TEXTILE-PRINTING. "Textile" (see WEAVING) is a general name for all woven fabrics (Lat. *texere*, to weave), and the art of ornamenting such fabrics by printing on designs or patterns in colour is very ancient, probably originating in the East. It has been practised in some form, with considerable success, in China and India from time immemorial, and the Chinese, at least, are known to have made use of engraved wood-blocks many centuries before any kind of printing was known in Europe. That the early Egyptians, too, were acquainted with the art is proved not merely by the writings of Pliny but by the discovery, in the Pyramids and other Egyptian tombs, of fragments of cloth which were undoubtedly decorated by some method of printing.

The Incas of Peru, Chile and Mexico also practised 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.

There is no doubt that India was the source from which, by two different channels, Europeans derived their knowledge of block-printing. By land its practice spread slowly westwards through Persia, Asia Minor and the Levant, until it was taken up in Europe—during the latter half of the 17th century. Almost at the same time 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.

I. 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 practised 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 colour were closely followed—even deliberately copied—by all other European printers; and, from the early days of the industry down to the latter half of the 19th 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 and 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 colour in definite patterns or designs, but in properly printed goods the colour becomes part and parcel of the fibre, 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 colour, in printing one or more colours are applied to it in certain parts only, and in sharply defined patterns. In principle these two branches of textile colouring are closely allied, for the colouring 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 dye-stuff, stirring it about constantly or otherwise manipulating it to prevent unevenness. In printing, however, the colour 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 colours also contain, besides the colouring 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 coloured patterns on cloth:—

(1) Hand block-printing.
(2) Perrotine or block-printing by machine.
(3) Engraved plate-printing.
(4) Engraved roller-printing.
(5) Stencilling, which although not really a printing process may be classed here as one.

(1) *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 warp—a defect 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 lamp-black and oil, of the outlines of the masses of the design. The portions to be left in relief are then tinted, between their outlines, in ammoniacal carmine or magenta, for the purpose of distinguishing them from those portions which have to be cut away. As a separate block is required for each distinct colour in the design, a separate tracing must be made of each and transferred (or " put on " as it is 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 block-cutter 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 colour 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 colour 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 mould, 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 lime-wood 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 mould, in wood of the original design. The casting is made in an alloy of low melting-point, and, 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 moulds 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 colour 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 woollen printer's 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 " colour 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 " colour sieve " proper, a frame similar to the last but covered with fine woollen cloth, is placed, and forms when in position a sort of elastic colour trough over the bottom of which the colour 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 coloured chalk and 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 colour 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 colours 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 colours 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 colours of a multicolour pattern at one operation, and for this purpose a block with the whole of the pattern cut upon it, and a specially constructed " colour 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 woollen 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 woollen 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 colour through a pipe connecting it with a colour box situated at the side of the sieve and a little above it, so as to exert just sufficient pressure on the colour to force it gently through the woollen 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 colour which it transfers to the cloth in the usual way. By this method of "tobying" from two to six colours may be printed at one operation, but it is obvious that it is only applicable to patterns where the different coloured 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 practised for the highest class of work in certain styles.

(2) *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 printer's 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 colour trough, distributing brush, and woollen colour pad or sieve, and is supplied automatically with colour by these appliances during the whole time that the machine is in motion. The first effect of starting the machine is to cause the colour sieves, which have a reciprocating motion, to pass over, and receive a charge of colour from the rollers, fixed to revolve, in the colour 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 colour evenly over their entire surfaces. At this point the blocks advance and are gently pressed twice against the colour pads (or sieves) which then retreat once more towards the colour troughs. During this last movement the cloth to be printed is drawn forward over the first table, and, immediately the colour 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 is fully printed in three separate colours, 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 blocks—an 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 exact—in 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 colours nor exceeding five inches in vertical repeat, whereas hand block-printing can cope with patterns of almost any scale and containing any number of colours. 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 colours varying in number from one to a dozen.

