CALICO-PRINTING

CALICO-PRINTING is the process of imprinting on textile fabrics patterns of one or more colours on a white or coloured ground. Though, as the name implies, the art is directed primarily, as it is by far most extensively, to calico or cotton textures, the same methods of ornamentation are also employed for certain woollen, linen, and silk fabrics, and the process of printing is also applied to unwoven yarns, notably in the case of worsted yarns intended for use in the weaving of tapestry carpets. But as certain of the processes employed for printing cotton agree essentially with those used for woollen and silk fabrics, it will be unnecessary here to refer specially to any other than the methods employed in the printing of calico proper.

There is a curious passage in *Pliny's Natural History* (xxxv. 42), from which it is evident that calico-printing in his time (the 1st century) was understood and practised in Egypt. The following is a translation of this passage :—

"There exists in Egypt a wonderful method of dyeing. The white cloth is stained in various places, not with dye-stuffs, but with substances which have the property of absorbing (fixing) colours. These applications are not visible upon the cloth ; but when the pieces are dipt into a hot caldron containing the dye, they are drawn out an instant after dyed. The remarkable circumstance is, that though there be only one dye in the vat, yet different colours appear on the cloth ; nor can the colours be afterwards removed. A vat which would of itself only confuse the colours on cloth previously dyed, in this way imparts several colours from a single dye-stuff, painting as it boils." It is evident enough that the substances employed to stain the cloth, as Pliny expresses it, were different mordants, which served to fix the dye upon the cloth. Thus if we suppose certain parts of a piece of cotton cloth to be impregnated with alumina, and the cloth afterwards dyed with madder, after the clearing, those parts only impregnated with the mordant would retain their red colour, while the remaining parts will continue white.

The general opinion is, that this ingenious art originated in India, and from that country made its way into Egypt. Whether this notion be well or ill founded, it is certain that calico-printing was known and executed by the Indians at a very early period. Their colours were beautiful and fast, and the varieties of pattern and the number of colours which they knew how to fix on different parts of the cloth gave to their printed calicoes a beauty and a value of no ordinary kind ; but their processes are so tedious and so clumsy that they could be put in practice only where labour was exceedingly cheap.

It was not till towards the close of the 17th century that calico-printing was introduced from India into Europe, having probably been practised first in Holland, to which country a knowledge of the art was carried by the Dutch East India Company. Evidence exists which shows that calico-printing was commenced in the neighbourhood of London so early as the year 1676, and there the art continued long to be practised. In 1738 it extended to Scotland, and took firm root in the country around Glasgow, but it was not till 1764 that it was introduced to what is now its chief centre, Lancashire. The extent of the industry in Great Britain at the present day is probably unequalled by the combined production of all other nations of the world. The other European countries where the art is prosecuted to any considerable extent are France, Switzerland, and Germany, to the last of which the annexation of the Rhine Provinces, consequent on the war of 1870–1, has added a famous centre of the industry. The art is also extensively cultivated in the United States, while Oriental communities still continue to prosecute it in their own peculiar fashions.

In Europe the art has been in a great measure created anew. By the application of machinery, and by the light thrown on the processes by the progress of chemistry, the tedious methods of the Indians have been wonderfully simplified ; and the processes are remarkable for the rapidity with which they are now executed, and for the beauty, fastness, and variety of the colours which are applied on the surface of cotton. So great have been these improvements, that at the present time in Manchester a piece (25 yds.) of calico can be printed in the short period of one minute; and the quantity of calicoes printed in Great Britain in one year cannot measure less than three quarters of a million of miles, seeing the exports alone of printed cotton piece goods during the year 1874 amounted to 1,003,101,107 yards, of a value of £19,602,706, an amount exceeded by 140,000,000 yards in 1872.

Grey calico is prepared for printing by an elaborate process of BLEACHING, for the details of which the reader is referred to the article under that head, vol. iii. p. 811. The bleached cloth previous to printing is generally passed through a shearing machine, which removes from its surface the fine downy pile and short threads, thus preparing a smooth uniform surface capable of taking a sharp distinct impression from the engraved printing-blocks or rollers. The printing processes which follow are exceedingly complex and varied, demanding for their proper execution an extended range of chemical knowledge and mechanical ingenuity ; and as commercial success depends largely on the tasteful and harmonious colouring of patterns, no little artistic ability and discrimination is required for the efficient superintendence of such works.

