Textile printing

Origins

Woodblock printing is a technique for printing text, images or patterns used widely throughout East Asia and probably originating in China in antiquity as a method of printing on textiles and later paper. As a method of printing on cloth, the earliest surviving examples from China date to before 220, and from Egypt to the 4th century.

via the Islamic world, from about the 12th century, and widely used. However the European dyes tended to run, which restricted the use of printed patterns. Fairly large and ambitious designs were printed for decorative purposes such as wall-hangings and lectern-cloths, where this was less of a problem as they did not need washing. When paper became common, the technology was rapidly used on that for woodcut prints. [2] Superior cloth was also imported from Islamic countries, but this was much more expensive.

The Incas of Peru, Chile and Mexico also practiced textile printing previous to the Spanish Invasion in 1519; but, owing to the imperfect character of their records before that date, it is impossible to say whether they discovered the art for themselves, or, in some way, learnt its principles from the Asiatics.

During the latter half of the 17th century the French brought directly by sea, from their colonies on the east coast of India, samples of Indian blue and white resist prints, and along with them, particulars of the processes by which they had been produced, which produced washable fabrics.

Technology

Textile printing was introduced into England in 1676 by a French refugee who opened works, in that year, on the banks of the Thames near Richmond. Curiously enough this is the first print-works on record; but the nationality and political status of its founder are sufficient to prove that printing was previously carried on in France. In Germany, too, textile printing was in all probability well established before it spread to England, for, towards the end of the 17th century, the district of Augsburg was celebrated for its printed linens, a reputation not likely to have been built up had the industry been introduced later than 1676.

On the continent of Europe the commercial importance of calico printing seems to have been almost immediately recognized, and in consequence it spread and developed there much more rapidly than in England, where it was neglected and practically at a standstill for nearly ninety years after its introduction. During the last two decades of the 17th century and the earlier ones of the 18th new works were started in France, Germany, Switzerland and Austria; but it was only in 1738 that calico printing was first, practiced in Scotland, and not until twenty-six years later that Messrs Clayton of Bamber Bridge, near Preston, established in 1764 the first print-works in Lancashire, and thus laid the foundation of what has since become one of the most important industries of the county and indeed of the country. At the present time calico printing is carried on extensively in every quarter of the globe, and it is pretty safe to say that there is scarcely a civilized country in either hemisphere where a print-works does not exist.

From an artistic point of view most of the pioneer work in calico printing was done by the French; and so rapid was their advance in this branch of the business that they soon came to be acknowledged as its leading exponents. Their styles of design and schemes of color were closely followed-even deliberately copied by all other European printers; arid, from the early days of the industry down to the latter half of the 10th century, the productions of the French printers in Jouy, Beauvais, Rouen, Alsace-Lorraine, &c., were looked upon as representing all that was best in artistic calico printing. This reputation was established by the superiority of their earlier work, which, whatever else it may have lacked, possessed in a high degree the two main qualities essential to all good decorative work, viz., appropriateness of pattern and excellency of workmanship. If, occasionally, the earlier designers permitted themselves to indulge in somewhat bizarre fancies, they at least carefully refrained from any attempt to produce those pseudo-realistic effects the undue straining after which in later times ultimately led to the degradation of not only French calico printing design, but of that of all other European nations who followed their lead. The practice of the older craftsmen, at their best, was to treat their ornament in a way at once broad, simple and direct, thoroughly artistic and perfectly adapted to the means by which it had to be reproduced. The result was that their designs were characterized, on the one hand, by those qualities of breadth, flatness of field, simplicity of treatment arid pureness of tint so rightly prized by the artist; and, on the other, by their entire freedom from those meretricious effects of naturalistic projection and recession so dear to the modern mind and so utterly opposed to the principles of applied art.

Methods of Printing

Broadly speaking textile printing means the local application, to textile fabrics, of any color in definite patterns or designs, but in properly printed goods the color becomes part and parcel of the fiber, or, in other words, the latter is dyed so as to resist washing and friction. Textile printing, then, may be looked upon as a form of dyeing; but, whereas in dyeing proper the whole fabric is uniformly covered with one color, in printing one or more colors are applied to it in certain parts only, and in sharply defined patterns. In principle these two bum of textile coloring are closely allied, for the coloring matters used in each case are practically identical, but in practice the means whereby their respective objects are attained bear little or no resemblance to each other. In dyeing, for instance, it is sufficient, for the most part, to immerse the fabric in an aqueous solution of the dyestuff, stirring it about constantly or otherwise manipulating it to prevent unevenness. In printing, however, the color must be applied by special means, either by a wooden block, a stencil or engraved plates, or rollers and thickened to prevent it from spreading, by capillary attraction, beyond the limits of the pattern or design. Many colors also contain, besides the coloring matter and thickening, all the substances necessary for their proper fixation on the cloth when the latter is simply passed through a subsequent process of steaming, and others again require to be subjected to many after treatments before they are thoroughly developed and rendered fast to light and washing.

There are five distinct methods at present in use for producing colored patterns on cloth:

1. Hand block printing.
2. Perrotine or block printing by machine.
3. Engraved plate printing.

4. Engraved roller printing.
5. Stenciling, which although not really a printing process may be classed here as one.

Hand Block printing

This process, though considered by some to be the most artistic, is the earliest, simplest and slowest of all methods of printing.

