

CALICO-PRINTING is the process of impressing designs in one or more colors upon cotton cloth. The coloring substances employed are divided into *substantives* and *adjectives*. The former are capable of producing permanent dyes of themselves; the latter require certain intermediate matters.

It is often necessary to apply some substances to the cloth which shall act as a bond of union between it and the coloring matter. These substances are usually metallic salts called *mordants*, which have an affinity for the tissue of the cloth as well as for the coloring matter when in a state of solution, and form with the latter an insoluble compound. The usual mordants are alum, and several salts of alumina, peroxide of iron, peroxide of tin, protoxide of tin, and oxide of chrome. Mordants are useful for all vegetable and animal coloring matters which are soluble in water, but have not a strong affinity for tissues.

To prevent the mordant or the coloring matter from spreading beyond the proper limits of the design, *thickeners* are used to bring it to the required consistence; the most useful are wheat starch and flour, but many other materials are used. The colors, with the proper thickeners, are prepared in vessels furnished with steam-jackets, for raising the contents to the required temperature.

There are eight different styles of calico-printing, each requiring different methods of manipulation, and peculiar processes:

1. The *madder style* (so called from its being chiefly practised with madder), to which the best chintzes belong, in which the mordants are applied to the white cloth with many precautions, and the colors are afterward brought up in the dye-bath. These constitute permanent prints.
2. The *padding style*, in which the whole surface of the calico is imbued with a mordant, upon which afterward different-colored figures may be raised by the topical application of other mordants joined to the action of the dye-bath.
3. The *resist style*, where the white cloth is impressed with figures in resist paste, and is afterward subjected first to a cold dye, as the indigo vat, and then to a hot dye-bath, with the effect of producing white or colored spots upon blue ground.
4. The *discharge style*, in which thickened acidulous matter, either pure or mixed with mordants, is imprinted in certain points upon the cloth, which is afterward padded with a dark-colored mordant, and then dyed, with the effect of showing bright figures on a dark ground.
5. *China blues*, a style resembling blue stone-ware, practised with indigo only.
6. The *decoloring style*, by the topical application of chlorine or chromic acid to dyed goods. This is sometimes called a discharge.
7. *Printing by steam*, a style in which a mixture of dye extracts and mordants is topically applied to calico, while the chemical reaction which fixes the colors to the fibre is produced by steam.
8. *Spirit colors*, produced by a mixture of dye extracts and a solution of tin. These colors are brilliant but fugitive.

The processes actually required for finishing a piece of cloth in the madder style, as, for example, in producing a red stripe upon a white ground, are numerous. The bleached cloth is submitted to nineteen operations, as follows: 1. Printing on mordant of red liquor (a preparation of alumina), thickened with flour, and dyeing; 2. Ageing for three days; 3. Duncing; 4. Wincing in cold water; 5. Washing at the dash-wheel; 6. Wincing in dung-substitute and size; 7. Wincing in cold water; 8. Dyeing in madder; 9. Wincing in cold water; 10. Washing at the dash-wheel; 11. Wincing in soap-water containing a salt of tin; 12. Washing at the dash-wheel; 13. Wincing in soap-water; 14. Wincing in a solution of bleaching powder; 15. Washing at the dash-wheel; 16. Drying by the hydro-extractor; 17. Folding; 18. Starching; 19. Drying by steam.

By different engraved rollers, each supplying a different mordant, various shades and colors are afterward brought out by one dye. Before the mordanted cloth is dyed, it is hung for some time in airy chambers in order that the mordants may intimately combine with the fibre. This operation, called ageing, is abbreviated by a process in which the goods are passed over rollers in a room in which a small quantity of steam is allowed to escape.

The aniline colors are largely used for calico-printing, and are applied topically, the only mordant used being albumen or vegetable gluten prepared in various ways.

The printing-cylinders are of copper, and vary in length from 30 to 40 inches, according to the width of the calico; the diameter varies from 4 to 12 inches. Each cylinder is bored through the axis, and accurately turned from a solid piece of metal. To engrave a copper cylinder by hand, with the multitude of minute figures which exist in many patterns, would be a very laborious and expensive operation; and the invention of Jacob Perkins of Massachusetts, for transferring engravings from one surface to another by means of steel roller dies, has long been applied to calico-printing with perfect success. The pattern is first drawn upon a scale of about 3 inches square, so that this size of figure, being repeated a number of times, will cover the printing-cylinder. This pattern is next engraved in intaglio upon a roller of softened steel, about 1 inch in diameter and 3 inches long, so that it will exactly occupy its surface. This small roller, which is called the *die*, is next hardened by heating it to redness in an iron case containing pounded bone-ash, and then plunging it into cold water, its surface being protected by a chalk paste. This hardened roller is put into a rotary press, and made to transfer its design to a similar roller in a soft state called the *mill*; the design which was sunk in the die now appears in relief on the mill. The mill in its turn is hardened, and,

being put into a rotary press, indents upon the large copper cylinder the whole of the intended pattern.

