ENCYCLOPÆDIA PERTHENSIS.

BLEACHING.

INTRODUCTION.

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

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

PART I.

OF THE OLD METHOD OF BLEACHING.

SECT. I. Of Bleaching in general.

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

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

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

(4.) The 2d operation, Bucking, or the application of filts, is thus performed: The first, or mother ley, is made in a copper, which we shall suppose, when full, holds 630 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; 20 lb. of Marcott ashes (or, if these cannot be got, about 30 lb. of Caithubs); 50 lb. of Muscovy, or blanche ashes; the three last ought to be well pounded.

(5.) 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 is fit for the operation.

(6.) Out of the first, or mother ley, the second, or that used in bucking, is made in this manner. Into another copper, holding 160 gallons, are put 150 gallons of water, 4 lb. of first soap, and 8 gallons of mother ley; or, for cheapness, in place of the soap, when they have ley which has been used to white linen, called white linen ley, they take 5 gallons of it, leaving out an equal quantity of water. This is called Bucking ley.

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

PART I.

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

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

This alternate course of bucking and watering is performed for the mold part from 5 to 7 times, or more, before the linen is fit for fouring; gradually increasing the strength of the ley, from the first to the middle bucking, and from that gradually decreasing it till the fouring begins. The leys in the middle buckings are generally about a third stronger than the first and last.

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

Into a large vat is poured such a quantity of butter-milk, or four milk, as will sufficiently wet the first row of cloth, which tied up in loose folds, and pressed down by two or three men bare-footed. If the milk be thick, about an eighth of water is added to it; if thin, no water. Sours made with bran, or rye-meal, and water are often used instead of milk, and used milk-warm. Over the first row of cloth a quantity of milk and water is thrown, to be imbiled 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 hail and secured with a post fixed to the joist, that it may not rife.

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

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

The ley, or used has no soap in it, except what 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 operations the leys are gradually made stronger, till the cloth feems of an uniform white. After this the ley is more speedily weakened than it was increased; so that the last which the cloth gets is weaker than any it got before. But the management of hours in quantity for they are used strongest at first, and decreased to strength, that the last four, considering the cloth is then always taken up wet, may be reckoned to contain three fourths of water.

The cloth, after bucking, goes to the watering, as formerly; then it returns to the four, milling, washin', bucking, and watering again. Those operations succeed one another alternately till the cloth is whitened; at which time it is blued, bleached, and dried.

This is the method used in the whitening of coarse cloths. Having forced 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 cheaper.

It is thus performed:
200 lbs. of Cobh-ashes
100 lbs. of white Muscovy
30 lb. of pearl ashes, boiled in 200 gallons of water for a quarter of an hour, make the mother or first ley. The cloth boiler is then to be filled two thirds full with water and mother ley, about 3 parts of the four to one of the latter; so that the ley used for boiling the coarse cloth is about one third weaker than that used in bucking the fine. Such a quantity of cloth is put into the foregoing quantity of ley, when cold, as can be well covered by it. The ley is brought gradually to the boil, and kept boiling for two hours; the cloth being fixed down all the time, that it may not rife above the liquor. The cloth is then taken out, spread on the field, and watered, like the fine cloth.

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

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

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

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

(23.) The common method of fousing linen is, to mix some warm water and bran in the vat; then pour a layer of cloth, then more bran, water, and cloth; and so on, till the cage is full. The whole is trampled with men's feet, and fixed as in the former processes. A hundred yards of cloth, yardwise, require between 4 and 6 pecks of bran. The cloth generally lies about 3 nights and two days in the four. Others prepare their four 24 hours before, by mixing the bran with warm water in a separate vessel, and before pouring this on the cloth, they dilute it with a sufficient quantity of water.

(24.) After the cloth is taken from the four, it ought to be well washed and rinsed again, and then to be well soaked 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, that convenience will allow of it. Two or three of these rubbings are sufficient, and the cloth seldom requires more. After the fousing begins, the ley is diminished in strength by degrees; and 3 boilings after that are common sufficient to finish the work.

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

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

Sect. II. Of Steeping and Milling.

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

(28.) The first thing, therefore, that is to be done in bleaching, is to take off all the fifth that is foreign to the flax, and might, in unskilful hands, be fixed in the cloth. This is the object of steeping; and to accomplish this, the cloth is laid in a blood-warm water. A smaller degree of heat than that would not dissolve the dressing so soon; and a greater degree of heat than that would make the cloth liable to being dissolved, and mixed with the water; and as it had acquired some degree of acidity before application, it becomes a species of ferment.

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

(30.) When this intenfrite motion is pretty much abated, and before the foam 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 great part of the fifth. But a longer stay would be attended with a much greater disadvantage. The putrid follows close upon the aceto-sulfuric fermentation; when the latter ends, the former begins, and were this to take place in any considerable degree, it would render the cloth black and tawny; so that this should be carefully prevented.