There are two modes of printing,—namely, *block-printing* and *machine-printing*. The former has been practised from time immemorial ; the latter is a modern invention, and originated after the introduction of the art of printing into Great Britain. In the case of block-printing the figure intended to be communicated to the cloth is cut out upon a block of sycamore, the parts which are to make the impression being left prominent, and the rest of the block cut away, just as practised for wood engravings. When the figure is too complicated, and the lines too fine, to admit of being cut in wood, it is made by means of small pieces of copper, which are very ingeniously driven into the block, and the interstices are filled up with felt.

By means of a modern invention several colours may be applied at once on the cloth by means of one block. The machine used for this purpose, which is called a "toby," consists of a box divided into several compartments filled with various colours, which are in communication through tubes with bottles filled with the same colours ; and by means of a gentle pressure the colouring fluid in each of the compartments of the machine is propelled through the felted cloth which covers each compartment. The block, being pressed against the cloth, takes the colour which is to be conveyed to the white calico by the block-printer.

By Continental printers an intricate apparatus for printing called the Perrotine, from the name of its inventor, is employed ; but it has never been introduced to any considerable extent in England. In this machine the intended figures are engraved upon a flat copper plate of about a square yard or more in size. Upon this plate the colour to be applied is spread. The plate is then pulled backwards, the excess of colour being removed by a "doctor," and the colour remaining on the engraving is then printed on the white cloth.

Printing is now almost universally accomplished by means of cylinder machines, in which the impression is given by one or a series of engraved copper cylinders ; a different cylinder being required for each separate colour or shade in the pattern. The cylinders are made about 3 feet 6 inches long and 6 inches in diameter ; and in establishments of any considerable extent many thousands of these are kept in stock, involving an enormous outlay of capital. There are three different methods in practice for engraving patterns or portions of patterns on the cylinders. In the first, the "die and mill" process, a cylindrical steel die is engraved with the pattern, which is afterwards transferred to a "mill" or cylinder of soft steel. The pattern on the mill is in relief, and after hardening it is by pressure impressed into the copper roller. The diameter of the mill is such that the repeats of the pattern fit with the utmost precision when transferred to the copper roller. The "die and punch" process is a modification of the foregoing, in which small patterns are impressed on the copper cylinder by means of a punch which has the pattern in relief transferred to it from a sunk steel die. The third process by which engraved rollers are prepared is by the aid of the pentagraph, a most complex and ingenious machine, with which by the movement of a single tracer in the deep lines of an enlarged pattern cut in a zinc plate, these lines are reproduced on the original scale, traced at five different places through a coating of bituminous varnish on the surface of the cylinder. After the engraving is complete, the cylinder is placed in a bath of dilute nitric acid, by which the pattern is bitten in along the surfaces of the metal exposed by the scratching of the pentagraph points.

Calico-printing machines are arranged to print with any number of such cylinders, from one up to as many as twenty ; but in practice few machines carrying more than eight cylinders are employed. The accompanying diagrammatic section (fig. 1.) illustrates the arrangements necessary for printing one colour, and each of the separate colours on a machine is similarly mounted round the periphery of the central bowl or cylinder *a*. Against this central bowl *a* the engraved copper cylinder *b* presses, and between them the cloth to be printed and a thick cloth or blanket pass. The cylinder is supplied with the printing material by means of a furnishing roddler *c*, which revolves in the colour-box *d*. The superfluous colour is removed from the cylinder by means of the colour doctor *e*, a steel blade which fits closely to the surface of the roller, and removes all colour except that which fills the engraved portions. The lint doctor *f* similarly removes all impurities which adhere to the roller after it has communicated its impression to the cloth. Fig 2 shows the elevation of a six-colour machine by Messrs Mather and Platt of Manchester, to whose courtesy we are indebted for illustrations of the most recent and approved forms of apparatus. The essential parts of this machine consist of the central iron bowl or cylinder A, and the six radiating arms B, each of which holds in position an engraved roller colour-box, &c., as shown in diagram fig. 1. By means of screws and other fine mechanical adjustments the pitch of each roller can be arranged so that its particular colour falls on the proper place with the utmost exactitude, producing a perfect pattern. In printing, the white calico is batched at C, and the cloth D passes inwards over tension rails, proceeding round the periphery of the bowl A, receiving from each roller B a separate colour or mordant, and issuing at D', printed and ready for the further processes to

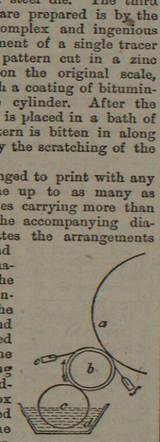

Fig. 1.

