trough is a steam pipe *b*, perforated at intervals, by which the requisite heat for the dyeing operation is raised and maintained. Sloping upward from the steam pipe is a perforated diaphragm of iron or midfeather *c*, and mounted on a strong framework over the trough is the winch D, which by its revolutions, effected by spur wheels, keeps the cloth moving down and up continuously into and out of the trough. A peg rail *e* runs along the length of the trough, which keeps the pieces from becoming entangled in their course. The figure shows the course of a chain of pieces being dyed on the endless system, in which about twenty-five pieces are sewn together, and passed in a spiral form up and down from end to end and back again, to go over the same course continuously throughout the entire time necessary for completing the operation. Another and more common method of arranging the pieces in the dye-vat is to pass two pieces, tied together end to end, over the winch between each separate pair of pegs, in which case the pieces revolve between the same pegs throughout the operation. Whichever method is followed, the operation and results are precisely the same. The required quantity of cold water is admitted into the trough, the pieces are arranged on the winch, the dye-stuff is introduced, and the machinery set in motion. Steam is then turned on, and the liquid is heated gently and gradually till it reaches about 180° Fahr. The process is continued for from an hour and a quarter to about two hours, during which time great care is taken to maintain the temperature arrived at, and to keep the pieces in constant circulation in and out of the vat. On the completion of the operation steam is shut off, and the pieces are rinsed through cold water, after which they are carefully and repeatedly washed. Fig. 6 presents a sectional view of an apparatus devised by Messrs Mather and Platt for loose washing after dyeing.

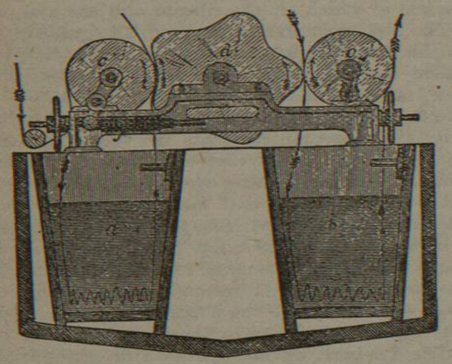

FIG. 6.—Mather and Platt's Washing Apparatus

In this machine there are two water-boxes *a*, *b*, and three bowls *c*, *d*, *e*, which are mounted horizontally in relation to each other. The central large bowl *d*, instead of being circular, has an irregular curved outline of alternate elevations and depressions. Against this irregular-shaped bowl the two side bowls *c* and *e* are made to press, and they move back and forward, following the irregular outline, pressed by powerful springs *f* acting on the axes on which they are mounted. They have thus a rubbing action in addition to their motion of revolution, an arrangement which produces a kind of flapping and squeezing action analagous to hand-washing.

Clearing.—At this point the dyed calicoes present a very unpromising appearance, the mordanted portions which have absorbed the dye being dull and heavy in colour, while the whites have a sickly pink aspect. The operations of clearing are necessary to remove all the dye-stuff which is loosely attached to the whites, and to develop and brighten the tints of dyed pattern. A variety of processes are pursued to accomplish this object, but in all the action of soap and some "chemick" or chlorine solution plays the principal part. The soap used must be free from all excess of alkali, and besides its detergent action it is supposed to be decomposed and give up part of its fatty acid to the lake formed by the mordant and the dye-stuff. The processes for clearing such calicoes as here described are as follows. After washing out of the dye-beck the goods are passed into a soaping beck, very similar in construction to the dye-beck, but surmounted with a pair of squeezing rollers instead of the winch of the dyeing apparatus. In this they are treated with a hot solution of soap; they are then washed out, squeezed, and again soaped,—the second time at a higher temperature than the first. After another washing they are "chemicked" in a weak chlorine solution, prepared by mixing chloride of lime with soda ash, with excess of soda, and from that a final washing in pure water should leave the goods clear and bright, ready for the finishing operations they receive in common with all other styles.

The reds and pinks produced by an alumina mordant with madder or artificial alizarin receive a different treatment. Mr Charles Dreyfus of Manchester, in a paper of great practical value communicated to the Society for the Promotion of Scientific Industry,[1] says of these colours: "They were some time ago dried and steamed; by the steaming a further quantity of colouring matter was combined to the mordant, and the shades thus obtained were fuller than if the goods had not been steamed. Now, instead of steaming only, the goods are passed through preparations the basis of which are fatty acids or fatty or resinous compounds; they are steamed after this preparation. I can speak highly of the good results obtained with some of these preparations, both as regards shade and saving of colour. The only difficulty is to obtain a good white; this can be overcome by careful and proper treatment of the goods. For reds and pinks there is a special and extra operation, commonly called the 'cutting.' It consists in passing the goods soaped and well washed through diluted nitromuriate of tin; the reds and pinks seem to be destroyed, becoming of a deep orange, but the subsequent soaping brings out again the brilliancy of the shade."