(3) *Engraved Copperplate-Printing.*—The printing of textiles from engraved copperplates was first practised 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 Switzerland for printing finely engraved borders on a special style of handkerchief the centre 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.

(4) *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. Bell's first patent was for a machine to print six colours 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 colour 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, Bell's 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 colours 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 colour from a wooden roller which revolves in a colour-box below it. The copper roller is mounted on a stout steel axle, at one end of which a cog-wheel is fixed to gear with the driving wheel of the machine, and at the other end a smaller cog-wheel to drive the colour-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 which rests on the engraved roller and serves to scrape off every vestige of superfluous colour 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 (the "doctor") 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 a moment at a time. A second "doctor" 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 colour and give rise to defective work.

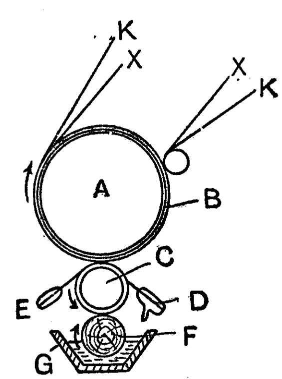

FIG. 1.

The working of the machine will be best understood by referring to the accompanying diagrammatic sketch of a single colour (fig. 1).

A is the cast iron pressure cylinder; B the lapping with which it is usually wrapped; C the engraved copper printing roller; D the steel "cleaning doctor"; E the brass "lint doctor"; F the colour-furnishing roller; G the colour-trough or "box" in which the latter (F) works partly immersed in colour; X an endless woollen blanket continually circulating between the cloth to be printed (K) and the cylinder A; and K the cloth in question. In operation, the cylinder A is screwed down with an even pressure into frictional contact with the roller C; the machine is then set in motion, turning in the direction indicated by the arrows; the cloth is now introduced between A and C and as it leaves the machine fully printed it is carried over a series of drying cylinders situated above and heated by steam. The printing roller C is the only part of the machine directly connected with the motor or main drive of the works through the cog-wheel on its axle—the "mandril"—all the other parts deriving their motion from *it*, either by friction as in the case of the cylinder or by a spur wheel as in that of the colour-furnishing roller. The mode of printing is almost self-evident; the roller C revolving in the direction of the arrow takes colour from the "furnisher" F, the excess is scraped off by the "doctor" G and, in continuing its course, it comes in contact with the cloth K, which being pressed by the cylinder A into the engraving abstracts the colour therefrom and of course receives an exact impression of the engraved pattern.

Larger machines printing from two to sixteen colours 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-colour 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 work 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 be 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 colour-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, despatch 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 yds. being commonly printed in one day of ten hours by a single-colour 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 colours of the "perrotine" to the broadest effects of block-printing and to patterns varying in "repeat" from 1 to 80 in.; and thirdly, the wonderful exactitude with which each portion of an elaborate multicolour pattern can be fitted into its proper place, and the entire absence of faulty joints at its points of "repeat" or repetition—a consideration of the utmost importance in fine delicate work, where such a blur would utterly destroy the effect.

(5) *Stencilling.*—The art of stencilling 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 uncoloured. The sheet is now laid on the material to be decorated and colour 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 colours as plates may be introduced into it. The peculiarity of stencilled 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 centre 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-colour work a stencilling machine was patented in 1894 by S. H. Sharp. It consists of an endless stencil plate of thin sheet steel which passes continuously over a revolving cast iron cylinder. Between the two the cloth to be ornamented passes and the colour is forced on to it, through the holes in the stencil, by mechanical means.

(6) *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 colour, it receives its supply from an endless blanket, one part of which works in contact with colour-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 multicolour 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 colours are used—colours which neither sink into the body of the hard linoleum nor tend to warp the roller.

The printing of yarns and warps is extensively practised. 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. (1) 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-colour tracing and then merely cut out with a steel graver, prismatic in section, and sharpened to a bevelled 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 which 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 colours roughly approximating to those in the original, and the outlines of each colour 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 colour 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.