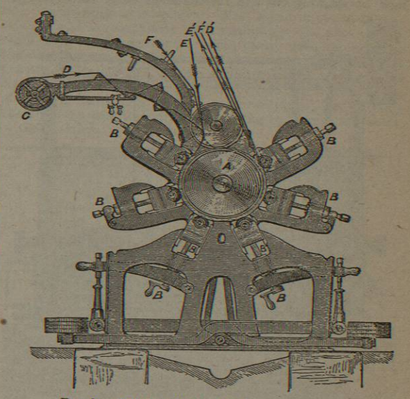

FIG. 2.—Cylinder Printing-Machine—six colours.

be hereafter detailed. Around the central bowl A are lapped, for the sake of elasticity, several folds of cloth. Between the central bowl and the cloth to be printed there passes, 1st, an endless band of cloth or blanket, seen entering at E and issuing at E' ; and 2d, a "grey back" or web of unbleached calico, used to keep the blanket clean, which enters at F and issues at F'.

By whatever mechanical means the printing is performed, whether by hand-block, perrotine, or cylinder machine, the effect is precisely the same, and the colours or mordants employed are in all cases alike. The substances to be printed on the surface of the calico have to be brought to a proper consistency for printing by means of thickeners, with which they are mixed up in colour pans. Although these are only mechanical agents, it is found in the practical operation of printing that particular thickeners are more suitable for certain colours or mordants than others, and the printer is guided by experience in selecting that thickening adjunct which gives the clearest impression. Among the numerous thickeners available, those most commonly employed are wheat flour and starch, potato starch, dextrin or British gum, and gum-senegal or other varieties of gum-arabic. The mordant or the colour and its appropriate thickeners are placed in a range of colour pans, in which the materials are thoroughly incorporated. A pair of these pans (one in section), as constructed by Messrs Mather and Platt, embracing the most recent and approved appliances, is shown in fig. 3. In the cut, A represents the driving pulleys, B the driving shaft, wheels, and catch-box, *c* wheels for giving a rotary motion to the brass stirrers *d*. E is the colour pan, of copper, double cased, made to swivel on centres or pivots f^1 and f^2. Through f^1 water and through f^2 steam are supplied to the space between the outer and inner body of the pan for the purpose of boiling and cooling down the contents of the pan alternately as required. The supply of steam or

of water to these pipes is regulated by the tap *g*. H is the framing, J stands, with the necessary appliances for turning over the pans to empty their contents, K a pipe and swivel tap for supplying water to the pans. L is the main steam pipe to f^1, *m* the water pipe to f^2 and K, and *n* and *o* are taps for washing out and for condense water respectively.

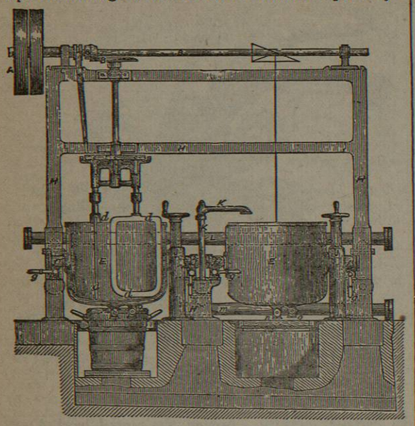

Fig. 3.—Colour Pans.

The variety of methods by which colours are produced on calicoes is almost endless, and the processes employed, both chemical and mechanical, as well as the tinctorial agents used, are also very numerous and diversified. The processes are in practical works generally classified under the heads of numerous different styles, combinations of several of which are frequently employed in the production of a single pattern It is at once impossible and unnecessary to enter into details of these various styles here; but they all resolve themselves into a few general groups, under which heads they will be briefly treated of. In certain styles a mordant, or chemical substance, which possesses an affinity for both the cloth and the dye-stuff, is the substance printed in the cylinder machine, and the calico has to undergo a subsequent process of dyeing by which those portions of the cloth which received the mordant are alone permanently dyed Again, the colour-box may contain all the ingredients necessary for the production of the colour, but to develop it in the fibre it is necessary to expose the printed cloth to the oxidizing influence of the atmosphere, or otherwise produce an oxidation of the dye-stuff by which the colour is developed and fixed. By a third process the colour is prepared and applied direct to the cloth mixed with some agent which, under the influence of heat and moisture, either mechanically attaches or chemically precipitates the colour in the fibre. And a fourth process, which may be regarded as a modification of the third, consists of mixing the dye with powerful mordanting substances, which, after printing, are merely dried, the mordant volatilizing sufficiently to fix the dye, not very fast, on the cloth. There are thus these four divisions—

I. Dye colours.
II. Oxidation colours.
III. Steam colours.
IV. Spirit colours

Along with these different methods patterns are also produced and modified by means of substances applied to cloth already dyed or printed in order to remove the colour from certain portions of it which are either intended to remain white, or to receive some other colour afterwards. These substances are known as "discharges," and examples of their action are seen in printed Turkey reds and bandannas.