The processes above described are followed, with only modifications as to strength of mordants and the clearing operations, for the printing of calicoes with the madder preparations,—garancin, garanceux, and alizarin. The colours produced by these substances are as brilliant as madder colours, but they do not possess such fastness. On the other hand, the whites are not deeply stained in the dye-beck, and they generally require only a simple padding through a weak chlorine solution, and washing to clear the whites and prepare the goods for finishing. Some garancin and alizarin shades stand soaping well, and are improved in tone by such a treatment. Artificial alizarin and madder extract are now however chiefly used as steam colours, and to such perfection has printing in that style attained that the dye-house has been abandoned altogether in certain Continental establishments. The retention of dye-colour printing may now indeed be looked on as a question of comparative expense, which is determined chiefly by the price of fuel

Turkey Red.—The production of this beautiful colour belongs rather to the province of Dyeing than to calico-printing; but as patterns are produced on it by means of discharges, it is necessary to include a notice of it under the head of dye colours. It is obtained with madder,

[1] Journal of the Society, vol. i. No. 3, Dec. 1874.

garancin, and both natural and artificial alizarin, but the pieces previously to being dyed have to undergo a long series of operations, which consist in passing them successively in olive oil and carbonate of soda, and hanging them in the air between the processes. They are then passed into a weak solution of red mordant, and afterwards of gall-nuts or sumach, well washed, and dyed in madder. When this has been effected, the colours are brightened by being boiled under pressure in a solution of soap and chloride of tin. On cloth so prepared certain discharge mixtures, principally tartaric acid properly thickened, are printed, and the pieces are passed through a solution of chloride of lime which removes the red, leaving a white pattern on a red ground. If a mineral colour or mordant is printed with the discharge it is left on the cloth in place of the discharged Turkey red, and thus various shades are produced in the brilliant red ground. In bandanna printing the Turkey red calico is folded between metallic plates, which are perforated with designs, and so arranged that each figure of the design corresponds through the pile of prints so folded. The whole is then submitted to pressure, and a chlorine liquor is forced by pressure to percolate through the mass, which destroys the red colour in all those parts where the perforated plates allow the bleaching liquor to circulate.

Although madder and its various derivatives are the principal dye colours, there are various others which may be and sometimes are so treated. Of these the most important is logwood, the wood of *Hæmatoxylon campechianum*, which, although chiefly used as an oxidation colour, also yields with alumina and iron mordants black and sombre slate tints, which, however, do not possess the peculiar fastness of madders. Sapanwood and peachwood are also used as dye colours, the mordant and method of dyeing being the same as for madder or garancin; the cloth, however, does not receive the same treatment after dyeing, and does not require it, because these colours are much more easily removed from the parts of the cloth which are destitute of mordant. Beautiful reds and pinks are produced by means of cochineal; but this dye-stuff is chiefly used as a steam colour and for mousselines de laine. The mordant in the case of calicoes is either alumina or oxides of tin, and the method of proceeding is similar to that already described for madder and garancin colours. Quercitron bark (*Quercus tinctoria*), and flavin—a preparation from it, fustic, the wood of *Maclura tinctoria*, and Persian berries, the fruit of *Rhamnus infectorius*, are all used as dye colours, chiefly for the production of various shades of yellow In the paper above quoted, Mr C. Dreyfus states that mahogany has lately been brought out as a colour-giving substance, that it gives with the tin and alumina mordants very bright and fast shades of brown, much more brilliant than those made from catechu, and that he has dyed some very good specimens with Spanish mahogany.

OXIDATION COLOURS.

Under this head is included a class of tinctorial substances which attach themselves to cotton fibre without the intervention of any mordant, but which for the development and fixation of their colour must undergo a process of oxidation after printing in the machine. The oxidation may be induced either by exposure of the pieces to atmospheric influences, by passing them through a solution containing an oxidizing agent, or by printing with the material some chemical substance which on exposure to heat gives off oxygen. The materials principally treated in this manner are indigo, catechu, aniline black, and certain blacks obtained from logwood. The processes adopted for the printing of indigo and aniline black—the two most important styles under this head—will make the practical application of the oxidation principle clear.