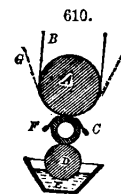
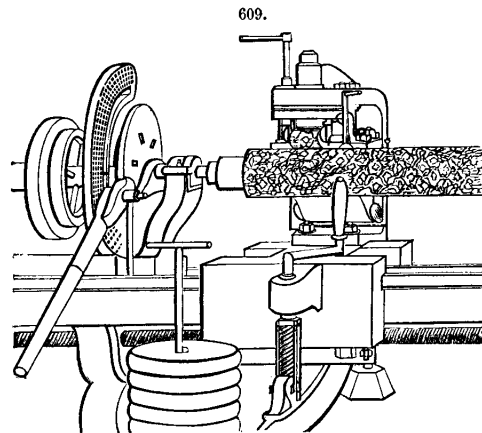
As the use of copper in rollers constitutes a large item of expense, there have been many inventions for rollers only partially of that metal or entirely of other substances. Iron has been used as an inner cylinder for a thin copper envelope; in one case these cylinders had corresponding grooves to prevent turning one upon the other. A seamless tube of copper has been placed upon a taper tube of sheet-iron, and tin has been employed to coat the interior of a copper shell, which is then soldered to an iron lining. Brass rollers have been tested, but the objection lies in the hardness and shortness of the alloy. Various other alloys, notably of zinc, and also German silver, have been employed, not, however, with success. Rollers, either entirely of papier-maché, or of that material covered with a half-inch tube of copper, have been tested, and numerous plans involving electric deposition of the metal have been broached. By the latter means, instead of turning off the worn face of the copper to expose a new surface, they were maintained at the original diameter by a new coating of copper at a minimum expense. One of the most practical plans for utilizing old copper rollers is that patented by Mr. T. Knowles, which dispenses with the necessity of adjusting the roller to the mandrel whenever the cylinder requires renewing. Over the old thin roller an exterior roller is forced, and when this is worn thin another new one is substituted. The exterior roller is held in due position tightly by means of a nib. The etching process is resorted to in case of injury to a roller whereby a sinking of the surface is produced, all but the sunk portion, which is covered with an acid-resisting paint, being exposed to the action of acid until the desirable flatness has been obtained. Strong aquafortis is employed to make deep cuts on the roller, thus saving the time which the engraver would otherwise be compelled to devote to making these cuts on the first steel die. The parts which it is desired shall not be attacked are painted by hand with an acid-proof paint. Pentagraphy is a system of tracing objects by means of diamond or steel points upon a varnished roller, and then submitting the roller to the etching process, the nitric acid attacking the roller where the bituminous varnish has been scraped off.

Fig. 609 represents the machine used in engraving the copper cylinders used in machine printing. In the printing-machine the cylinders upon which the pattern is engraved, one cylinder for each color, are mounted on a strong frame-work, so that each cylinder revolves against two other cylinders, one of which is covered with woolen cloth, and dips into a trough containing coloring matter properly thickened, so that, as it revolves, it takes up a coating of color and distributes it over the engraved roller, which transfers the pattern to the cloth. The cloth to be printed passes over a large iron drum covered with several folds of woolen cloth, so as to form a somewhat elastic printing surface: an endless web of blanketing is made to pass round this drum, which serves as a sort of guide, and defence, and printing surface to the calico which is being printed. The superfluous color is removed from the engraved roller by a sharp-edged knife or plate, usually of steel or gun-metal, called the *color-doctor*, so arranged that the color scraped off shall fall back into the trough; another plate of steel removes the fibres which the roller acquires from the calico. This arrangement will be understood from Fig. 610, in which *A* is the iron drum over which passes the blanket *B*; *C* is the calico which passes over the engraved roller below; *D* is the color-roller, *E* the color, *F* the color-doctor, and *G* the lint-doctor. To realize an idea of a 12 or 20 colored printing machine, it is only necessary to imagine a large circle and a plurality of repetitions of this mechanism arranged around its circumference.