(3) 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 ½ 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 re-polished, 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. Particulars of bleaching will be found in the article BLEACHING (*q.v.*).

The chemical preparations used for special styles will be mentioned in their proper places; but a general "prepare," employed for most colours that are developed and fixed by steaming only, consists in passing the bleached calico through a weak solution of "sulphated" or turkey red oil containing from 2½ per cent. to 5 per cent. of fatty acid. Some colours 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, colours 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 which 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 "cross-overs," 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 centres into rolls of convenient size for mounting on the printing machines.

Preparation of Colours

The art of making colours 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 colour any mixture whatever may be used so long as it fulfils all conditions as to shade, quality and fastness; but where two or more colours 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 colouring matter or not are known technically as "colours," and are referred to as such in the sequence.

Colours vary considerably in composition. The greater number of them contain all the elements necessary for the direct production and fixation of the colour-lake. Some few contain the colouring 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 which combines with the colouring principle to form an insoluble colour-lake, either directly by steaming, or indirectly by dyeing.

All printing colours require to be thickened, for the twofold object of enabling them to be transferred from colour-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 ℔ 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 colours. 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 aluminium and iron mordants, for which it is eminently adapted.

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 colours of soft muslins and sateens on account of the property they possess of dissolving completely out of the fibres 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 colours 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 fibres. Stock solutions of these two gums are usually made by dissolving 6 or 8 ℔ 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 colour. Its thickening power decreases and its "gummy" nature increases as the temperature at which it is roasted is raised. The lighter coloured gums or dextrines will make a good thickening with from 2 to 3 ℔ of gum to one gallon of water, but the darkest and most highly calcined require from 6 to 10 ℔ per gallon to give a substantial paste. Between these limits all qualities are obtainable. The darkest qualities are very useful for strongly acid colours, and with the exception of gum senegal, are the best for strongly alkaline colours and discharges.

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

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 colours and mordant colours. 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 colours than starch paste alone. Used by itself it is suitable for printing all kinds of dark grounds on goods which 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 which 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 colours. In special instances the blood albumen solution is made as strong as 50 per cent., but this is only in cases where very dark colours are required to be absolutely fast to washing. After printing, albumen-thickened colours are exposed to hot steam, which coagulates the albumen and effectually fixes the colours.

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

Colours 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 colours.

Before printing it is very essential to strain or sieve all colours 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 colour.

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

Styles of Printing

The widely differing properties of the hundreds of colouring 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 colour 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 colour known. Its essential feature is that the colouring 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 colours 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.

(*a*) *Application of Mordant Dye-Stuffs.*—Mordant colours include both artificial and natural dye-stuffs (see also under Dyeing), the most important of all being *alizarine*, an artificial preparation of the colouring-principle of the madder root. With different metallic oxides alizarine forms different colour-lakes all exceedingly fast to light and soap. Aluminium mordant gives red and pink lakes; iron mordant, purples and lavenders; chromium yields maroons; and uranium gives grey shades. Mixture of iron and aluminium produce various tones of chocolate and brown.

In addition to alizarine the following are a few of the more important mordant dye-stuffs employed in textile-printing:—

Alizarine orange with aluminium and chrome mordants for orange and warm brown shades respectively; alizarine bordeaux, with alumina, for violets; alizarine blue with chrome and zinc for quiet blue shades; coeruleine and alizarine viridine for greens and olives with chromium mordants; gallocyanine, chrome violet blue, alizarine cyanines, &c., with chromium for various shades of blue and violet; alizarine yellows and anthracene brown for yellows and fawn shades respectively with either aluminium or chrome mordants. The natural dye-stuffs belonging to this series are chiefly: logwood, with chromium and iron mordants, for blacks; Persian berries and quercitron bark, with aluminium, tin and chromium mordants, for colours ranging from brilliant yellow to quiet old golds and browns; catechu, with chromium, for very fast dark browns; and, occasionally, in mixtures, sapan-wood, peach-wood, Brazil-wood, and divi-divi extracts with any of the above-mentioned mordants.

