ENCYCLOPÆDIA PERTHENSIS.

BLEACHING.

INTRODUCTION.

(1.) BLEACHING may be defined, the art of whitening linen and cotton cloths, yarns, &c. It is a proceſs of conſiderable importance to manufacturers, and in which ſome very valuable improvements have been lately introduced. The practice of wetting cloths on the field is not now followed; and the uſe of ſulphuric acid (oil of vitriol) for ſouring, in place of butter-milk and bran, is now univerſal.

(2.) We ſhall firſt deſcribe the methods, which, with ſome few variations, were formerly practiſed: and, after taking notice of the chemical improvements of the old method, give an account of the *new proceſs*, for which we are chiefly indebted to the French chemiſts, and particularly to M. BERTHOLLET.

PART I.

OF THE OLD METHOD OF BLEACHING.

SECT. I. *Of* BLEACHING *in* GENERAL.

(3.) THE proceſs of bleaching is for the moſt part conducted in the following manner, by thoſe bleachers who have not availed themſelves of the late diſcoveries.

(4.) As ſoon as the cloth, which is intended to be bleached, has been ſorted into parcels of an equal fineneſs, each parcel is latched, linked, and then ſteeped. I. STEEPING is the firſt operation which the cloth undergoes, and is thus performed: the cloths are folded up diſtinctly, and laid in a large wooden veſſel; into which is thrown, blood-warm, a ſufficient quantity of water, or equal parts of water and ley, which has been uſed to white cloth only, or water with rye-meal or bran mixed with it, till the whole is thoroughly wet, and the liquor riſes over all. A cover of wood is then laid over the cloth, and ſecured with a poſt between the boards and the joiſting, to prevent the cloth from riſing, during the fermentation which enſues.

(5.) About ſix hours after the cloth has been ſteeped in warm water, and about twelve in cold, bubbles of air ariſe; a pellicle is formed on the ſurface of the liquor, and the cloth ſwells when it is not preſſed down. This effect continues from 36 to 48 hours, according to the warmth of the weather; about which time the pellicle or ſcum begins to fall to the bottom. But before this precipitation happens, the cloth muſt be taken out, and the proper time for taking it out is when no more air-bubbles ariſe. The cloth muſt now be well rinſed, diſpoſed regularly by the ſelvage, and waſhed in the pot-mill to carry off the looſe duſt. After this it is to be ſpread on the field to dry; and when thoroughly dried, it is then ready for bucking.

(6.) II. The 2d operation, BUCKING, or the application of falts, is thus performed: The firſt, or mother ley, is made in a copper, which we ſhall ſuppoſe, when full, holds 680 gallons of water. The copper is filled three fourths full of water, which is brought to boil: juſt when it begins, the following proportion of aſhes is put into it, viz. 30 lb. of blue, and as much white pearl aſhes; 200 lb. of Marcoſt aſhes (or, if theſe cannot be got, about 300 lb. of Caſhub); 300 lb. of Muſcovy, or blanch aſhes: the three laſt ought to be well pounded.

(7.) This liquor is allowed to boil for a quarter of an hour, ſtirring the aſhes from the bottom very often; after which the fire is taken away. The liquor muſt ſtand till it has ſettled, which takes at leaſt ſix hours, and then it is fit for the operation.

(8.) Out of the firſt, or mother ley, the ſecond, or that uſed in bucking, is made in this manner. Into another copper, holding 160 gallons, are put 150 gallons of water, 2 lb. of ſoft ſoap, and 8 gallons of mother ley; or, for cheapneſs, in place of the ſoap, when they have ley which has been uſed to white linen, called *white linen ley*, they take 56 gallons of it, leaving out an equal quantity of water. This is called BUCKING LEY.

(9.) The linens, after being taken up from the field to dry, are ſet in the *vat* or *cave* in rows, endwiſe, that they may be equally wetted by the ley; which, made blood-warm, is now thrown on them, and the cloth is afterwards trodden down by a man with wooden ſhoes. Each row undergoes the ſame operation, until the veſſel is full, or all the cloth in it. At firſt the ley is put on milk-warm, and, after ſtanding a little time on the cloth,

it is again let off by a cock into the bucking-copper, heated to a greater degree, and then put on the cloth again. This courſe is repeated for 6 or 7 hours, and the degree of heat gradually increaſed, till, at the laſt turn or two, it is thrown on boiling hot. The cloth remains after this 3 or 4 hours in the ley; after which the ley is let off, thrown away, or uſed in the firſt buckings, and the cloth undergoes another kind of proceſs.

(10.) III. The cloth is carried out, generally early in the morning, ſpread on the graſs, pinned down, expoſed to the ſun and air, and watered for the firſt ſix hours, ſo often, that it never is allowed to dry. Afterwards it is allowed to lie till dry ſpots appear before it is watered. After 7 at night it gets no more water, unleſs it be a very drying night. Next day, in the morning and forenoon, it is watered twice or thrice if the day be very dry; but if the weather be not drying, it gets no water; after which it is taken up dry if the green be clean; if not, it is rinſed, mill-waſhed, and laid out to dry again, to become fit for bucking.

(11.) This alternate courſe of bucking and watering is performed for the moſt part from 6 to 7 times, or more, before the linen is fit for ſouring; gradually increaſing the ſtrength of the ley from the firſt to the middle bucking, and from that gradually decreaſing it till the ſouring begins. The leys in the middle buckings are generally about a third ſtronger than the firſt and laſt.

(12.) IV. The 4th operation is SOURING, or the application of acids to cloth. It is not eaſy to ſay when this operation ſhould commence, as it depends moſtly on the experience of the bleacher. When the cloth has an equal colour, and is moſtly freed from the outer bark of the lint, it is though fit for ſouring; which is performed in the following manner.

(13.) Into a large vat is poured ſuch a quantity of butter-milk, or ſour milk, as will ſufficiently wet the firſt row of cloth; which is tied up in looſe folds, and preſſed down by two or three men barefooted. If the milk be thick, about an eighth of water is added to it; if thin, no water. Sours made with bran, or rye-meal and water, are often uſed inſtead of milk, and uſed milk-warm. Over the firſt row of cloth a quantity of milk and water is thrown, to be imbibed by the ſecond; and ſo it is continued till the linen to be ſoured is ſufficiently wet, and the liquor riſes over the whole. The cloth is then kept down by covers filled with holes, and ſecured with a poſt fixed to the joiſt, that it may not riſe.

(14.) Some hours after the cloth has been in the ſour, air-bubbles ariſe, a white ſcum is formed on the ſurface, and an inteſtine motion goes on in the liquor. In warm weather it appears ſooner, is ſtronger, and ends ſooner, than in cold weather. Juſt before this fermentation, which laſts 5 or 6 days, is finiſhed, (at which time the ſcum falls down,) the cloth ſhould be taken out, rinſed, mill-waſhed, and delivered to the women to be waſhed in ſoap ſuds.

(15.) V. The 5th operation is WASHING with ſoap and water. It is performed by two women, each placed oppoſite at a tub, made of very thick ſtaves, ſo that the edges, which ſlope inwards, are about 3 inches in thickneſs. A ſmall veſſel full of warm water is placed in each tub. The cloth is folded ſo that the ſelvage may be firſt rubbed with ſoap and warm water lengthwiſe, till it is ſufficiently impregnated with it. In this manner all the parcel is rubbed with ſoap, and afterwards carried to be bucked.

(16.) The ley now uſed has no ſoap in it, except what it gets from the cloth; and is equal in ſtrength to the ſtrongeſt formerly uſed, or rather ſtronger, becauſe the cloth is now put in wet. From the former operation theſe leys are gradually made ſtronger, till the cloth ſeems of an uniform white. After this the ley is more ſpeedily weakened than it was increaſed; ſo that the laſt which the cloth gets is weaker than any it got before. But the management of ſours is different; for they are uſed ſtrongeſt at firſt, and decreaſed ſo in ſtrength, that the laſt ſour, conſidering the cloth is then always taken up wet, may be reckoned to contain three fourths of water.

(17.) The cloth, after bucking, goes to the watering, as formerly; then it returns to the ſour, milling, waſhing, bucking, and watering again. Theſe operations ſucceed one another alternately till the cloth is whitened; at which time it is blued, ſtarched, and dried. This is the method uſed in the whitening FINE cloths.

(18.) The following is the method uſed in the whitening of COARSE cloths. Having ſorted the cloths according to their quality, they are ſteeped in the ſame manner as the fine, rinſed, waſhed in the mill, and dried before boiling. In this proceſs boiling ſupplies the place of bucking, as it takes leſs time, and conſequently is cheapeſt.

(19.) It is thus performed: 200 lb. of Caſhub-aſhes, 100 lb. of white Muſcovy, and 30 lb. of pearl aſhes, boiled in 500 gallons of water for a quarter of an hour, make the mother or firſt ley. The cloth boiler is then to be filled two thirds full with water and mother ley, about 9 parts of the former to one of the latter; ſo that the ley uſed for boiling the coarſe cloth is about one third weaker than that uſed in bucking the fine. Such a quantity of cloth is put into the foregoing quantity of ley, when cold, as can be well covered by it. The ley is brought gradually to the boil, and kept boiling for two hours; the cloth being fixed down all the time, that it may not riſe above the liquor. The cloth is then taken out, ſpread on the field, and watered, like the fine cloth.

(20.) As this boiling does not exhauſt the ſalts of the ley, the ſame liquor is continued to be uſed all that day, adding, at each boiling, ſo much of the mother ley as will bring it to the ſame ſtrength as at firſt. The ley by boiling loſes in quantity ſomewhat betwixt a 3d and a 4th; and it is ſuppoſed, that in ſtrength it loſes about a half, becauſe, in practice, it is found that adding to it half its former ſtrength in freſh ley, has the ſame effect on cloth. Therefore ſome freſh ley, containing a 4th part of the water, and the half of the ſtrength of the firſt ley, makes the 2d boiler equal in ſtrength to the firſt. To the 3d boiler they add ſomewhat more than the former proportion, and go on ſtill increaſing gradually to the 4th and 5th, which

which is as much as can be done in a day. The boiler is then cleaned, and next day they begin with freſh ley.

(21.) Theſe additions of freſh ley ought always to be made by the maſter bleacher, as it requires judgment to bring ſucceeding leys to the ſame ſtrength as the firſt. When the cloth comes to get the ſecond boiling, the ley ſhould be ſtronger by about a 30th part, and the deficiencies made up in the ſame proportion. For 6 or 7 boilings, or fewer, if the cloth be thin, the ley is increaſed in this way, and then gradually diminiſhed till the cloth is fit for ſouring.

(22.) The whiteſt cloth ought always to be boiled firſt, that it may not be hurt by what goes before. In this proceſs, if the cloth cannot be got dry for boiling, buſineſs does not ſtop as in the fine; for after the coarſe has been drained, on racks made for that purpoſe, it is boiled, making the ley ſtrong in proportion to the water in the cloth.

(23.) The common method of ſouring linen is, to mix ſome warm water and bran in the vat; then put a layer of cloth; than more bran, water, and cloth; and ſo on, till the cave is full. The whole is trampled with men's feet, and fixed as in the former proceſs. A thouſand yards of cloth, yard-wide, require betwixt 4 and 6 pecks of bran. The cloth generally lies about 3 nights and two days in the four. Others prepare their four 24 hours before, by mixing the bran with warm water in a ſeparate veſſel; and before pouring it on the cloth, they dilute it with a ſufficient quantity of water.

(24.) After the cloth is taken from the four, it ought to be well waſhed and rinſed again. It is given to men to be well ſoaped on a table, and afterwards rubbed betwixt the rubbing-boards. When it comes from them, it ſhould be well milled, and warm water poured on it all the time, if convenience will allow of it. Two or three of theſe rubbings are ſufficient, and the cloth ſeldom requires more. After the ſouring begins, the ley is diminiſhed in ſtrength by degrees; and 3 boilings after that are commonly ſufficient to finiſh the work.