Indigotin, the colouring principle of indigo, is a substance obtainable from several other plants besides the species of *Indigofera*, from which it is commercially prepared. It is a body altogether insoluble in water, alcohol, ether, oils, or dilute acids or alkalies; but in presence of a variety of substances it takes up an additional equivalent of hydrogen, and thus is converted into white indigo, a colourless substance soluble in solutions of alkalies and alkaline earths. The change is thus represented.

$$\underset{\text{Indigotin}}{2(C_8H_5NO)} + \underset{\text{Hydrogen}}{2H} = \underset{\text{White Indigo}}{C_{16}H_{12}N_2O_2}.$$

White indigo is a most unstable compound, taking up oxygen with great facility either from the air or from certain solutions, and thus becoming retransformed into blue indigo. Advantage is taken of these circumstances in printing indigo colours; the colour is hydrogenized and dissolved, in which condition it is applied to calico, and on exposure of the pieces so dyed to the influence of oxygen the blue colour is both developed and fixed in the fibre. The following are the principal styles in practice:—

Indigo-blue dips.—This fine blue colour is produced in the old copperas vat method by putting in a vat holding 2000 gals. of water 60 ℔ of finely ground indigo, to which is gradually added 120 ℔ of green copperas, or sulphate of protoxide of iron, together with 180 ℔ of slaked lime. Owing to the lime removing the sulphuric acid from the salt of iron, the protoxide of that metal is liberated, and by its affinity for oxygen it decomposes the water, liberating hydrogen, which in its nascent condition reacts on the blue indigo, and thus transforms it into white indigo, which is soluble in the excess of lime employed in the operation. A zinc vat of recent introduction is now much more generally adopted than the above, its advantages being that the indigo is much more quickly converted, and by avoiding the abundant precipitate of sulphate of lime a better class of work is produced. The zinc vat is prepared by adding to the 2000 gals. of water 20 ℔ of ground indigo, 30 ℔ of iron filings, 30 ℔ of finely powdered zinc, and 35 ℔ of lime. The powdered zinc in presence of the lime decomposes the water, giving off hydrogen, which is taken up by the indigo, which then as white indigo dissolves in the lime.

By whichever process prepared, the dye-vat being ready, a piece of calico is hooked on a wooden frame and well stretched out; it is then dipped into the vat for fifteen minutes, taken out, and left exposed to the air for five minutes. The piece of calico, which is white when it comes out of the vat, gradually becomes green and then blue, owing to the oxygen of the air oxidizing the white indigo, and transforming it into blue, which is insoluble in water and fixed on the calico. The number of successive dips that the piece undergoes varies according to the various shades of blue which the printer requires. The pieces, after having been passed into a weak solution of sulphuric acid or "sours," which fixes the indigo thoroughly, only require to be well washed and dried.

To produce the well-known style of print which consists in a blue ground and white design, it is necessary to print a resist, pass the pieces into a vat containing lime, and then dye them in the above indigo vat. The principal resist used is the *blue resist*, a mixture of sulphate, acetate, and sometimes nitrate of copper, and the solution is thickened with British gum, or calcined flummery, together with pipe-clay for the block, and flour for the machine printing. When the cloth on which this paste has been printed is dipped into an indigo vat, the indigo is oxidized before it reaches the surface of the cloth. After dyeing, the pieces are passed through weak sulphuric acid, not only to remove the oxide of copper, which has been precipitated, but also to fix the indigo on the calico, by liberating it entirely from its lime combination. Various other resist pastes are employed when it is desired to print other colours over the white portions, as for example, when orange or yellow grounds are desired the mixture consists of a salt of copper to resist the blue indigo vat, with a salt of lead to produce the chromate of lead by treatment with bichromate of potash after the blue dyeing is complete. The late J. Lightfoot of Accrington devised and patented, in 1867, a method of printing reduced indigo simultaneously with the mordants for madder, garancin, and other dye colours, by which a combination of indigo blue with other tints can be obtained of perfect clearness and brilliancy, without resorting to the complex and tedious processes involved in discharging colours, repeated printings, &c., when colours are blocked on a blue ground. The success of his process depends on the preparation of a pulp of indigotin and tin, in which he carefully avoided any excess of tin salt, so that it does not attract the alizarin in the madder beck, and in consequence leaves the indigo effects clear and unclouded.

China Blue.—This style of print is obtained by printing on the calico a mixture composed of pulverized indigo and sulphate of protoxide of iron, to which is sometimes added orpiment, and thickened with British gum. The pieces so printed are passed alternately, by means of rollers, first into a milk of lime, and then into a solution of sulphate of protoxide of iron, when there ensues one of the most interesting phenomena of calico-printing; for as fast as the blue indigo is reduced into white indigo, instead of being dissolved by the lime of the bath, it is retained with force through the molecular attraction of the fibre of the calico, and prevented leaving the cloth until it is fixed by the exposure of the piece to the oxygen of the atmosphere. The pieces then only require to be passed into weak sulphuric acid, washed, and dried, in order to be completed. This process is not now much used.

