BLEACHING (Ang.-Sax. *blæcan*, from *blæc*, pale, bleak) is generally understood to mean the process of whitening or decolorising cloth; but the term is also applied to the decolorising of such substances as the fixed oils, Irish moss, &c. Until about the close of the 18th c., B. depended upon the natural bleaching agencies present in the atmosphere and in the sun's rays. The usual plan was to spread out the cloth on a grass field, called a bleaching-green, and to continue sprinkling it with water several times a day. After being thus exposed for several months to the action of air, light, and moisture, the cloth was rendered white. The process was necessarily tedious and occupied much valuable land, and for this reason a large quantity of the cloth required to be bleached was sent to Holland for that purpose. A particular kind of linen, which was regularly sent to Holland, received on that account the name of *Hollands;* and another variety of linen, which, from its fineness, was generally spread on the better grass-fields or lawns, received the title of *lawn.* An improvement in the preceding process was to dip the cloth occasionally in a weak *alkaline lye*, or solution of an alkali, such as soda in water, which step was called *bucking;* after which, the cloth was spread out on the grass for some weeks, and regularly moistened with water, this stage being styled *crofting;* the cloth was then soaked in sour milk and water, which was called *souring*, and again exposed on grass to the action of air and sun-light. By repeating the bucking, crofting, and souring operations several times, the bleaching was very much hastened, and the amount of land occupied in bleaching-greens lessened. The next improvement was the introduction of dilute sulphuric acid instead of sour milk, as the souring agent; and this was so effectual, that it lessened the time required for B. from about eight months, which was the original time, to about four months.

Till very recently, it was thought that the agent in this natural mode of B. was entirely resident in the sun's rays, but the discovery of the substance called Ozone (q. v.), which possesses very powerful B. properties, and which in greater or less quantity exists in the air of country districts at all times, has led to the opinion, now held by chemists, that the B. which takes place when cloth is moistened and exposed to the air is mainly due to the ozone present therein; though the chemical rays which accompany the luminous rays of the sun may assist in the B., and also aid in the formation of the ozone. That the ozone has very much to do in open-air B., is observable from the fact that in town districts, where little or no ozone exists in the air, cloth is never bleached white.

In the year 1785, Berthollet, a distinguished French chemist, discovered the powerful B. properties of *Chlorine* (q. v.), and immediately thereafter it was suggested that chlorine would be useful in the B. of cloth. At the first, the gas chlorine was employed, and being diffused in the atmosphere of a vessel or small apartment, cloth hung therein was speedily bleached. It was found, however, that the chlorine, which bleaches, or destroys colour by uniting with the hydrogen of the colouring principle and thus decomposing the colour, could also unite with the hydrogen of the fibre (see LIGNIN) and destroy or render tender the textile fabric. So long as chlorine was employed in the gaseous state, it was very difficult to use it of such strength as only to destroy the colour, without also rotting the cloth. It was then suggested, that as chlorine was soluble in water, to the extent of two volumes of chlorine gas in one volume of cold water, the solution of chlorine might be employed. But although chlorine water was found to act efficiently and safely when the solution was of the proper strength, it was very difficult always to make it of the same strength, and more so to preserve it when made; as the least exposure to light causes more or less of the chlorine to unite with the hydrogen of the water, forming hydrochloric acid, which does not possess B. properties. After attempts to fix the chlorine in alkaline solutions, it was found that dry slaked lime was an admirable absorber of chlorine gas. The material produced from the union of chlorine with dry slaked lime is known as the *chloride of lime*, or *Bleaching powder* (q. v.), and this is the substance which has continued from 1799 up

to the present time to be the great artificial bleacher of cotton and linen fabrics. It is not serviceable in the destruction of the colour of wool, silk, or the oils and fats; such materials being bleached by the employment of other agents, as will be afterwards noticed.

