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 divided 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 joistling, 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 puffed down. This intine 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 rinfed, disposed regularly by the selvage, and walked 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 fats, 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 Marcella ashes, (or, if they have not these, about 300 lb. of Calhub); 300 lb. of Muscovy, or blanch ashes; the three last ought to be well powdered.

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 case, 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 grafs, 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 rinfed, mill-washed, and laid out to dry again, to become fit for bucking.

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This alternate course of bucketing and watering, is performed for the most part, from ten to fifteen times, or more, before the linen is fit for fouring; gradually increasing the strength of the lye from the first to the middle bucketing, and from that gradually decreasing it till the fouring begins. The lyes in the middle bucketings 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 fouring; which is performed in the following manner. Into a large vat or vessel is poured such a quantity of buttermilk, or four 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 foured 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 poll fixed to the joist, that it may not rise. Some hours after the lye has been in the four, air-bubbles arise, a white scum is found on the surface, and an intense 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 thaves, 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 bucketed.

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, not any darknefs 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 fours is different; for they are used strongest at first, and decreased fo in strength, that the last four, considering the cloth is then always taken up wet, may be reckoned to contain three fourths of water.

From the bucketing 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 four, milling, washing, bucketing, and watering again. These operations succeed one another alternately till the cloth is whitened; at which time it is bleached, strained, 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 flopped in the same manner as the fine, rinsed, washed in the mill, and dried before boiling.

In this process, boiling supplies the place of bucketing, as it takes less time, and consequently is thought cheaper. It is done in the following manner: 200 lb. catnub ashes, 100 lb. white Nucovy, and 30 lb. pearl-ashes, boiled in 102 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 bucketing 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 lasts 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 half 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 mafter-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 fouring. The whitest cloth ought always to be boiled firft, that it may not be hurt by what goes before.

In this process, if the cloth cannot be got dry for boiling, bullions does not stop as in the fine; for after the coarse
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To accomplish this end, the cloth is laid to steep in blood-warm water. A smaller degree of heat would not diffuse the dregs 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 dregs made use in washing 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 interline 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 acetic 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 interline motion and swelling of the whole liquor. That it must be the acetic fermentation, appears from this, that the vegetable particles, already in part foured, must still undergo this process.

The effect of all fermentations is to set the liquor in motion; to raise 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 dregs are in small quantity in proportion to the water, these effects are gentle and slow. The acid falls are no sooner separated, by the acetic fermentation, from the aboretent 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, diffuse them, and render them, in some degree, miscible with water. In this state they are soon washed off by the interline 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 plant and soft than what it was.

Whenever this interline 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 the whole part of the filth. But a longer stay would be attended with a much greater disadvantage. The putrid follows close upon the acetic 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 proper reft 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 pullock-mill, to be freed of all its loose fouled. There can be nothing contrived so effectual as 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.

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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 yses, 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 Marcolft and Calabur are very hard, and with some difficulty yield their fafts. As these two last contain a very considerable proportion of a real sulphureous matter, which muff in some degree tinge white cloth; and as this is dissolved much more by boiling, than by the inferior degrees of heat, while the fafts 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 fafts 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 shew the quantity of alkaline fafts dissolved. But it cannot shew the dangerous qualities of these fafts for the lefs caustic and lefs 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 fafts 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 unaided 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 greater parts will continue suspended in water, there appeared stronger reasons for supposing 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, flood for two days, and about the fourth part of it had been used. The glass weighed 3 drachms 1½ grains in the lye, and 3 drachms 7½ grains in river-water. The same glass weighed in the Same lye, when almost all used, 2 grains lefs than it had done before. This shews, 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 fafts, I repeated the experiment in a different way.

"I took from the surface some of the lye, after the fafts were dissolved, and the liquor was become clear. At the same time I immerfed 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 firing, filled the bottle full of the lye near the bottom. The glasses weighed in river-water 3 drachms 3½ grains; in the lye taken from the surface 3 drachms 4½ grains; and in the lye taken from the bottom 3 drachms 3½ grains. This experiment shews, that the lye at the bottom was, in this case, ¼ stronger than 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 quibble yet doubtful, though deferring 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 Chriffie, 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 affects. 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 1yes act by removing somewhat from the cloth, and that the lefs 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 fafts: That they act by altering the external texture of the cloth, or by separating the mucilaginous parts from the resp, or by extracting the oil etc, which is laid up in the cells of the plant. The first is the general opinion, or rather conjecture, for none of them defends any better name; but may we venture to affirm, that it is so without any better title to pre-emi-
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Alkaline fats dissolve oils; therefore these fats 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 substancc, as it had lost in weight; and consequently the substancc 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 substancc extracted from the cloth, flow 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 the 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 drollery remaining in the web. 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 substancc felt oily to the fingers, but would not latter in water as soap does. It decomposed with nitre in a fusain, and afforded a tincture to spirit of wine. By this experiment the substancc seems to have an oily inflammable substancc joined with them.