(25.) VI. The laſt operation is to ſtarch, blue, dry, and bittle it, in a machine made for that purpoſe, which ſupplies the place of a calender, and is preferred by many. This method of bleaching coarſe cloths is that practiſed in Ireland for both fine and coarſe. The only material difference is, that there the bleachers uſe ſeldom other aſhes but kelp or caſhub. A ley is drawn from the former by cold water, which diſſolves the ſalts, and not the ſulphureous particles of the kelp-aſhes. This ley is uſed till the cloth is half whitened, and then they lay aſide the kelp ley for one made of caſhub-aſhes.

(26.) Agreeably to the preceding account, bleaching is naturally divided into, 1. Steeping and milling: 2. Bucking and boiling: 3. Alternate watering and drying: 4. Souring: 5. Rubbing with ſoap and warm water: and, 6. Starching and blueing. We ſhall treat of theſe different parts in their order, more particularly.

SECT. II. *Of* STEEPING *and* MILLING.

(27.) LINEN, in the different changes which it undergoes, before it arrives at the ſtate of what is called *Green linen*, contracts a great degree of foulneſs. This is chiefly communicated to it by the matters uſed in the dreſſing, which ſhould be effectually cleared off.

(28.) The firſt thing, therefore, that is to be done in bleaching, is to take off all the filth that is foreign to the flax, and might, in unſkilful hands, be fixed in the cloth. This is the object of ſteeping; and to accompliſh this end, the cloth is laid in a blood-warm water. A ſmaller degree of heat than that would not diſſolve the dreſſing ſo ſoon; and a greater might coagulate and fix, in the body of the linen, thoſe particles which ſhould be carried off. In a few hours the dreſſing made uſe of in weaving is diſſolved, and mixed with the water; and as it had acquired ſome degree of acidity before application, it becomes a ſpecies of ferment.

(29.) Each ferment promotes its own particular ſpecies of inteſtine motion; the putrid ferment ſets in motion the putrefactive fermentation; the vinous ferment gives riſe to the vinous fermentation; and the acid ferment to the acetous fermentation. That there is a real fermentation going on in ſteeping is evident from the air bubbles which ariſe, from the ſcum which gathers on the ſurface, and from the inteſtine motion of the whole liquor. That it muſt be the acetous fermentation, appears from this, that the vegetable particles, already ſoured, muſt firſt undergo this proceſs. The conſequence of this operation on the whole is, that the cloth comes out freed in a great meaſure from its ſuperficial dirt, and more pliant and ſoft than it was before.

(30.) When this inteſtine motion is pretty much abated, and before the ſcum ſubſides, bleachers take out their cloth. The ſcum, when no more air-bubbles riſe to ſupport it, ſeparates and falls down; and would again communicate to the cloth great part of the filth. But a longer ſtay would be attended with a much greater diſadvantage. The putrid follows cloſe upon the acetous fermentation; when the latter ends, the former begins, and were this to take place in any conſiderable degree, it would render the cloth black and tender; ſo that this ſhould be carefully prevented.

(31.) On theſe principles, the firſt queſtion to be conſidered, is, What is the moſt proper liquor for ſteeping cloth? The bleachers uſe plain water; white linen ley and water, equal parts; and rye-meal or bran mixed with water; but they always make uſe of ley when they have it.

(32.) After ſteeping, the cloth is carried to the putſtock mill, to be freed of all its looſe foulneſſes. There can be nothing contrived to anſwer the purpoſe ſo effectually as this mill. Its motion is eaſy, regular, and ſafe. While it preſſes gently, it turns the cloth; which is continually waſhed with a ſtream of water. Care muſt be taken, however, that no water be detained in the folds of the linen, otherwiſe that part may be injured.

SECT. III. *Of* BUCKING *and* BOILING.

(33.) THE ſubject of this ſection is the moſt important part of the whole proceſs, and deſerves a very nice examination. Its deſign is to looſen, and carry off, by the help of alkaline lixivia, that particular ſubſtance in cloth, which is the cauſe

of its brown colour. All aſhes uſed in ley, pearl aſhes excepted, ought to be well pounded, before they are put into the copper; for the marcoſt and caſhub are very hard, and with ſome difficulty yield their ſalt. As theſe two laſt contain a very conſiderable proportion of a matter, which will in ſome degree tinge white cloth; and as this is diſſolved much more by boiling than by the inferior degrees of heat, while the ſalts may be as well extracted by the latter; the water ſhould never be brought to boil, and ſhould be continued for ſome time longer under that degree of heat. The pearl aſhes ſhould never be put in till near the end, as they are very ſoluble in water. If theſe ſalts were always of an equal ſtrength, the ſame quantities would always make a ley equally ſtrong; but they are not. Salts of the ſame name differ very much from each other.

(34.) The Muſcovy aſhes become weaker every day, as every bleacher muſt have obſerved, till at laſt they turn quite effete. A decoction from them when new, muſt differ very much from one when they have been long kept. Hence a neceſſity of ſome exact criterion to diſcover when leys are of an equal ſtrength. The taſte cannot ſerve, as that is ſo variable, cannot be deſcribed to another, and is blunted by repeated trials. The proof-ball will ſerve the purpoſe of the bleachfied ſufficiently; and, by diſcovering the ſpecific gravity, will ſhow the quantity of alkaline ſalts diſſolved. But it cannot ſhow the dangerous qualities of theſe ſalts; for the leſs cauſtic and leſs heavy this liquor is, the more dangerous and corroſive it may be for the cloth. The third ley, which they draw from theſe materials by an infuſion of cold water, in which the taſte of lime is diſcoverable, appears plainly to be more dangerous than the firſt. The ſecond ley, which they extract from the ſame aſhes, and which is reckoned about a third in ſtrength, when compared with firſt, muſt be of the ſame nature; nor ſhould it be uſed without an addition of pearl-aſhes, which will correct it.

(35.) One general rule is, That the ſolution of any body in its menſtruum is equally diffuſed through the whole liquor. The bleachers, depending on this, uſe equal quantities of the top and bottom of their ley, when once clear and ſettled; taking it for granted, that there is an equal quantity of ſalts in equal quantities of the ley. But it is a fact, that the ley will be in ſome places much ſtronger than the cloth can with ſafety bear; and hence there is a neceſſity for uſing a degree of caution to avoid miſchief. That general law of ſolution muſt have taken its riſe from particular experiments, and not from reaſoning.

(36.) Whether a ſufficient number of experiments have been tried to aſcertain this point, and to eſtabliſh an undoubted general rule, may very reaſonably indeed be called in queſtion. Dr HOME ſays, "When I had diſcovered that lime makes part of the diſſolved ſubſtance, and reflected how long its groſſer parts will continue ſuſpended in water, there appeared ſtronger reaſons for ſuſpecting that this rule, though it may be pretty general, does not take place here; at leaſt it is worth the purſuit of experiment. I weighed at the bleachfield a piece of glaſs in ſome cold ley, after it had been boiled, ſtood for two days, and about the fourth part of it had been uſed. The glaſs weighed 3 drams 2½ grains in the ley, and 3 drams 7½ grains in river water. The ſame glaſs weighed in the ſame ley, when almoſt all uſed, 2 grains leſs than it had done before. This ſhows, that the laſt of the ley contained a third more of the diſſolved body; and, conſequently, was a third ſtronger than the firſt of the ley.

(37.) "As this might, perhaps, be owing to a continuation of the ſolution of the ſalts, I repeated the experiment in a different way. I took from the ſurface ſome of the ley, after the ſalts were diſſolved, and the liquor was become clear. At the ſame time I immerſed a bottle, fixed to a long ſtick, ſo near the bottom, as not to raiſe the aſhes there, and, by pulling out the cork by a ſtring, filled the bottle full of the ley near the bottom. The glaſs weighed in river-water 3 drams 38½ grains; in the ley taken from the ſurface 3 drams 34½ grains; and in the ley taken from the bottom 3 drams 31½ grains. This experiment ſhows, that the ley at the bottom was, in this caſe, ¾ths ſtronger than the ley at the ſurface.

(38.) "At other times when I tried the ſame experiment, I found no difference in the ſpecific gravity; and therefore, I leave it as a queſtion yet doubtful, though deſerving to be aſcertained by thoſe who have an opportunity of doing it. As the ley ſtands continually on the aſhes, there can be no doubt but what is uſed laſt muſt be ſtronger than the firſt. I would therefore recommend, to general practice, the method uſed by Mr John Chriſtie, who draws off the ley, after it has ſettled into a ſecond receptacle, and leaves the aſhes behind. By this means it never can turn ſtronger; and he has it in his power to mix the top and bottom, which cannot be done ſo long as it ſtands on the aſhes."

(39.) Let us inquire how the ley acts. On this inquiry depends almoſt the whole theory of bleaching, as its action on cloth is, at leaſt in this country, abſolutely neceſſary. It is found by experiment, that one effect leys have on cloth is the diminiſhing of its weight; and that their whitening power is generally in proportion to their weakening power. Hence ariſes a probability, that theſe leys act by removing ſomewhat from the cloth, and that the loſs of this ſubſtance is the cauſe of whiteneſs. This appears ſtill plainer, when the bucking, which laſts from Saturday night to Monday morning, is attended to.

(40.) Chemiſts differ greatly with regard to the operations of theſe ſalts; whether they act by altering the external texture of the cloth, or by ſeparating the mucilaginous parts from the reſt, or by extracting the oil which is laid up in the cells of the plant. The laſt is the general opinion, or rather conjecture, for none of them deſerves any better name; but we may venture to affirm, that it is ſo, without any better title to pre-eminence than the others have. Alkaline ſalts diſſolve oils, therefore that theſe ſalts diſſolve the oil of the cloth, is all the foundation which this theory has to reſt on; too ſlight when unſupported by experiment, to be relied on.

(41.) Dr Home endeavours to ſettle this queſtion by the following experiments and obſervations.—"Wax (ſays he) is whitened by being expoſed to the

the influence of the ſun, air, and moiſture. A diſcovery of the change made on it by bleaching, may throw a light upon the queſtion. Six drams of wax were ſliced down, expoſed on a S. window, Sept. 10, and watered. That day being clear and warm, bleached the wax more than all the following. It ſeemed to me to whiten quicker, when it had no water thrown on it than when it had. Sept. 15, it was very white, and 1 dram 3 grains lighter. 3½ drams of this bleached wax, and as much of unbleached, taken from the ſame piece, were made into two candles of the ſame length and thickneſs, having cotton wicks of the ſame kind. The bleached candle burnt 1 hour 33 minutes; the unbleached 3 minutes longer. The former ran down 4 times, the latter never. The former had an obſcure light and dull flame; the latter had a clear pleaſant one, of a blue colour at the bottom. The former, when burning, ſeemed to have its wick thicker, and its flame nearer the wax, than the latter. The former was brittle, the latter not.

(42.) "It plainly appears from theſe facts, that the unbleached wax was more inflammable than the bleached; and that the latter had loſt ſo much of an inflammable ſubſtance as it had loſt in weight; and conſequently the ſubſtance loſt in bleaching of wax is the oily part. As I had not an opportunity of repeating the former experiment, I do not look on it as entirely concluſive; for it is poſſible that ſome of the duſt, flying about in the air, might have mixed with the bleached wax, and ſo have rendered it leſs inflammable. Nor do I think the analogical reaſoning from wax to linen without objections. Let us try then if we cannot procure the ſubſtance extracted from the cloth, ſhow it to the eye, and examine its different properties. The proper place to find it, is in a ley already uſed, and fully impregnated with theſe colouring particles.

(43.) "I got in the bleachfield ſome ley, which had been uſed all that day for boiling coarſe linen, which was tolerably white, and had been twice boiled before. There could be no dreſſing remaining in theſe webs. No ſoap had ever touched that parcel; nor do they mix ſoap with the ley uſed for coarſe cloth. Some of this impregnated ley was evaporated, and left a dark-coloured matter behind. This ſubſtance felt oily betwixt the fingers, but would not lather in water as ſoap does. It deflagrated with nitre in fuſion, and afforded a tincture to ſpirit of wine. By this experiment the falts ſeem to have an oily inflammable ſubſtance joined with them.

(44.) "Could we ſeparate this colouring ſubſtance from theſe falts, and exhibit it by itſelf, ſo that it might become the object of experiment, the queſtion would be ſoon decided. Here chemiſtry lends us its aſſiſtance. Whatever has a ſtronger affinity or attraction to the falts with which it is joined, than this ſubſtance has, muſt ſet it at liberty, and make it viſible. Acids attract alkaline ſalt from all other bodies; and therefore will ſerve our purpoſe.