Pencil Blue is obtained by reducing blue into white indigo, by boiling it for several hours with protochloride of tin and alkali. When the indigo is well reduced, citrate of soda and starch are added; and after the whole is carried to the boiling-point, the calico is printed with it, passed into a milk of lime, washed, and dried.

Aniline Black is a most beautiful and fast colour, prepared by mixing a salt of aniline with a metallic salt and an oxidizing agent, which substances on exposure gradually react on each other, and develop a rich velvety black. There is thus produced one of the most unalterable colours known, resisting soap, acids, and even chlorine to a remarkable extent. It is a colour of recent introduction, having been first printed by Mr John Lightfoot of Accrington, in 1859, and patented in 1863; but it is now in very extensive use, many different methods for producing it having been devised and patented. The most extensively employed system is that patented in 1871 by Mr Lightfoot, the originator of the colour, which is thus given by Mr Dreyfus—30 pints chlorate of ammonia, prepared either by means of tartaric acid and chlorate of potash, or by another process without tartaric acid, are thickened with 6 to 8 ℔ wheat starch and 6 to 8 ℔ best dark British gum. When this colour has been well boiled, it is allowed to get cool, and then 7 pints of a solution of the purest and most neutral aniline salt that it is possible to get are added; this solution is made with 8 ℔ of salt to the gallon of water, with three-quarters to one pint of sulphide of copper paste. After the mixture is printed, the pieces are lightly dried and hung in the ageing room in a moist warm atmosphere, with the dry bulb thermometer about 80° and the wet bulb 10° lower. From thirty hours to two days are required to develop the colour, the printer judging of the progress of the ageing by the tint. According to Mr William Mather an ordinary ageing machine will effectually "age" the aniline black, if only a proper current of air is maintained of the requisite moisture and temperature. This is readily accomplished by having a properly contrived outlet to the chamber at the top, the draught of which is controllable, and inlets for fresh air in the sides of the chamber. This mode Mr Mather states is in successful operation, and by simple mechanical contrivances may be universally adopted. When the pattern has assumed a deep bottle-green tint, the goods are removed and passed through a solution either of bichromate of potash, of carbonate of soda, or of both mixed, and then soaped and dried. When aniline blacks are to be further printed with steam colours or dye colours, as is commonly the case, the treatment of the pieces after ageing is modified according to the necessities of the case.

Chrome Black is an oxidation colour produced by printing with logwood liquor and passing the goods through a bath of bichromate of potash, when the colouring principle of the logwood—hæmatoxylin—undergoes a special oxidation. The colours obtained from catechu are also fixed by oxidation, the colouring principle—catechuin—being only soluble in its unoxidized condition, and when oxidized after printing, it yields various browns and drabs, which have a very high degree of fastness

Steam Colours.

The various processes of printing included under this head are of modern introduction, but they have steadily risen in importance, till now they embrace the largest part of the art, having so largely and rapidly superseded all other styles that the process would appear to be destined to become the predominant style of the future. Indeed, to such perfection have steam colours been brought that in some Continental establishments, it appears, the dye-house has been altogether closed and steam colours only now printed. As compared with the printing of dye colours the "topical" or steam colour style is simple, direct, and expeditious, requiring no tedious dyeing, and only light soaping, clearing, and finishing operations. By the dyeing processes alone the range of shades which it is practicable to print on one piece is strictly limited by what the mordants and their various combinations will yield with the particular dye-stuff used. But in steam colours there is no limit to the number and variety of shades which may be produced, each colour-box on the cylinder printing-machine containing the whole ingredients essential to the production and fixation of a separate and distinct shade or colour. In addition to this the steaming process can be and is extensively employed to supplement the effect of madder-printed or Turkey red goods by printing steam colours into the whites, produced either by resist pastes or by discharges printed on the dyed texture.

The distinguishing peculiarities of steam colours consist—1st, in printing direct and at one operation on the cloth the whole of the materials of the dye and its fixing agent properly mixed and thickened; and 2d, in submitting the printed cloth to the influence of steam, which effects the fixation of the colour. The effect produced by the combined heat and moisture of the steaming process is, in the case of certain combinations, purely mechanical, while in others a chemical reaction ensues. In the printing of what are termed pigment colours, or, in other words, insoluble coloured powders such as used by painters, they are simply mechanically fastened or glued to the cloth by means of albumen, or some body of similar constitution, which coagulates and becomes insoluble on the application of a

certain heat. In the case of the regular steam colours and aniline dyes there is printed on the cloth a chemical mixture or solution, which on the application of heat produces a reaction resulting in the precipitation of an insoluble compound in the fibres, or a volatilization of the solvent medium is caused, so that in both cases the same result—an insoluble precipitate—is produced.