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

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

Sect. III. Of Bucking and Boiling.

(33.) The subject of this section is the most important part of the whole process, and deserves a very nice examination. Its design is to loosen, and carry off, by the help of alkaline lixivius, that particular sub stance in cloth, which is the cause of
of its brown colour. All ashes used in ley, pearl ashes excepted, ought to be well pounded, before they are put into the copper, for the mar-1
sag and caldum are very hard, and with some difficulty yield their salt. As these two last contain a very considerable proportion of a matter, which will in some degree tinge white cloth; and as this is diffused much more by heat than by the inferior degrees of heat, while the fats 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 he boiled to the end, as they are very soluble in water. If these fats were always of an equal strength, the same quantities would always make a ley equally strong; but as the pearl ashes differ very much from each other.

(34) The Muscovy ashes become weaker every day, as every bleacher must have observed, till at last they turn quite effete. A decoction from them when new, must differ very much from one when they have been long kept. Hence a necessity of some exact criterion to discover when leys are of an equal strength. The tafe cannot serve, as that is so variable, cannot be described to another, and is blunted by repeated trials. The proof-bill will serve the purpose of the bleached sufficiently: and, by discovering the specific gravity, will show the quantity of alkaline fats dissolved. But it cannot show the dangerous qualities of these fats; for the heavy and less heavy the night is, the more dangerous and corrosive it may be for the cloth. The three leys, which they draw from these materials by an infusion of cold water, in which the tafe of lime is disagreeable, appears plainly to be more dangerous than the first. The second leys, which they extract from the same ashes, and which is reckoned about a third in strength, when compared with first, must be of the same nature; and should it be used without an addition of pearl ashes, which will correct it.

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

(36) Whether a sufficient number of experiments have been tried to ascertain this point, and to establish an undoubted general rule, may very reasonably indeed be called in question. Dr Home says, when I had discovered that lime makes part of the diffused substance, and reflected how long its grosser parts will continue suspended in water, there appeared stronger reasons for suspending that this rule, though it may be pretty obvious, does not take place here; at least it is worth the pursuit of experiment. I weighed at the bleachfield a piece of glas in some cold ley, after it had been boiled, fluid for two days, and about the fourth part of it had been used. The glas weighed 3 drams 12 grains in the ley; and 3 drams 7 grains in river water. The same glas weighed in the same ley, when almost all used, 1·5 grains less than it had done before. This shows, that the last of the ley contained a third more of the diffused body; and, consequently, was a third stronger than the first. This is so, as it was dissolved, and the liquor was become clear. At the same time I immersed a bottle, fixed to a long fliker, so near the bottom, as not to raise the ashes there; and, by pulling out the cork by a string, filled the whole full of the ley near the bottom. The glas weighed in river-water 3 drams 383 grains; in the ley taken from the surface 5 drams 343 grains; and in the ley taken from the bottom 3 drams 313 grains. This experiment shows, that the ley at the bottom was in this case, 3ths stronger than the ley at the surface.

(37) At other times when I tried the same experiment, I found no difference in the specific gravity; and therefore, I leave it at a question yet doubtful, though deserving to be ascertained by those who have an opportunity of doing it. As the ley stands continually on the ashes, there can be no doubt but what is used last must be stronger than the first. I would therefore recommend, to general practice, that the first ley be used in the piece, and the last in the bottom, which cannot be done so long as it stands on the ashes.

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

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

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

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

§ 32. It plainly appears from these facts, that the bleached wax was more inflammable than the unbleached; 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 analogous reasoning from wax to linen without objectionable foundation. I cannot suppose that the substance extracted from the cloth, that the eye, and examine its different properties. The place proper to find it, is in a ley already used, and fully impregnated with these coloring particles.

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

§ 35. Could we separate this Colouring substance from these fatts, and exhibit it by itself, so that it might become the object of experiment, the question would be soon decided. Here chemist lends us its influence. Whatever has a stronger affinity or attraction to the fatts with which it is joined, than this substance has, must set it at liberty, and make it visible. Acids attract alkaline falt from all other bodies; and therefore will serve our purpose.

§ 36. Into a quantity of the impregnated ley mentioned in the former experiment, I poured in oil of vitriol. Some bubbles of oil arose, an intense motion was to be perceived, and the liquor changed its colour from a dark to a turbid white. It curdled like a solution of soaps, and a scum soon gathered on the surface, about half an inch in thickness, the deeper of the liquor not being above 6 inches. What was below was now pretty clear. A great deal of the same matter lay at 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 much darker than the cloth which had been boiled in it.

§ 37. 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.