In the four-color printing-machine, Fig. 611, the pressure is normal, in all the engraved rollers, by means of the levers *P*. These rollers are turned by a belt communicating with the prime mover. The regulators are adjusted by screws, to which are attached hands, indicating upon dials the space to be run by the rollers in order to reach the regulators: this is known without stopping the works. The engraved rollers can be brought up to the pressing-cylinder, or withdrawn from it, without changing the places of the color-vessels or of the scrapers; for all the different pieces, fixed against the pillows on the turning pieces of the engraved rollers, move with these last. Finally, there is an apparatus placed behind the under cloth, the intermediate cloth, and the stuff to be engraved, by which the workman governs these three pieces at will.

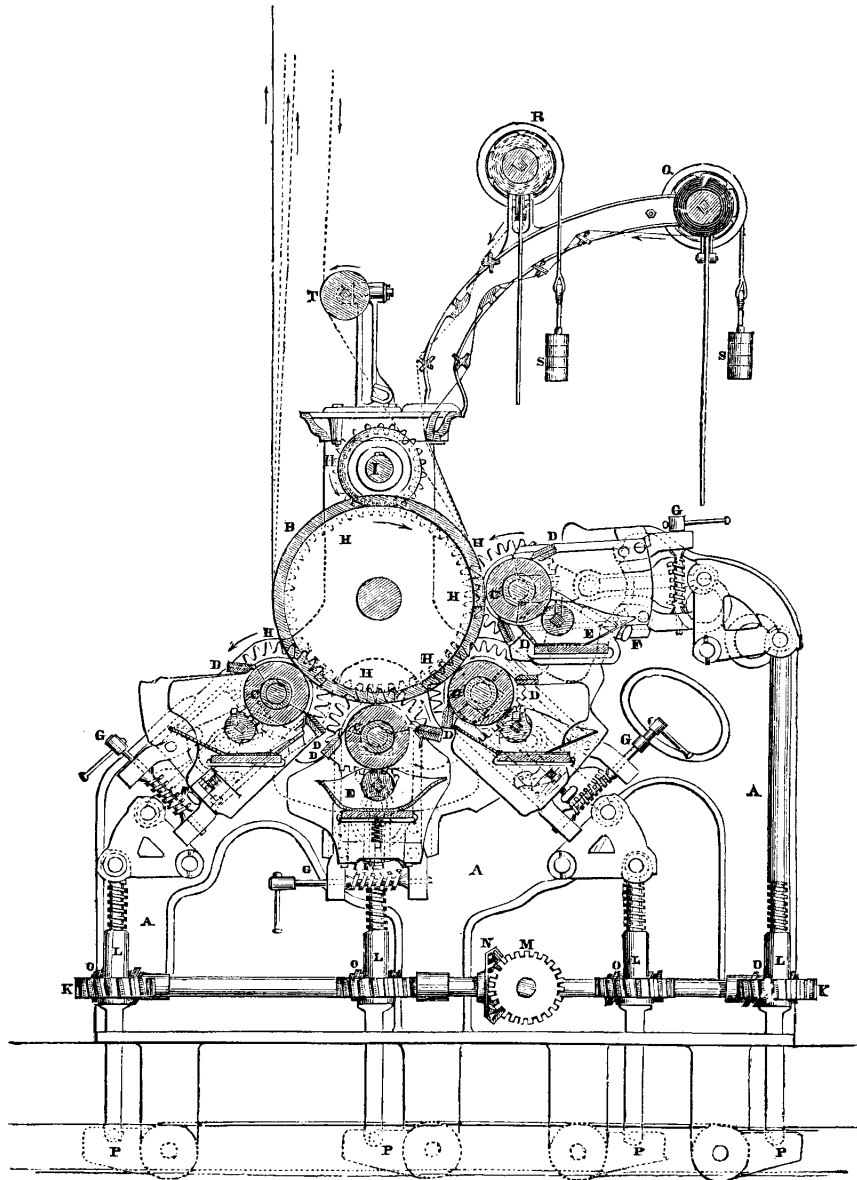
The vessels in which the rollers dip are made of copper or wood. It is necessary to keep them supplied with a constant quantity of printing material, for the rollers would soon only skim over the surface of the fluid and leave but a feeble impression; to this end a reservoir pours a continual supply. A partition is placed in a position which enables it to clear the roller of the froth with which its surface may be covered.