The mordants are mostly in the form of acetates which are stable in the cold but decompose during the steaming process, and combine as hydroxides with the colours, forming and fixing on the fabric the insoluble lake.

Alizarine reds and pinks are the most complicated of the mordant colours, requiring for their proper production the addition of brightening agents, such as oxalate of tin, oils, tartaric acid, and also acetate of lime. This also applies to alizarine orange, but all the other colours are very simple to compound and are stable for a long time after making. Reds, pinks and oranges are best prepared freshly each day; their constituents are liable to combine if the colour stands twenty-four hours before printing.

The following types of recipes will give some idea of the way in which colours are mixed:—

Red.	$6\frac{1}{2}$ gallons	thick starch and tragacanth paste.
	$1\frac{1}{4}$,,	alizarine (20 per cent. commercial paste).
	1 ,,	nitrate of alumina, 18° Tw.
	$\frac{1}{2}$,,	acetate of lime, 28° Tw.
	$\frac{1}{4}$,,	oxalate of tin, 10° Tw.
	$\frac{1}{2}$,,	10 per cent. solution of tartaric acid.
Pink.	$6\frac{1}{2}$ gallons	starch-tragacanth paste.
	1 ,,	blue shade alizarine (20 per cent. paste).
	$1\frac{1}{4}$,,	sulphocyanide of alumina, 18° Tw.
	$\frac{3}{8}$,,	acetate of lime, 28° Tw.
	$\frac{1}{4}$,,	oxalate of tin.
	$\frac{1}{2}$,,	citrate of alumina, 40° Tw.

For reds and pinks the nitrate, sulphocyanide and citrate of alumina are generally preferred in practice to the acetate though the latter is also largely used. Oranges from alizarine orange are made similarly.

Purple.	$9\frac{1}{8}$ gallons	starch paste.
	$\frac{1}{8}$,,	blue shade alizarine, 20 per cent.
	$\frac{1}{2}$,,	acetic acid.
	$\frac{1}{8}$,,	acetate of lime, 28° Tw.
	$\frac{1}{8}$,,	acetate of iron, 24° Tw.
Maroon.	$5\frac{1}{2}$ gallons	paste.
	1 ,,	alizarine, 20 per cent.
	$\frac{3}{4}$,,	acetate of chrome, 32° Tw.
	$\frac{3}{8}$,,	acetate of lime, 28° Tw.

Blues and the other colours are made by leaving out the lime in the last recipe and replacing the alizarine with another colour.

Alizarine Blue.	$\frac{1}{2}$ lb	alizarine blue shade (powd.).
(*Light Shade.*)	1 gallon	water.
	$3\frac{1}{2}$,,	thick paste.
	$1\frac{1}{2}$,,	acetate of chrome, 40° Tw.

Logwood and other natural colours are specially boiled.

Logwood Black.	15 lb	starch.
	10 ,,	British gum.
	$4\frac{1}{2}$ gallons	water.
	$\frac{3}{4}$,,	acetic acid.
	$1\frac{1}{2}$,,	logwood extract, 48° Tw.
	$\frac{3}{8}$,,	quercitron extract, 48° Tw.
	Boil, cool and add:—	
	$\frac{1}{2}$ lb	red prussiate of potash.
	$\frac{1}{4}$ gallon	water.
	2 ,,	acetate of chrome, 40° Tw.
	2 oz.	chlorate of potash.
Quercitron Yellow.	$1\frac{1}{2}$ gallons	quercitron extract, 48° Tw.
	$6\frac{1}{2}$,,	water.
	11 lb	starch.
	Boil, cool and add:—	
	$\frac{3}{4}$ gallon	acetate of chrome, 30° Tw.