§ 38. From the inflammability of this substance, its resisting of water, and dissolving in spirit of wine, we discover its oleaginous nature; but from its great specific gravity, and its black appearance, it is very much from the excreta 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 excreta or oils; because these when joined to alkaline fatts, 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 flux. The substance extracted from cloth by alkaline keys appears then to be a composition of a heavy oil, and the solid earthy particles of the flux.—In what manner these fatts act, so as to dissolve the oils, and detach the solid particles, is uncertain; but we are evidently how much cloth may be weakened by an improper use of them, as we find the solid particles themselves are separated.
into it, the water is kept from getting at the faults from the outside of the beef being hardened.

(49.) If we consider how much of an oily substance there is in the cloth, especially at first, which will for some time keep off the water, and how the boiling of the threads, and cloths 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 les 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 les are washed off, it is as black, in some parts, as when it was fleeced. This must be owing to the discharge of the colouring particles, from those places to which the les have access, and to their remaining where it has not. It seems advisable, then, in the first bucking or two, when the cloth is foul, to use the les carefully below the boiling point; that by this soaking or maceration, the faults may be entirely discharged, and the cloth quite opened for the speedy reception of the boiling les in the buckings which succeed. The les should likewise be weakened in the first buckings, because they act only on the more external parts; whereas, when the cloth is more opened, and the field of action is increased, the active power ought to be too; for this reason they are at the strongest after some frettings.

(50.) As to the management of the coarse cloth, where boiling is substituted in place of bucking, this species of linen cannot afford the time and labour necessary for the latter operation; and therefore they must undergo a shorter and more active method. As the heat continues longer at the degree of boiling, the les 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 heat to penetrate more speedily. In the cloths kinds, however, the final application of the faults of bucking should be made without a boiling heat being used.

Sect. IV. Of Alternate Watering and Drying.

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

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

(53.) What is the nature then of this substance? As it appears (§ 40.) that the whitening, in the operation of bleaching, depends on the extracting the heavy oil, and solid particles of the flux; it is highly probable, that the effects of water, and exposure to the sun, air, and winds, are produced by the evaporation of the flux, and of the oil, which, to the faults, with which composite body the cloth is impregnated, when exposed on the field. That these faults are in a great measure carried off or destroyed, appears from the cloth being allowed to dry without any danger, after the evaporation has gone on for some time. "If we can show (says Dr Home) that oils and faults, when joined together, are capable of being exhaled, in this manner by the heat of the atmosphere, we shall reduce this question to a very great degree of certainty. Sept. 10, I exposed in a SW. window half an oz. of Calamine soap, and was down and watered. Sept. 14, when well dried, it weighed about 3 dr. 6 grs. Sept. 25, it weighed 3 dr. 2 grs. Sept. 24, it weighed 1 dr. 50 grs. It then formed a very little whitest; but was much more mucilaginous in its tinge, and had no degree of falsness which it had before."

(54.) It appears from this experiment, that soap is so volatile, when watered, and exposed to air not very warm, that it looses above half its weight in 14 days. The same must happen to the sapaceous substance, formed from the conjunction of the alkaline faults, heavy oil, and earthy particles of the flux. 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 loosed by the former process of bucking.

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

(56.) * The
Sect. IV. V. BLEACHING.

"(56.)" The other objection is, that cloth dries much faster in windy weather than in calm, which would seem to show, that the sun has a more 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 coolness of the windy weather will all be from the surface. Clear sunshine, with a very little wind, is observed to be the best weather for bleaching; a convincing proof that this reasoning is just.

"(57.)" It has been allowed to follow as a corollary from this reasoning, that the number of waterings should in general be in proportion to the strength of the sun; for the stronger the sun is, the more there is to be evaporated; and the greater the evaporation, in case the wind is but moderate, the hotter it is, and the less time允许 the water a free passage. Perhaps that colour may retain a greater degree of heat, and in that way suffer still a little. Cloth, therefore, after the first buckings, must be more carefully watered than after the last.

"(58.)" It follows likewise from this reasoning, that the sun of the bleach-field should be gravely or finely, that the water may pass quickly through it, and that the heat may be increased by the reflection of the sun, for the faces 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 refine the cloth in water, and then give it a milling, to take out all dirt else it would be fixed in the cloth by the following buckings, as it is not soluble by the ley.

"(59.)" This operation has more attributed to it by the bleachers than it can justify claim. The cloth appears, to the eye, to whiten under these alternate waterings and dryings; and these naturally get the barm of it, when it more properly belongs to the former operation. Here lies the fallacy. Alkaline faults give a very high colour to the decotions or infusion of vegetables. This is probably owing to the solution of the vegetable colloids in the plant, which particles, being opened and separated by the faults, 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 depth of its colour. This rule, in general, is good. I observe that in those buckings which continue from the Saturday night to the Monday morning, the cloth has always the deepest colour. When that cloth has been exposed some hours to the influence of the air, these colouring particles, which are but loosely attached to it, are evaporated, and the linen appears of a brighter colour. This operation does no more than complete what the former had almost finished. If its own merit were thoroughly known, there would be no occasion to attribute 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.

