employed, with the best effects, for heating and drying linen, cotton, and woollen goods, after they have been washed :—it has also been used in the *drying-rooms* of several paper manufactories. When it is used for any of these purposes, it should be introduced into tubes of large diameter, or into several smaller tubes, constructed of very thin sheet copper (or into any other metallic tubes, *having a large surface*, that would be cheaper) and these tubes should be placed nearly in an horizontal position in the *lower part* of the drying-room, and *under* the goods that are to be dried ; and, (in order to economize the heat as much as possible) the water resulting from the condensation of the steam in the steam-tubes, should be conducted, by small tubes, well covered with warm covering, into the reservoir which feeds the steam-boiler.

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