BLEACHING.

BLEACHING is the art of whitening linen cloth, thread, *&c.*; which is conducted in the following manner by the bleachers of this country.

After the cloth has been ſorted into parcels of an equal fineneſs, as near as can be judged, they are latched, linked, and then ſteeped. Steeping is the firſt operation which the cloth undergoes, and is performed in this manner. The linens are folded up, each piece diſtinct, and laid in a large wooden veſſel; into which is thrown, blood-warm, a ſufficient quantity of water, or equal parts of water and lye, 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. Then a cover of wood is laid over the cloth, and that cover is ſecured with a poſt betwixt the boards and the joiſting, to prevent the cloth from riſing during the fermentation which enſues. 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 inteſtine motion continues from thirty-ſix to forty-eight hours, according to the warmth of the weather; about which time the pellicle or ſcum begins to fall to the bottom. 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. This is allowed to be the juſteſt guide by the moſt experienced bleachers.

The cloth is then taken out, well rinſed, diſpoſed regularly by the ſelvage, and waſhed in the put-mill to carry off the looſe duſt. After this it is ſpread on the field to dry: When thoroughly dried, it is ready for bucking; which is the ſecond operation.

Bucking, or the application of ſalts, is performed in this manner. The firſt, or mother lye, is made in a copper, which we ſhall ſuppoſe, for example, when full, holds 170 Scots 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 they have not theſe, about 300 lb. of Caſhub); 300 lb. of Muſcovy, or blanch aſhes; the three laſt ought to be well pounded. 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 uſe.

Out of their firſt, or mother-lye, the ſecond, or that uſed in bucking, is made in this manner. Into another copper, holding, for example, 40 Scots gallons, are put 38 gallons of water, 2 lb. ſoft ſoap, and 2 gallons of mother-lye; or, for cheapneſs, in place of the ſoap, when they have lye which has been uſed to white linen, called *white-linen lye*, they take 14 gallons of it, leaving out an equal quantity of water. This is called *bucking-lye*.

After the linens are taken up from the field dry, they are ſet in the vat or cave, as their large veſſel is called, in rows, endwiſe, that they may be equally wet by the lye; which, made blood-warm, is now thrown on them, and the cloth is afterwards ſqueezed 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 lye 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 ſix or ſeven hours, and the degree of heat gradually increaſed, till it is, at the laſt turn or two, thrown on boiling hot. The cloth remains after this for three or four hours in the lye; after which the lye is let off, thrown away, or uſed in the firſt buckings, and the cloth goes on to another operation.

It is then carried out, generally early in the morning, ſpread on the graſs, pinned, corded 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 ſeven 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.

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

Souring, or the application of acids to cloth, is the fourth operation. It is difficult to ſay when this operation ſhould commence, and depends moſtly on the ſkill and experience of the bleacher. When the cloth has an equal colour, and is moſtly freed from the ſprat, or outer bark of the lint, it is then thought fit for ſouring; which is performed in the following manner. Into a large vat or veſſel is powered 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 bare-footed. If the milk is 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. Some hours after the cloth has been in the ſour, air-bubbles ariſe, a white ſcum is found 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 five or ſix 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 with ſoap and water.

Waſhing with ſoap and water, is the fifth operation; and is performed thus. Two women are placed oppoſite at each tub, which is made of very thick ſtaves, ſo that the edges, which ſlope inwards, are about four 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 lengthways, till it is ſufficiently impregnated with it. In this manner all the parcel is rubbed with ſoap, and afterwards carried to be bucked.

The lye 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 lyes are gradually made ſtronger, till the cloth ſeems of an uniform white, nor any darkneſs or brown colour appears in its ground. After this the lye 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.