"(60.)" Since the only advantage of watering is the removal of the faults, and what they have dissolved, mighty, it is this which brings 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 benefit, which we might take out the alkaline faults by acids; but then the other substance would be left in the cloth, nor would any washing be able to remove it. Mill-walking appears a more probable method of taking out all faults and ordinary, and we would deem 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 washed and all of which it then and not allowing the air to a free passage. Perhaps that colour may retain a greater degree of heat, and in that way suffer still a little. Cloth, therefore, after the first buckings, must be more carefully watered than after the last.

Sect. V. OF SOURING.

"(56.)" That alkaline faults are convertible, by different methods, into absorbent earth, is a fact well known in chemistry. Frequent solution in water and evaporation of it again, is one of these. The transformation then of these faults, which are not volatilize or washed away, must be continued upon the surface of the cloth; owing to the faults being washed off more speedily than the sulphur, to which they are united in the ley. The attachment between these two bodies we know is very loose, and the separation easily made. Evaporation then alone is sufficient to carry off their fulminating particles."
3 BLEACHING

(65.) Frequent buckings and bleachings lead 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 wash out of the cloth. The acid liquors commonly used, are butter-milk, which is reckoned the best, four milk, infusion of bran, rye-meal, &c. kept for some days till they four. Sour why is thought to give the cloth a yellow tinge.

(66.) Before the linen is put in the four, it should be dried, that the acid particles may act 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; manifested signs of a fermentation. The following experiment, says Dr. Home, shows the degree of heat which attends it. "May 25, I put a thermometer of Fahrenheit's into some butter milk, of which the bleachers were composting their four, and which stood at a vat adjoining to another, where the milk was the same, and the fouring procours had gone on for two days. After the thermometer had been 20 minutes in the butter milk, the mercury stood at 64 degrees. In the fouring vat it rose to 68 degrees. An increase of four degrees shows a pretty brisk indifinite motion."

(67.) "To what are all these effects owing? To the acetic fermentation going on in those vegetable liquors, whose acids, extracting themselves, produce heat, indifinite 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 with 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 indifinite motion, which attend it, to affect 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 appears not absolutely necessary."

(68.) When these absorbent particles are fully extracted, the remaining acids may unite with, and have some effect in extracting the colouring particles. This appears from the following experiment. Sept. 10, a piece of cloth which had been steeped, weighing 43 grs. was put into a half pound of butter milk, whipped, and well boiled, by a mixture of water, and by boiling. Dec. 24, when taken out, and washed in water, it appeared a very little white. The mineral acids, as will appear afterwards, whiten cloth, even though they are very much diluted.

(69.) Just before the acetic 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. 10, a piece of cloth weighing 42 grs. was laid in butter milk unwhipped. Novem. 13, the milk had a putrefied smell. The cloth was a little whiter, but very tender; and weighed, when well washed in warm water, and dried, 40 grs.

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

(71.) The four sours are used strongest at first, and gradually weakened till the cloth hath 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. There are two ways of improving this method of obtaining the same end. As it takes five or six days, it retards the whiting of the cloth considerably; and as bleachers are obliged to fend for milk at a great distance, it becomes very dear. This method of making the cloth with the four, that, when used, it can have no good effect; perhaps it may have a bad one.

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

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

ter, which would not fail to discolour the cloth. Besides, the demand of the bleachfields would raise their price too high. But the mineral acids have neither of these objections. They are exceedingly cheap, and contain no oil. "I will freely own (says Dr. Home), that at first I had no great opinion of succour from the mineral acids, from two reasons: their want of all fermentation, which I then looked on as necessary; and their extreme corrosiveness. But the experience of two different summers, in two different bleachfields, has convinced me that they will answer all the purposes of the milk and bran four; and, in some respects, he much preferable to them. I have seen many pieces of cloth, which had had no other four but thofe of vitriol, and were as white and strong as thofe 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 following is the method in which it has been hitherto used: The proportion of the oil of vitriol to the water with which it is diluted, is half an ounce, or at most three quarters, to a gallon of water. As the milk fours are diminished in strength, so ought the vitriol fours. The whole quantity of the oil of vitriol to be used, may be first mixed with a small quantity of water, then added to the whole quantity of water, and well mixed together. The water should be milk warm, by which means the acid particles will penetrate farther, and operate sooner. The cloth should then be put dry into the liquor, in 7 pieces. This four performs its task much sooner than that composed of milk and bran, for, in making the trial, have been used to lay the milk fours 24 hours before the vitriol. Five hours will do as much with this four as five hours with the common for. But the cloth can receive no harm by allowing it to remain for some days in the four; but rather an advantage. The cloth is then taken out, well rinsed, and well-washed in the ordinary way."