(45.) "Into a quantity of the impregnated ley mentioned in the former experiment, I poured in oil of vitriol. Some bubles of oil aroſe, an inteſtine motion was to be perceived, and the liquor changed its colour from a dark to a turbid white. It curdled like a ſolution of ſoap, and a ſcum ſoon gathered on the ſurface, about half an inch in thickneſs, the deepneſs of the liquor not being above 6 inches. What was below was now pretty clear. A great deal of the ſame matter lay in the bottom; and I obſerved that the ſubſtance on the ſurface was precipitated, and ſhowed itſelf heavier than water, when the particles of air, attached to it in great plenty, were diſpelled by heat. This ſubſtance was in colour darker than the cloth which had been boiled in it.

(46.) "I procured a conſiderable quantity of it by ſkimming it off. When I tried to mix it with water, it always fell to the bottom. When dried by the air, it diminiſhed very much in its ſize, and turned as black as a coal. In this ſtate it deflagrated ſtrongly with nitre in fuſion; gave a ſtrong tincture to ſpirit of wine; and, when put on a red hot iron, burnt very ſlowly, as if it contained a heavy ponderous oil; and left ſome earth behind.

(47.) "From the inflammability of this ſubſtance, its rejecting of water, and diſſolving in ſpirit of wine, we diſcover its oleaginous nature; but from its great ſpecific gravity we ſee that it differs very much from the expreſſed or cellular oil of vegetables; and yet more from their mucilage. That it diſſolves in ſpirit of wine, is not a certain argument of its differing from expreſſed oils; becauſe theſe when joined to alkaline falts, and recovered again by acids, become ſoluble in ſpirit of wine. The quantity of earthy powder left behind after burning, ſhows that it contains many of the ſolid particles of the flax. The ſubſtance extracted from cloth by alkaline leys appears then to be a compoſition of a heavy oil, and the ſolid earthy particles of the flax.—In what manner theſe falts act, ſo as to diſſolve the oils, and detach the ſolid particles, is uncertain; but we ſee evidently how much cloth muſt be weakened by an improper uſe of them, as we find the ſolid particles themſelves are ſeparated."

(48.) That the falts may enter into the body of the cloth along with the water, it is abſolutely neceſſary that the cloth be dry before bucking; for they will not enter in ſuch quantity if it be wet, and, by acting too powerfully on the external threads, may endanger them. The degree of heat is a very material circumſtance in this operation. As the action of the falts is always in proportion to the heat, it would appear more proper to begin with a boiling heat, by which a great deal of time and labour might be ſaved. The reaſon why this method is not followed appears to be this: If any vegetable, or vegetable ſubſtance, is to be ſoftened, and to have its juices extracted, it is found more proper to give it gentle degrees of heat at firſt, and to advance gradually, than to plunge it all at once in boiling water. This laſt degree of heat is ſo ſtrong, that, when applied at once to a vegetable, it hardens inſtead of ſoftening its texture. Dried vegetables are immediately put into boiling water by cooks, that theſe ſubſtances may preſerve their green colour, which is only to be done by hindering them from turning too ſoft. Boiling water has the ſame effect on animal ſubſtances; for, if ſalt beef is put into

into it, the water is kept from getting at the ſalts from the outſide of the beef being hardened.

(49.) If we conſider how much of an oily ſubſtance there is in the cloth, eſpecially at firſt, which will for ſome time keep off the water, and how the twiſting of the threads, and cloſeneſs of the texture, hinders the water from penetrating, we ſhall find that, if boiling water were put on it at once, the cloth might be liable, in ſeveral parts, to a dry heat, which would be much worſe than a wet one. That the leys have not acceſs to all parts of the cloth at firſt, appears plainly from this, that when it has lain after the firſt bucking, till all the leys are waſhed out, it is as black, in ſome parts, as when it was ſteeped. This muſt be owing to the diſcharge of the colouring particles, from thoſe places to which the ley has acceſs, and to their remaining where it has not. It ſeems adviſeable, then, in the firſt bucking or two, when the cloth is foul, to uſe the ley conſiderably below the boiling point; that by this ſoaking or maceration, the foulneſs may be entirely diſcharged, and the cloth quite opened for the ſpeedy reception of the boiling ley in the buckings which ſucceed. The leys ſhould likewiſe be weakeſt in the firſt buckings, becauſe then they act only on the more external parts; whereas, when the cloth is more opened, and the field of action is increaſed, the active powers ought to be ſo too. For this reaſon they are at the ſtrongeſt after ſome ſourings.

(50.) As to the management of the coarſe cloth, where *boiling* is ſubſtituted in place of *bucking*, this ſpecies of linen cannot afford the time and labour neceſſary for the latter operation; and therefore they muſt undergo a ſhorter and more active method. As the heat continues longer at the degree of boiling, the leys uſed to the coarſe cloth muſt be weaker, than thoſe uſed to the fine. There is not ſo much danger from heat in the coarſe as in the fine cloth, becauſe the former is of a more open texture, and will allow the ley to penetrate more ſpeedily. In the cloſer kinds, however, the firſt application of the ſalts ſhould be made without a boiling heat being uſed.

SECT. IV. *Of* ALTERNATE WATERING *and* DRYING.

(51.) WHEN the cloth has been bucked, it is carried out to the field, and frequently watered for the firſt ſix hours. For if, during that time, when it is ſtrongly impregnated with ſalts, it is allowed to dry, the ſalts approaching cloſer together, and aſſiſted by a greater degree of heat, increaſing always in proportion to the dryneſs of the cloth, act with greater force, and deſtroy its very texture. After this, dry ſpots are allowed to appear before it gets any water. In this ſtate it profits moſt, as the latter part of the evaporation comes from the more internal parts of the cloth, and will carry away moſt from thoſe parts. The bleaching of the wax, in Dr Home's experiment (§ 41,) confirms this; for it ſeemed to whiten moſt when the laſt particles of water were going off.

(52.) This continual evaporation from the ſurface of the cloth ſhows, that the operation carries off ſomewhat remaining after the former proceſs of bucking. This appears likewiſe from a fact known to all bleachers, that the upper ſide of cloth, where the evaporation is ſtrongeſt, attains to a greater degree of whiteneſs than the under ſide. But it is placed beyond all doubt by the fact, that cloth turns much lighter by being expoſed to the influence of the ſun, air, and winds, even though the ſalts have been waſhed out of it.

(53.) What is the nature then of this ſubſtance? As it appears (§ 40,) that the whitening, in the operation of bucking, depends on the extracting the heavy oil, and ſolid particles of the flax; it is highly probable, that the effects of watering, and expoſure to the ſun, air, and winds, are produced by the evaporation of the ſame ſubſtance, joined to the ſalts, with which compoſite body the cloth is impregnated, when expoſed on the field. That theſe ſalts are in a great meaſure carried off or deſtroyed, appears from the cloth being allowed to dry without any danger, after the evaporation has gone on for ſome time. "If we can ſhow (ſays Dr Home) that oils and ſalts, when joined together, are capable of being exhaled, in this manner by the heat of the atmoſphere, we ſhall reduce this queſtion to a very great degree of certainty. Sept. 10, I expoſed in a SW. window half an oz. of Caſtile ſoap, ſliced down and watered. Sept. 14, when well dried, it weighed about 3 dr. 6 gr. Sept. 22, it weighed 2 dr. 2 gr. Sept. 24, it weighed 1 dr. 50 gr. It then ſeemed a very little whiter; but was much more mucilaginous in its taſte, and had no degree of ſaltneſs which it had before.

(54.) "It appears from this experiment, that ſoap is ſo volatile, when watered, and expoſed to air not very warm, that it loſes above half its weight in 14 days. The ſame muſt happen to the ſaponaceous ſubſtance, formed from the conjunction of the alkaline ſalts, heavy oil, and earthy particles of the flax. The whole deſign, then, of this operation, which by way of pre-eminence gets the name of BLEACHING, is to carry off, by the evaporation of water, whatever has been looſened by the former proceſs of bucking.

(55.) Againſt this doctrine there may be brought two objections, ſeemingly of great weight. It is a general opinion amongſt bleachers, that linen whitens quicker in March and April than in any other months: but as the evaporation cannot be ſo great at that time as when the ſun has a greater heat; hence the whitening of cloth is not in proportion to the degree of evaporation; and therefore the former cannot be owing to the latter. This objection vaniſhes, when we conſider, that the cloth that comes firſt into the bleachfield, in the ſpring, is cloſely attended, having no other to interfere with it for ſome time; and as it is the whiteſt, gets, in the after buckings, the firſt of the ley; while the ſecond parcel is often bucked with what has been uſed to the firſt. Were the fact true, on which the objection is founded, this would be a ſufficient anſwer to the objection.—But it appears not to be true, from an obſervation of Mr John Chriſtie, That cloth laid down in the beginning of June, and finiſhed in September, takes generally leſs work, and undergoes fewer operations, than what is laid down in March and finiſhed in June.

(56.) "The

(56.) "The other objection is, That cloth dries much faſter in windy weather than in calm ſunſhine; but it does not bleach ſo faſt. This would ſeem to ſhow, that the ſun has ſome particular influence independent on evaporation. In anſwer to this objection, let it be conſidered, that it is not the evaporation from the ſurface, but from the more internal parts, that is of benefit to the cloth. Now, this latter evaporation muſt be much ſtronger in ſunſhine than in windy weather, on account of the heat of the ſun, which will make the cloth more open; while the coldneſs of windy weather muſt ſhut it up, ſo that the evaporation will all be from the ſurface. Clear ſunſhine, with a very little wind, is obſerved to be the beſt weather for bleaching; a convincing proof that this reaſoning is juſt.

(57.) "It would ſeem to follow as a corollary from this reaſoning, that the number of waterings ſhould in general be in proportion to the ſtrength of the ley; for the ſtronger the ley is, the more there is to be evaporated; and the greater the danger, in caſe the cloth ſhould be allowed to dry. But there is an exception to this general rule, ariſing from the conſideration of another circumſtance. It is obſerved, that cloth when brown dries ſooner than when it becomes whiter, ariſing from the cloſeneſs and oilineſs which it then has, not allowing the water a free paſſage. Perhaps that colour may retain a greater degree of heat, and in that way aſſiſt a very little. Cloth, therefore, after the firſt buckings, muſt be more carefully watered than after the laſt.

(58.) "It follows likewiſe from this reaſoning, that the ſoil of the bleach-field ſhould be gravelly or ſandy, that the water may paſs quickly through it, and that the heat may be increaſed by the reflection of the ſoil, for the ſucceſs of this operation depends on the mutual action of heat and evaporation. It is likewiſe neceſſary that the water ſhould be light, ſoft, and free from mud or dirt, which not being able to riſe along with the water, muſt remain behind. When there is much of this, it becomes neceſſary to rinſe the cloth in water, and then give it a milling, to take out the dirt elſe it would be fixed in the cloth by the following bucking, as it is not ſoluble by the ley.

(59.) "This operation has more attributed to it by the bleachers than it can juſtly claim. The cloth appears, to the eye, to whiten under theſe alternate waterings and dryings; and theſe naturally get the honour of it, when it more properly belongs to the former operation. Here lies the fallacy. Alkaline ſalts give a very high colour to the decoctions or infuſion of vegetables. This is probably owing to the ſolution of the oleaginous colouring particles of the plant; which particles, being opened and ſeparated by the ſalts, occupy a greater ſpace, and give a deep colour to the liquor. The cloth participates of the liquor and colour. Hence bleachers always judge of the goodneſs of the bucking by the deepneſs of its colour. This rule, in general, is good. I obſerve that in thoſe buckings which continue from the Saturday night to the Monday morning, the cloth has always the deepeſt colour. When that cloth has been expoſed ſome hours to the influence of the air, theſe colouring particles, which are but looſely attached to it, are evaporated, and the linen appears of a brighter colour. This operation does no more than complete what the former had almoſt finiſhed. If its own merit were thoroughly known, there would be no occaſion to attribute that of another operation to it. Thread, and open cloaths, ſuch as diaper, may be reduced to a great degree of whiteneſs, after one bucking by it alone. No cloth, as would appear, can attain to a bright whiteneſs without it.