From the bucking it goes to the watering, as formerly, obſerving only to overlap the ſelvages, and tie it down with cords, that it may not tear; 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. 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 thought cheapeſt. It is done in the following manner: 200 lb. caſhub aſhes, 100 lb. white Muſcovy, and 30 lb. pearl-aſhes, boiled in 105 Scots gallons of water for a quarter of an hour, as in the proceſs for the fine cloth, makes the mother or firſt lye. The cloth-boiler is then to be filled two thirds full with water and mother-lye, about nine parts of the former to one of the latter; ſo that the lye uſed for boiling the coarſe cloth, is about a third weaker than that uſed in bucking the fine. Such a quantity of cloth is put into the foregoing quantity of lye, when cold, as can be well covered by it. The lye is brought gradually to the boil, and kept boiling for two hours; the cloth being fixed down all the time, that it does not riſe above the liquor. The cloth is then taken out, ſpread on the field, and watered, as mentioned before in the fine cloth.

As the ſalts of the lye are not exhauſted by this boiling, the ſame is continued to be uſed all that day, adding, at each boiling, ſo much of the mother-lye as will bring it to the ſame ſtrength as at firſt. The lye by boiling loſes in quantity ſomewhat betwixt a third and a fourth; and they reckon that in ſtrength it loſes about a half, becauſe they find in practice, that adding to it half its former ſtrength in freſh lye, has the ſame effect on cloth. Therefore ſome freſh lye, containing a fourth part of the water, and the half of the ſtrength of the firſt lye, makes the ſecond boiler equal in ſtrength to the firſt. To the third boiler they add ſomewhat more than the former proportion, and go on ſtill increaſing gradually to the fourth and fifth, which is as much as can be done in a day. The boiler is then cleaned, and next day they begin with freſh lye. Theſe additions of freſh lye ought always to be made by the maſter-bleacher, as it requires judgment to bring ſucceeding lyes to the ſame ſtrength as the firſt.

When the cloth comes to get the ſecond boiling, the lye ſhould be a little ſtronger, about a thirtieth part, and the deficiencies made up in the ſame proportion. For ſix or ſeven boilings, or fewer, if the cloth be thin, the lye is increaſed in this way, and then gradually diminiſhed till the cloth is fit for ſouring. 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

coarſe has dreeped on racks made for the purpoſe, it is boiled, making the lye ſtrong in proportion to the water in the cloth.

The common method of ſouring coarſe linen is, to mix ſome warm water and bran in the vat, then put a layer of cloth, then more bran, water, and cloth; and ſo on, till the cave is full. The whole is tramped with mens feet, and fixed as in the former proceſs. A thouſand yards of cloth, yard-broad, require betwixt four and ſix pecks of bran. The cloth generally lies about three nights and two days in the four. Others prepare their four twenty-four 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. After the cloth is taken from the four, it ought to be well waſhed and rinſed again. It is then 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 conveniency will allow of it. Two or three of theſe rubbings are ſufficient, and the cloth very ſeldom requires more.

The lye, after the ſouring begins, is decreaſed in ſtrength by degrees; and three boilings after that are commonly ſufficient to finiſh the cloth. Afterwards it is ſtarched, blued, dried, and bittled in a machine made for that purpoſe, which ſupplies the place of a calendar, and is preferred by many to it.

This method uſed in the bleaching of our coarſe cloths, is very like that practiſed in Ireland for both fine and coarſe. The only material difference is, that there the bleachers uſe no other aſhes but the kelp or caſhub. A lye is drawn from the former by cold water, which diſſolves the ſalts, and not the ſulphureous particles of the kelp aſhes. This lye is uſed till the cloth is half whitened, and then they lay aſide the kelp-lye for one made of caſhub aſhes.

In the preceding hiſtory of bleaching we may obſerve, that it naturally divides itſelf into ſeveral different branches or parts, all tending to give linen the degree of whiteneſs required. How they effectuate that comes next to be conſidered.

The general proceſs of bleaching divides itſelf into theſe different parts. 1. Steeping and milling. 2. Bucking and boiling. 3. Alternate watering and drying. 4. Souring. 5. Rubbing with ſoap and warm water, ſtarching, and bluing. We ſhall treat of theſe different parts in their order.