Fig. 612 shows the construction of a machine for printing 8 colors, and Fig. 613 one for printing 20 colors. The surface-roller machine executes similar styles of work to those produced by the per-



rotine described below. Here the pattern cylinder is in relief. In Fig. 612, *A* is the frame-work; *B* the bowl or cylinder, which is hollow, and made with arms inside; *C C* are the surface-rollers, supplied with color by the endless web or sieve *F* revolving around the wooden tension rollers *D D*

611.

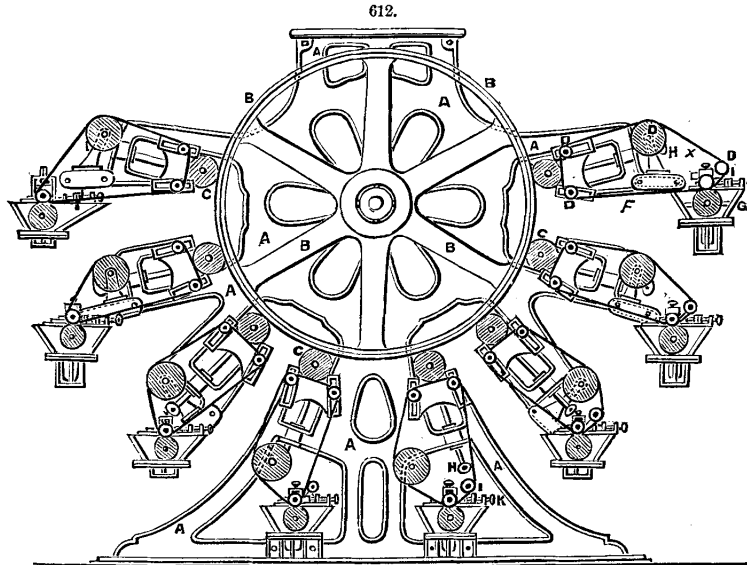


A A A, framework.
B, pressing cylinder.
C C C C, engraved cylinders.
D D D D, scrapers.
E E E E, vessels containing the coloring matter: they are raised and lowered at pleasure, by the screws *F*.
G G G G, endless screws, guiding the regulators.
H H H H H H H H, pinions and wheels which turn all the machinery.

I, a shaft communicating with the moving power.
K K K K, wheels adapted to the female screws *L L L L*, which put the levers in communication with the pillows of the rollers.
M, a wheel communicating with the driving-power, whose office is to press the rollers; it also moves the wheel *N*, and the endless screws *O O O O*, which are engaged with the wheels *K K K K*.

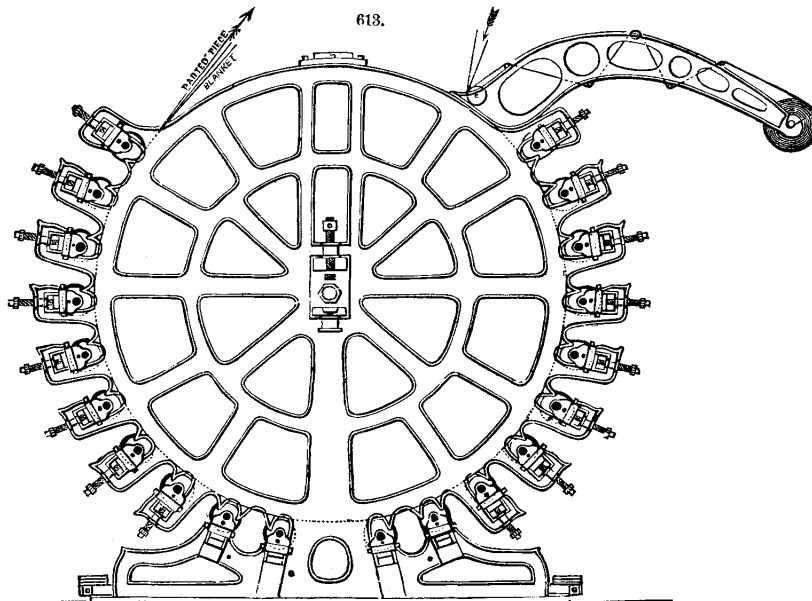
P P P P, levers which are loaded with weights in proportion with the pressure required: they are situated beneath the floor.
Q, the cylinder round which the cloth to be printed is rolled.
R, the cylinder round which the intermediate cloth is wound.
S, a weight which keeps the cloth stretched on the cylinders *Q R*.
T, a roller used to give an inclination to the cloth when printed, and regulate the speed.