The blocks may be made of box, lime, holly, sycamore, plane or pear wood, the latter three being most generally employed. They vary in size considerably, but must always be between two and three inches thick, otherwise they are liable to warping, which is additionally guarded against by backing the wood chosen with two or more pieces of cheaper wood, such as deal or pine. The several pieces or blocks are tongued and grooved to fit each other, and are then securely glued together, under pressure, into one solid block with the grain of each alternate piece running in a different direction.

The block, being planed quite smooth and perfectly flat, next has the design drawn upon, or transferred to it. This latter is effected by rubbing off, upon its flat surface, a tracing in lampblack and oil, of the outlines of the masses of the design. The portions to be left in relief are then tinted, between their outlines, an ammoniacal carmine or magenta, for the purpose of distinguishing them from those portions that have to be cut away. As a separate block is required for each distinct color in the design, a separate tracing must be made of each and transferred (or put on as it a termed) to its own special block.

Having thus received a tracing of the pattern the block is thoroughly damped and kept in this condition by being covered with wet cloths during the whole process of cutting. The blockcutter commences by carving out the wood around the heavier masses first, leaving the finer and more delicate work until the last so as to avoid any risk of injuring it during the cutting of the coarser parts. When large masses of color occur in a pattern, the corresponding parts on the block are usually cut in outline, the object being filled in between the outlines with felt, which not only absorbs the color better, but gives a much more even impression than it is possible to obtain with a large surface of wood. When finished, the block presents the appearance of flat relief carving, the design standing out like letterpress type.

Fine details are very difficult to cut in wood, and, even when successfully cut, wear down very rapidly or break off in printing. They are therefore almost invariably built up in strips of brass or copper, bent to shape and driven edgewise into the flat surface of the block. This method is known as coppering, and by its means many delicate little forms, such as stars, rosettes and fine spots can be printed, which would otherwise be quite impossible to produce by hand or machine block printing.

Frequently, too, the process of coppering is used for the purpose of making a mold, from which an entire block can be made and duplicated as often as desired, by casting. In this case the metal strips are driven to a predetermined depth into the face of a piece of lime-wood cut across the grain, and, when the whole design is completed in this way, the block is placed, metal face downwards in a tray of molten type-metal or solder, which transmits sufficient heat to the inserted portions of the strips of copper to enable them to carbonize the wood immediately in contact with them and, at the same time, firmly attaches itself to the outstanding portions. When cold a slight tap with a hammer on the back of the limewood block easily detaches the cake of the type-metal or alloy and along with it, of course, the strips of copper to which it is firmly soldered, leaving a matrix, or mold, in wood of the original design. The casting is made in an alloy of low melting-point, anti, after cooling, is filed or ground until all its projections are of the same height and perfectly smooth, after which it is screwed on to a wooden support and is ready for printing. Similar molds are also made by burning out the lines of the pattern with a red-hot steel punch, capable of being raised or lowered at will, and under which the block is moved about by hand along the lines of the pattern.

In addition to the engraved block, a printing table and color sieve are required. The table consists of a stout framework of wood or iron supporting a thick slab of stone varying in size according to the width of cloth to be printed. Over the stone table top a thick piece of woolen printers blanket is tightly stretched to supply the elasticity necessary to give the block every chance of making a good impression on the cloth. At one end, the table is provided with a couple of iron brackets to carry the roll of cloth to be printed and, at the other, a series of guide rollers, extending to the ceiling, are arranged for the purpose of suspending and drying the newly printed goods. The color sieve consists of a tub (known as the swimming tub) half filled with starch paste, On the surface of which floats a frame covered at the bottom with a tightly stretched piece Of mackintosh or oiled calico. On this the color sieve proper, a frame similar to, the last but covered with fine woolen cloth, is placed, and forms when in position a sort of elastic color trough over the bottom of which the color is spread evenly with a brush.

The modus operandi of printing is as follows: The printer commences by drawing a length of cloth, from the roll, over the table, and marks it with a piece of colored chalk arid a ruler to indicate where the first impression of the block is to be applied.

He then applies his block in two different directions to the color on the sieve and finally presses it firmly and steadily on the cloth, ensuring a good impression by striking it smartly on the back with a wooden mallet. The second impression is made in the same way, the printer taking care to see that it fits exactly to the first, a point which he can make sure of by means of the pins with which the blocks are provided at each corner and which are arranged in such a way that when those at the right side or at the top of the block fall upon those at the left side or the bottom of the previous impression the two printings join up exactly and continue the pattern without a break. Each succeeding impression is made in precisely the same manner until the length of cloth on the table is fully printed. When this is done it is wound over the drying rollers, thus bringing forward a fresh length to be treated similarly.

If the pattern contains several colors the cloth is usually first printed throughout with one, then dried, re-wound and printed with the second, the same operations being repeated until all the colors are printed.

Many modifications of block printing have been tried from time to time, but of these only two tobying and rainbowing are of any practical value. The object of tobey printing is to print the several colors of a multicolor pattern at one operation and for this purpose a block with the whole of the pattern cut upon it, and a specially constructed color sieve are employed. The sieve consists of a thick block of wood, on one side of which a series of compartments are hollowed out, corresponding roughly in shape, size and position to the various objects cut on the block. The tops of the dividing walls of these compartments are then coated with melted pitch, and a piece of fine woolen cloth is stretched over the whole and pressed well down on the pitch so as to adhere firmly to the top of each wall; finally a piece of string soaked in pitch is cemented over the woolen cloth along the lines of the dividing walls, and after boring a hole through the bottom of each compartment the sieve is ready for use. In operation each compartment is filled with its special color through a pipe connecting it with a color box situated at the side of the sieve and a little above it, so as to exert just sufficient pressure on the color to force it gently through the woolen cloth, but not enough to cause it to overflow its proper limits, formed by the pitch-soaked string boundary lines.