(60.) "Since the only advantage of watering is the removal of the ſalts, and what they have diſſolved, might we not effectuate this by ſome cheaper and more certain method? for it occupies many hands; and muſt depend altogether on the uncertainty of the weather; ſo that in the beginning of the ſeaſon, the bleacher is often obliged to repeat his buckings without bleaching. We might take out the alkaline ſalts by acids; but then the other ſubſtance would be left alone in the cloth, nor would any waſhing be able to remove it. Mill-waſhing appears a more probable method of taking out both ſalts and oils; and it would ſeem that this might in a great meaſure ſupply the place of watering; but upon trial it does not ſucceed. Two parcels of linen were managed equally in every other reſpect, except in this, that one was watered, and expoſed to the influence of the air, and the other was only mill-waſhed. This method was followed until they were fit for touring. The cloth which had been mill-waſhed had a remarkable green colour, and did not recover the bright colour of the pieces managed in the common way, until it had been treated like them for a fortnight. The green colour was certainly owing to a precipitation of the ſulphureous particles, with which the ley is impregnated, upon the ſurface of the cloth; owing to the ſalts being waſhed off more ſpeedily than the ſulphur, to which they are united in the ley. The attachment betwixt theſe two bodies we know is very looſe, and the ſeparation eaſily made. Evaporation then alone is ſufficient to carry off theſe ſulphureous particles."

SECT. V. *Of* SOURING.

(61.) THAT alkaline ſalts are convertible, by different methods, into abſorbent earths, is a fact well known in chemiſtry. Frequent ſolution in water and evaporation of it again, is one of theſe. The tranſmutation then of theſe ſalts, which are not volatiliſed or waſhed away, muſt be continually going on in the cloth under theſe alternate waterings and dryings of the former proceſs: not much indeed after the firſt two or three buckings; becauſe the ſalts, not having entered deep into the cloth, are eaſily waſhed off, or evaporated. But when they penetrate into the very compoſition of the cloth and minuteſt fibres, of which the firſt veſſels are made, they have great difficulty of eſcaping again, and muſt be more ſubject to this tranſmutation. But if we conſider the bleaching aſhes as a compoſition of lime and alkaline ſalts, we muſt diſcover a freſh fund for the depoſition of this abſorbent earth. The common cauſtic, a compoſition of this very kind, is ſoon converted if expoſed to the open air, into a harmleſs earthy kind of powder.

(62.) Fre-

(62.) Frequent buckings and bleachings load cloth with this ſubſtance. It becomes then neceſſary to take it out. No waſhing can do that, becauſe earth is not ſoluble in water. Nothing but acids can remove it. Theſe are attracted by the abſorbent earth, join themſelves to it, and compoſe a kind of neutral imperfect ſalt, which is ſoluble in water, and therefore eaſily waſhed out of the cloth. The acid liquors commonly uſed, are butter-milk, which is reckoned the beſt, ſour milk, infuſion of bran, rye-meal, &c. kept for ſome days till they ſour. Sour why is thought to give the cloth a yellow tinge.

(63.) Before the linen is put in the four, it ſhould be dried, that the acid particles may penetrate along with the watery, through the whole. A few hours after it has been there, air-bubbles ariſe, the liquor ſwells, and a thick ſcum is formed; manifeſt ſigns of a fermentation. The following experiment, ſays Dr Home, ſhows the degree of heat which attends it. "May 25, I put a thermometer of Fahrenheit's into ſome butter milk, of which the bleachers were compoſing their ſours, and which ſtood at a vat adjoining to another, where the milk was the ſame, and the ſouring proceſs had gone on for two days. After the thermometer had been 20 minutes in the butter milk, the mercury ſtood at 64 degrees. In the ſouring vat it roſe to 68 degrees. An increaſe of four degrees ſhows a pretty briſk inteſtine motion.

(64.) "To what are all theſe effects owing? To the acetous fermentation going on in thoſe vegetable liquors, whoſe acids, extricating themſelves, produce heat, inteſtine motion, and air-bubbles. As the change is ſlow, the proceſs takes five or ſix days before it is finiſhed. During this time the acid particles are continually uniting themſelves to the abſorbent earth in the cloth. That this fermentation goes on in the liquor alone, appears from this conſideration, that the ſame effects, *viz.* air-bubbles, and ſcum, are to be ſeen in the butter milk alone. The only effect then it has is, by the ſmall degree of heat, and inteſtine motion, which attend it, to aſſiſt the junction of the acid and abſorbent particles. We ſhall preſently ſee that this proceſs may be carried on to as great advantage, without any fermentation; and therefore it appears not abſolutely neceſſary.

(65.) "When theſe abſorbent particles are fully ſaturated, the remaining acids may unite with, and have ſome ſmall effect in extracting the colouring particles. This appears from the two following experiments. Sept. 30, a piece of cloth which had been ſteeped, weighing 41½ gr. was put into a half pound of butter milk, whigged, and well ſoured, by a mixture of water, and by boiling. Dec. 24, when taken out, and waſhed in water, it appeared a very little whiter. The mineral acids, as will appear afterwards, whiten cloth, even though they are very much diluted.

(66.) "Juſt before the acetous fermentation is finiſhed, the cloth ſhould be taken out; otherwiſe the ſcum will fall down and lodge in the cloth, and the putrefaction which then begins will weaken it. This appears from the following experiment. Sept. 16, a piece of cloth weighing 42 gr. was laid in butter milk unwhigged. Novem. 15, the milk had a putrefied ſmell. The cloth was a little whiter, but very tender; and weighed, when well waſhed in warm water, and dried, 40 gr."

(67.) Sours made of bran, rye-meal, &c. ought to be prepared before uſe to ſave time. Beſides, when the water is poured upon the cloth, the linen is not in a better ſituation than if it had been taken up wet from the field; and thus the acid particles cannot penetrate ſo deep. Again, this method of mixing the bran with the cloth, may be attended with ſtill worſe conſequences. All vegetable ſubſtances, when much preſſed, fall into the putrefcent, and not the acetous fermentation. This often happens to the bran preſſed betwixt the different layers of the linen, which muſt weaken the cloth. Hence, all ſours ſhould be prepared before the cloth is ſteeped in them; and none of the bran or meal ſhould be mixed with the cloth.

(68.) The ſours are uſed ſtrongeſt at firſt, and gradually weakened till the cloth hath attained to its whiteneſs. In the firſt ſourings, there is more of the earthy matter in the cloth, from the many buckings it has undergone, than there can be afterwards. As the quantity of this matter decreaſes, ſo ſhould the ſtrength of the ſour. There is not, however, the leaſt danger, at any time, from too ſtrong a ſour. What is moſt wanted in this operation is a more expeditious and cheap method of obtaining the ſame end. As it takes five or ſix days, it retards the whitening of the cloth conſiderably; and as bleachers are obliged to ſend for milk to a great diſtance, it becomes very dear. This laſt conſideration makes them keep it ſo long, that, when uſed, it can have no good effect; perhaps it may have a bad one.

(69.) One conſideration may lead us to ſhorten the time. The ſouring proceſs is ſooner finiſhed in warm than in cold weather. Heat quickens the fermentation, by aiding the inteſtine motion. The vats therefore ſhould not be buried in the ground, as they always are, and which keeps them cold: there ſhould be pipes along the wall of the room, to give it that degree of heat which, on trial, anſwers beſt. There are few days in ſummer ſo hot as is neceſſary; and the beginning and end of the ſeaſon are by much too cold. That this is no ideal ſcheme, the following fact proves. There are two vats in Salton bleachfield, adjoining to a partition wall, at the back of which there is a kitchen fire. In theſe vats the ſouring proceſs is finiſhed in three days, whereas it laſts five or ſix days in thoſe that are placed round the ſame room.

(70.) This improvement, though it ſhortens the time of ſouring a very little, yet is no remedy againſt the ſcarcity and dearneſs of milk ſours. Such a liquor as would ſerve our purpoſe, muſt be found either among the vegetable acids, which have no farther fermentation to undergo, or among the mineral acids. The former are a large claſs, and contain within themſelves many different ſpecies; ſuch as the acid juice of ſeveral plants, vinegars made of fermented liquors, and acid ſalts, called *tartars*. But there is one objection againſt theſe vegetable acids: they all contain, along with the acid, a great quantity of oily matter,

ter, which would not fail to diſcolour the cloth. Beſides, the demand of the bleachfields would raiſe their price too high. But the mineral acids have neither of theſe objections. They are exceedingly cheap, and contain no oil.

(71.) "I will freely own (ſays Dr Home,) that at firſt I had no great opinion of ſucceſs from the mineral acids, from two reaſons; their want of all fermentation, which I then looked on as neceſſary; and their extreme corroſiveneſs. But the experience of two different ſummers, in two different bleachfields, has convinced me that they will anſwer all the purpoſes of the milk and bran ſours; nay, in ſome reſpects be much preferable to them. I have ſeen many pieces of fine cloth, which had no other ſours but thoſe of vitriol, and were as white and ſtrong as thoſe bleached in the common way. I have cut ſeveral webs through the middle, and bleached one half with milk and the other with vitriol; gave both the ſame number of operations, and the latter were as white and ſtrong as the former."

(72.) The following is the method in which it has been hitherto uſed: The proportion of the oil of vitriol to the water with which it is diluted, is half an ounce, or at moſt three quarters, to a gallon of water. As the milk ſours are diminiſhed in ſtrength, ſo ought the vitriol ſours. The whole quantity of the oil of vitriol to be uſed, may be firſt mixed with a ſmall quantity of water, then added to the whole quantity of water, and well mixed together. The water ſhould be milk warm, by which means the acid particles will penetrate farther, and operate ſooner. The cloth ſhould then be put dry into the liquor; as this ſour performs its taſk much ſooner than that compoſed of milk and bran, ſome, in making the trial, have been uſed to lay the milk ſours 24 hours before the vitriol. Five hours will do as much with this ſour as five hours with the common ſort. But the cloth can receive no harm by allowing it to remain for ſome days in the four; but rather an advantage. The cloth is then taken out, well rinſed, and mill-waſhed in the ordinary way.

(73.) While the cloth lies in this four, the liquor is leſs acid the ſecond day than the firſt, leſs the third than the ſecond, and ſo diminiſhes by degrees. At firſt it is clear, but by degrees a mucilaginous ſubſtance is obſerved to float in it when put into a glaſs. This foulneſs increaſes every day. This ſubſtance extracted by the acid is the ſame with what is extracted by the alkaline ſalts; and blunts the acidity of the former, as it does the alkaleſcency of the latter. Hence the liquor loſes by degrees its acidity. But as the acid ſalts do not unite ſo equally with oily ſubſtances as the alkaline, the liquor is not ſo uniformly tinged in the former as in the latter caſe, and the mucous ſubſtance preſents itſelf floating in it.

(74.) In the firſt touring, which is the ſtrongeſt, the liquor, which was a pretty ſtrong acid before the cloth was put in, immediately afterwards becomes quite vapid; a proof how very ſoon it performs its taſk. But in the following operations, as the linen advances in whiteneſs, the acidity continues much longer; ſo that in the laſt operations the liquor loſes very little of its acidity. This happens although the firſt buckings after the firſt ſourings are increaſed in ſtrength, while the ſours are diminiſhed. There are two cauſes for this. The texture of the cloth is now ſo opened, that although the leys are ſtrong, the alkaline ſalts and abſorbent earth are eaſily waſhed out; and the oily particles are in a great meaſure removed which help to blunt the acidity of the liquor.

(75.) There are two objections, however, againſt the uſe of vitriolic ſours. One is, that the proceſs of touring with milk is performed by a fermentation; and as there is no fermentation in the vitriol ſours, they cannot ſerve the purpoſe ſo well: the other, that they may hurt the texture of the cloth. The anſwer to the former objection is very ſhort; that the vitriol ſours operate ſucceſsfully without a fermentation, as experience ſhews; and therefore in them a fermentation is unneceſſary. As to the latter objection, that oil of vitriol being a very corroſive body, will hurt the cloth; that will vaniſh likewiſe, when it is conſidered how much the vitriol is diluted with water, that the liquor is not ſtronger than vinegar, and that it may be ſafely taken into the human body. Indeed that it may be ſafely uſed much ſtronger than what is neceſſary in the bleachfield, appears from the following experiment with regard to the ſtamping of linen.