E. The roller *E* is screwed down so as to press the sieves on the furnishing-roller, which revolves in the copper color-box *G*. The two tension-rollers next to the surface-roller move in slides, so that, by means of screw *H*, the sieve can be pressed against the surface-roller; on leaving the furnishing-



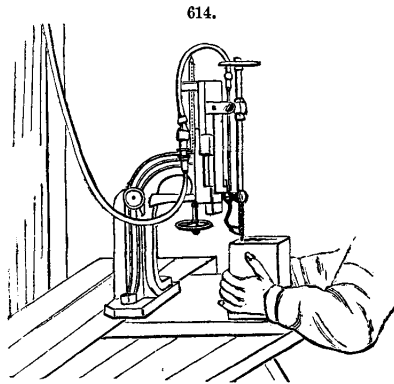
roller, the sieve is wiped by the doctor *I*. The surface-machine is well adapted for woollen fabrics, and the colors, being laid on the top of the cloth, have a very rich appearance.

The perrotine machine executes a style of work very similar to hand-block printing. Wooden blocks varying from 2½ to 3 feet in length, according to the width of the pieces, and varying in breadth from 2 to 5 inches, have the pattern engraved in relief on their surface. By the gas-process illustrated in Fig. 614, the graving-tool is heated to redness by means of a small gas-burner, and destroys all parts of the surface except those left in relief. Fig. 615 represents designs produced by



the gas-process. The blocks are fixed with their faces at right angles to each other, in a stout iron frame, and can each in turn be brought down upon the front, top, and back of a four-sided iron prism, faced with cloth and revolving upon an axis. The goods to be printed pass between the

prism and the pattern-block, and receive the impressions in succession. The effect of these successive applications in producing the different shades of a flower is represented in Figs. 615, 616, and 617. The blocks are forced down upon the calico by means of springs, so as to imitate the pressure of the hand of the block-printer.



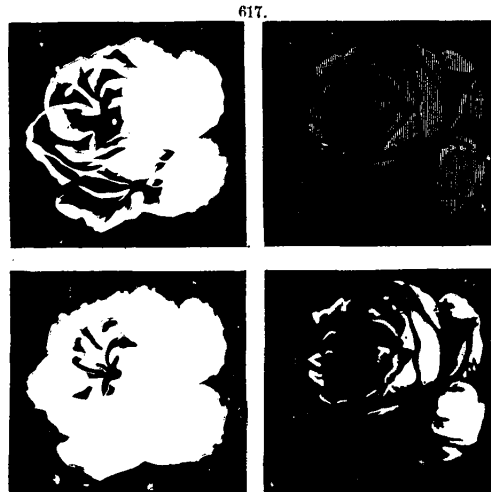
the stuff during the operation of the printing. The stuff to be printed is rolled off the beam *l*, and, passing over one stretching-roller, three stretching-bars, and a wooden guide-roller, is carried by means of the needle-rollers *m*¹ *m*² *m*³ *m*⁴ *m*⁵ over the printing-tables, passing out of the machine at *v*, and being then led off to a drying apparatus. With a further rotation of the crank-pins, the pressure-bars advance so far only that the forms touch the color-plates, the embossed designs of the former thus being caused to receive color from the latter. The pressure-bars *b*¹ *b*² *b*³ *b*⁴ *b*⁵ are now withdrawn with the form covered with color, while the color-plates pass back in the mean time to the coloring apparatus, where they receive a fresh supply. Another rotation of the crank-pins advances the forms close to the printing-table, and presses the design covered with color upon the stuff in front of the printing-tables. After this operation the forms are drawn back, the color-plates are again placed between the

Fig. 618 represents an eight-color perrotine machine. *a*¹ *a*² *a*³ *a*⁴ *a*⁵ are the forms, fastened to iron supports, which are carried by the pressure-bars *b*¹ *b*² *b*³ *b*⁴ *b*⁵. These latter execute an interference motion, which, as may be examined in the case of the pressure-bar *b*¹, is produced by the two crank-pins *c* and *d*—of which *c* makes twice as many revolutions in a given time as *d*—by the joint-levers *e* and *f*, and the stay or frame *g*. Through the rotation of the crank-pins *c* and *d*, the forms are at first fully drawn back, while, by means of a special combination of levers, all the color-plates *h* are placed between the forms *a*¹ *a*² *a*³ *a*⁴ *a*⁵, and the printing-tables *i*¹ *i*² *i*³ *i*⁴ *i*⁵. The color-plates are flat cast-iron plates covered with an elastic material, upon which color is transferred while passing the color-rollers *k*¹ *k*² *k*³ *k*⁴ *k*⁵. The printing-tables, which are also covered with an elastic material, serve as a support for

615.