The proportions here given are liable to variations according to circumstances. Indeed, no two works employ quite the same recipes, although the proportion of mordant to dye-stuff is pretty generally known and observed.

After printing, the goods are dried, steamed for one hour, and then washed and finished.

(*b*) *Application of Basic Aniline Dye-Stuffs.*—These colours all form insoluble lakes with tannic acid; hence tannic acid is the common fixing agent of the group. Arsenic in combination with alumina also gives basic-colour lakes, but their poisonous character and their inferior fastness to most reagents considerably limit their application.

The more important basic dye-stuffs are: methylene blue, methyl violet, rhodamine, auramine yellow, safranine emerald green and indoine blue. Most of them are fairly fast to soaping, but towards the action of light they vary a good deal, methylene blue being perhaps as good as any, and the malachite greens the least stable.

Their application is simple. A solution of the colouring matter is added to the requisite quantity of starch paste or gum, and, when well mixed in, the tannin is added in the form of a solution also. If desired they may be boiled up like the extract dye-stuffs (logwood, &c.), but this is not necessary unless large quantities are required, when it would be more convenient to boil the whole at once than to mix small batches by hand.

Methylene blue will serve as a type of the method by which all basic colours are compounded.

Blue. 2 gallons methylene blue, 10 per cent. solution in water and acetic acid.
6 ,, thick starch paste.
1 ,, tragacanth mucilage.
1 ,, tannic acid solution, 50 per cent.

10 gallons.

All other basic colours are made up for printing in a similar way by replacing the blue with the required dye-stuff.

After printing, goods containing basic dyes are "steamed," and passed through a solution of tartar emetic, or other salt of antimony, whereby an insoluble double tannate of antimony and colouring matter is formed, which constitutes a much faster colour than the single tannate of the dye-stuff.

Basic colours may be printed along with "mordant" and albumen colours.

(*c*) *Application of Direct Dyeing Colours.*—These colours have a natural affinity for the cotton fibre and therefore require no mordant. They are not very "fast," however, and, though used enormously in the dyeing of plain shades, they find but little employment in printing except for the tinting of printed goods, and for the "crepon" style, where the colours must be able to withstand the action of caustic soda.

They are usually printed with the addition of a slightly alkaline salt (phosphate of soda) and sulphate of soda. Amongst the hundreds of direct colours equally suitable for printing mention may be made of erica for pinks; diamine sky-blue for blues; diamine violet, and diamine, chrysamine, chloramine and dianil yellows. In fact, most of the benzidine, diamine, dianil and Congo dye-stuffs can be used for printing, but with the exception of the yellows none of them will resist the action of light and washing to anything like the extent that "mordant" and basic colours will. The general formula for printing these colours is as follows:—

4 oz. colouring matter.
¼ gallon water.
¾ ,, starch or tragacanth thickening.
4 oz. phosphate of soda.
2 oz. sulphate of soda.

After printing, with direct colours, the goods are first steamed, then slightly washed in a weak tepid soap solution and finally finished.

(*d*) *Application of Pigment Colours.*—Before the introduction of coal-tar colours, pigments and lakes played a much more important part in textile-printing than they do at present, though they are still largely used for certain styles of work. They form a series of colours more difficult to work than those already mentioned, but very fast to soap and light.

Pigment colours, being insoluble mineral precipitates or lakes, can only be fixed on the fibre mechanically; consequently they require to be applied in conjunction with vehicles which cause them to adhere to the fabric in much the same way that paint adheres to wood.

Of these vehicles, albumen is the most important and the best. It forms a smooth viscous solution with cold water, mixes readily with all the colours used in pigment printing, and possesses the property of coagulating when heated to the temperature of boiling water. When cloth printed with colours containing albumen is passed through hot steam or hot acid solutions, as in the indigo discharge style, the albumen coagulates, forming a tough insoluble colloidal deposit, which firmly fixes on the fibre any colour with which it is mixed.