STEEPING.

GREEN linen, in the different changes which it has undergone before it arrives at that ſtate, contracts a great foulneſs. This is chiefly communicated to it by the dreſſing compoſed of tallow and ſowen, which is a kind of flummery made of bran, flour, or oat-meal ſeeds. The firſt thing to be done in the bleachfield is to take off all that filth which is foreign to the flax, would blunt the future action of the ſalts, and might, in unſkilful hands, be fixed in the cloth. This is the deſign of ſteeping.

To accompliſh this end, the cloth is laid to ſteep in blood-warm water. A ſmaller degree of heat would not diſſolve the dreſſing ſo ſoon; and the greater might coagulate and fix, in the body of the linen, thoſe particles which we deſign to carry off. In a few hours the dreſſing made uſe in weaving is diſſolved, mixed with the water; and, as it had acquired ſome degree of acidity, before application, it becomes a ſpecies of ferment. Each ferment promotes its own particular ſpecies of fermentation, or 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, one muſt be ſoon convinced, who attends to the air-bubbles which immediately begin to ariſe, to the ſcum which gathers on the ſurface, and to the inteſtine motion and ſwelling of the whole liquor. That it muſt be the acetous fermentation, appears from this, that the vegetable particles, already in part ſoured, muſt firſt undergo this proceſs.

The effect of all fermentations is to ſet the liquor in motion; to raiſe in it a degree of heat; and to emit air-bubbles, which, by carrying up ſome of the light oleaginous particles along with them, produce a ſcum. But as the dreſſing is in ſmall quantity in proportion to the water, theſe effects are gentle and ſlow. The acid ſalts are no ſooner ſeparated, by the acetous fermentation, from the abſorbent earth, which made them not perceptible to the tongue in their former ſtate, than they are united to the oily particles of the tallow, which likewiſe adhere ſuperficially, diſſolve them, and render them, in ſome degree, miſſible with water. In this ſtate they are ſoon waſhed off by the inteſtine motion of the liquor. The conſequence of this operation is, that the cloth comes out freed in a great meaſure from its ſuperficial dirt; and more pliant and ſoft than what it was.

Whenever 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. Were this to take place, in any conſiderable degree, it would render the cloth black and tender. Bleachers cannot be too careful in this article.

The firſt queſtion that ariſes to be determined on theſe principles is, What is the propereſt liquor for ſteeping cloth? Thoſe uſed by bleachers are plain water; white-linen lye and water, equal parts; and rye-meal or bran mixed with water. They always make uſe of lye when they have it.

After ſteeping, the cloth is carried to the putſtock-mill, to be freed of all its looſe foulneſs. There can be nothing contrived ſo effectual to anſwer the purpoſe 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 that no water be detained in the folds of the linen, otherwiſe that part may be damaged.

BUCKING

BUCKING and BOILING.

This is the moſt important operation of the whole proceſs, and deſerves a thorough examination. Its deſign is to looſen, and carry off, by the help of alkaline lixives or lyes, that particular ſubſtance in cloth, which is the cauſe of its brown colour.

All aſhes uſed in lye, the pearl 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 ſalts. As theſe two laſt contain a very conſiderable proportion of a real ſulphureous matter, which muſt 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 eaſily diſſolved in water.

If the ſalts were always of an equal ſtrength, the ſame quantities would make a lye equally ſtrong; but they are not. Salts of the ſame name differ very much from one another. The Muſcovy aſhes are turning 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 lyes 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 bleachfield 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 lye, 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 lye, which they extract from the ſame aſhes, and which is reckoned about a third in ſtrength, when compared to the firſt, muſt be of the ſame nature; nor ſhould it be uſed without an addition of pearl-aſhes, which will correct it.