The block is then carefully pressed on the sieve, and, as the different parts of its pattern fall on different parts of the sieve, each takes up a certain color that it transfers to the cloth in the usual way. By this method of tobying from two to six colors may be printed at one operation, but it is obvious that it is only applicable to patterns where the different colored objects are placed at some little distance apart, and that, therefore, it is of but limited application.

Block printing by hand is a slow process~ it is, however, capable of yielding highly artistic results, some of which are unobtainable by any other means, and it is, therefore, still largely practiced for the highest class of work in certain styles.

Perrotine printing

The perrotine is a block-printing machine invented by Perrot of Rouen in 1834, and practically speaking is the only successful mechanical device ever introduced for this purpose. For some reason or other it has rarely been used in England, but its value was almost immediately recognized on the Continent, and although block printing of all sorts has been replaced to such an enormous extent by roller printing, the perrotine is still largely employed in French, German and Italian works.

The construction of this ingenious machine is too complex to describe here without the aid of several detailed drawings, but its mode of action is roughly as follows: Three large blocks (3 ft. long by 3 to 5 in. wide), with the pattern cut or cast on them in relief, are brought to bear successively on the three faces of a specially constructed printing table over which the cloth passes (together with its backing of printers blanket) after each impression. The faces of the table are arranged at right angles to each other, and the blocks work in slides similarly placed, so that their engraved faces are perfectly parallel to the tables. Each block is moreover provided with its own particular color trough, distributing brush, and woolen color pad or sieve, and is supplied automatically with color by these appliances during the whole time that the machine is in motion. The first effect of starting the machine is to cause the color sieves, which have a reciprocating motion, to pass over, and receive a charge of color from, the rollers, fixed to revolve, in the color troughs. They then return to their original position between the tables and the printing blocks, coming in contact on the way with the distributing brushes, which spread the color evenly over their entire surfaces. At this point the blocks advance and are gently pressed twice against the color pads (or sieves) which then retreat once more towards the color troughs. During this last movement the cloth to be printed is drawn forward over the first table, and, immediately the color pads are sufficiently out of the way, the block advances and, with some force, stamps the first impression on it. The second block is now put into gear and the foregoing operations are repeated for both blocks, the cloth advancing, after each impression, a distance exactly equal to the width of the blocks. After the second block has made its impression the third comes into play in precisely the same way, so that as the cloth leaves the machines it's fully printed in three separate colors, each fitting into its proper place and completing the pattern. If necessary the forward movement of the cloth can be arrested without in any way interfering with the motion of the block, san arrangement which allows any insufficiently printed impression to be repeated in exactly the same place with a precision practically impossible in hand printing.

For certain classes of work the perrotine possesses great advantages over the hand-block; for not only is the rate of production greatly increased, but the joining up of the various impressions to each other is much more exacting fact, as a rule, no sign of a break in continuity of line can be noticed in well-executed work. On the other hand, however, the perrotine can only be applied to the production of patterns containing not more than three colors nor exceeding five inches in vertical repeat, whereas hand block printing can cope with patterns of almost any scale and continuing any number of colors. All things considered, therefore, the two processes cannot be compared on the same basis: the perrotine is best for work of a utilitarian character and the hand-block for decorative work in which the design only repeats every 15 to 20 in. and contains colors varying in number from one to a dozen. -

Engraved copperplate printing

The printing of textiles from engraved copperplates was first practiced by Bell in 1770. It is now entirely obsolete, as an industry, in England, and is only mentioned here because it is, to a slight extent, still used in Switzer land for printing finely engraved borders on a special style of handkerchief the center of which is afterwards filled in by block printing.

The presses first used were of the ordinary letterpress type, the engraved plate being fixed in the place of the type. In later improvements the well-known cylinder press was employed; the plate was inked mechanically and cleaned off by passing under a sharp blade of steel; and the cloth, instead of being laid on the plate, was passed round the

pressure cylinder. The plate was raised into frictional contact with the cylinder and in passing under it transferred its ink to the cloth.

The great difficulty in plate printing was to make the various impressions join up exactly; and, as this could never be done with any certainty, the process was eventually confined to patterns complete in one repeat, such as handkerchiefs, or those made up of widely separated objects in which no repeat is visible, like, for instance, patterns composed of little sprays, spots, &c.

Roller printing, cylinder printing, or machine printing

This elegant and efficient process was patented and worked by Bell in 1785 only fifteen years after his application of the engraved plate to textiles. It will probably remain a moot question as to whether he was the originator of the idea, but it is beyond doubt that he was the first man to put into practice the continuous printing of cloth from engraved copper rollers. Bells first patent was for a machine to print six colors at once, but, owing probably to its incomplete development, this was not immediately successful, although the principle of the method was shown to be practical by the printing of one color with perfectly satisfactory results. The difficulty was to keep the six rollers, each carrying a portion of the pattern, in perfect register with each other. This defect was soon overcome by Adam Parkinson of Manchester, and in 1785, the year of its invention, Bells machine with Parkinson's improvement was successfully employed by Messrs Livesey, Hargreaves, Hall & Co., of Bamber Bridge, Preston, for the printing of calico in from two to six colors at a single operation.