"Could we separate this colouring substancc from these fats, 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 fats with which it is joined, than this substancc has, must set it at liberty, and make it visible. Acids attract alkaline fats 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 intelligible 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 to an inch thick, 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 substancc on the surface was precipitated, and showed itself heavier than water, when the particles of air, attached to it in great plenty, were expelled by heat. This substancc 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 tried by the air, it diminished very much in its size, and turned as black as a coal. In this state it dehydrated strongly with nitre in a fusain; gave a strong tincture to spirit of wine; and when set 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 substancc, its rejection 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 subsides in spirit of wine, is not a certain argument of its differing from expressed oils; because thefe, when mixed to alkaline fats, 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 substancc extractcd 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 fats 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 fats 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 fats 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 substancc 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.
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 fats, from the outside of the beef being prevented.

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 twining of the threads, and cleonens 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 salt has lain, after the first bucking, till all the lyes are walked 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 advisable, then, in the first bucking or two, when the cloth is foul, to use the lye considerably below the boiling point; that by this foaming 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 weakened 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 fourings.

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 cloths, however, the first application of the fats 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 fats, it is allowed to dry, the fats approaching closer together, and, assisted by a greater degree of heat, increasing always in proportion to the driesness 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 more 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 shows, that cloth turns much lighter by being exposed to the influence of the sun, air, and winds, even though the fats 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 fold particles of the flax; it appears 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 fats, with which composite body the cloth is impregnated when exposed on the field. That these fats 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 these fats, when joined together, are capable of being excluded, in this manner, by the heat of the atmosphere, we shall reduce this question to a very great degree of certainty."

"Sept. 19. I exposed, in a south-well window, half an oz. of Callicope soap, sliced down, and watered. 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 tincture, and had no degree of falttness, 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 fatty substance, formed from the conjunction of the alkaline fats, 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
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be a sufficient answer to the objection. But it appears not to be true, from an observation of Mr John Chrifte, That cloth laid down in the beginning of June, and finifhed in September, takes generally less work, and undergoes fewer operations, than what is laid down in March, and finifhed in June.

"The other objection is, That cloth dries much faster in windy weather than in calm sunshine; but it does not bleach so fair. 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 will 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 cloveneys and oilineys 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 abit 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 mingling, 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 ocznieous 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 finifhed. 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 fats, 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 fats 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 fats and oils; and it would seem that this might, in a great measure, supplant the place of watering; but upon trial it does not succeed. Two parcels of henn 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 fouling. 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 sulphurous particles, with which the lye is impregnated, upon the surface of the cloth; owing to the fats being washed off more quickly than the sulphur, to which they are united in the lye. The attachment between these two bodies we know is very loose, and the separation easily made. Evaporation then alone is sufficient to carry off these sulphurous particles."

SOURING.

It is well known to all chymists, that alkaline fats 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 fats, which are not volatile or washed away, must be continually going on in the cloth under these alternate waterings and dryings of the former processes; not much indeed after the first two or three buckings; because the fats, not having entered deep into the cloth, are easily washed off, or evaporated. But when they penetrate into the very composition of the leaf and muscle fibres, of which the fibre 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 after as a composition of lime and alkaline salts, we must discover a fifth 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 this, 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, four 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 four, that the acid particles may penetrate, along with the water, 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, 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 fours, and which stood in a vat adjoining to another, where the milk was the same, and the fouring 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 fouring vat it rose to 68 degrees. An increase of 4 degrees shows a pretty brisk intelline motion.

"To what are all these effects owing? To the acetous fermentation going on in those vegetable liquors, whose acids, extracting themselves, produce heat, intelline 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 intelline motion, which attend it, to afflict 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 saturates, 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, whipped, 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.

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

All the fours made of bran, rye-meal, &c. ought to be prepared before use; for by this means the 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 preffed, fall into the putrefactive, and not the acetous fermentation. This often happens to the bran preffed between the different layers on the linen, which must weaken the cloth. Hence, all fours should be prepared before the cloth is steeped in them; and none of the bran or meal should be mixed with the cloth.

The fours are used strongest at first, and gradually weakened till the cloth has attained to its whiteness. In the first fourings, 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 four. There is not, however, the least danger, at any time, from too strong a four.

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 feed 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 fouring process is sooner finished in warm than in cold weather. Heat quickens the fermentation, by aiding the intelline 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 fouring 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 fouring a very little, yet is no remedy against the fanci-unity and dearth of milk fours. Such a liquor as would serve our purpose, must be found either among the vegeta-
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It is observed, that, in the full souring, which is the strongest, the liquor, which was a pretty strong acid before the cloth was put in, immediately afterwards becomes quite rapid; 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 full operations the liquor loses very little of its acidity. This happens although the full backings, after the full sourings, are increased in strength, while the fours are diminished. There are two caukses to which this is owing. The texture of the cloth is now so open, 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 fours. One is, that the proceeds of souring with milk is performed by a fermentation; and, as there is no fermentation in the vitriol fours, 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 fours 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 stumping 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 four of water and oil of vitriol. After fifteen times stronger than that made ufe 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 fours must have over the milk. The latter is full of oily particles, some of which must be left in the cloth: But the coarse is worse when the cess is allowed to precipitate upon the cloth. The former is liable to neither of these objections.