It is taken for a general rule, 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 lye, when once clear and ſettled; taking it for granted, that there is an equal quantity of ſalts in equal quantities of the lye. But if there is not, the miſtake may be of fatal conſequence, as the lye may be in ſome places ſtronger than what the cloth can with ſafety bear. That general law of ſolution muſt have taken its riſe from particular experiments, and not from reaſoning. Whether a ſufficient number of experiments have been tried to aſcertain this point, and to eſtabliſh an undoubted general rule, may be called in queſtion.

"But, ſays Dr Home, 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 lye, after it had been boiled, ſtood for two days, and about the fourth part of it had been uſed. The glaſs weighed 3 drachms $1\frac{1}{4}$ grains in the lye, and 3 drachms $7\frac{1}{2}$ grains in river-water. The ſame glaſs weighed in the ſame lye, when almoſt all uſed, 2 grains leſs than it had done before. This ſhows, that the laſt of the lye contained a third more of the diſſolved body; and, conſequently, was a third ſtronger than the firſt of the lye.

"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 lye, 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 lye near the bottom. The glaſs weighed in river-water 3 drachms $38\frac{1}{4}$ grains; in the lye taken from the ſurface 3 drachms $34\frac{1}{4}$ grains; and in the lye taken from the bottom 3 drachms $31\frac{1}{4}$ grains. This experiment ſhows, that the lye at the bottom was, in this caſe, $\frac{1}{4}$ ſtronger then the lye at the ſurface.

"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 lye 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 lye, 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."

Having conſidered the lye, let us next inquire how it 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 they 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 lyes act by removing ſomewhat from the cloth, and that the loſs of this ſubſtance is the cauſe of whiteneſs. This appears yet plainer, when the bucking, which laſts from Saturday night to Monday morning is attended to.

There are various and different opinions with regard to the operation of theſe ſalts: That 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 may we venture to affirm, that it is ſo without any better title to pre-eminence,

nence, than what the others have. Alkaline ſalts diſſolve oils, therefore theſe ſalts diſſolve the cellular 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.

Dr Home endeavours to ſettle this queſtion by the following experiments and obſervations.

"Wax, ſays he, is whitened by being expoſed to the influence of the ſun, air, and moiſture. A diſcovery of the changes made on it by bleaching, may throw a light upon the queſtion.

"Six drachms of wax were ſliced down, expoſed on a ſouth 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 drachm 3 grains lighter. 3½ drachms 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 burned one hour thirty-three minutes; the unbleached three minutes longer. The former run down four 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. 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 lye already uſed, and fully impregnated with theſe colouring particles.

"I got in the bleachfield ſome lye, 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 lye uſed for coarſe cloth. Some of this impregnated lye 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 ſalts ſeem to have an oily inflammable ſubſtance joined with them.

"Could we ſeparate this colouring ſubſtance from theſe ſalts, and exhibit it by itſelf, ſo that it might become the object of experiment, the queſtion would be ſoon decided. Here chymiſtry lends us its aſſiſtance. Whatever has a ſtronger affinity or attraction to the ſalts 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.

"Into a quantity of the impregnated lye mentioned in the former experiment, I poured in oil of vitriol. Some bubbles of air 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 ſix 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.

"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.

"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 ſalts, 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 lyes appears then to be a compoſition of a heavy oil, and the ſolid earthy particles of the flax.

"In what manner theſe ſalts 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."

It is neceſſary that cloth ſhould be dry before bucking, that the ſalts may enter into the body of the cloth along with the water; 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 ſalts 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 it, the water is kept from getting at the ſalts, from the outſide of the beef being hardened.

But when 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 lyes 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 lyes 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 lye has acceſs, and to their remaining where it has not. It would ſeem adviſeable, then, in the firſt bucking or two, when the cloth is foul, to uſe the lye 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 lye in the buckings which follow.

The lyes 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.

The only thing that now remains to be conſidered, is, 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 lyes 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 lye to penetrate more ſpeedily. In the cloſer kinds, however, the firſt application of the ſalts ſhould be made without a boiling heat.