What Parkinson's contribution to the development of the modern roller printing machine really was is not known with certainty, but it was possibly the invention of the delicate adjustment known as the box wheel, whereby the rollers can be turned, whilst the machine is in motion, either in or against the direction of their rotation.

In its simplest form the roller-printing machine consists of a strong cast iron cylinder mounted in adjustable bearings capable of sliding up and down slots in the sides of the rigid iron framework. Beneath this cylinder the engraved copper roller rests in stationary bearings and is supplied with color from a wooden roller that revolves in a color-box below it. The copper roller is mounted on a stout steel axle, at one end of which a cogwheel is fixed to gear with the driving wheel of the machine, and at the other end a smaller cogwheel to drive the color-furnishing roller. The cast iron pressure cylinder is wrapped with several thicknesses of a special material made of wool and cotton lapping the object of which is to provide the elasticity necessary to enable it to properly force the cloth to be printed into the lines of engraving. A further and most important appliance is the doctor a thin sharp blade of steel that rests on the engraved roller and serves to scrape off every vestige of superfluous color from its surface, leaving only that which rests in the engraving. On the perfect action of this doctor depends the entire success of printing, and as its sharpness and angle of inclination to the copper roller varies with the styles of work in hand it requires an expert to get it up (sharpen it) properly and considerable practical experience to know exactly what qualities it should possess in any given case. In order to prevent it from wearing irregularly it is given a to-and-fro motion so that it is constantly changing its position and is never in contact with one part of the engraving for more than of brass or a similar alloy is frequently added on the opposite side of the roller to that occupied by the steel or cleaning doctor; it is known technically as the lint doctor from its purpose of cleaning off loose filaments or lint, which the roller picks off the cloth during the printing operation. The steel or cleaning doctor is pressed against the roller by means of weighted levers, but the lint doctor is usually just allowed to rest upon it by its own weight as its function is merely to intercept the nap which becomes detached from the cloth and would, if not cleaned from the roller, mix with the color and give rise to defective work.

Larger machines printing from two to sixteen colors are precisely similar in principle to the above, but differ somewhat in detail and are naturally more complex and difficult to operate. In a twelve-color machine, for example, twelve copper rollers, each carrying one portion of the design, are arranged round a central pressure cylinder, or bowl, common to all, and each roller is driven by a common driving wheel, called the crown wheel, actuated, in most cases,

by its own steam-engine or motor. Another difference is that the adjustment of pressure is transferred from the cylinder to the rollers which works in specially constructed bearings capable of the following movements: (1) Of being screwed up bodily until the rollers are lightly pressed against the central bowl; (2) of being moved to and fro sideways so that the rollers may he laterally adjusted; and (3) of being moved up or down for the purpose of adjusting the rollers in vertical direction. Notwithstanding the great latitude of movement thus provided each roller is furnished with a box-wheel, which serves the double purpose of connecting or gearing it to the driving wheel, and of affording a fine adjustment. Each roller is further furnished with its own color-box and doctors.

With all these delicate equipments at his command a machine printer is enabled to fit all the various parts of the most complicated patterns with an ease, dispatch and precision, which are remarkable considering the complexity and size of the machine.

In recent years many improvements have been made in printing machines and many additions made to their already wonderful capacities. Chief amongst these are those embodied in the Intermittent and the Duplex machines. In the former any or all of the rollers may be moved out of contact with the cylinder at will, and at certain intervals. Such machines are used in the printing of shawls and sarries for the Indian market. Such goods require a wide border right across their width at varying distances sometimes every three yards, sometimes every nine yards and it is to effect this, with rollers of ordinary dimensions, that intermittent machines are used. The body of the sarrie will be printed, say for six yards with eight rollers; these then drop away from the cloth and others, which have up to then been out of action, immediately fall into contact and print a border or crossbar, say one yard wide, across the piece; they then recede from the cloth and the first eight again return and print another six yards, and so on continually.

The Duplex or Reversible machine derives its name from the fact that it prints both sides of the cloth. It consists really of two ordinary machines so combined that when the cloth passes, fully printed on one side from the first, its plain side is exposed to the rollers of the second, which print an exact duplicate of the first impression upon it in such a way that both printings coincide. A pin pushed through the face of the cloth ought to protrude through the corresponding part of the design printed on the back if the two patterns are in good fit.

The advantages possessed by roller printing over all other processes are mainly three: firstly, its high productivity, 10,000 to 12,000 yards being commonly printed in one day of ten hours by a single-color machine; secondly, by its capacity of being applied to the reproduction of every style of design, ranging from the fine delicate lines of copperplate engraving and the small repeats and limited colors of the perrotine to the broadest effects of block printing and to patterns varying in repeat from I to 80 in.; and thirdly, the wonderful exactitude with which each portion of an elaborate multicolor pattern can be fitted into its proper place, and the entire absence of faulty joints at its points of repeat or repetition consideration of the utmost importance in fine delicate work, where such a blur would utterly destroy the effect.

Stenciling

The art of stenciling is very old. It has been applied to the decoration of textile fabrics from time immemorial by the Japanese, and, of late years, has found increasing employment in Europe for certain classes of decorative work on woven goods for furnishing purposes.

The pattern is cut out of a sheet of stout paper or thin metal with a sharp-pointed knife, the uncut portions representing the part that is to be reserved or left uncolored. The sheet is now laid on the material to be decorated and color is brushed through its interstices.