While the cloth lies in this four, the liquor is left acid the second day than the first, less the third than the second, and 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 founsete increases every day. This substance extracted by the acid is the same with what is extracted by the alkaline farts; and blunts the acidity of the former, as it does the alkaline farts of the latter. While the liquor loses by degrees its acidity. But as the acid farts do not unite so equally with oily substances as the alkaline, the liquor is not to uniformly tinged in the former as in the later, and the mucous substance prevents itself floating in it."

In the first, the vitriol, which is the strongest, the liquor, which was a pretty strong acid before the cloth was put in, immediately afterwards becomes quite weak; 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 bleaching after the first fourings are increased in strength, while the fours are diminished. There are two causes for this. The texture of the cloth is now so opened, that although the hairs are strong, the alkaline farts and absorbant earth are easily washed out; and the oily particles are in a great measure reduced which help to blunt the acidity of the liquor.

There are two objections, however, against the use of vitriolic fours. One is, that the process of fouring with milk is performed by a fermentation; and in this four, pieces of 28 yards of 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 fine cloths, which had had no other fours but thofe of vitriol, and were as white and strong as thofe 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."

After the linen is boiled in a lay of ashes, it is bleached for some time, after which, to make it receive the colour, it is steeped in a four of water and oil of vitriol, about 15 times stronger than that made use of in the bleachfield; for to 100 gallons water are added 3 of oil of vitriol. Into this quantity of liquor, made fo warm at the hand, that it can justly be laid in 45 yards each. The linen remains in it about two hours, and comes out remarkably whiter. The fine cloths often undergo this operation twice; nor is there any danger if the oil of vitriol is well mixed with the water. But if the two are not well mixed together, and the vitriolic acid remains in some parts undiluted, the cloth will be corroded.

The vitriolic fours have various advantages: they are a great improvement on the common; they have the advantage of all the farts, and the colour of the vitriol fours is not subject to putrefaction at all. Milk fours are very cheap, and often difficult to be got; those of vitriol are cheap, and may be easily procured at any time. The milk takes 3 or 4 days to perform its task: but the vitriolic fours do it in many hours, if only kept in 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 four; the cloth has no sooner imbibed the acid liquor, than it loses all acidity, and becomes immediately rapid. "This
BLEACHING.

PART I.

The effect of vitriol four must be of great advantage in the bleachfield, as the bleachers are at present hindered from enjoying the facility of the bleaching, which not often occur in the four process. The whole round of operations takes 7 days, or which they must have 7 parts, which are often mixing together, and causing mistakes. As 3 days at most will be sufficient for all the operations when vitriol four is used, there needs be no more than 3 parts. The cloth will be kept a shorter time in the bleaching, and arrive sooner at market.

(79.) Vitriol has also another advantage in its power of whitening cloth. Even in this diluted state, its whitening power is very considerable. We have already seen, that it removes the fame colouring particles which the alkaline leys do. That then remains of it, after the alkaline and absorbent particles are neutralized in the cloth, must act as acid colouring particles, and help to whiten the cloth. That this is really the case, appears from the following fact. A bleacher being obliged to use 100 of the pieces to 100, he took 9 of the pieces which were bleached with vitriol, and 1 of the pieces which were bleached with whitewash. On the whole, from both reason and experience it appears, that it must be for the advantage of our linen manufacturers to use vitriol instead of milk four.

SECTION VI. OF WASHING, HAND-RUBBING, RUBBING BOARDS, STARCHING, &c.

(80.) As soon as the cloth comes from the fouring, it should be well washed in the washing-mill, to take off all the acid particles which adhere to its surface. All the oils 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 alkaline oils are not evaporated by bleaching. Hence it is necessary to apply soap and warm water, which unite with, diffuse, and carry them off. It is observed, that if the cloth, when it is quite white, gets too much soap, the following bleaching is apt to make it yellow; on that account the soap should be washed out.

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

(82.) In this operation, the management of the cloth is very different from that of the fine. Instead of being rubbed with hands, which would be too expensive, it is laid on a table, run over with soap, and then put between two rubbing boards, which have ridges or grooves from one side to another, like teeth. These boards have small edges to keep in the soap and water, which lives the cloth. They are moved either by hand or by a water-wheel, which is more equal and cheap. The cloth is either drawn by degrees through the boards, by men; or, which is better, the same wheel moves two rollers, with ridge and groove, so that the former enters the latter, and by a gentle motion round their own axis, the cloth is gradually pulled through the boards. This mill was invented in Ireland above 40 years ago. The Irish bleachers use it for their fine as well as coarse cloths. These rubbing boards were dischired some years ago in Ireland, by the trustees for the manufactures of that country, being convinced from long experience of their bad effects. But as proper care might be taken to instruct the bleachers by degrees in a safer method, they continued in the old, made a party, and kept possession of the rubbing boards. There were considerable improvements made in them in this country, such as the addition of the ledges, to keep the cloth moist; and of the rollers, which pull the cloth more gradually than men’s hands. These improvements were first made in Salton bleachfield.