ALTERNATE WATERING AND DRYING

After 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 drineſs of the cloth, act with greater force, and deſtroy its very texture. After this time, 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 a preceding experiment, helps to confirm this; for it ſeemed to whiten moſt when the laſt particles of water were going off.

This continual evaporation from the ſurface of the cloth ſhows, that the deſign of the operation is to carry 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 experiment, which ſhews, 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.

What, then, is this ſubſtance? As we have diſcovered in the former ſection, that the whitening, in the operation of bucking, depends on the extracting or looſening the heavy oil, and ſolid particles of the flax; it appears highly probable, that the effects of watering, and expoſition 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's 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 ſouth-weſt window, half an oz. of Caſtile ſoap, ſliced down, and watered. Sept. 14. when well dried, it weighed but 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.

"It appears from this experiment, that ſoap is ſo volatile, when watered, and expoſed to air not very warm, that it loſes above the half its weight in fourteen 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.

"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 which 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 lye; 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

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.

"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.

"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 lye; for the ſtronger the lye 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.

"It follows likewiſe from this reaſoning, that the ſoil of the bleachfield 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 lye.

"This operation has more attributed to it by bleachers than it can juſtly claim. The cloth appears, even 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. The 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 cloths, 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.

"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 ſouring. 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 lye 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 lye. 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."

SOURING.

It is well known to all chymiſts, that alkaline ſalts are convertible, by different methods, into abſorbent earths. Frequent ſolution in water, and evaporation of it again, is one of theſe. This 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 laſt and minuteſt fibres, of which the firſt veſſels are made, they find greater difficulty of eſcaping again, and muſt be more ſubject to this tranſmutation. But if we conſider the

bleaching

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, ſoon converts itſelf, if expoſed to the open air, into a harmleſs earthy powder.

Frequent buckings and bleachings load the 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, infuſions of bran, rye-meal, *&c.* kept for ſome days till they ſour. Sour whey is thought to give the cloth a yellow colour.

The linen ought to be dried before it is put in the ſour, that the acid particles may penetrate, along with the watery, through the whole. A few hours after it has been there, air-bubles ariſe, the liquor ſwells, and a thick ſcum is formed; manifeſt ſigns of a fermentation. The following experiment, ſays Dr Home, ſhews 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 in a vat adjoining to another, where the milk was the ſame, and the ſouring proceſs had been going on for two days. After the thermometer had been twenty minutes in the butter-milk, the mercury ſtood at 64 degrees. In the ſouring vat it roſe to 68 degrees. An increaſe of 4 degrees ſhows a pretty briſk inteſtine motion.

"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.

"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. 20. A piece of cloth which had been ſteeped, weighing 41½ gr. was put into a half-pound of butter-milk, whigged, and well foured, by a mixture of water, and by boiling. Sept. 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.

"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.

"Sep. 16. A piece of cloth, weighing 42. gr. was laid in butter-milk unwhigged. Novem. 15. The milk had a putrified ſmell. The cloth was a little whiter, but very tender; and weighed, when well waſhed in warm water and dried, 40 gr."

All the ſours made of bran, rye-meal, *&c.* ought to be prepared before uſe; for by this means ſo much time will be ſaved. Beſides, when the water is poured upon the cloth, and bran, as is done in the management of coarſe cloth, the linen is not in a better ſituation than if it had been taken up wet from the field; and by this means the acid particles cannot penetrate ſo deep. Again, this method of mixing the bran with the cloth, may be attended with yet worſe conſequences. All vegetable ſubſtances, when much preſſed, fall into the putreſcent, and not the acetous fermentation. This often happens to the bran preſſed betwixt the different layers on 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.

The ſours are uſed ſtrongeſt at firſt, and gradually weakened till the cloth has 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 what 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 cheaper 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.

There is one conſideration that may lead us to ſhorten the time. It is obſerved, that 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, which muſt keep them cold; there ſhould rather be pipes along the walls of the room, to give it that degree of heat, which, on trial, may be found to anſwer beſt. There are few days in ſummer ſo hot as is neceſſary; and the beginning and end of the ſeaſon is by much too cold. That this is no ideal ſcheme, the following fact is a ſufficient proof. 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 the others placed round the ſame room.