It is obvious that with suitable planning an all over pattern may be just as easily produced by this process as by hand or machine printing, and that moreover, if several plates are used, as many colors as plates may be introduced into it. The peculiarity of stenciled patterns is that they have to be held together by ties, that is to say, certain parts of them

have to be left uncut, so as to connect them with each other, and prevent them from falling apart in separate pieces. For instance, a complete circle cannot be cut without its center dropping out, and, consequently, its outline has to be interrupted at convenient points by ties or uncut portions. Similarly with other objects. The necessity for ties exercises great influence on the design, and in the hands of a designer of indifferent ability they may be very unsightly. On the other hand, a capable man utilizes them to supply the drawing, and when thus treated they form an integral part of the pattern and enhance its artistic value whilst complying with the conditions and the process.

For single-color work a stenciling machine was patented in 1894 by S. H. Sharp. It consists of an endless stencil plate of thin sheet steel that passes continuously over a revolving cast iron cylinder. Between the two the cloth to be ornamented passes and the color is forced on to it, through the holes in the stencil, by mechanical means.

Other Methods of Printing

Although most work is executed throughout by one or other of the five distinct processes mentioned above, combinations of them are not infrequently employed. Sometimes a pattern is printed partly by machine and partly by block; and sometimes a cylindrical block is used along with engraved copper-rollers in the ordinary printing machine. The block in this latter case is in all respects, except that of shape, identical with a flat wood or coppered block, but, instead of being dipped in color, it receives its supply from an endless blanket, one part of which works in contact with color-furnishing rollers and the other part with the cylindrical block. This block is known as a surface or peg roller. Many attempts have been made to print multicolor patterns with surface rollers alone, but hitherto with little success, owing to their irregularity in action and to the difficulty of preventing them from warping. These defects are not present in the printing of linoleum in which opaque oil colors are used, colors that neither sink into the body of the hard linoleum nor tend to warp the roller.

The printing of yarns and warps is extensively practiced. It is usually carried on by a simple sort of surface printing machine and calls for no special mention.

Lithographic printing, too, has been applied to textile fabrics with somewhat qualified success. Its irregularity and the difficulty of printing all over patterns to repeat properly, have restricted its use to the production of decorative panels, equal in size to that of the plate or stone, and complete in themselves.

Engraving of copper rollers

The engraving of copper rollers is one of the most important branches of textile printing and on its perfection of execution depends, in great measure, the ultimate success of the designs. Roughly speaking, the operation of engraving is performed by three different methods, viz. (I) By hand with a graver which cuts the metal away; (2) by etching, in which the pattern is dissolved out in nitric acid; and (3) by machine, in which the pattern is simply indented.

(1) Engraving by hand is the oldest and most obvious method of engraving, but is the least used at the present time on account of its slowness. The design is transferred to the roller from an oil color tracing and then merely cut out with a steel graver, prismatic in section, and sharpened to a beveled point. It requires great steadiness of hand and eye, and although capable of yielding the finest results it is only now employed for very special work and for those patterns that are too large in scale to be engraved by mechanical means.

(2) In the etching process an enlarged image of the design is cast upon a zinc plate by means of an enlarging camera and prisms or reflectors. On this plate it is then painted in colors roughly approximating to those in the original, and the outlines of each color are carefully engraved in duplicate by hand. The necessity for this is that in subsequent operations the design has to be again reduced to its original size and, if the outlines on the zinc plate were too small at first, they would be impracticable either to etch or print. The reduction of the design and its transfer

to a varnished copper roller are both effected at one and the same operation in the pantograph machine. This machine is capable of reducing a pattern on the zinc plate from one-half to one-tenth of its size, and is so arranged that when its pointer or stylus is moved along the engraved lines of the plate a series of diamond points cut a reduced facsimile of them through the varnish with which the roller is covered. These diamond points vary in number according to the number of times the pattern is required to repeat along the length of the roller. Each color of a design is transferred in this way to a separate roller. The roller is then placed in a shallow trough containing nitric acid, which acts only on those parts of it from which the varnish has been scraped. To ensure evenness the roller is revolved during the whole time of its immersion in the acid. When the etching is sufficiently deep the roller is washed, the varnish dissolved off, any parts not quite perfect being retouched by hand.

In machine engraving the pattern is impressed in the roller by a small cylindrical mill on which the pattern is in relief. It is an indirect process and requires the utmost care at every stage. The pattern or design is first altered in size to repeat evenly round the roller. One repeat of this pattern is then engraved by hand on a small highly polished soft steel roller, usually about 3 in. long and 1/2 in. to 3 in. in diameter; the size varies according to the size of the repeat with which it must be identical. It is then repolished, painted with a chalky mixture to prevent its surface oxidizing and exposed to a red-heat in a box filled with chalk and charcoal; then it is plunged in cold water to harden it and finally tempered to the proper degree of toughness. In this state it forms the die from which the mill is made. To produce the actual mill with the design in relief a softened steel cylinder is screwed tightly against the hardened die and the two are rotated under constantly increasing pressure until the softened cylinder or mill has received an exact replica in relief of the engraved pattern. The mill in turn is then hardened and tempered, when it is ready for use. In size it may be either exactly like the die or its circumferential measurement may be any multiple of that of the latter according to circumstances.

The copper roller must in like manner have a circumference equal to an exact multiple of that of the mill, so that the pattern will join up perfectly without the slightest break in line.