BLEACHING OF COTTON AND LINEN FABRICS.—The substances requiring to be got rid of in the purification of cotton and linen cloth, are (1) the organic colouring matter naturally present in the fibre; (2) resinous and fatty bodies, also inherent in the fibre; (3) weavers' dressing and perspiration taken up during the process of spinning; and (4) certain saline or earthy substances. The *first stage* in the B. is the singeing of the cloth, which is accomplished by drawing the cloth rapidly over a red-hot iron cylinder, or a numerous series of gas jets, which burn off the minute particles of fibre, resembling in appearance short hairs or down, and leave the cloth perfectly smooth. The *second stage* is the washing or scouring of the cloth, which consists in rolling up the pieces of calico or linen into bundles like coils of rope, and throwing a number of pieces into a large vat among lukewarm water, and allowing them to lie till fermentation begins, and proceeds some length, when the cloth is taken out, and thoroughly washed in the dash-wheels; which are large horizontal cylinders divided into several compartments, into each of which a stream of water keeps running while the wheel is turning. The *third stage* is boiling with lime-water, or *bucking*. The apparatus employed is called the *Bouking* or *Bucking Kier*, and consists of two compartments. The lower part is a boiler containing the lime-water, and the upper part is a capacious circular tank, into which the cloth in bundles, as it comes from the dash-wheels, is placed. By an ingenious arrangement, the lime-water is alternately forced up, by the compression of the steam, through a pipe into the upper compartment, and falls in a shower upon the cloth, through which it percolates and sinks again through perforations into the boiler, to be again propelled into the upper compartment. Instead of using lime alone, a mixture of lime and carbonate of soda ($NaOCO_2$) is occasionally employed, which acts by forming the inert carbonate of lime or chalk ($CaOCO_2$) and caustic soda (NaO), which possesses high detergent properties. The chemical action which the boiling lye exerts on the cloth is in the formation of a soap with the resinous and fatty substances naturally inherent in the cotton or linen fibre, or communicated to it in the process of weaving, the greater portion of which is detached by the lye in the *bucking kier* and ultimately removed by a subsequent washing with water. This takes place either in the dash-wheels, or in a more effectual washing arrangement, consisting of a series of boxes or vats of different depths, placed side by side, into which the cloth is made to dip successively by passing over and under two sets of rollers. As the cloth moves on from the lower vats to the higher, it is passing from the soiled water to the more pure, as a stream of pure water is kept constantly running through the vats from the higher to the lower. The *fourth stage* in B. is the *souring* or *chemicking* in dilute sulphuric acid, of the strength of one gallon of the acid to from 25 to 30 gallons of water. The weak acid liquid is put into a large stone vat, and the goods are steeped in it. The acid acts beneficially in removing the remaining traces of the lime-soap which have adhered to the cloth, and a second washing in water, followed by bucking or scouring in soda lye, and a third washing in water are generally found necessary to obtain the cloth in the condition best suited for the subsequent operations. The *fifth stage* is *chemicking with B. liquor*, obtained by dissolving *B. powder* (q. v.) in water, and allowing the impurities or insoluble matter to subside. The B. liquor is much diluted with water, and the cloth is steeped in it for about six hours, then taken out, and allowed to soak for other six hours in a second vat containing water, after which it is drawn out and exposed to the atmosphere, when the carbonic acid of the air sets free a portion of the chlorine from the B. powder, imbibed by the cloth. The *sixth stage* is another *souring* process, during which the cloth is immersed for about four hours in a steeping vat, containing dilute sulphuric acid of the strength ranging from 1 to 8 gallons of acid in 200 gallons of water. This acid liquid, as it soaks the cloth, encounters the B. liquid which previously saturated the fibre of the cloth, and the acid combining with the lime of the B. liquid, liberates the chlorine, which attacks the remaining traces of colour and removes them from the cloth.

The cloth, on being removed from the souring-vat, is boiled with soda lye, washed, and again treated with dilute sulphuric acid, which more effectually removes the decomposed colouring matter. It is thereafter thoroughly washed, passed through rollers to remove some of the water; then introduced into the *Hydro-extractor*, to get rid of the water more effectually; and lastly, the cloth is dried by being suspended in the air, or by being passed over a series of heated tin rollers, called *Steam Cans*. In the ordinary course of B., cotton loses about one-twentieth of its weight, and linen about one-third.