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 vege-

table

table acids, which have no further 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 particles, which would not fail to diſcolour the cloth. Beſides, the demand of the bleachfields would raiſe their price too high.

The mineral acids have neither of theſe objections. They are exceedingly cheap, and contain no oil. "I will freely own, ſays Dr Home, that at firſt I had no great opinion of ſucceſs from the mineral, 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 ſeveral 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."

The method in which it has been hitherto uſed is this. 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 further, and operate ſooner. The cloth ſhould then be put dry into the liquor.

It is obſerved, that this ſour performs its taſk much ſooner than thoſe of milk and bran; ſo that Mr John Chryſtie, in making the trial, uſed to lay the milk-ſours twenty-four hours before the vitriol. Five hours will do as much with this ſour, as five days with the common ſort. But the cloth can receive no harm in allowing it to remain for ſome days in the ſour; but rather, on the contrary, an advantage. The cloth is then taken out, well rinſed, and mill-waſhed in the ordinary way.

The liquor, while the cloth lies in this ſour, 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 do, the liquor is not ſo uniformly tinged in the former as in the latter caſe, and the mucous ſubſtance preſents itſelf floating in it.

It is obſerved, that, 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 tourings, are increaſed in ſtrength, while the ſours are diminiſhed. There are two cauſes to which this is owing. The texture of the cloth is now ſo opened, that although the lyes 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.

Two objections are made againſt the uſe of vitriol-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 not neceſſary.

As to the latter objection, that oil of vitriol, being a very corroſive body, may 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.

That it may be uſed with ſafety, much ſtronger than what is neceſſary in the bleachfield, appears from the following experiment with regard to the ſtamping of linen. After the linen is boiled in a lye of aſhes, it is bleached for ſome time. After this, in order to make it receive the colour, it is ſteeped in a ſour of water and oil of vitriol, about fifteen times ſtronger than that made uſe of in the bleachfield; for, to 100 gallons of water are added two and a half of oil of vitriol. Into this quantity of liquor, made ſo warm as the hand can juſt be held in it, is put ſeven 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 oil of vitriol remains in ſome parts undiluted, the cloth is corroded into holes.

Let us now take a view of the advantages which the vitriol-ſours muſt have over the milk. The latter is full of oily particles, ſome of which muſt be left 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, from 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 corrupted before it is uſed; and, without acting as a ſour, has all the bad effects of putrefaction. The vitriol-ſours are not ſubject to putrefaction.

The milk takes five days to perform its taſk, but the

vitriol-ſours do it in as many hours; nay, perhaps as many minutes. Their junction with the abſorbent particles in the cloth muſt be immediate, whenever theſe acid particles enter with the water. An unanſwerable proof that the fact is ſo, ariſes from the circumſtances which happen when the cloth is firſt ſteeped in the vitriol-ſour; the cloth has no ſooner imbibed the acid liquor than it loſes all acidity, and becomes immediately vapid. This effect of vitriol ſours muſt be of great advantage in the bleachfield, as the bleachers are at preſent hindered from enjoying the ſeaſon by the tedioufneſs of the ſouring proceſs. The whole round of operations takes ſeven days; to anſwer which they muſt have ſeven parcels, which are often mixing together, and cauſing miſtakes. As three days, at moſt, will be ſufficient for all the operations when vitriol-ſours are uſed, there will be no more than three parcels. The cloth will be kept a ſhorter time in the bleachfield, and arrive ſooner at market.

The milk-ſours are very dear, and often difficult to be got; but the vitriol are cheap, may be eaſily procured, and at any time.

There is yet another advantage in the uſe of vitriol, and that is 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 lyes do. What of it then remains, 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. Mr Chryſtie being obliged to chuſe twenty of the whiteſt pieces out of a hundred, five of the twenty were taken out of ſeven pieces which were bleached with vitriol.