With the development of steam colours efforts have been made with success to improve on the original crude and unsatisfactory manner in which the steaming was performed. The old method, still largely employed, consists in wrapping the printed cloth around a perforated cylinder of copper, called a "column," into one end of which a pipe passes for the admission of steam. Around the column are first wrapped several folds of felt, above which comes white calico, next the printed goods, and lastly an outer envelope of white calico. When so prepared the column is set perpendicularly on a steam pipe, a stop cock is opened, and steam is admitted into the interior of the column, which presses through and acts on the printed goods. Immediately on the conclusion of the process the column must be dismounted and the goods run off, otherwise steam might condense in the cloth and cause certain colours to run.

The most common arrangement for steaming, however, consists of the chest or "cottage," which is a cylindrical steam-tight chamber, into which a carriage is introduced. The carriage is mounted with a series of rollers on which the pieces to be steamed are hung, or, in a different arrangement, the cloth is fastened on a range of hooks projecting from a steam pipe. In the latter arrangement the hooks are heated by steam before the carriage is thrust into the chest, to prevent condensation of steam on the cold spikes, and consequent rust-staining of the cloth. Fig. 7 shows a

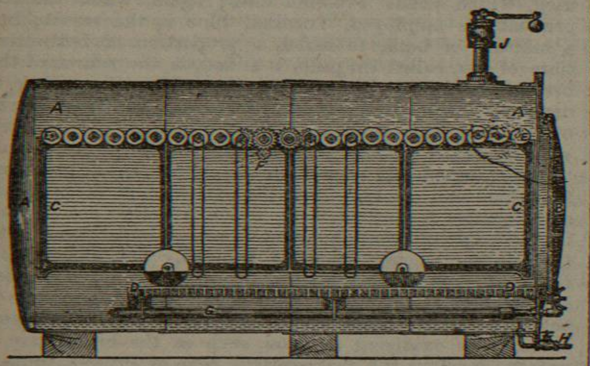

Fig. 7.—Section of Steaming Chest.

sectional view of an ordinary steaming chest by Messrs Mather and Platt. A represents the body of the chest; B the steam-tight door, which draws up when the chamber is to be opened; C the carriage or waggon fitted with a range of square wooden rollers E. The rollers are all geared to move by means of a cog-wheel F, which is turned by the attendant outside the chamber. The carriage is run in upon the rails D; steam is admitted by the perforated steam-pipe G; H is a tap for running off condensed water, and J is a safety-valve. While one carriage is in the chamber another is being filled and prepared outside to take its place when the goods are sufficiently steamed.

The steaming chest is at best only a crude and disconnected manner of performing one process in printing, and as all the others are continuous, it forms an awkward break in the series. To obviate this, and to secure expedition and continuity, a method of steaming has been devised by M. Cordillot of Moscow and Mr William Mather of Salford, which they patented in 1874. Their apparatus, of which a sectional illustration is shown in fig. 8, they claim will effectually steam 1000 pieces of 25 yards per

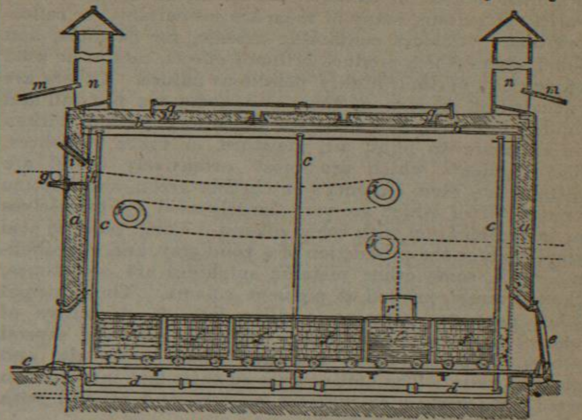

Fig. 8.—Cordillot and Mather's Steaming Apparatus.