The common fours hasten very fast to corruption; and if, from want of proper care, they ever arrive at that state, will 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 four, has all the bad effects of purerication. The vitriol fours are not subject to purerication.

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

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Vitriol-fours 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-fours; the cloth has no sooner imbibed the acid liquor than it loses all acidity, and becomes immediately vaporous. This effect of vitriol fours must be of great advantage in the bleach-field, as the bleachers are at present hindered from enjoying the seafon by the tediousness of the fouring process. The whole round of operations takes seven days; to anwser 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 fours are used, there will be no more than three parcels. The cloth will be kept a shorter time in the bleach-field, and arrive sooner at market.

The milk-fours 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 lies 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-fours.

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

After 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 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 women’s hands, with soap and water. 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 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-felt in this kind, which is not in the soft, and as this felt 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 between 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 same water-wheel moves two rollers, with ridge and groove, so that the former enters the latter, and, by a gentle motion round 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 cloth. These rubbing-boards were discharged, some years ago, in Ireland, by the Trustees for the manufactory 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 men’s 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 worn; 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 cotton 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 expense 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 linens have 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
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all the dirt and filth which the rubbing-boards have loosened, and which, at the next boiling, would discolour the cloth. Besides, it is observed, that it makes the cloth feel cottony, and more firm, than when whitened by rubbing alone.

The last operation is that of furching and bluing. It often happens, that the cloth, when exposed to the weather to be dried after this operation, gets rain; which undoes all again, and forces the bleacher to a new expense. To remedy this inconvenience, Mr. Chryfie, some years ago, invented the dry-house, where the cloth may be dried, after this operation, in any weather. This invention meets with universal approbation.

A METHOD OF BLEACHING SAFELY WITH LIME.

Dr. Home has found by repeated trials, that alkaline fats added to lime, diminish its power of weakening and corroding cloth; and that in proportion to the quantity of these fats added to the lime. This composition, as it is not so dangerous as lime alone, so it is not so expedient in whitening. When equal parts of each are used, the whitening power is strong, 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 fats. This fully accounts for an observation made by all bleachers, that the bleaching fats, when mixed together, operate safer and better than when used separately. For the corrosive power of the Mucovy, Marcot, and Calhub ashes is corrected by the pearl ashes, and the whitening quality of the latter is increased by that of the former.

There is not a more corroding sub stance, with regard to animals, than alkaline fats and lime joined together, especially when fused in the fire. This is the composition of the common cau lific. But lime, and lime-water alone, preserve animal substances in a found entire state. It appears then surprising, that fats and lime should be found so little destr uctive of cloth, when lime, or lime-water alone, destroys it so remarkably. But that this is a fact, is made evident by many experiments, and has been practised both with success and safety, by a bleacher who gives the following account of his method of bleaching with lime.

"First, says he, I steep the cloth in warm water for twenty-four hours; then clean it in a washing mill, of all the dreeing, 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 Calhub ashes. A pound to each piece of 18 or 20 yards long is sufficient. This I do twice, as no lime ought to be given to cloth before it is a third whitened; as it by no means advances the whitening of the cloth, but, on the contrary, pro tracts 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 lyes in the first buckings. Lime is by no means fit for discharging the oil in the cloth, but for clearing it of the dead part, commonly called frat. The cloth, being cleaned, is laid upon a dreeper. It must not be dree 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 make it stick on the outside of the cloth. I take a lippy of the finest and richly powdered lime that can be got, of the brightest 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 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 lye have the nearest resemblance to milk, that breaks in boiling, of any thing I can think of: For this soap-blunts the hones 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 soon heats the cloth, and tends to it. If a hot sun shines upon it, 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. I take it up the second day after bucking, and give it a little milling, or hand-bleaching, or bating, commonly called basketing; and lay it on the field again, watering it carefully as before. The effect is more visible the second 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 three or four times at most, is sufficient for any cloth, except that made of flux-pulled either over green, or which grows in a dryish fashion, or perhaps not so well heckled as it should be. This fort occasions great trouble and expense 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 lye, 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 frat surprisingly. Then I boil it with pearl ashes, and give it the last boil with soap.

"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 use it. Some of them begin whitening of their cloth with it, which I have already observed to be wrong, and give 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 grofs body of the lime is in the sub stance 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 sub stance do not end here. When the cloth is put on board, it contracts
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tracts a dampness, which not only makes it yellow, and
loose 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, espe-
cially if the winter-season should come on before it is
dispersed or made use of. These I take to be the prin-
cipal 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 thejunction of the alkaline
salts, during the bucking, to the particles of lime which
were on the surface of the cloth.