The colours chiefly employed in pigment printing are: chrome yellow and orange, Guignet's green or chrome green; artificial ultramarine; lamp black for greys; the various ochres for golds and browns; zinc oxide; vermilion and its substitutes, and occasionally lakes of the natural and artificial colouring matters. All these bodies are applied in exactly the same way and may be mixed together in any proportion to form compound shades. The amount of albumen necessary to fix them varies according to the depth of shade required (between 10 and 25 per cent. of the total weight of the made-up printing colour), and although it is usually considered in text-books as a thickening agent it is rarely used as such in practice on account of its expense. As a rule the colouring matter is beaten up into a smooth paste with the necessary quantity of a strong solution of albumen and then reduced to its proper strength by the addition of tragacanth mucilage or starch paste.

The main factor in the successful working of pigment colours is their fineness of division; the finer they are the better they print and the more beautiful is their quality of colour. If they are too coarse they give rise to innumerable defects, either by sticking in the engraving or by scratching the roller, or, if they print at all, by yielding uneven masses of colour, granular and speckled in appearance and quite unsaleable. Even when finally ground they are liable to clog the engraving of the rollers—a defect which is more or less successfully overcome by replacing the colour-furnishing roller in the printing machine by a revolving brush.

The following formula of dark ultramarine blue will serve as a type of all other pigment printing colours:—

24 lb artificial ultramarine.

Place in grinding machine and beat up gradually with
4½ gallons 40 per cent. blood albumen solution.
2½ ,, tragacanth mucilage, 8 oz. per gallon.
$\frac{1}{32}$,, ammonia.
$\frac{1}{16}$,, glycerin.
$\frac{1}{32}$,, turpentine.
$\frac{1}{16}$,, olive or cotton-seed oil.

Make to 8 gallons with tragacanth or water, and grind the whole until perfectly homogeneous.

The small quantities of ammonia, turpentine, glycerin and oil are added to prevent the colour from frothing during the printing process.

Chrome yellows and oranges are frequently mixed with a little cadmium nitrate to counteract the action of sulphuretted hydrogen on the lead salts.

The great disadvantage of pigment colours is that although extremely fast to light and soap they are liable to rub off, if the fabric is subjected to much friction in washing. They also impart considerable stiffness to the goods, and for these two reasons they are therefore restricted to the printing of small patterns, or are used for such styles as window-blinds where the stiffness is not objectionable. In very pale shades they are used for printing the grounds or "blotches" of multicolour patterns, the small quantity of albumen they then contain being insufficient to appreciably affect the softness of the cloth. In several discharge styles too —notably indigo—they find extensive use, and on the whole they constitute a most useful class of colours.

(*e*) *Application of Indigo.*—Indigo is printed on cloth by several different methods, the chief of which are: (1) Schlieper and Baum's glucose process; (2) the hydrosulphite process; and (3) the production of indigo on the fibre itself by means of Kalle's indigo salt and several other artificial preparations. The first and second processes depend upon the facts that indigo in presence of caustic alkalis may be converted into indigo-white by reducing agents, and that the indigo-white, being soluble in the alkali, penetrates into the fibres of the cloth, where it is subsequently re-oxidized to its original insoluble state.

In Schlieper and Baum's process (also known as the glucose process) the cloth is first prepared in glucose, and then printed with a colour containing finely ground indigo, caustic soda and dextrine thickening (also made with caustic soda). After printing, the cloth is "aged," that is, passed through damp steam for a few minutes to effect the reduction and solution of the indigo, and is then hung up in a cool chamber for a day or two, in order to re-oxidize the indigo-white to indigo by the action of the oxygen in the air. A wash in cold water finally completes the fixation of the indigo, and the cloth may then be soaped and finished as usual. The cloth is prepared by running through a box containing a 30 per cent. solution of glucose in water; the excess is squeezed out in a mangle, and the cloth dried. It is then printed with the following colours according to shade required:—

	Dark Blue.	Medium Blue.	Light Blue.
Alkaline dextrine paste	7½ gals.	8 gals.	8 gals.
Caustic soda, 38° Tw.	1 ,,	1¼ ,,	1¾ ,,
Indigo 20 per cent. paste	1½ ,,	¾ ,,	¼ ,,
	10 gals.	10 gals.	10 gals.