(76.) After the linen is boiled in a ley of aſhes, it is bleached for ſome time; after which, to make it receive the colour, it is ſteeped in a four of water and oil of vitriol, about 15 times ſtronger than that made uſe of in the bleachfield; for to 100 gallons water are added 2½ of oil of vitriol. Into this quantity of liquor, made ſo warm as the hand can juſt be held in it, is put 7 pieces, of 28 yards each. The linen remains in it about two hours, and comes out remarkably whiter. The fine cloth often undergoes this operation twice; nor is there any danger if the oil of vitriol is well mixed with the water. But if the two are not well mixed together, and the vitriolic acid remains in ſome parts undiluted, the cloth will be corroded.

(77.) The vitriolic ſours have various advantages over thoſe of milk. The latter is full of oily particles, ſome of which muſt remain in the cloth; but the caſe is worſe when the ſcum is allowed to precipitate upon the cloth. The former is liable to neither of theſe objections. The common ſours haſten very faſt to corruption; and if, for want of proper care, they ever arrive at that ſtate, muſt damage the cloth very much. As the milk is kept very long, it is often putrid before it is uſed; and, without acting as a four, has conſiderable bad effects, while the vitriol ſours are not ſubject to putrefaction at all. Milk ſours are very dear, and often difficult to be got; thoſe of vitriol are cheap, and may be eaſily procured at any time. The milk takes 5 days to perform its taſk: but the vitriol ſours do it in as many hours; nay, perhaps in as many minutes. Their junction with the abſorbent particles in the cloth muſt be immediate, whenever theſe acid particles enter with the water.

(78.) An unanſwerable proof, that the fact is ſo, ariſes from the circumſtances which happen when the cloth is firſt ſteeped in the vitriol four; the cloth has no ſooner imbibed the acid liquor, than it loſes all acidity, and becomes immediately vapid. This

effect of vitriol four muſt be of great advantage in the bleachfield, as the bleachers are at preſent hindered from enjoying the ſeaſon by the tedioufneſs of the fouring proceſs. The whole round of operations takes 7 days, to anſwer which they muſt have 7 parcels, which are often mixing together, and cauſing miſtakes. As 3 days at moſt will be ſufficient for all the operations when vitriol fours are uſed, there needs be no more than 3 parcels. The cloth will be kept a ſhorter time in the bleaching, and arrive ſooner at market.

(79.) Vitriol has alſo another advantage in its power of whitening cloth. Even in this diluted ſtate, its whitening power is very conſiderable. We have already ſeen, that it removes the ſame colouring particles which the alkaline leys do. What then remains of it, after the alkaline and abſorbent particles are neutralized in the cloth, muſt act on theſe colouring particles, and help to whiten the cloth. That this is really the caſe, appears from the following fact. A bleacher being obliged to chooſe 20 of the whiteſt pieces out of 100, he took 20 of the pieces which were bleached with vitriolic acid. On the whole, from both reaſon and experience it appears, that it muſt be for the advantage of our linen manufacturers to uſe vitriolic inſtead of milk fours.

SECT. VI. *Of* WASHING, HAND-RUBBING, RUBBING BOARDS, STARCHING, *&c.*

(80.) As ſoon as the cloth comes from the fouring, it ſhould be well waſhed in the waſhing-mill, to take off all the acid particles which adhere to its ſurface. All acids decompoſe ſoap, by ſeparating alkaline ſalts and oily parts from each other. Were this to happen on the ſurface of the cloth, the oil would remain; nor would the waſhing-mill afterwards be able to diveſt it of the oily ſubſtance. As the liquors, which are generally employed for fouring, are impregnated with oily particles, many of theſe muſt lodge in the cloth, and remain, notwithſtanding the preceding milling. It is probable that all the heavy oils are not evaporated by bleaching. Hence it is neceſſary to apply ſoap and warm water, which unite with, diſſolve, and carry them off. It is obſerved, that if the cloth, when it is pretty white, gets too much ſoap, the following bleaching is apt to make it yellow; on that account the ſoap ſhould be wrung out.

(81.) It has been doubted, whether it be better to uſe hard or ſoft ſoap for the cloth. Moſt bleachers agree, that hard ſoap is apt to leave a yellowneſs in the cloth, and it is ſaid, that it is diſuſed in Holland on that account. As there muſt be a conſiderable quantity of ſea-ſalt in the hard, which is not in the ſoft ſoap, and as this ſalt appears prejudicial to cloth, the ſoft ſoap ought certainly to be preferred.

(82.) In this operation, the management of the COARSE cloth is very different from that of the FINE. Inſtead of being rubbed with hands, which would be too expenſive, it is laid on a table, run over with ſoap, and then put between two rubbing boards, which have ridges or grooves from one ſide to another, like teeth. Theſe boards have ſmall edges to keep in the ſoap and water, which ſaves the cloth. They are moved either by hand or by a water-wheel, which is more equal and cheap. The cloth is either drawn by degrees through the boards, by men; or, which is better, the ſame wheel moves two rollers, with ridge and groove, ſo that the former enters the latter, and by a gentle motion round their own axis, the cloth is gradually pulled through the boards. This mill was invented in Ireland above 40 years ago. The Iriſh bleachers uſe it for their fine as well as coarſe cloths. Theſe rubbing boards were diſcharged ſome years ago in Ireland, by the truſtees for the manufactures of that country, being convinced from long experience of their bad effects. But as proper care was not taken to inſtruct the bleachers by degrees in a ſafer method, they continued in the old, made a party, and kept poſſeſſion of the rubbing boards. There were conſiderable improvements made in them in this country; ſuch as the addition of the ledges, to keep the cloth moiſt; and of the rollers, which pull the cloth more gradually than men's hands. Theſe improvements were firſt made in SALTON bleachfield.

(83.) Conſiderable objections have been urged, however, againſt theſe rubbing boards. By rubbing on ſo unequal a ſurface, the fibrous part of the cloth is worn, by which it is much weakened. Theſe boards alſo give the cloth a cottony ſurface, ſo that it does not long keep clean. They alſo flatten the threads, and take away all that roundneſs and firmneſs, which is the diſtinguiſhing property of cloth bleached in the Dutch method. For theſe reaſons they muſt be very prejudicial to *fine* cloth, and ſhould never be uſed in bleaching it. As they ſeem to be in ſome meaſure neceſſary to leſſen the expence of bleaching *coarſe* linen, they ought never to be uſed above twice, or thrice at moſt. They might be rendered much more ſafe, by lining their inſides with ſome ſoft elaſtic ſubſtance, that will not wear the cloth ſo much as the wooden teeth do. Short hair has been tried in one inſtance, and is found to anſwer very well.

(84.) When the coarſe cloth has undergone a rubbing, it ſhould be immediately milled for an hour, and warm water poured now and then on it to make it lather. This milling has very good effects; for it clears away all the dirt which the rubbing boards have looſened, and which, at the next boiling, would have diſcoloured the cloth; and beſides, it makes the cloth leſs cottony, and more firm, than when whitened by rubbing only.

(85.) Of the laſt operation, STARCHING and BLUEING, we need ſay nothing in this place, as there is nothing peculiarly different in the proceſs, from that to which landry women are accuſtomed. It often happens that the cloth, when expoſed to the weather to be dried after this operation, gets rain, which undoes all again, and puts the bleacher to a new expence. To remedy this inconvenience, ſome bleachers very properly employ a dry-houſe, where the cloth may be dried after this operation, in any kind of weather.

SECT. VII. *Of* BLEACHING *with* LIME.

(86.) THE proceſs of bleaching, it is believed, may be very ſafely undertaken with the aſſiſtance of LIME. Dr Home has found, by repeated trials, that

that alkaline ſalts added to lime, diminiſh its power of weakening and corroding cloth, in proportion to the quantity of the ſalts. The compoſition, as it is not ſo dangerous as lime alone, ſo it is not ſo expeditious in whitening. When equal parts of each are uſed, the whitening power is ſtreng, and the weakening power not very conſiderable; ſo that they might be uſed with ſafety to bleach cloth, in the proportion of one part of lime to four of pure alkaline ſalts. This is agreeable to an obſervation made by all bleachers, That the bleaching ſalts, when mixed together, operate ſafer and better, than when uſed ſeparately. For the corroſive power of the Muſcovy, Marcoſt, and Caſhub aſhes, is corrected by the pearl aſhes, and the whitening quality of the latter is increaſed by that of the former.

(87.) No ſubſtance is more cauſtic when applied to animal bodies, than alkaline ſalts and lime joined together, eſpecially when fuſed in the fire. But lime alone, or lime-water will preſerve animal matter in a ſound ſtate. It appears then ſurpriſing, that ſalts and lime ſhould be found ſo little deſtructive of linen cloth, when lime, or lime-water alone deſtroys it ſo remarkably. But chemiſtry affords many facts equally unaccountable; and that this is a fact, is evident from many experiments. It has been practiſed with ſucceſs and ſafety, by a bleacher, who gives the following account of his method of employing lime.

(88.) "Firſt, (ſays he) I ſteep the cloth in warm water for 24 hours; then clean it in a waſhing mill, of all the dreſſing, or *ſowen*, as the vulgar term it. Afterwards I buck cloth with cow-dung and water, and bleach it with this for 3 days; then clean it again, and boil it with a ley made of Caſhub aſhes. A pound to each piece of 18 or 20 yards is ſufficient. This I do twice, as no lime ought to be given to cloth before it is a full third whitened; as it by no means advances the whitening of the cloth, but, on the contrary, protracts it: for, inſtead of looſening the oil and dirt in the cloth, when brown, it rather fixes them; juſt as when fine cloth is bucked with over-warm leys in the firſt buckings. Lime is by no means fit for diſcharging the oil in the cloth, but for cleaning it of the dead part, commonly called *ſprat*.

(89.) "The cloth, being cleaned, is laid upon a dreeper. It muſt not be drier before bucking with lime, otherwiſe it will take in more than can be got out again before the next application: for as I have obſerved already, that lime is only fit for diſcharging the dead part, bucking thus wet makes it reſt on the outſide of the cloth. I take a lippy of the fineſt and richeſt powdered lime that can be got, of the brighteſt white colour, as poor lime does more hurt than good, to 30 pieces of the above length; and make a cold ley of it, by ſtirring and pouring water off the lime, until all be diſſolved but the droſs, which is thrown away: then I add a little ſoap, which makes the ley have the neareſt reſemblance to milk that breaks in boiling, of any thing I can think of: for this ſoap blunts the hotneſs of the lime. Then I take the cloth and dip it in the lime-ley, and that moment out again, and lay it on a dreeper until it be bucked: then put it on the field, watering it carefully; for if allowed to dry, it is much damaged. This is done always in the morning; as it cannot be done at night, in regard of the hot quality of the lime, which ſoon heats the cloth and tenders it. If a hot ſun ſhine follows, it has great effect; for lime is juſt like all other materials for bleaching, that have more or leſs effect, according as the weather is good or bad.

(90.) "I take it up the 2d day after bucking, and give it a little milling, or hand-rubbing, or bittling, commonly called *knocking*; and lay it on the field again, watering it carefully as before. The effect is more viſible the 2d than the firſt day. As all cloth when limed ſhould have a great deal of work, otherwiſe more than half the effect is loſt; and not only that, but a great deal of labour and pains is requiſite to take the lime out of the cloth again; it muſt never be expoſed on the Sabbath day, but carefully kept wet always while uſed in this way. Thus bucking for 3 or 4 times at moſt, is ſufficient for any cloth except that made of flax pulled either over-green, or which grows in a droughty ſeaſon, or perhaps not ſo well heckled as it ſhould be. This ſort occaſions great trouble and expence to the bleacher. But the moſt effectual and expeditious way I ever found for this kind was, after boiling, to take a little of the warm ley, and mix a very ſmall quantity of lime with it, and draw the cloth through that as hot as poſſible, and put it on the field directly, watering it carefully. This will clean it of the ſprat ſurpriſingly. Then I boil it with pearl aſhes, and give it the laſt boil with ſoap.