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

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

SECTION VII. OF BLEACHING with LIME.

(86.) The process of bleaching, it is believed, may be very safely undertaken with the assent of dry-house, where the cloth may be dried after this operation, in any kind of weather.
Sect. VII.

Bleaching.

That alkaline salts added to lime, diminish its power of weakening and corroding cloth, in proportion to the quantity of the salts. The composition, as it is not so dangerous as lime alone, is not so expensive 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 8 parts of lime to four of pure alkaline salts. This is agreeable to an observation made by all bleachers. That the bleaching salts, when mixed together, operate more powerfully, than when used separately. For the corrosive power of the Mutvow, Marcon, and Calabah ashes, is corrected by the pearl ashes, and the whitening quality of the latter is increased by that of the former.

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

(88) "First, (says he) I stop the cloth in warm water for 12 hours; then clean it in a washing tub, and then put it into a large tub of a water of 12 yards is sufficient. This done, it ought to be given to cloth before it is a full third whitened; as by no means advances the whitening of the cloth, but, on the contrary, provokes it; for, instead of loosening the oil and dirt in the cloth, when brown, it rather fixes them; just as when fine cloth is soaked with over-warm leys in the first buckings. Lime is by no means fit for discharging the oil in the cloth, but for cleaning it of the dead part, commonly called gross.

(89) "The cloth, being cleaned, is laid upon a draper. It must not be drier before bucking with lime, otherwise it will take in more than can be got out again before the next operation: for as I have observed already, that lime is only fit for discharging the dead part, bucking thus wet makes it red on the outside of the cloth. I take a lippy of the finest and richest powdered lime that can be got, of the brightest white colour, as poor lime does more hurt than good, to 30 pieces of the above length; and make a cold ley of it, by fining and pouring water off the lime, until all be dissolved but the dregs, which is thrown away; then I add a little soap, which makes the ley have the best resemblance to milk, that breaks in boiling, of any thing I can think of; for this soap blunts the hotness of the lime. Then I take the cloth and dip it in the lime-ley, and that moment out again, and lay it on a draper 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 renders it stiff. If a hot fun shine follows, it has great effect; for lime is just like all other materials for bleaching, that have more or less effect, according as the weather is good or bad.

(90) "I take it up the 3d day after bucking, and give it a little mulling, or hand-robbering, or bitting, commonly called knocking; and lay it on the field again, watering it carefully as before. The effect is more visible the 3d than the 1st day. As all cloth when limed should have a great deal of work, some of them begin whitening off their loft; and not only that, but a great deal of labour and pains is requisite to take the lime out of the cloth again; it must never be exposed on the Sabbath day, but carefully kept wet always while used in this way. Thus bucking for 3 or 4 times at most, is sufficient for any cloth except that made of flax pulled either over green, or which grows in a droughty situation, or perhaps not so well hanked as it should be. This fort occasions great trouble and expense to the bleacher. This makes the most effectual and expeditious way I ever found for this kind was, after boiling, to take a little of the warm ley, and mix a very small quantity of lime with it, and draw the cloth through that as hot as possible, and put it on the field directly, watering it carefully. This will clean it of the first furiously. Then I boil it with pearl ashes, and give it the last boil with soap.

(91) "There are some, as the vulgar term it. Afterwards I buck cloth with cow-dung and water, and bleach it with this for 3 days; then clean it again, and boil it with a ley made of Calabah ashes. A pound to each piece of 18 or 20 yards is sufficient. This done, it ought to be given to cloth before it is a full third whitened; as by no means advances the whitening of the cloth, but, on the contrary, provokes it; for, instead of loosening the oil and dirt in the cloth, when brown, it rather fixes them; just as when fine cloth is soaked with over-warm leys in the first buckings. Lime is by no means fit for discharging the oil in the cloth, but for cleaning it of the dead part, commonly called gross.

(92) "The cloth, being cleaned, is laid upon a draper. It must not be drier before bucking with lime, otherwise it will take in more than can be got out again before the next operation: for as I have observed already, that lime is only fit for discharging the dead part, bucking thus wet makes it red on the outside of the cloth. I take a lippy of the finest and richest powdered lime that can be got, of the brightest white colour, as poor lime does more hurt than good, to 30 pieces of the above length; and make a cold ley of it, by fining and pouring water off the lime, until all be dissolved but the dregs, which is thrown away; then I add a little soap, which makes the ley have the best resemblance to milk, that breaks in boiling, of any thing I can think of; for this soap blunts the hotness of the lime. Then I take the cloth and dip it in the lime-ley, and that moment out again, and lay it on a draper 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 renders it stiff. If a hot fun shine follows, it has great effect; for lime is just like all other materials for bleaching, that have more or less effect, according as the weather is good or bad.