616.



After this operation the forms are drawn back, the color-plates are again placed between the forms and the printing-tables, and the same operations are repeated during the following rotations of the crank-pins.

During the time the coloring-plates are moved up and down again, or, in other words, during the time in which the forms are not in contact with the stuff, the latter advances as much as the width of the form (length of guide), so that the next impression takes place close behind the one previously executed.

By a special contrivance, it is rendered possible to cause each form to strike the stuff on one and the same place twice successively, after having taken up color in the intermediate time.

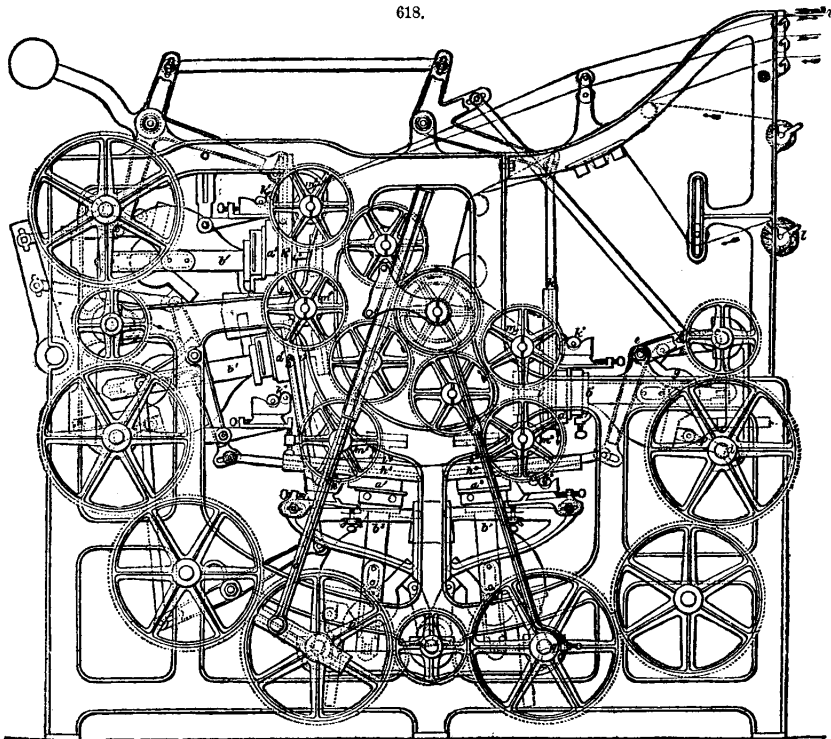
There are numerous machines connected with calico-printing for descriptions of which the reader is referred to the works of reference cited below. Among them may be noted the pentagraph for reproducing several times at once the lines of an enlarged pattern on the rollers; the color-pans and dye-vats, washing apparatus, construction of the ageing-room, and steaming-chests. Good brief descriptions of many of these appear

in the article on calico-printing in the "Encyclopædia Britannica," 9th edition.

All the finishing processes to which calico is subjected have one common end, namely, to fill up

the interstices which exist in the fabrics, and thus give them a more glossy and substantial appearance. This is effected by filling the cloth with starch, to which sulphate of lime or baryta is often added to give fictitious weight and solidity. The various operations are stretching (see CLOTH-FIN-

618.



ISHING MACHINERY), bleaching in a chlorine solution, which is followed by steaming, water-mangling, and drying. In the starching machine, a roller revolves in a starch solution and carries it up to the cloth, which passes around upper rollers, where it becomes saturated by the squeezing action produced. After starching, the goods are again dried, sprinkled, and calendered. (See CALENDER.) Lastly, each piece is folded. (See CLOTH-FINISHING MACHINERY.)

Works for Reference.—"Traité Théorique et Pratique de l'Impression des Tissus," Persoz, Paris, 1846; "A Practical Treatise on Dyeing and Calico-Printing," anonymous, New York, 1846; "A

Dictionary of Calico-Printing and Dyeing," O'Neill, London and Manchester, 1862; "A Practical Handbook of Dyeing and Calico-Printing," Crookes, London, 1874 *; "Dyeing and Calico-Printing," Calvert, London and New York, 1876. For details of various improvements in calico-printing and dyeing, see files of the *Textile Colourist*, an English monthly periodical published during 1876 and 1877.

the literature of dyeing, and, with Dr. various dyes and methods of printing.