Sometimes a substance is applied to cloth before it is dyed, in order to prevent the indigo, or any other colour, from being fixed on those parts to which it is applied, that they may remain white, or be afterwards made to receive other colours. Substances possessed of this property are called "resists."

Dye Colours.

Under this head are included prints prepared by printing the pattern in one or more mordants—substances which have an affinity for the fibre on the one hand and the dye stuff on the other. The mordanted cloth is subsequently submitted to a process of dyeing, when the dye-stuff is fixed only on such parts of the cloth as have been impregnated with the mordant. By using more than one mordant, by mixing them, or by employing the same at different degrees of strength, a variety of shades or colours is produced in the process of dyeing with one dye-stuff.

Mordants.—The principal mordants employed for dye colours are the following :—

1. *Red Liquor.*—The acetate of alumina mordant or "red liquor" of the calico-printer is prepared by partly decomposing alum, held in solution by impure acetate of lime, commonly called pyrolignite of lime; sulphate of lime precipitates and acetosulphate of alumina is thus obtained Red liquors thus prepared have a specific gravity of 1·08, and are composed as follows :—

Composition of four red Mordants per Gallon.

Substances.	Mordant A.		Mordant B.		Mordant C.		Mordant D.	
	grains.	oz. grs	grains.	oz. grs.	grains.	oz. grs.	grains.	oz. grs
Alumina ..	1680	0 3 367	1830	0 4 80	1239	0 2 364	2164	4 4 414
Sulphuric acid	2642	5 6 20	2800	0 6 175	3017	0 6 392	1664	6 3 352
Acetic acid	3369	8 7 307	3970	0 9 32	1281	7 2 406	3679	2 8 179
Ammonia and water	674	1 1 236	910	0 2 35	693	1 1 255	...	...

In the manufacture of "red liquor," sulphate of alumina is frequently substituted for alum, and acetate of lead for pyrolignite of lime.

2. *Iron Liquor.*—The oxides of iron are much used as mordants, either in the state of protoxide or peroxide. The salt most employed is the impure pyrolignite of protoxide of iron, which is prepared either by decomposing green copperas with pyrolignite of lime, or by placing in large vats pyrolignous acid and old iron, when, after a few months, the iron, which is gradually oxidized, dissolves in the acid, and gives rise to pyrolignite of protoxide of iron. This valuable mordant is thickened with calcined farina, flour, starch, or gum, and applied on the calico. After being exposed for a few days in a moist atmosphere, it loses a part of the acid, and becomes partially peroxidized. Pyrolignite of iron of the specific gravity of 1·05 gives a black with madder and several "tannin" substances. Various shades of purple are obtained by adding different proportions of water to the mordant previously to applying it to the cloth; and various shades of chocolates are produced by mixing this with the alumina mordant previously described, and then dyeing also with madder.

These two mordants are the principal employed for madder colours; but several others are employed for special shades. Among these may be enumerated the aluminate of soda or alkaline pink (used as a mordant when it has to act as a resist for another colour such as aniline black), and acetates of chromium, copper, tin, and other metals.

Dye Colours.—The principal dye colour is madder or some of its derivatives, including artificial alizarin, the dyeing principle of madder obtained synthetically from anthracene. Madder is the root of a plant, *Rubia tinctoria*, a native of Central Asia, but introduced and extensively cultivated in south Europe, especially at Avignon in France. For the purposes of the calico-printer, madder-root is prepared by simply grinding, or in the form of flowers of madder (*fleurs de garance*), of garancin, of garanceux, or of alizarin. Fleurs de garance is powdered madder deprived of its soluble constituents and redried, whereby the tinctorial strength of the preparation is increased nearly one-half. Garancin is prepared by boiling powdered madder in sulphuric acid; garanceux is spent madder similarly prepared; and alizarin, the chief tinctorial principle of madder, is obtainable from garancin by the action of superheated steam. Among the chemical principles of tinctorial value yielded by madder there is, besides alizarin, an allied substance named purpurin. Alizarin of precisely similar composition and behaviour is now artificially made from anthracene, one of the products of coal-tar, and purpurin also is obtainable by the oxidation of artificial alizarin. By chemical agency the essential ingredients of madder are thus now produced in a cheaper, more convenient, and more effective form than it was formerly possible to extract them from the cultivated root. Madder extract, garancin, and alizarin dye heavier and more brilliant colours than madder, and they require less soaping or other treatment to clean the whites after dyeing. Madder extract and artificial alizarin are also used as steam colours.