(91.) "There are innumerable miſtakes in the uſe of lime committed by the vulgar, who are ignorant of its quality and effects. They know only this in general, that it is a thing which whitens cloth cheap, and is eaſy purchaſed; therefore they will uſe it. Some of them begin whitening of their cloth with it, which I have already obſerved to be wrong, and given reaſons for it, and continue it until the cloth is bleached; give it a boil or two at moſt, and then waſh it up while the groſs body of the lime is in the ſubſtance of the cloth. This makes limed cloth eaſily diſtinguiſhable from unlimed, as the former has a yellowiſh colour, and is full of a powder. Beſides, as lime is of a very hot corroding nature, it muſt by degrees weaken the cloth. The bad effects of this ſubſtance do not end here. When the cloth is put on board, it contracts a dampneſs, which not only makes it yellow, and loſe any thing of colour it has, but directly rots it. And although it ſhould eſcape this, which it is poſſible it may, by a quick and ſpeedy paſſage; yet whenever it is put in any warehouſe, it will meet with moiſture there, eſpecially if the winter ſeaſon ſhould come on before it is diſpoſed or made uſe of. Theſe I take to be the principal reaſons for ſo much complaint in bleaching with this material."

(92.) It is evident, the whole art and ſafety in uſing lime, according to this method, depends on the junction of the alkaline ſalts, during the bucking, to the particles of lime which were on the ſurface of the cloth. As bleaching depends on the extraction of a certain quantity of phlogiſtic matter from the cloth, it is natural to ſuppoſe that it might be accelerated by rendering the alkali very cauſtic. Thus the ſalt would be entirely

freed from the fixed air, with which in the uſual experiments of chemiſtry it appears to have a greater affinity than with oil; for ſoap may be partially decompoſed by fixed air, nor can it be prepared without an exceedingly cauſtic alkaline ley.

(93.) In this light the matter has appeared to ſome very eminent chemiſts; and Dr BLACK thought it of importance ſufficient to publiſh printed directions to the practical bleachers how to render their alkali ſufficiently cauſtic with lime, and at the ſame time recover it from the chalky reſiduum with as little loſs as poſſible. This method has accordingly been tried; but does not altogether anſwer the ſanguine expectations at firſt raiſed by the propoſal. In the large way of operating, fixed alkali quits the fixed air to unite with the oily or other matter to be extracted from the cloth. The only advantage therefore to be gained by Dr Black's improvement is, that the action of the alkali is thus quickened, and ſome quantity of fuel ſaved; but this is not, by the bleachers, reckoned an equivalent to the trouble of rendering the alkali cauſtic, unleſs in places where fuel is very ſcarce.

PART II.

OF THE NEW METHOD OF BLEACHING.

INTRODUCTION.

(94.) THE uſe of ACIDS, in bleaching, was formerly in a great meaſure unaccounted for; but from the late diſcoveries concerning the uſe of dephlogiſticated ſpirit of ſalt in this art, it appears probable that they act by means of the dephlogiſticated air they contain. This, however, is not always the caſe; for ſilk is rendered yellow by the action of dephlogiſticated air, though rendered white by the action of the volatile ſulphureous acid, which undoubtedly contains a portion of this kind of air, though much leſs than the concentrated vitriolic acid. The nitrous acid, which contains a great quantity of dephlogiſticated air, likewiſe communicates a yellow colour to ſilk; and indeed ſeems very much inclined to produce this colour upon all the ſubſtances it touches. At any rate, its price would be a ſufficient objection againſt its uſe in bleaching.

(95.) The marine acid, more generally known by the name of *ſpirit of ſalt*, in its common ſtate, is ſaid by M. Berthollet to be uſed with ſucceſs by ſome bleachers in France, inſtead of the vitriolic; but ſuch experiments as have been made upon it in this country have not anſwered the purpoſe. This new method of bleaching is founded upon the remarkable property, which that acid when dephlogiſticated poſſeſſes, of deſtroying vegetable colours; and various attempts have been made to introduce it into practice, though in this country the difficulties or diſadvantages attending it have prevented it from coming into general uſe, ſo that many of our bleachers obſtinately perſevere in the old method. M. Scheele was the inventor of this kind of acid; but M. Barthollet ſeems to have been the firſt who attempted to apply it to the operation of bleaching.—From a treatiſe on the new method of bleaching, which has been lately publiſhed in Edinburgh, we have collected the following particulars.

SECT. I. ACCOUNT *of* M. BERTHOLLET'S METHOD *of* BLEACHING.

(96.) M. BERTHOLLET having procured the dephlogiſticated marine acid, in as ſtrong and concentrated a ſtate as he could, immerſed into it thread and cloth; which by that means were conſiderably whitened. In a ſhort time the liquor ſeemed to loſe its ſtrength; upon which it was poured off, and more put in its place; and ſo on until the ſubſtance immerſed became perfectly white. Thus, however, the proceſs was not only very expenſive, but the ſtuff was conſiderably injured; ſometimes even loſing its coheſion altogether, ſo that there was a neceſſity for trying ſome other method.

(97.) II. Uſing a diluted ſpirit, he ſucceeded perfectly in rendering the cloths completely white; but by keeping them for ſome time, or expoſing them for a little to the action of an alkaline ley, they became again brown or yellow.

(98.) III. On conſidering the proceſs of bleaching in the common method, he found that the action of the ſun and air are ſubſervient to bleaching only as they prepare the colouring particles for being diſſolved and ſeparated by alkaline lixivia. To inveſtigate this ſubject, he examined the nature of the dews, both ſuch as are precipitated from the atmoſphere and thoſe which tranſpire from vegetables. Both theſe were found ſo ſtrongly impregnated with dephlogiſticated air, that they deſtroyed the colour of paper when faintly tinged with turnſole. Hence he obſerves, that it is by no means improbable, that the ancient prejudices concerning May-dews might have ariſen from ſome obſervations analogous to this; more eſpecially as in that month the tranſpiration of plants is extremely copious.

(99.) IV. By imitating with the dephlogiſticated marine acid and alkaline ley the common proceſs of bleaching, he ſucceeded in making a perfect and permanent white. For this purpoſe an alkaline lixivium was employed alternately with the dephlogiſticated marine acid; the latter being no longer uſed in a concentrated ſtate. Thus he avoided both the inconvenience ariſing from the ſuffocating ſmell of the liquid, and that of its deſtroying the texture of the ſtuff immerſed in it.

(100.) V. The cloth is prepared for bleaching in this manner, by ſteeping it 24 hours in water, to extract the dreſſing it receives from the weaver: a little old ley, which has already loſt the greateſt part of its ſtrength in other proceſſes, may be uſed with advantage. It is next to be expoſed once or twice to the action of ſome good freſh alkaline ley; to ſeparate, by means of this cheaper liquid, all the colouring matter which it can extract, and thereby ſave the dephlogiſticated acid.

(101.) VI. The ſtuff muſt next be carefully waſhed with water, to ſeparate any remains of the ley which might adhere to it, and weaken the action of the liquor. It is then to be diſpoſed in wooden troughs, ſo that the dephlogiſticated acid may paſs freely through every part of it; to allow which, it muſt lie quite looſe, without being tightened or ſtraitened in any part. All theſe troughs

BLEACHING

Pl. XXXIX.

Fig. 1

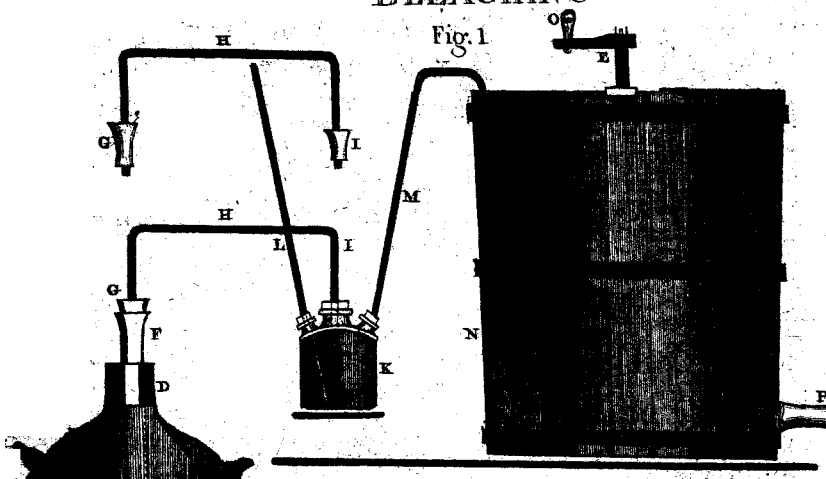


Fig. 5.
Spring Block.

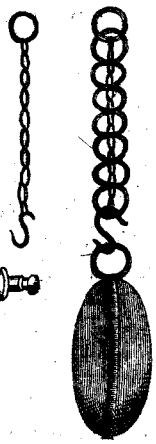
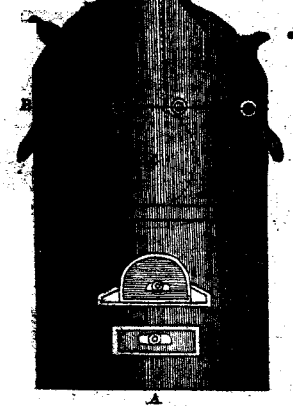


Fig. 2.



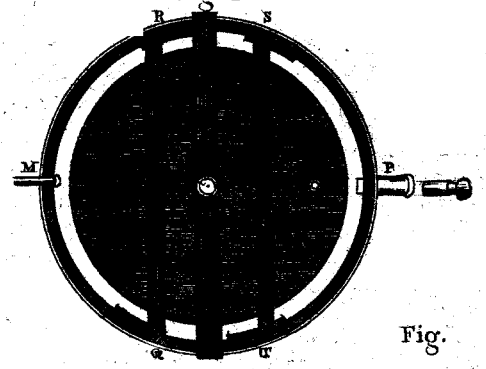


Fig.

Fig. 3.

Fig. 4.

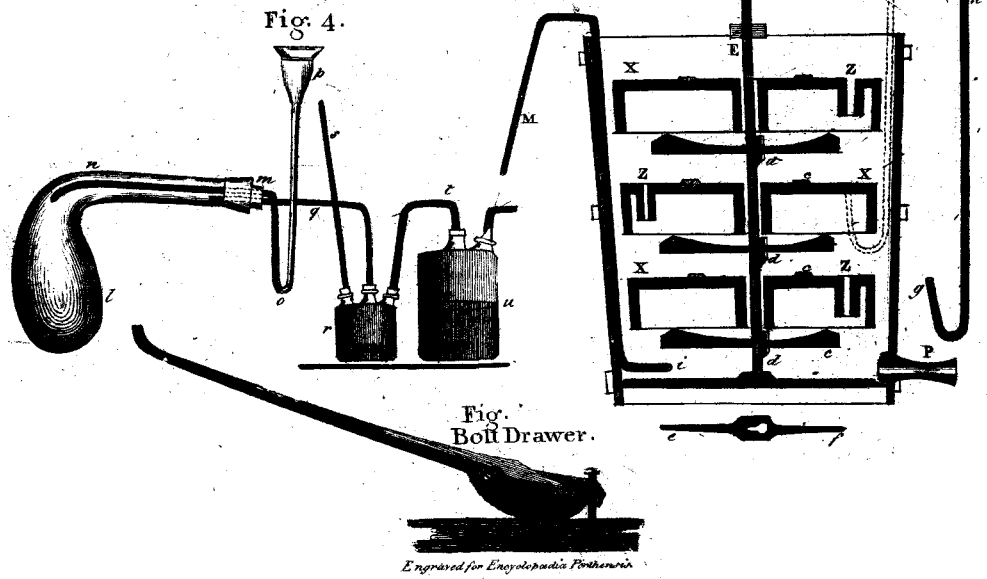


Fig.
Bolt Drawer.

Engraved for Encyclopædia Perthensis.

troughs ought to be conſtructed entirely of wood without any iron, as that would eaſily be corroded and ſtain the cloth.