day. According to their specification, it consists of "a brick or other chamber *a*, the roof of which is lined with a curved steam jacket *b*, connected by side pipes *c c* to the perforated pipe *d* near the floor. At each end of the chamber *a* is an opening closed by a steam-tight door *e*, through which openings the waggons for receiving the steamed fabrics are admitted and discharged. The fabric is fed into the chamber *a* over the feed roller *g* and between the small guide roller or tube *h* and copper troughs *i* and *i*, both of which and the tube *h* are heated by steam and project on each side of the wall to collect any moisture that may run down. When the fabric is in the chamber it is carried around three or other convenient number of rollers marked *j*, the last of which delivers it into one of the waggons *f*." The rollers are all heated by steam to prevent condensation, and as very moist steam is required for some colours, the supply pipe passes through water before entering through the pipes *q* into the curved jacket *b*, and thence going by the side pipes *c c* into the perforated pipe *d* as before described. "When the apparatus is in operation the steamed fabrics are deposited in one of the waggons, as shown in the figure, and when one is full both end doors are opened to allow the last waggon near the left-hand door to be discharged and to move the full waggon one step towards the exit door by the introduction of an empty waggon through the right-hand door; this brings another waggon in position for receiving the steamed fabrics, and while this is being filled the full waggon (after the four empty ones introduced to fill up the chamber at starting have passed through) that had been discharged can be emptied and brought back to the entrance door." The waggons are made of strong wire and are heated up before entering the chamber. By this system the patentees affirm that the goods are long enough exposed to the steam to allow the chemical reactions to take place in the cloth, so that the colours neither print off nor run during the remainder of the process, and the fixation is completed while the goods lie in the waggons inside the chamber. This system of steaming is in successful operation in some Manchester print-works.

Steam colours include two distinct classes of work—1st, pigment colours, or the series fixed by a mechanical effect produced in steaming; and 2d, ordinary steam colours, in which the fixation is effected more by chemical agency.

Pigment Colours are so named because the tinctorial agents employed are coloured lakes, and the insoluble mineral powders used otherwise as painters' colours Only a limited number of painters' colours are so used, as, for a variety of reasons, many of them are not suitable for calico-printing. Colours containing arsenic, for example, and some others which produce brilliant effects, cannot be used on account of their highly poisonous nature. Others are excluded on account of their cost, some are too dull and muddy in colour, and some are liable to tarnish or darken on exposure to light, air, moisture, or other influences. The pigments which are most extensively useful are ultramarine blue, Guignet's or chrome green, and chrome orange, all of which are very largely used by themselves or in combination with other colours. Lamp black is also employed for the production of a solid grey, and vermilion-red with some other metallic sulphides are sometimes, though rarely, printed as pigment colours. The principal lakes used are carmine, corallin lake (a derivative of phenol or carbolic acid), black logwood lake, and several others prepared from the dye-woods with tin and alumina salts. The aniline dyes on their first introduction were also worked as pigment colours. and printed with albumen.

The first medium employed for fixing mineral pigments and lakes to calico was a solution of India rubber in coal naphtha, an agent which, so far as clearness and permanency of the printed colour is concerned, was perfectly satisfactory. The steaming dissipated the highly volatile naphtha and left the thin film of caoutchouc mixed with the colour firmly adherent to the tissue. But the inflammability of the copious naphtha fumes evolved gave rise to many serious accidents, and the method had on that account to be abandoned. No other medium has been found to give so satisfactory results as the protein compounds, of which albumen obtained from the white of eggs is the type. Besides egg albumen, blood albumen, lactarin or casein from milk, and gluten from wheaten flour are used as agents for fixing pigments. In printing with albumen advantage is taken of its well-known peculiarity of coagulating and becoming quite insoluble at a temperature under the boiling point. It is mixed with the colour and deposited on the cloth in its soluble state, when, by the operation of steaming, it coagulates and remains firmly attached to the tissue, imprisoning with it the particles of colour with which it was mixed. The cloth is not in reality dyed, but has only a coloured pattern mechanically fastened or glued to it. Egg albumen gives the most delicate and clear shades, but recent improvements in the preparation of blood albumen render it increasingly available for bright colours. Lactarin and gluten, dissolved by means of caustic alkalies, are used for printing ultramarine and other pigment colours. The length of time that pigment colours are left in the steaming apparatus varies from half-an-hour to an hour.

Ordinary Steam Colours.—The essential features of this style consist in printing direct on the cloth the dyeing material, mixed in proper proportion, with any necessary mordant, and certain acids or salts to keep the mixture in solution. On the application of moist heat after printing, the acid is evaporated or a chemical decomposition takes place in the case of the salt, and an insoluble precipitate is produced in the fibre. Steam colours possess great brilliancy, but they have not the fastness and solidity of madder-dyed goods. The dyes in the case of steam colours must be in the form of decoctions or prepared extracts of the special chemical tinctorial principles. Such preparations have of recent years come into very wide use, and with the progress of chemical science they are daily attaining greater prominence and perfection, so that the older application of crude materials is rapidly being supplanted by the use of agents of known strength and quality. Thus, as already mentioned, madder extract and artificial alizarin, treated as steam or "topical" colours, have largely taken the place of madder root as a dye colour, and by the preparation of artificial alizarin from anthracene, printers are now rendered independent of the vegetable kingdom as a source of their hitherto most important dye-stuff.