We may now briefly follow the stages in printing a madder style, taking for example a calico printed in four 'colours' (the technical name for whatever is printed by the machine, whether mordant or dye), with a padding or blotch of weak iron liquor. In this case the mordants or colours are—

Black from strong solution of iron liquor.
Purple from weak solution of iron liquor.
Red from solution of red liquor.
White resist of solution of citric acid (lime juice).
Purple pad or cover of weak iron liquor, which falling on the acid resist forms a soluble ferric citrate.

Drying.—The cloth after receiving these impressions passes into a drying apparatus, generally a closed chamber, highly heated by radiation from steam-chests of cast-iron. Through such a chamber the cloth passes up and down over numerous rollers, traversing a long distance before it emerges dry and ready for the next process. Another means of drying, employed in some of the best establishments, such as Thornliebank, is by passing the cloth round a long series of revolving steam cans or cylinders, the metallic surface of which is covered with felt. Recently a most effective system of drying has been introduced, which consists of forcing a strong current of heated air through an enclosed chamber by the action of a fan, connected with which is an apparatus filled with pipes, through which the air passes, while surrounding the pipes is a steam space. By this plan any temperature may be obtained, and the current of air adjusted by the speed of the fan.

Ageing.—From the drying apparatus the goods pass to the ageing room, a lofty and spacious chamber (fig. 4), where they are exposed to the combined influence of heat and steam. The pieces pass, as shown by the arrows, up and down over rollers from end to end of the room, travelling over a long space, for twenty minutes or thereby. The atmosphere is rendered moist by jets of steam blowing from pipes *a*, *a*, and hot by radiation from the same and other steam pipes. A difference of four degrees is maintained between the dry and wet thermometers; the readings average 80° and 76° Fahr. The cloth takes up about 5 per cent. of its weight of moisture in its passage, and as it issues at the further end of the apartment, it is piled up in loose bundles, and so left for two or three days in a warm moist atmosphere. The object of the operation of ageing is to precipitate the mordants in the fibre of the cloth, they in the meantime being partly decomposed with the disengagement of abundant fumes of acetic acid. The practical development of the modern process of ageing is due to the scientific ingenuity of the late Mr Walter Crum of Thornliebank, the method previously practised having been tedious and uncertain, depending upon variable states of the weather.

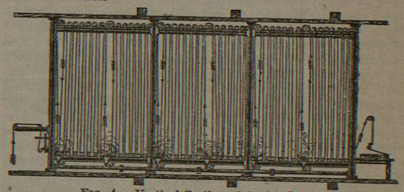

Fig. 4.—Vertical Section of Ageing Room.

Dunging.—It is next necessary to remove any superfluous uncombined mordant which may be on the cloth, and to take away the thickening agent with which the mordant was printed. These objects are accomplished by passing the goods through hot water, in which it was formerly the practice to dissolve cow's dung, hence the name; but now some of the numerous dung substitutes are chiefly used, the principal of which are the silicate and the arseniate of soda. The first operation in dunging is to pass the pieces through the "fly dunging" apparatus,—a cast-iron trough with rollers top and bottom,—by which the cloth is made to pass, in the open state, through the hot solution. This operation fixes the mordant in the fibre and prevents it from spreading to unmordanted parts of the cloth in the subsequent washing and dyeing operations to which it is subjected. Immediately after the fly-dunging the goods are washed and submitted to a second dunging, this time in a different kind of apparatus, through which they are passed in a coil or loose rope form. They are then thoroughly washed at a machine to remove the last traces of thickening matter and all uncombined ingredients.

Dyeing.—At this point the goods are ready for dyeing, the most important process in the whole series of operations. The dye-beck or vat, one form of which is shown in longitudinal and transverse section in fig. 5, consists of

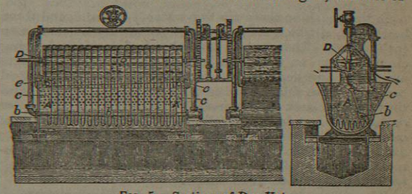

Fig. 5.—Sections of Dye Vat.

an iron cistern or trough A, into which the dyeing solution is introduced. Running along the whole length of the