After the B. operations have been successfully performed, it is customary to proceed to the *finishing* of the cloth, which consists in, firstly, passing it through a large mangle, where the crumpled piece of cloth becomes smooth; secondly, drawing the cloth over rollers, which cause it to dip in a trough containing starch; thirdly, drying the starched cloth; and, fourthly, passing it through a large mangle or calender, consisting of a series of rollers, alternately of polished cast iron and solid paper, and which not only smooth out the cloth, but communicate a fine glazed surface, such as is generally exhibited in bleached cloth when purchased. The cloth intended to be printed upon or to be dyed is not starched or calendered.—The operations connected with the B. of cloth by chlorine exert no injurious effect on the health of men and women engaged in them. Some of the bleach-works near Glasgow are of long standing, and give regular employment to several hundred women. The rapidity with which the B. by chlorine can be carried on, may be understood from the fact, that when pressed for time, it is no uncommon thing to bleach, finish, and return to town 1000 pieces of cloth within 48 hours. Valuable in many respects, however, as is the rapidity of B. by means of chemical agents, it must be admitted that the process exerts a certain weakening effect on the cloth, and that, after all, B. according to the old method on the grass is preferable. Grass-B. is therefore still in use where time admits, as also for clearing linen and cotton apparel in domestic washing. See WASHING.

BLEACHING OF WOOL is never accomplished by B. powder, but recourse is had to sulphurous acid, which disguises the colour of the wool by combining with it to form a colourless compound. Originally the wool is contaminated with a greasy substance called the *yolk*, which naturally exudes from the skin of the sheep, and this unctuous matter mainly consists of a kind of soap soluble in water. The *first stage* in the B. of W. is to get rid of the yolk, which can be done by long-continued washing

in water; but as this is tedious, the general plan is to steep the wool in a vat containing one part of stale urine and five parts of water, then boil for some time, and ultimately strain the wool and wash well. The agent in the stale urine which acts upon the yolk is carbonate of ammonia, and this acting upon the oily matters forms a soap which can be readily washed away. When woollen cloth is to be bleached, it is customary to substitute carbonate of soda (washing soda) for the stale urine, and this forms an alkaline lye, which performs the same part as the carbonate of ammonia. Soap is sometimes used as an auxiliary. The *second stage* of bleaching wool is the *sulphuring*, which takes place in a small wooden apartment, in which the damp cloth is suspended in regular folds from the roof to the floor, and a small pan of ignited sulphur being introduced, the doors, &c., are firmly closed. There are little openings round the sides of the chamber, for the admission of air, which can be closed at pleasure. The sulphur (S) in burning takes up two atoms of oxygen from the air, forming sulphurous acid (SO_2), which is the bleaching agent; and in about 24 hours the operation is finished, and the woollen material only requires to be thoroughly washed with water, which may contain a little potash or soda. Where the wool is naturally high-coloured, it is necessary to repeat the various stages of the process several times before the bleaching is complete. Instead of applying sulphurous acid in the gaseous form, a solution of it in water is sometimes used. An economical method of preparing the solution of sulphurous acid is to introduce a mixture of sulphate of iron and sublimed sulphur into an earthenware retort, and apply a low red heat, when sulphurous acid is disengaged, which is passed through a vessel containing some porous matter, such as moss, to retain mechanical impurities, and then transmitted through a series of bottles containing water, where it is dissolved to the extent of forty volumes of the gas for every one volume of the water. The bleaching of wool by sulphurous acid is not so complete as the bleaching of cotton or linen by chlorine. In the latter case, the colour is destroyed, but in the former, the sulphurous acid merely combines with the colouring matter to produce a colourless compound, from which the colour can again be revived, either by soaking the wool in a dilute acid, such as sulphuric acid, or a dilute alkali, such as soda. Hence it is that new woollen cloth or garments, such as flannel, blankets, and underclothing, though almost colourless when purchased, yet after being washed several times, return to their natural yellow; for the soda used, as well as the soap which contains potash or soda, destroys the colourless compound formed in the texture of the wool during the sulphuring, and resuscitates the original colour.

Bleaching of Silk is carried on in a manner very similar to that pursued in the bleaching of wool. The silk has naturally a good deal of wax, accompanied by oil and colouring matter, enveloping the fibre, and the silk stuffs are repeatedly boiled in water containing a little soap or carbonate of soda, the alkaline nature of the solution being occasionally tempered by the admixture of some bran, which contains an acid. When well scoured and washed, the silk is obtained white enough for many kinds of printing; but where it is desirable that a pure white be obtained, the silken stuffs are introduced into a very weak solution of sulphurous acid, and thereafter thoroughly washed.

Other substances employed in the arts and manufactures are subjected to a process of bleaching; as the rags which are being manufactured into Paper (q. v.), the palm-oil which is being converted into Candles (q. v.) and night-lights, and the Straw (q. v.) of which hats or bonnets are made; but the details of the processes followed in these and other operations, will be described more properly under their respective headings.