(93) "I take it up the 3d day after bucking, and give it a little mulling, or hand-robbering, or bitting, commonly called knocking; and lay it on the field again, watering it carefully as before. The effect is more visible the 3d than the 1st day. As all cloth when limed should have a great deal of work, some of them begin whitening off their loft; and not only that, but a great deal of labour and pains is requisite to take the lime out of the cloth again; it must never be exposed on the Sabbath day, but carefully kept wet always while used in this way. Thus bucking for 3 or 4 times at most, is sufficient for any cloth except that made of flax pulled either over green, or which grows in a droughty situation, or perhaps not so well hanked as it should be. This fort occasions great trouble and expense to the bleacher. This makes the most effectual and expeditious way I ever found for this kind was, after boiling, to take a little of the warm ley, and mix a very small quantity of lime with it, and draw the cloth through that as hot as possible, and put it on the field directly, watering it carefully. This will clean it of the first furiously. Then I boil it with pearl ashes, and give it the last boil with soap.

(94) "There are some, as the vulgar term it. Afterwards I buck cloth with cow-dung and water, and bleach it with this for 3 days; then clean it again, and boil it with a ley made of Calabah ashes. A pound to each piece of 18 or 20 yards is sufficient. This done, it ought to be given to cloth before it is a full third whitened; as by no means advances the whitening of the cloth, but, on the contrary, provokes it; for, instead of loosening the oil and dirt in the cloth, when brown, it rather fixes them; just as when fine cloth is soaked with over-warm leys in the first buckings. Lime is by no means fit for discharging the oil in the cloth, but for cleaning it of the dead part, commonly called gross.

(95) "The cloth, being cleaned, is laid upon a draper. It must not be drier before bucking with lime, otherwise it will take in more than can be got out again before the next operation: for as I have observed already, that lime is only fit for discharging the dead part, bucking thus wet makes it red on the outside of the cloth. I take a lippy of the finest and richest powdered lime that can be got, of the brightest white colour, as poor lime does more hurt than good, to 30 pieces of the above length; and make a cold ley of it, by fining and pouring water off the lime, until all be dissolved but the dregs, which is thrown away; then I add a little soap, which makes the ley have the best resemblance to milk, that breaks in boiling, of any thing I can think of; for this soap blunts the hotness of the lime. Then I take the cloth and dip it in the lime-ley, and that moment out again, and lay it on a draper 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 renders it stiff. If a hot fun shine follows, it has great effect; for lime is just like all other materials for bleaching, that have more or less effect, according as the weather is good or bad.

(96) "I take it up the 3d day after bucking, and give it a little mulling, or hand-robbering, or bitting, commonly called knocking; and lay it on the field again, watering it carefully as before. The effect is more visible the 3d than the 1st day. As all cloth when limed should have a great deal of work, some of them begin whitening off their loft; and not only that, but a great deal of labour and pains is requisite to take the lime out of the cloth again; it must never be exposed on the Sabbath day, but carefully kept wet always while used in this way. Thus bucking for 3 or 4 times at most, is sufficient for any cloth except that made of flax pulled either over green, or which grows in a droughty situation, or perhaps not so well hanked as it should be. This fort occasions great trouble and expense to the bleacher. This makes the most effectual and expeditious way I ever found for this kind was, after boiling, to take a little of the warm ley, and mix a very small quantity of lime with it, and draw the cloth through that as hot as possible, and put it on the field directly, watering it carefully. This will clean it of the first furiously. Then I boil it with pearl ashes, and give it the last boil with soap.

(97) "There are some, as the vulgar term it. Afterwards I buck cloth with cow-dung and water, and bleach it with this for 3 days; then clean it again, and boil it with a ley made of Calabah ashes. A pound to each piece of 18 or 20 yards is sufficient. This done, it ought to be given to cloth before it is a full third whitened; as by no means advances the whitening of the cloth, but, on the contrary, provokes it; for, instead of loosening the oil and dirt in the cloth, when brown, it rather fixes them; just as when fine cloth is soaked with over-warm leys in the first buckings. Lime is by no means fit for discharging the oil in the cloth, but for cleaning it of the dead part, commonly called gross.
bleaching. part ii.

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

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

part ii.

of the new method of bleaching.

introduction.

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

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

sect. i. account of m. berthollet's method of bleaching.

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

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

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

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

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

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

13

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

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

(103.) VIII. The second immersion in the acid is to continue only about half an hour; after which the tube is to be taken out and wrung as before.

The same liquor may serve for several immersions; only when it appears to be much exhausted, it is to be restored by the addition of fresh liquor.