From both experience and reaſon, it appears, that it would be for the advantage of our linen-manufacture to uſe vitriol in place of milk-ſours.

Hand-rubbing *with Soap and Warm Water*, Rubbing-boards, Starching, *and* Bluing.

After the cloth comes from the ſouring, 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 the alkaline ſalts and oily parts from one another. Were this to happen on the ſurface of the cloth, the oil would remain; nor would the waſhing-mill afterwards be able to carry it off.

From the waſhing-mill the fine cloth is carried to be rubbed by womens hands, with ſoap and water. As the liquors, which are generally employed for ſouring, 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 becomes 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 they often wring out the ſoap.

It is a matter worth inquiring into, whether hard or ſoft ſoap is beſt for cloth. Moſt bleachers agree, that hard ſoap is apt to leave a yellowneſs in the cloth. It is ſaid, that the uſe of hard ſoap is diſcharged in Holland. As there muſt be a conſiderable quantity of ſea-ſalt in this kind, which is not in the ſoft, and as this ſalt appears prejudicial to cloth, the ſoft ſoap ought to be preferred.

The management of the coarſe cloth is very different, in this operation, from 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 betwixt the rubbing-boards, which have ridges and grooves from one ſide to another, like teeth. Theſe boards have ſmall ledges to keep in the ſoap and water, which ſaves the cloth. They are moved by hands, or a water-wheel, which is more equal and cheaper. The cloth is drawn, by degrees, through the boards, by men who attend; or, which is more equal and cheaper, the ſame water-wheel moves two rollers, with ridge and groove, ſo that the former enters the latter, and, by a gentle motion roond their own axis, pull the cloth gradually through the boards.

This mill was invented in Ireland about thirty years ago. The Iriſh bleachers uſe it for their fine, as well as coarſe cloath. Theſe rubbing-boards were diſcharged, ſome years ago, in Ireland, by the Truſtees for the manufactures of that country, 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 mens hands. Theſe improvements were firſt made in Salton bleachfield.

The objections againſt theſe rubbing-boards, are unanſwerable. By rubbing on ſuch an unequal ſurface, the ſolid fibrous part of the cloth is wore; by which means it is much thinned, and in a great meaſure weakened before it comes to the market. As a proof of this, if the water which comes from the cloth in the rubbing-boards be examined, it will be found full of cottony fibrous matter. Theſe boards give the cloth a cottony ſurface, ſo that it does not keep long clean. Again, they 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. Mr Chryſtie at Perth has lined his boards with ſhort hair for ſome years paſt, and finds that it anſwers very well.

After the coarſe linen 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 cleans the cloth of

all the dirt and filth which the rubbing-boards have loofened, and which, at the next boiling, would difcolour the cloth. Befides, it is obferved, that it makes the cloth lefs cottony, and more firm, than when whitened by rubbing alone.

The laft operation is that of ftarching and bluing. It often happens, that the cloth, when expofed to the weather to be dried after this operation, gets rain; which undoes all again, and forces the bleacher to a new expence. To remedy this inconvenience, Mr Chryftie, fome years ago, invented the dry-houfe, where the cloth may be dried, after this operation, in any weather. This invention meets with univerfal approbation.

A METHOD OF BLEACHING SAFELY WITH LIME.

Dr Home has found by repeated trials, that alkaline falts added to lime, diminifh its power of weakening and corroding cloth; and that in proportion to the quantity of thefe falts added to the lime. This compofition, as it is not fo dangerous as lime alone, fo it is not fo expeditious in whitening. When equal parts of each are ufed, the whitening power is ftrong, and the weakening power not very conliderable; fo that they might be ufed with fafety to bleach cloth, in the proportion of one part of lime to four of pure alkaline falts. This fully accounts for an obfervation made by all bleachers, That the bleaching falts, when mixed together, operate fafer and better than when ufed feparately. For the corrofive power of the Mufcovy, Marcoft, and Caftiub aftes is corrected by the pearl aftes, and the whitening quality of the latter is increafed by that of the former.