The printed goods should be dried quickly, and "aged" as soon as possible to prevent the absorption of carbonic acid gas from the air, after which the operations already mentioned may be proceeded with at leisure.

The well-known blue and red pattern is produced by this process, the only difference being that, instead of white cloth, turkey red dyed cloth is used, the strong alkali dissolving out, or "discharging," completely the colour from those parts of the cloth upon which it falls, and leaving the indigo as a blue pattern on a red ground.

In the *hydrosulphite process*, which is much quicker than the preceding, the reducing agent, the indigo and the alkali are all printed together on unprepared white cloth. The goods are then "aged," and allowed to lie a short time, after which they are washed-off in cold water first, until the indigo is thoroughly reoxidized, and then in hot water or soap.

The hydrosulphite printing colour is as follows:—

{ 200 parts hydrosulphite N.F. (or 100 of the concentrated product).
{ 450 ,, alkaline dextrine paste.
{ 150 ,, indigo 20 per cent. paste (ground up in gum).
{ 200 ,, alkaline dextrine paste.
Thickening { 150 parts dextrine or British gum.
{ 850 ,, caustic soda, 70° Tw.

Print, dry, "age" and wash off in a copious supply of cold water

The third process with Kalle's salt is not properly speaking the printing of indigo, but of a special preparation capable of forming indigo when treated with caustic alkalis. The salt is merely dissolved and thickened with gum or starch, printed, and then passed direct through a solution of caustic soda, when the indigo is immediately developed. Instead of being passed through the alkali, which is apt to cause the colour to run before it is properly developed, the cloth is more commonly printed with thickened caustic soda, whereby the indigo is equally well produced without any fear of "running."

Besides indigo, other vat dye-stuffs, such as indanthrenes, the algol, helindone and ciba colours, thioindigo scarlet, &c., are also printed largely at the present time, yielding colours of hitherto unattained fastness to washing and to light.

(*f*) *Insoluble Azo-Colours.*—These colours do not exist as such, but require to be produced on the fibre itself from their components. They form a range of exceedingly fast colours, including orange, red, pink, maroon, brown, chocolate, blue and black, and are produced by the combination of various diazo-bodies with phenols, the most important of which latter is β-naphthol (beta-naphthol).

In practice their application is briefly as follows:—The bleached cloth is prepared in a solution of β-naphthol in caustic soda (naphtholate of soda), then gently dried and printed with the thickened diazotized amine required to produce the desired shade. The printing colour must be cooled with ice to prevent its decomposition; hence such colours are sometimes known as "ice colours."

The two colours most extensively used are para-nitraniline red and α-naphthylamine maroon, both of which are bright fast colours, only equalled by turkey red and madder chocolate for general usefulness.

On β-naphthol prepare the following colours may be obtained:—

Red with paranitraniline.
Maroon with α-naphthylamine.
Orange with orthonitrotoluidine.
Pink with azo pink 2 B.
Chocolate with benzidine.
Brown with benzidine and orthonitrotoluidine.
Blue with dianisidine.
Black with dianisidine and benzidine.

Other naphthols and other bases give a still greater variety of shades.

The naphthol prepare requires to be freshly made, and the cloth prepared with it carefully dried, if good results are to be obtained.

Paranitraniline is made up for printing by dissolving in hydrochloric acid. Nitrite of soda is then added, and, after standing a short time to complete the reaction, the resulting diazo-solution is mixed with thickening, and acetate of soda is then added to neutralize any free mineral acid still remaining, the presence of which would prevent the formation of the colour.