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

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

SECT. II. METHOD OF PREPARING THE DEPHLOGISTICATED MARINE ACID; WITH A DESCRIPTION OF THE APPARATUS.

(106.) For preparing the dephlogisticated acid, M. Berthollet recommends 6 ounces of black manganese finely powdered, 16 ounces of sea-felt like wax powder, and 12 ounces of concentrated vitriolic acid, to be diluted with 8 ounces of water; but the quantity of this mixt must be varied according to the strength of the acid and the dryness of the salt. If the manganese is impure, its quantity is to be augmented in proportion to the suppos'd impurity; and it is known whether a sufficient quantity has been employed, by a portion remaining behind and retaining its black colour. When the materials are prepared, the manganese and common salt, both reduced to fine powder, must be mixed accurately together, and put into the distilling vessel placed in a sand bath; the vitriolic acid, diluted with water, and allowed to cool, is then to be poured upon them, and the junctures exactly luted. The receiver may be of wood covered in the inside with wax, and of a very large size; for the gas is absorbed in proportion to the surface of the water it acts upon.

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

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

(109.) Figs. 3. 4. APPARATUS FOR THE DISTILLATION OF MURIATIC ACID. In this Q R S T are four flues which are thicker than the others, and which project within the tub, where they are hollowed so as to receive the ends of two wooden bars U V, which serve to keep in their places the cavities or receivers X, Y, Z.

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

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

PART II.

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

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

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

SECTION III. ADVANTAGES OF THE NEW METHOD OF BLEACHING.

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

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

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

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

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

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

(122.) The warehouseman, in a city which is unfavourable to the ordinary method of bleaching, is not able to fulfil his engagements without great difficulty; he is obliged to employ a considerable capital to fill his warehouses, in the fea- son in which the bleaching is executed; he is unable...
Sect. III. BLEACHING.

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

(151.) "The consumer will also find his advantages, for the fame diminution in the price of cloths and thread, but the new bleaching, when properly executed, diminishes the original strength of flax and hemp much less than the long and often repeated operation of common bleaching. It even appears, by the experiments of M. Decroisset, that the oxygenated nitric acid, by contracting the pores of cotton, gives it more solidity, and also communicates to it the property of taking more brilliant colours.

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

(153.) "Besides, may not those vast meadows, which are not only, in the end, with cloths (which it is necessary to keep spread over them all the fine weather), be gained for the purposes of agriculture, to which they are now allotted?

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

(155.) "I shall now proceed to describe some other uses, in which the oxygenated nitric acid may be employed. It appears that it may be successfully made use of to destroy the matter ground of printed cloths. When these cloths are printed with different colores, they are washed through the water, where the different shades, according to the nature of the colour, but at the same time the ground of these cloths is the matter of the colourless: this colour, which is much left permanent than that which has been fixed by the colouring, it is necessary to destroy by means of cow-dung and bran, and by long exposure in the fields. When I first tried, instead of these means, to use the oxygenated nitric acid, I found that the colours, which ought to be preferred, were themselves much injured.

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

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

(158.) "In the trials made at Jouy, the expense has been greater than that of the ordinary processes; on account of the price of salt; it is a great disadvantage to manufacturers, which are established in countries subject to a tax on salt."

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

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

(161.) From these particulars it is probable, that by combining the process of making depellogliitated spirit of salt with that of preparing the mineral alkali, bleaching might be performed at an easier and cheaper rate than has yet been done; though even here there is some doubt, that without an encouragement from government, by taking off the duties from salt and sulphur used in
the different operations, a project of this kind might miscarriage, to the great detriment of the individual who should attempt it.

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

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

It was always my intention (says he,) when I published the description of the method of bleaching by means of the nitric acid, to communicate such a full account of the process as to ensure the success of the experiment. The acid, as I have before remarked, I could add to it, whether they arose from my own observations, or from those of my correspondents, provided the latter were not made known to me under the title of secrecy; for, it is natural that those who have been engaged in the practice of any particular art, should wish to keep secret those improvements which they may succeed in making; and there is no kind of property which ought to be more respected, than those discoveries which arise from industry.

M. Welte has found it advantageous to furnish the process of bleaching, by exposing the clothing thread or the thread after being washed in pure water. He thinks that this exposition is absolutely necessary, in order to take away a yellow tinge, which are apt to remain, but he observes that cotton does not want this operation.

Others, however, have bleached to the entire satisfaction of the dealers, without this exposition, and I have convinced myself, by many experiments, that linen may be brought to the most perfect whiteness without it; nevertheless, when thread or cloth is prepared together in any parts, during the process (which, when a large quantity is bleached at the same time, it is very difficult to avoid,) those parts are apt to preserve a yellow tinge, which it would perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps perhaps possibly
BLEACHING.

The expense of it, according to their calculation, was too great.

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

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