As a preparatory to printing, the cloth is mordanted or prepared by passing it through a solution of stannate of soda, and treating with a very weak solution of sulphuric acid which decomposes the stannate, combining with the soda, and leaves the stannic acid (peroxide of tin) precipitated in the fibres. Cloth thus prepared has much purer and brighter shades than simple bleached calico. The common steam colours include black and chocolate from logwood liquor, orange from annatto, yellow from Persian berry liquor and from bark liquor, green from Persian berries and yellow prussiate of potash, purple from logwood and red prussiate of potash, dark red from sapanwood and bark liquor, reds, purples, and chocolate from madder extract and alizarin, and blues from Prussian blue. Iron, alumina, and other mordants are used with these colours according to their character and the nature of the shades desired. The solvent principally employed is acetic acid, which readily volatilizes in the steaming process, but oxalic acid is also employed to keep certain special oxides in solution during the printing. Oxidizing agents, as the chlorate or bichromate of potash, are also required for the development of some colours. Steam blue is printed, not by using the Prussian blue colours ready formed, but by effecting the chemical reaction on the cloth itself, which results in the blue colour. In some cases yellow prussiate of potash is used, which yields Prussian blue; again, when the red prussiate is employed, Turnbull blue is the result; but a mixture of both, to which a proportion of ferro-prussiate of tin, called tin pulp, is added, is the source of the best steam blue. The reaction by which the colour is developed will be understood by instancing the development of Prussian blue from the yellow prussiate. It is mixed with an acid—tartaric, oxalic, or sulphuric—or the whole three combined, and printed on the cloth. In the steaming the added acid combines with the potassium of the prussiate and liberates ferrocyanic acid, which is further decomposed into cyanide of iron, abundant fumes of hydrocyanic acid (prussic acid) being meantime evolved. On withdrawing the goods from the steaming chest after this decomposition is complete the pieces are quite colourless, but exposure to the atmosphere in an ageing chamber, or passing them through an oxidizing solution, such as the bichromate of potash, develops the characteristic blue of Prussian blue.

Aniline Colours.—These colours now constitute the largest and most important section of steam-fixed dyeing materials, and in their behaviour and method of printing they form a class by themselves. The range of aniline colours now embraces almost every possible shade; and in no other department of scientific and technical research has equal activity been displayed within the few years which have passed since these colours were introduced; and the rewards of investigation have been commensurate. The number of colours introduced, and the methods of preparing them which have been suggested are beyond computation, and the list of those which are now in current use is exceedingly extensive. In addition to the dyes procured from aniline many more of an allied nature are prepared from other derivatives of coal-tar, phenol, naphthalin, and anthracene, some of which have also come into extensive use, and the applicability of others has been demonstrated. The topical use of these colours in connection with extract of madder, Guignet's green, ultramarine, &c., has exercised a powerful influence in improving the art of design in con-

nection with calico-printing, placing as they do at the disposal of the designer an unlimited range of the most striking, brilliant, and pure colours.

Aniline colours have a powerful affinity for animal substances, dyeing silk and woollen tissues readily without the intervention of any mordant. Taking advantage of this property aniline colours were, on their introduction, printed as dye colours, albumen being used as a mordant. An albuminous solution was printed and fixed on the cotton, and on its introduction, so prepared, into the dye-vat the albumen readily took up the colour, while the unmordanted portions merely imbibed an easily discharged stain. Aniline colours were also printed with albumen in the manner already described as applied to pigments and coloured lakes; and the patents secured by Mr Walter Crum, in 1859, for the application of gluten and lactarin in printing, had reference chiefly to the use of aniline colours. The process of fixing these colours now generally adopted is known as the arsenite of alumina process. In this process the dye is dissolved in water or acetic acid, carefully filtered through a fine cloth and mixed with acetate of alumina, a thickener, and arsenious acid dissolved in glycerine. This mixture is printed on the cloth, which is then introduced into the steaming chest. In the steaming, acetic acid is liberated and arsenite of alumina formed, which with the aniline colour is precipitated in the fibres as a brilliant insoluble lake.

Spirit Colours.