The modus operandi of engraving is as follows. The mill is placed in contact with one end of the copper roller, and being mounted on a lever support as much pressure as required can be put upon it by adding weights. Roller and mill are now revolved together, during which operation the projection parts of the latter are forced into the softer substance of the roller, thus engraving it, in intaglio, with several replicas of what was cut on the original die. When the full circumference of the roller is engraved, the mill is moved sideways along the length of the roller to its next position, and the process is repeated until the whole roller is fully engraved.

Preparation of cloth for printing

Goods intended for calico printing ought to be exceptionally well-bleached, otherwise mysterious stains, and other serious defects, are certain to arise during subsequent operations.

The chemical preparations used for special styles will be mentioned in their proper places; but a general prepare, employed for most colors that are developed and fixed by steaming only, consists in passing the bleached calico through a weak solution of sulfated or turkey red oil containing from 21/2 per cent, to 5 per cent, of fatty acid. Some colors are printed on pure bleached cloth, but all patterns containing alizarine red, rose and salmon shades, are considerably brightened by the presence of oil, and indeed very few, if any, colors are detrimentally affected by it.

Apart from wet preparations the cloth has always to be brushed, to free it from loose nap, flocks and dust that it picks up whilst stored. Frequently, too, it has to be sheared by being passed over rapidly revolving knives arranged spirally round an axle, which rapidly and effectually cuts off all filaments and knots, leaving the cloth perfectly smooth and clean and in a condition fit to receive impressions of the most delicate engraving. Some figured fabrics, especially those woven in checks, stripes and crossovers, require very careful stretching and straightening on a special machine, known as a stenter, before they can be printed with certain formal styles of pattern which are intended in

one way or another to correspond with the cloth pattern. Finally, all descriptions of cloth are wound round hollow wooden or iron centers into rolls of convenient size for mounting on the printing machines.

Preparation of colors

The art of making colors for textile printing demands both chemical knowledge and extensive technical experience, for their ingredients must not only be properly proportioned to each other, but they must be specially chosen and compounded for the particular style of work in hand. For a pattern containing only one color any mixture whatever may he used so long as it fulfils all conditions as to shade, quality and fastness; but where two or more colors are associated in the same design each must be capable of undergoing without injury the various operations necessary for the development and fixation of the others.

All printing pastes whether containing coloring matter or not are known technically as colors, and are referred to as such in the sequence.

Colors vary considerably in composition. The greater number of them contain all the elements necessary for the direct production and fixation of the color-lake. Some few contain the coloring matter alone and require various after-treatments for its fixation; and others again are simply mordants thickened. A mordant is the metallic salt or other substance that combines with the coloring principle to form an insoluble color-lake, either directly by steaming, or indirectly by dyeing.

All printing colors require thickening, for the two-fold object of enabling them to be transferred from color-box to cloth without loss and to prevent them from running or spreading beyond the limits of the pattern.

Thickening Agents

The thickening agents in most general use as vehicles in printing, are starch, flour, gum arabic, gum senegal and gum tragacanth, British gum or dextrine and albumen.

With the exception of albumen all these are made into pastes, or dissolved, by boiling in double or jacketed pans, between the inner and outer casings of which either steam or water may be made to circulate, for boiling and cooling purposes. Mechanical agitators are also fitted in these pans to mix the various ingredients together, and to prevent the formation of lumps by keeping the contents thoroughly stirred up during the whole time they are being boiled and cooled.

Starch paste

This is made by mixing 15 lb of wheat starch with a little cold water to a smooth creamy paste; a little olive oil is then added and sufficient water to bring the whole up to 10 gallons. The mixture is then thickened by being boiled for about an hour and, after cooling, is ready for use.

Starch is the most extensively used of all the thickenings. It is applicable to all but strongly alkaline or strongly acid colors. With the former it thickens up to a stiff unworkable jelly, while mineral acids or acid salts convert it into dextrine, thus diminishing its thickening power. Acetic and formic acids have no action on it even at the boil.

Flour paste is made in a similar way to starch paste. At the present time it is rarely used for anything but the thickening of aluminum and iron mordants, for which it is eminently adapted.

Gums

Gum arabic and gum senegal are both very old thickenings, but their expense prevents them from being used for any but pale delicate tints. They are especially useful thickenings for the light ground colors of soft muslins and sateens on account of the property they possess of dissolving completely out of the fibers of the cloth in the washing process after printing. Starch and artificial gums always leave the cloth somewhat harsh in feel unless they are treated specially, and are moreover incapable of yielding the beautifully clear and perfectly even tints resulting from the use of natural gums. Very dark colors cannot well be obtained with gum senegal or gum arabic thickenings; they come away too much in washing, the gum apparently preventing them from combining fully with the fibers. Stock solutions of these two gums are usually made by dissolving 6 or 8 lb of either in one gallon of water, either by boiling or in the cold by standing.

British gum or dextrine is prepared by heating starch. It varies considerably in composition sometimes being only slightly roasted and consequently only partly converted into dextrine, and at other times being highly torrefied, and almost completely soluble in cold water and very dark in color. Its thickening power decreases and its gummy nature increases as the temperature at which it is roasted is raised. The lighter colored gums or dextrines will make a good thickening with from 2 to 3 lb of gum to one gallon of water, but the darkest and most highly calcined require from 6 to lb per gallon to give a substantial paste. Between these limits all qualities are obtainable. The darkest qualities are very useful for strongly acid colors, and with the exception of gum senegal, are the best for strongly alkaline colors and discharges.