(102.) VII. The firſt immerſion in the dephlogiſticated acid is to continue 3 hours; after which the cloth is to be removed, and the liquor wrung out of it. It muſt then be waſhed a ſecond time with alkaline ley; which being alſo waſhed out, it is to be again immerſed in dephlogiſticated acid.

(103.) VIII. The ſecond immerſion in the acid is to continue only about half an hour; after which it is to be taken out and wrung as before. The ſame liquor may ſerve for ſeveral immerſions; only when it appears to be much exhauſted, it is to be reſtored by an addition of freſh liquor.

(104.) IX. After the cloth ſeems to be ſufficiently whitened, excepting only ſome few black threads and the ſelvages, it is to be filled with black ſoap, and ſtrongly rubbed for ſome time: after which it is to be again waſhed in alkaline ley, and receive another immerſion in the acid liquor.

(105.) X. It has not yet been determined what number of immerſions in the acid are neceſſary to whiten linen cloth, though our author ſuppoſes from 6 to 8 to be ſufficient for the purpoſe.

SECT. II. METHOD *of* PREPARING *the* DEPHLOGISTICATED MARINE ACID; *with a* DESCRIPTION *of the* APPARATUS.

(106.) FOR preparing the dephlogiſticated acid, M. Berthollet recommends ſix ounces of black manganeſe finely powdered, 16 ounces of ſea-ſalt likewiſe in powder, and 12 ounces of concentrated vitriolic acid to be diluted with 8 ounces of water: but the quantity of this laſt muſt be varied according to the ſtrength of the acid and the dryneſs of the ſalt. If the manganeſe is impure, its quantity is to be augmented in proportion to the ſuppoſed impurity; and it is known whether a ſufficient quantity has been employed, by a portion remaining behind and retaining its black colour. When the materials are prepared, the manganeſe and common ſalt, both reduced to fine powder, muſt be mixed accurately together, and put into the diſtilling veſſel placed in a ſand-bath; the vitriolic acid, diluted with water, and allowed to cool, is then to be poured upon them, and the junctures exactly luted. The receiver may be of wood covered in the inſide with wax, and of a very large ſize; for the gas is abſorbed in proportion to the ſurface of the water it acts upon.

(107.) M. BERTHOLLET deſcribes an apparatus, rather complicated, but of which we have given a repreſentation in *Plate* XXXIX. *Fig.* 1. is an elevation of the apparatus, in which is repreſented a reverberatory furnace A B C D, having, on a line with B, many ſmall openings in its circumference, to ſerve as chimneys; within which, upon a ſand-bath *a*, is placed a matraſs *b*, the neck of which ſtands out above the furnace, running through the opening D, which is to be cloſed with clay. The mouth F, of the neck of the matraſs, is cloſed by a cork G, through the middle of which paſſes a tube H, which forms a communication between the inſide of the matraſs *b*, and the intermediate veſſel K, where it alſo paſſes through a cork I, which cloſes one of the three openings of that veſſel. The corks G and I ought to be prepared before-hand, and well fitted to each end of the tube of communication H, which is to be ſo diſpoſed that it may be fitted in immediately after the mixture is made in the matraſs.

(108.) The intermediate veſſel K is about $\frac{1}{6}$ part full of water; into it is plunged the *tube of ſafety* L, to prevent danger from regurgitation. This tube ought to be ſo high, that the weight of the water which enters into it, by the preſſure of the gas, may be great enough to cauſe the gas to paſs into the pneumatic tub N O P, by the tube of communication N, which is plunged therein, and reaches to the bottom, where it is bent horizontally, ſo that the gas may be emitted under the firſt of the three wooden, or (if they can be procured) ſtone ware cavities, or receivers, which are placed in the inſide of the tub, one above the other. O is a handle which ſerves to turn the agitator E, the movement of which facilitates the combination of the gas with the water. P is a ſpigot and faucet to draw off the liquor.

(109.) *Fig.* 2. UPPER PART *of the* PNEUMATIC TUB. In this Q R S T are four ſtaves which are thicker than the others, and which project within the tub, where they are hollowed ſo as to receive the ends of two wooden bars U V, which ſerve to keep in their places the cavities or receivers X.

(110.) *Fig.* 3. SECTION *of the* TUB. Each cavity X is ſo conſtructed that it may receive the gas which is emitted at *i* from the tube of communication M. The gas, as it comes out, is collected under the loweſt cavity, and increaſes in quantity until it paſſes by the funnel Z to that in the middle, and afterwards to the upper one.—The opening through which the agitator E paſſes, in the centre of each cavity, is in the ſhape of a funnel, and is ſo formed as to hinder the gas from eſcaping along the agitator, which is furniſhed with three tranſverſe arms, *c*, *c*, *c*, each being faſtened by a wedge *d*, *d*, *d*,—*e f* repreſents one of theſe arms in a horizontal direction. The bent tube *g h* ſerves to draw off the atmoſpheric air which is contained under the cavities, after the tube has been filled with water. To make uſe of this tube, the bent part is ſucceſſively introduced under each cavity, as is ſhewn at *g*; we muſt then blow into it, at the end *h*, till the water in it is forced out; after which the air contained under the cavity will immediately make its eſcape.

(111.) *Fig.* 4. APPARATUS *for the* DISTILLATION *of* MURIATIC ACID. In this, *l* repreſents a retort, which is to be placed in a reverbatory furnace; the mouth of the retort is to be cloſed by a cork *m*, having two holes, through one of which paſſes the tube *n*, bent at *o*, and terminating at the top in the form of a funnel *p*, by means of which the vitriolic acid is to be introduced into the retort. The other hole of the cork *m* receives the end of a tube *q*, which forms a communication between the retort and a veſſel *r*; which veſſel has three openings, and is to be about $\frac{1}{3}$ part full of water, into which is to be plunged the *tube of ſafety s*, to prevent danger from regurgitation; the veſſel *r* has a communication with a ſecond veſſel *u*, by means of the tube *t*: the ſecond veſſel is to be half full of water, and is to have a communi-

communication with a 3d ſimilar veſſel: this 3d veſſel ſhould alſo be provided with a tube of ſafety, and ſhould communicate with a 4th.

(112.) In the conſtruction of an apparatus for this purpoſe, it is evident the requiſites are, that the receiver ſhould not only be capacious but broad, that the gas, which is very volatile, may meet with a large ſurface of water to abſorb as much of it as poſſible. It is very improbable, however, that all the gas can be abſorbed by a ſingle receiver, let us make it as large as we will; for which reaſon it will be proper to have ſeveral of them connected with each other by glaſs tubes, ſo that what eſcapes from one may be abſorbed by another. Thus we are ſure of having the water fully impregnated with the gas; though we cannot by any means concentrate this liquid like the mineral acids.

(113.) By means of condenſing engines, indeed, a greater quantity of it might be forced into the water than it can naturally contain: but this could anſwer no uſeful purpoſe; for the moment that a bottle containing ſuch liquor was opened, the ſuperfluous gas would fly off, with violence and danger to the perſon who opened it. The bottles themſelves would alſo be liable to burſt on every ſlight alteration of temperature in the atmoſphere. It is proper, therefore, not to attempt the preparation of the liquor, in any great degree of ſtrength; though this is indeed attended with a very conſiderable inconvenience, viz. the difficulty of tranſporting it from the place where it is prepared to the bleachfield, on account of the great bulk and weight of it. M. Berthollet propoſes to have it made at the place where the cloth is to be bleached; and ſo near that the dephlogiſticated ſpirit of ſalt might be conveyed by ſpouts to the troughs which contain the cloth. This, however, muſt in many caſes be impracticable, unleſs we ſuppoſe the generality of bleachers to be poſſeſſed of a ſkill in managing chemical operations, which at preſent they are not. When great quantities of liquor are to be brought from diſtant places, however, it muſt undoubtedly be a great diſcouragement, eſpecially if the beſt methods, and the cheapeſt alſo, have not been uſed in the preparation of the acid.

SECT. III. ADVANTAGES *of the* NEW METHOD *of* BLEACHING.

(114.) IT would add much to the importance of this new method of bleaching, if a comparative eſtimate of the expence of that and of the old mode were fairly laid before the public, and the preference in this reſpect appeared juſtly due to the former. This, however, has not yet been done; nor even the firſt and moſt eſſential ſtep towards it taken, viz. the determining how much ſtuff a certain quantity of dephlogiſticated ſpirit of ſalt will whiten. From ſuch experiments as have been made on the ſubject, it is probable, that the acid drawn from one pound of ſalt will whiten 4 of linen cloth without any addition.—This may ſeem a ſmall expence; but if we conſider the vitriolic acid to be made uſe of, and that the reſiduum is uſeleſs, it would ſoon be found very conſiderable. Glauber's ſalt may indeed be prepared from the reſiduum of the diſtillation; but ſo much of that article is prepared otherwiſe, that at preſent the making of it is no object. M. Berthollet mentions the ſeparation of the mineral alkali from the reſiduum; and ſays he has received ſome inſtructions on this head from M. Morveau and others, but conceals them on account of their being communicated as ſecrets.

(115.) To enable the reader to judge for himſelf of the expence of M. Berthollet's method we inſert the latter part of his memoir, in which this part of the ſubject is more particularly conſidered.

(116.) "If (ſays he) at preſent, when the oxygenated muriatic acid coſts nearly three *deniers* (about half an Engliſh farthing a quart,) in the provinces which are not ſubject to the GABELLE, (a tax no longer exiſting in France,) the new method of bleaching, when properly conducted, is frequently advantageous notwithſtanding this expence; it is not to be doubted but that it may become much more ſo, by means of theſe œconomical practices which I have juſt mentioned. But, ſo long as the preparation of the bleaching liquor is at all expenſive, there will always be a great advantage in favour of fine cloths; becauſe, in equal quantities of ſurface, they preſent a leſs quantity of matter, and are bleached much eaſier; ſo that an ell, or a pound of fine cloath, requires much leſs liquor than an ell, or a pound of coarſer cloth.

(117.) "But, that the advantages of this proceſs may be fully enjoyed, it is neceſſary to eſtabliſh it in a country which is not ſubject to the tax on ſalt, called the *gabelle*; for, where ſalt is not at a low price, the oxygenated muriatic acid becomes too expenſive.

(118.) "Nevertheleſs, it is not by the expence of the new proceſs, rigorouſly compared with that of the ordinary method of bleaching, that we muſt judge of its advantages, as it is attended with ſome particular ones which would compenſate a ſuperior price. Cloths and thread, which in ſome places require many months, may be eaſily bleached in five or ſix days, even in a large manufactory; and the bleaching of a few pieces only, may, without difficulty, be terminated in two or three days. Beſides, the new method of bleaching may be executed in the winter as well as in the ſummer, only the drying requires more time.

(119.) "An induſtrious countryman, whoſe family employ their intervals of leiſure in ſpinning, is obliged to wait for favourable weather, and perhaps to ſend his thread and cloths to a great diſtance, where they remain a long time in bleaching; or, if his neceſſities are preſſing, he is obliged to ſell them, at a loſs, to ſome intermediate factor, who lays a tax upon his poverty. But, if the manufactories for making oxygenated muriatic acid increaſe in number ſufficiently, thoſe who weave a piece of cloth will be able to bleach it themſelves, and to enjoy the whole fruit of their labour, as ſoon as it is out of their hands.

(120.) "The warehouſeman, in a ſeaſon which is unfavourable to the ordinary method of bleaching, is not able to fulfil his engagements without great difficulty: he is obliged to employ a conſiderable capital to fill his warehouſe, in the ſeaſon in which the bleaching is executed; he is unable

able to enter upon ſpeculations which might lead to profit (by his taking advantage of opportunities which unexpectedly offer themſelves), becauſe it would require too much time to bleach the quantity of cloths which he may want.

(121.) "The conſumer will alſo find his advantage, as there will not only, in the end, reſult ſome diminution in the price of cloths and thread, but the new bleaching, when properly executed, diminiſhes the original ſtrength of flax and hemp much leſs than the long and often repeated operations of common bleaching. It even appears, by the experiments of M. DECROISILLE, that the oxygenated muriatic acid, by contracting the pores of cotton, gives it more ſolidity, and alſo communicates to it the property of taking more brilliant colours.