This style of printing consists simply of a modification of the process for ordinary steam colours, but excluding the steaming. All the decoctions and extracts used for regular steam colours may be employed in this method, but they are mixed with such large proportions of the mordants and acids that were they submitted to the action of steam the fibre would be quite destroyed. When printed, spirit colours are therefore simply dried and aged for several hours, after which they are rinsed in water, washed, and dried. The style yields very brilliant but very loose and fugitive colours, and is now falling into disrepute.

Finishing Processes.

After the prints have undergone the various operations described above, they are submitted to a series of processes, whose object is to give to the fabrics such an appearance as will please the eye of the buyer. All the finishing processes have one common end, namely, to fill up the interstices which exist in the fabrics, and thus give to the calico a more substantial and glossy appearance; and this is effected by filling the cloth with boiled starch, farina, or sour flour, which is obtained from wheat flour which has been allowed to ferment. To these are often added large quantities of sulphate of lime or baryta, and other similar substances, with the object of imparting to the cloth a weight and appearance of solidity which it does not really possess. The finishing processes are varied according to the nature of the print, muslins requiring a quite distinct method of treatment from ordinary calicoes, and furniture chintzes also receive a finish peculiar to glazed goods. Some of the apparatus employed in finishing will be found figured under the heading BLEACHING, where also the subject is entered into in some detail. As the general features of finishing, including water-mangling, drying, damping, starching, and calendering are the same both for white cottons and prints, it is unnecessary here to detail these operations. The machines and operations in a finishing-room may be briefly noticed as follows. The goods are opened by passing over a winch at a considerable elevation, and if necessary stretched in breadth on a machine which evens the texture and draws it out laterally. They are then passed into the chloring machine, which has two rollers, one of brass and one covered with india-rubber. The lower one is made to revolve in an aqueous solution of chlorine, and as the cloth passes between the rollers it is saturated with this solution. It passes immediately through a box containing a vapour of steam, which at once arrests the action of the chlorine, the momentary contact being considered sufficient to brighten the white ground without giving time for the colours to be affected. From the steaming box the piece passes through a water mangle, where pure water is spurted on the cloth, and after passing through the trough it receives a hard squeeze to extract as much moisture as possible before the drying is reached. The machine is a range of steam cans, generally made of copper. The next operation is that of starching, the machinery of which is almost identical with that used for chloring, starch paste, however, occupying the place of the chlorine liquor. The lower roller revolves in and carries up the starch to the cloth, which passes round the upper rollers and becomes saturated by the squeezing action produced and regulated by the screws and levers of the machine. After starching, the goods pass direct to another drying machine, whence they are taken to be damped by a slight sprinkling of water, which they receive in passing over a simple machine for the purpose, consisting of a rapidly revolving brush throwing up a fine spray. Calendering is the next and final operation, after which each piece is separated and folded up by a plaiting machine, or hooked by hand. It is then made up in the ordinary book form, and after being pressed in a screw or hydraulic press is ready for the market. (J. PA.)

CALICUT, or KOLIKOD, a seaport town of India on the western coast, in the British district of Malabar and the presidency of Madras, situated about 560 miles S. of Bombay, in 11 15′ N. lat. and 75° 52′ E. long. The town stands on the sea-shore in a low and unsheltered position; and as there is neither river nor harbour, ships are compelled to anchor in five or six fathoms water, about two or three miles from land The houses are for the most part built either of sun-dried brick or laterite, and have a tidy appearance. In the quarter of the Moplahs or Mapillas there are several mosques, and the Portuguese quarter possesses a Roman Catholic church One of the largest buildings is the jail, which can accommodate 600 prisoners. The port is frequented by vessels from the Red Sea and the Persian Gulf, which return with freights of rice, cocoanuts, ginger, cardamoms, sandal-wood, and teak. The weaving of cotton, for which the place was at one time so famous that its name became identified with its *calico*, is no longer of any importance. Calicut is of considerable antiquity; and about the 7th century it had its population largely increased by the immigration of the Moplahs, a fanatical race of Mahometans from Arabia, who entered enthusiastically into commercial life. It was the first place in India visited by any European navigator, for it was there that Vasco de Gama arrived in May 1498, ten months and two days after his departure from Lisbon. At that time it was a very flourishing city, and contained several stately buildings, among which was especially mentioned a Brahminical temple, not inferior to the largest monastery in Portugal. In 1509 the Marshal Don Fernando Continho made an unsuccessful attack on the city; and in the following year it was again assailed by Albuquerque with 3000 troops. On this occasion the palace was plundered and the town burnt; but the Portuguese were finally repulsed, and fled