Like the natural gums, neither light nor dark British gums penetrate into the fiber of the cloth so deeply as pure starch or flour, and are therefore unsuitable for very dark strong colors.

Gum tragacanth, or Dragon, is one of the most indispensable thickening agents possessed by the textile printer. It may be mixed in any proportion with starch or flour and is equally useful for pigment colors and mordant colors. When added to starch paste it increases its penetrative power, adds to its softness without diminishing its thickness, makes it easier to wash Out of the fabric and produces much more level colors than starch paste alone. Used by itself it is suitable for printing all kinds of dark grounds on goods that are required to retain their soft clothy feel. A tragacanth mucilage may be made either by allowing it to stand a day or two in contact with cold water or by soaking it for twenty-four hours in warm water and then boiling it up until it is perfectly smooth and homogeneous. If boiled under pressure it gives a very fine, smooth mucilage (not a solution proper), much thinner than if made in the cold.

Albumen

Albumen is both a thickening and a fixing agent for insoluble pigments such as chrome yellow, the ochres, vermilion and ultramarine. Albumen is always dissolved in the cold, a process that takes several days when large quantities are required. The usual strength of the solution is 4 lb per gallon of water for blood albumen, and 6 lb per gallon for egg albumen. The latter is expensive and only used for the lightest shades. For most purposes one part of albumen solution is mixed with one part of tragacanth mucilage, this proportion of albumen being found amply sufficient for the fixation of all ordinary pigment colors. In special instances the blood albumen solution is made as strong as 50 per cent, but this is only in cases where very dark colors are required to be absolutely fast to washing. After printing, albumen thickened colors are exposed to hot steam, which coagulates the albumen and effectually fixes the colors.

Formerly colors were always prepared for printing by boiling the thickening agent, the coloring matter and solvents, &c., together, then cooling and adding the various fixing agents. At the present time, however, concentrated solutions of the coloring matters and other adjuncts are often simply added to the cold thickenings, of which large quantities are kept in stock.

Colors are reduced in shade by simply adding more starch or other paste. For example, a dark blue containing 4 oz. of methylene blue per gallon may readily be made into a pale shade by adding to it thirty times its bulk of starch paste or gum, as the case may be. Similarly with other colors.

Before printing it is very essential to strain or sieve all colors in order to free them from lumps, fine sand, &c., which would inevitably damage the highly polished surface of the engraved rollers and result in bad printing. Every scratch on the surface of a roller prints a fine line in the cloth, and too much care, therefore, cannot be taken to remove, as far as possible, all grit and other hard particles from every color.

The straining is usually done by squeezing the color through fine cotton or silk cloths. Mechanical means are also employed for colors that are used hot or are very strongly alkaline or acid.

Styles of Printing

The widely differing properties of the hundreds of coloring matters now on the market give rise to many different styles of textile printing. Generally speaking, these fall into the following four great divisions:

1. Direct printing.
2. The printing of a mordant upon which the color is afterwards dyed.
3. The discharge style.
4. The resist or reserve style.

The fact that each of these divisions is further sub-divided into many smaller divisions renders it out of the question to give more than a few typical examples of the various styles they include.

(1) Direct Printing

This style is capable of application to almost every class of color known. Its essential feature is that the coloring matter and its fixing agent are both applied to the fabric simultaneously. In some instances the fabric requires to be previously prepared for certain of the colors used along with those characteristic of the process; but this is one of many cases where two styles are combined, and it must be classed with the one which it most resembles.

Silk printing

Silk printing calls for no special mention. The colors and methods employed are the same as for wool, except that in the case of silk no preparation of the material is required before printing and the ordinary dry steaming is preferable to damp steaming.

Both acid and basic dyes play an important role in silk printing, which for the most part is confined to the production of articles for wearing apparel dress goods, handkerchiefs, scarves, articles for which bright colors are in demand. Alizarine and other mordant colors are mainly used, or ought to be, for any goods that have to resist repeated washings and prolonged exposure to light. In this case the silk frequently requires to be prepared in alizarine oil, after which it is treated in all respects like cotton steamed, washed and soaped the colors used being the same.

Silk is especially adapted to discharge and reserve effects. Most of the acid dyes can be discharged in the same way as when they are dyed on wool; and reserved effects are produced by printing mechanical resists, such as waxes and fats, on the cloth and then dyeing it up in cold dye-liquor. The great affinity of the silk fiber for basic and acid dyestuffs enables it to extract coloring matter from cold solutions, and permanently combine with it to form an insoluble lake. After dyeing, the reserve prints are washed, first in cold water to get rid of any color not fixed on the fiber, and then in hot water or benzene, to dissolve out the resisting bodies.

As a rule, after steaming, silk goods are only washed in hot water, but, of course, those printed entirely in mordant dyes will stand soaping, and indeed require it to brighten the colors and soften the material. (E. K.)