(122.) "As the cloths are leſs worn, an apparent diſadvantage ariſes, in the eyes of ſome dealers, from the new method; which is, that they do not appear ſo fine as cloths of the ſame quality bleached in the common manner. M. BONJOUR has even been obliged to contrive methods of wearing the cloths, which have been bleached in the manufactory which he directs. It is evident that ſuch methods are not difficult to be found; but thoſe who are willing to give up this apparent fineneſs, will, of courſe, have their cloths of greater ſtrength.

(123.) "Beſides, may not thoſe vaſt meadows, which in very fertile countries are taken up with cloths (which it is neceſſary to keep ſpread over them all the fine weather), be gained for the purpoſes of agriculture, to which they are now almoſt loſt?

(124.) "If I do not deceive myſelf, the proceſs which I have deſcribed ought to be diſtinguiſhed from thoſe which merely contribute to the progreſs of the arts; it deſerves to be warmly patronized by thoſe whoſe duty it is to watch over the public proſperity, as, beſides its advantage to commerce, it may directly contribute to improve the country, which, being the primary ſource of our riches, has the ſtrongeſt claim to our attention.

(125.) "I ſhall now proceed to deſcribe ſome other uſes, in which the oxygenated muriatic acid may be employed. It appears that it may be ſucceſsfully made uſe of to deſtroy the madder ground of printed cloths. When theſe cloths are printed with different corroſives, they are paſſed through the madder bath, where the deſigns take different ſhades, according to the nature of the corroſives, but at the ſame time the ground of theſe cloths takes the colour of the madder: this colour, which is much leſs permanent than that which has been fixed by the corroſives, it is neceſſary to deſtroy by means of cow-dung and bran, and by long expoſure in the fields. When I firſt tried, inſtead of theſe means, to uſe the oxygenated muriatic acid, I found that the colours, which ought to be preſerved, were themſelves much injured.

(126.) "But Mr HENRY, of Mancheſter, an able chemiſt, found that mild alkalis, either vegetable or mineral, prevented this bad effect of the liquor, and he has ſince that time uſed it with ſucceſs; I am not acquainted with the particulars of the method which he follows. M. Decroiſile wrote to me, nearly about the ſame time, that he had made the ſame obſervation, and I ſoon after was convinced of the truth of it, by making uſe of the proceſs which I deſcribed when ſpeaking of the Javelle ley, namely, by weakening, with a great deal of water, the liquor thereby obtained. M. Oberkampf, to whom I communicated this proceſs, and who neglects nothing which may contribute to the perfection of his excellent manufactory at Jouy, immediately began to make ſome trials, which he has lately continued with M. ROYER, and which promiſe to be ſucceſsful, except with reſpect to colours in which iron has been employed; for, thoſe are weakened; the reds, on the contrary, become brighter than by the ordinary proceſs; but my knowledge of this art is not yet ſufficiently perfect to enable me to be more particular.

(127.) M. Berthollet adds, in a note, "It appears from what I have juſt learnt from Mr TAYLOR, a celebrated manufacturer at Mancheſter, where they begin to make uſe of the new method, that there is not always a neceſſity for adding alkali to the oxygenated muriatic acid; and that the colours which contain iron are not always weakened. Theſe different effects probably depend upon the various methods uſed in printing the cloths."

(128.) "In the trials made at Jouy, the expence has been greater than that of the ordinary proceſs, on account of the price of ſalt; this is a great diſadvantage to manufactories of printed cloths eſtabliſhed in countries ſubject to a tax on ſalt."

(129.) As to the preparation of mineral alkali, ſome celebrated chemiſts have aſſerted that the calces of lead, or lead itſelf, will decompoſe ſea-ſalt, and thus afford an eaſy method of procuring it. On this principle indeed attempts have been made to procure it, but hitherto without ſucceſs; and from ſuch experiments as we have made, it ſeems to be totally impracticable. The method of decompoſing Glauber's ſalt and other vitriolic ſalts by means of charcoal, is perhaps the only one that ſeems to promiſe ſucceſs. The difficulty here is, that the ſalt is converted into an *hepar ſulphuris*, which cannot be decompounded but by means of an acid.

(130.) A trial has been lately made of applying *ſorrel* for this purpoſe, and not without a proſpect of ſucceſs. The particulars hitherto diſcovered concerning this method are, 1. Sea-ſalt yields one half its weight of pure alkali. 2. From 20 to 25 pounds of freſh ſorrel leaves are to be uſed for every pound of ſea-ſalt. 3. The plant is eaſily cultivated, yields three crops annually if properly managed, and is ſuperior in acidity in its cultivated ſtate to the wild ſorrel. The above calculation was made with wild ſorrel. 4. An acre of ground will produce as much ſorrel as is ſufficient for making from a ton to a ton and a half of alkali. It will not thrive except in moiſt ground.

(131.) From theſe particulars it is probable, that by combining the proceſs of making dephlogiſticated ſpirit of ſalt with that of preparing the mineral alkali, bleaching might be performed at an eaſier and cheaper rate than has yet been done; though even here there is ſome doubt, that without an encouragement from government, by taking off the duties from ſalt and ſulphur uſed in the

the different operations, a project of this kind might miſcarry, to the great detriment of the individual who ſhould attempt it.

(132.) On the whole, the principal objections to the new method of bleaching are, that little or none of the alkali commonly uſed can be ſaved. The air alſo and light of the ſun, which in the common way is had for nothing, muſt in the new way be bought at a certain price. The only advantage therefore is, that in the new method, a conſiderable portion of time is ſaved. Hence it is impoſſible to make an exact comparative calculation of the expence of both methods, without eſtimating how much labour is ſaved in the new way. If the price of the labour ſaved exceeds that of the dephlogiſticated ſpirit of ſalt, there is no doubt that the uſe of it will be attended with profit, but not otherwiſe. It is aſſerted by M. Berthollet, that in the new way of bleaching, the texture of the cloth is leſs hurt than in the old one: this too muſt be reckoned an advantage: though by the bleachers, and indeed by the public in general, it will probably be overlooked, unleſs they are induced by the *cheapneſs* to prefer the new to the old proceſs.

(133.) The following important particulars have been publiſhed by M. Berthollet in the *Annales de Chimie*, in addition to what he had before advanced.

(134.) "It was always my intention (ſays he), when I publiſhed the deſcription of the method of bleaching by means of the muriatic acid, to communicate to the public every uſeful remark I could add to it, whether they ariſe from my own obſervations, or from thoſe of my correſpondents, provided the latter were not made known to me under the tie of ſecrecy; for, it is natural that thoſe who devote themſelves to the practice of any particular art, ſhould wiſh to keep ſecret thoſe improvements which they may ſucceed in making; and there is no kind of property which ought to be more reſpected, than thoſe diſcoveries which ariſe from induſtry.

(135.) "M. Welter has found it of advantage to finiſh the proceſs of bleaching, by expoſing the cloths and thread on the field for 3 or 4 days, during which they ſhould be ſometimes wetted, and afterwards waſhed in pure water. He thinks that this expoſition is abſolutely neceſſary, in order to take away a yellow tinge, which they are apt to retain, but he obſerves that cotton does not want this operation.

(136.) "Others, however, have bleached to the entire ſatisfaction of the dealers, without this expoſition, and I have convinced myſelf, by many experiments, that linen may be brought to the moſt perfect whiteneſs without it; nevertheleſs, when thread or cloth is preſſed together in any parts, during the proceſs (which, when a large quantity is bleached at the ſame time, it is very difficult to avoid), thoſe parts are apt to preſerve a yellow tinge, which it would perhaps require ſeveral operations to efface equally throughout; theſe repeated operations would increaſe the charge, and tend to weaken the texture of the linen; whereas a ſhort expoſition on the field entirely takes away that tinge. This practice, therefore, ſeems to me proper to be adopted with reſpect to linen; it requires but a ſmall extent of ground, and it occaſions but a ſmall loſs of time.

(137.) "M. Decroisille, whoſe eſtabliſhment at Rouen is in full vigour, has made many advantageous alterations in the proceſs; as indeed might be expected from the attention of ſo able a chemiſt. I have his permiſſion to publiſh the following extract from one of his letters. 'We bleach 'here, at about the ſame price as other bleachers, 'coarſe cotton cloths, fine linen for ſhirts, ſtock-'ings, caps, &c. of thread and cotton. I flatter 'myſelf, that I have improved upon your diſco-'very: my great recipient, in the diſtilling appa-'ratus, is of a kind entirely new; I have no wood 'in any part of it, and each of my diſtilling mat-'raſſes contains 60lb. of vitriol acid, &c. I have 'alſo left off uſing wood for thoſe veſſels in which 'the ſubjects to be bleached are plunged; and the 'whiteneſs of our goods is now eſteemed to be ſu-'perior to that produced by the Engliſh before 'your diſcovery. Cotton yarn bleached by your 'proceſs takes, very advantageouſly, the red dye 'called the Turkey red; as, by means of that pro-'ceſs, about one third of the uſual labour is ſpa-'red; leſs oil is required in the preparation; and 'your ley, employed in certain ſtages of the ope-'ration, in concurrence with the other ingredi-'ents, produces a much more beautiful colour. 'Your diſcovery will be particularly uſeful to our 'city, many merchants finding it worth while to 'give us dyed cloths to have their colours diſchar-'ged; *no colour reſiſts*, and we return them their 'cloths *as found* and *as white* as if they had never 'been dyed or printed.'

(138.) "The making uſe, inſtead of wood (for the pneumatic tub, and troughs), of a matter which is not acted upon by the liquor, is certainly of great advantage to the ſucceſs of this method of bleaching; as, by that means, we not only avoid the loſs of that portion of the liquor, which exerts its action upon the wood, but we alſo ſave expence in repairing the veſſels, which are very ſoon worn out.

(139.) "I have ſaid that the cloths, when taken out of the water acidulated with vitriolic acid, ought to be plunged into common water; but that precaution is not ſufficient, they muſt be plunged into a weak cauſtic ley, moderately warm, and kept in it during ſome minutes.

(140.) "When the liquor is immediately drawn off into the troughs, as I directed, we muſt take care that it is firſt well ſtirred with the agitator; otherwiſe, that which is at the bottom of the tub, and is moſt ſaturated with acid, would firſt run off, and would act too ſtrongly upon the cloths. We may, indeed, omit the uſe of the agitator, by drawing off only half, or three quarters, of the liquor, which muſt afterwards be mixed with a proper quantity of water, according to the proportions I have pointed out; and the reſt of the liquor, which is but weakly impregnated, may ſerve, with an additional quantity of water, for another diſtillation.

(141.) "Many perſons have attempted to execut this proceſs without having any knowledge of chemiſtry, and without attending to the quality of the thread and cloth they meant to bleach; and it either did not ſucceed with them, or the

expence

expence of it, according to their calculation, was too great.

(142.) "No one muſt flatter himſelf that he can execute this proceſs, ſimple as it is, unleſs he is guided at firſt by ſome perſon who is accuſtomed to the operations of chemiſtry. Reſpecting the expences of the proceſs, I think it right to be more particular; we muſt not expect a decreaſe, or even an equality of expence (in compariſon with the common method), except in bleaching fine cloths, unleſs we are acquainted with a good proceſs for extracting the mineral alkali from the reſidue of the diſtillations; and, without this advantage, we ought not to undertake to bleach the coarſer kinds of cloth, except in thoſe caſes where the quickneſs of the operation, the power of executing it in all places and ſeaſons, and the diminution of the capital required in the linen trade, may compenſate for the increaſe of expence.

(143.) "It is impoſſible to eſtabliſh *data* upon which to determine in every particular caſe, but I would adviſe thoſe who are intereſted in this ſubject, to begin by trials upon a ſmall ſcale, and, from them, to form fair calculations, without ſeeking to flatter themſelves; on the other hand, they muſt not be led aſtray by thoſe loſſes to which every one is liable, before he becomes familiarized with the management of the proceſs; it is, however not very expenſive to follow, for a certain time, ſuch operations on a ſmall ſcale as may lead us afterwards to undertake, with advantage, others on a large one."