There is not a more corroding fubftance, with regard to animals, than alkaline falts and lime joined together, efpecially when fufed in the fire. This is the compofition of the common cauftic. But lime, and lime-water alone, preferve animal fubftances in a found entire ftate. It appears then furprifing, that falts and lime fhould be found fo little deftructive of cloth, when lime, or lime-water alone, deftroys it fo remarkably. But that this is a fact, is made evident by many experiments, and has been practifed both with fuccefs and fafety, by a bleacher who gives the following account of his method of bleaching with lime.

" Firft, fays he, I fteep the cloth in warm water for twenty-four hours; then clean it in a waftiing mill, of all the dreffing, or fowen, as the vulgar term it. Afterwards I buck the cloth with cow-dung and water, and bleach it with this for three days; then clean it again, and boil it with a lye made of Caftiub aftes. A pound to each piece of 18 or 20 yards long is fufficient. 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, inftead of loofening the oil and dirt in the cloth, when brown, it rather fixes them; juft as when fine cloth is bucked with over-warm lyes in the firft buckings. Lime is by no means fit for difcharging the oil in the cloth, but for cleaning it of the dead part, commonly called *fprat*. The cloth, being cleaned, is laid upon a dreeper. It muft not be drier before bucking with lime, otherwife it will take in more than can be got out again before the next application: For as I have obferved already, that lime is only fit for difcharging the dead part, bucking thus wet make it reft on the outfide of the cloth. I take a lippy of the fineft and richeft powdered lime that can be got, of the brighteft white colour, as poor lime does more hurt than good, to thirty pieces of the above length; and make a cold lye of it, by ftirring and pouring water off the lime, until all be diffolved, but the drofs, which is thrown away: Then I add a little foap, which makes the lye have the neareft refemblance to milk that breaks in boiling, of any thing I can think of: For this foap blunts the hotnefs of the lime. Then I take the cloth, and dip it in the lime-lye, 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 foon heats the cloth, and tenders it. If a hot funfhine follows, it has great effect; for lime is juft like all other materials for bleaching, that have more or lefs effect according as the weather is good or bad. I take it up the fecond day after bucking, and give it a little milling, or hand-bleaching, or bittling, commonly called *knocking*; and lay it on the field again, watering it carefully as before. The effect is more vifible the fecond than the firft day. As all cloth when limed fhould have a great deal of work, otherwife more than half the effect is loft; and not only that, but a great deal of labour and pains is requifite to take the lime out of the cloth again; it muft never be expofed on the Sabbath day, but carefully kept wet always while ufed in this way. Thus bucking for three or four times at moft, is fufficient for any cloth, except that made of flax pulled either over-green, or which grows in a droughty feafon, or perhaps not fo well heckled as it fhould be. This fort occafions great trouble and expence to the bleacher. But the moft effectual and expeditious way I ever found for this kind, was, after boiling, to take a little of the warm lye, and mix a very fmall quantity of lime with it, and draw the cloth through that as hot as poffible, and put it on the field directly, watering it carefully. This will clean it of the fprat furprifingly. Then I boil it with pearl aftes, and give it the laft boil with foap.

" There are innumerable miftakes in the ufe 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 eafy purchafed; therefore they will ufe it. Some of them begin whitening of their cloth with it, which I have already obferved to be wrong, and given reafons for it, and continue it until the cloth is bleached; give it a boil or two at moft, and then wafh it up while the grofs body of the lime is in the fubftance of the cloth. This makes limed cloth eafily diftinguifhable from unlimed, as the former has a yellowifh colour, and is full of a powder. Befides, as lime is of a very hot corroding nature, it muft by degrees weaken the cloth. The bad effects of this fubftance do not end here. When the cloth is put on board, it contracts

tracts 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."

The whole art and ſafety in uſing the 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.