Art and Archaeology

Printing patterns on textiles whether of flax, cotton or silk, by means of incised wooden blocks, is so closely related in its ornamental effects to other different methods of similar intention, such as by painting and by processes of dyeing and weaving, that it is almost impossible to determine from the picturesque indications afforded by ancient records and writings of pre-Christian, classical or even medieval times, how far, if at all, allusion is being made in them to this particular process. Hence its original invention must probably remain a matter of inference only. As a process, the employment of which has been immensely developed and modified in Europe during the last hundred years by machinery anti the adoption of stereotypes and engraved metal plates, it is doubtless traceable to a primeval use of blocks of stone, wood, &c., so cut or carved as to make impressions on surfaces of any material; and where the existence of these can be traced in ancient civilizations, e.g. of the Chinese, Egyptians and Assyrians, there is a probability that printing ornament upon textiles may have been practiced at a very early period. Nevertheless, highly skilled as the Chinese are, anti for ages have been, in ornamental weaving and other branches of textile art, there seem to be no direct evidences of their having resorted so extensively to printing for the decoration of textiles as peoples in the East Indies, those, for instance, of the Punjab and Bombay, from whose posterity 16th century European and especially Dutch merchants bought goods for Occidental trade in Indiennes or printed and painted calicoes.

Whilst the earlier history of stamping patterns by hand on to textiles in the East has still to be written, a serious attempt has recently been made to account for the existence of this decorative process in Europe during several centuries, prior to the introduction of the Indiennes above mentioned. As in, the case of weaving and embroideries, specimens of printed stuffs have of recent years been obtained from disused cemeteries in Upper Egypt (Akhmim and elsewhere) and tell us of Egypto-Roman use of such things. Some few of them are now lodged in European museums. For indications that earlier Egyptians, Greeks and Romans were likely to have been acquainted with the process, one has to rely upon less certain evidence. Of textiles painted by Egyptians there are many actual examples. Apart from these there are wall paintings, e.g., those of Beni Hassan--about 2100 B.C. in which are represented certain Asiatic people wearing costumes irregularly patterned with spots, stripes and zigzags, which may have been more readily stamped than embroidered or woven. A rather more complicated and orderly pattern well suited to stamping occurs in a painting about 1320 BC, of Hathor and King Meneptha I. Herodotus, referring to the garments of inhabitants of the Caucasus, says that representations of various animals were dyed into them so as to be irremovable by washing. Pliny describes a very remarkable process employed in Egypt for the coloring of tissues. After pressing the material, which is white at first, they saturate it, not with colors, but with mordants that are calculated to absorb color. He does not explain how this saturation is done. But as it is clearly for the purpose of obtaining a decorative effect, stamping or brushing the mordants into the material may be inferred. When this was finished the cloth was plunged into a cauldron of boiling dye and removed the next moment fully colored. It is a singular fact, too, that although the dye in the pan is of one uniform color, the material when taken out of it is of various colors according to the nature of the mordants that have been respectively applied to it. Egypto-Roman bits of printed stuffs from Akhrnim exhibit the use, some three hundred years later than the time of Pliny, of boldly cut blocks for stamping figure-subjects and patterns on to textiles. Almost concurrent with their discovery was that of a fragment of printed cotton at Arles in the grave of St Caesarius, who was bishop there about A.D. 542. Equal in archaeological value are similar fragments found in an ancient tomb at Quedlinburg. These, however, are of comparatively simple patterns. Other later specimens establish the fact that more important pattern printing on textiles had become a developed industry in parts of Europe towards the end of the 12th and the beginning of the 13th century.

According to Forrer (Die Kunst des Zeugdrucks, 1898) medieval Rhenish monasteries were the cradles of the artistic craft of ornamental stamp or block cutting. In rare monastic MSS. earlier in date than the 13th century, initial letters

(especially those that recurred frequently) were sometimes stamped from hand-cut blocks; and German deeds of the 14th century bear names of block cutters and textile stampers as those of witnesses. Between the 11th and 14th centuries there was apparently in Germany no such weaving of rich ornamental stuffs as that carried on in Spain and Italy, but her competitive and commercial instincts led her to adapt her art of stamping to the decoration of coarse textiles, and thus to produce rather rough imitations of patterns woven in the Saracenic, Byzantine and Italian silks and brocades. Amongst the more ancient relics of Rhenish printed textiles are some of thin silken stuff, impressed with rude and simplified versions of such patterns in gold and silver foil. Of these, and of a considerable number of later variously dyed stout linens with patterns printed in dark tones or in black, specimens have been collected from reliquaries, tombs and old churches. From these several bits of evidence Dr. Forrer propounds an opinion that the printing of patterns on textiles as carried on in several Rhenish towns preceded that of printing on paper. He proceeds to show that from after the 14th century increasing luxury and prosperity promoted a freer use of woven and embroidered stuffs, in consequence of which textile printing fell into neglect, and it was not until three centuries later that it revived, very largely under the influence of trade importing into Europe quantities of Indian printed and painted calicoes.

Augsburg, famous in the 17th century for its printing on linens, &c., supplied Alsace and Switzerland with many craftsmen in this process. After the revocation of the edict of Nantes, French refugees took part in starting manufactories of both painted and printed cloths in Holland, England and Switzerland; some few of the refugees were allowed back into France to do the same in Normandy: manufactories were also set up in Paris, Marseilles, Nantes and Angers; but there was still greater activity at Geneva, Neuchtel, Zurich, St Gall and Basel. The first textile printing works in Great Britain are said to have been begun towards the end of the 17th century by a Frenchman on the banks of the Thames near Richmond, and soon afterwards a more considerable factory was established at Bromley Hall in Essex; many others were opened in Surrey early in the 18th century. At Muihouse the enterprise of Koechlin, Schmatzer and Dollfus in 1746, as well as that of Oberkampf at Jouy, led to a still wider spread of the industry in Alsace. In almost every place in Europe where it was taken up and followed, it was met by local and national prohibitions or trade protective regulations and acts, which, however, were gradually overcome.