In practice the following formulae have given good results:—

(1) Paranitraniline Red

Prepare the bleached cloth in:—

47	parts	β-naphthol.
3	,,	naphthol R.
107	,,	caustic soda, 50° Tw.
400	,,	hot water.
10	,,	tartar emetic.
12	,,	tartaric acid.

Make up to 1000 parts with hot water.

The cloth is passed through a trough containing this solution, the excess is squeezed out between two wooden rollers, and the cloth is gently dried and then printed with:—

36	parts	paranitraniline C.
100	,,	ice.
100	,,	hydrochloric acid, 30° Tw.
70	,,	water.

Mix and add quickly:

24	parts	nitrite of soda, 93 per cent.
70	,,	water (cold).

And just before printing add further:

100	parts	acetate of soda.
100	,,	ice in large pieces.
400	,,	tragacanth mucilage, 12 per cent.

Print, dry and wash.

A similar prepare without the naphthol R. may be used for α-naphthylamine maroons, the printing colour for which is made up as follows:—

36	parts	α-naphthylamine.
93	,,	hydrochloric acid, 30° Tw.
171	,,	tragacanth mucilage.

Grind till perfectly smooth in a mill and then add:

100	parts	ice.
20	,,	nitrite of soda of 93 per cent. strength.
80	,,	water.
400	,,	starch and tragacanth thickening.
25	,,	benzine.
75	,,	acetate of soda.
1000		

Print, dry and wash.

Immediately these diazo-colour pastes come in contact with the naphthol-prepared cloth the colour itself is formed and fixed and requires no further treatment except that of washing to remove the naphthol from the unprinted parts of the cloth.

The other bases are diazotized in precisely the same way, the quantities of acid and nitrite of soda being varied according to the molecular weights of each base.

Several processes of printing azo-colours directly, without any previous preparation of the cloth, have been proposed, but they are not in general use as yet; those which have passed the experimental stage are not very successful on the large scale, and have, for the most part, been abandoned.

(*g*) *Application of Sulphur Dyes.*—Of late years the class of colours known as "sulphur colours" have assumed a prominent place in textile-printing. They are really direct dyeing colours, but their special properties entitle them to be classed apart from those usually known under this name.

There are now an enormous number of sulphur-colours on the market under many different names, but, as they are all similar in general properties, it is needless to mention more than one series. The "thiogen colours" of Meister, Lucius and Bruning will serve as well as any to exemplify the application of these dye-stuffs in printing. They comprise yellows, golds, browns, violets, blues, greys and blacks, all fairly, and some very, fast to light and soap, and, under proper conditions, easy of application to a variety of styles.

The general recipe for printing is as under:—

30	parts by weight of	colouring matter.
50	,, ,, ,,	glycerin.
80	,, ,, ,,	water.
50	,, ,, ,,	china clay beaten up with
50	,, ,, ,,	water.
40	,, ,, ,,	concentrated hydrosulphite N.F., 50 per cent. solution.
700	,, ,, ,,	alkaline British gum thickening.
1000		

This paste is printed on unprepared bleached cloth, gently dried and then passed through a rapid steam ager, in from 4 to 7 minutes in dry steam at 212° F. to 220° F. (or twice for 3 minutes), after which the cloth is passed in the open width through the washing and soaping machines, and finally dried up and finished.

The sulphur colours may be used in combination with the azo-colours, on naphthol-prepared cloth, for the production of multi-colour effects, and are eminently adapted also to the production of coloured discharges on paranitraniline red and the direct-dyeing colours.

(*h*) *Aniline Black.*—Aniline black was discovered and first used by Lightfoot in 1863. It is one of the fastest blacks known, and is equally useful for direct printing by itself, and for working along with printed mordants and discharge pastes. Aniline black is formed by the oxidation of aniline.

As a rule the oxidation of the aniline is brought about by means of sodium chlorate in presence of suitable oxygen carriers such as copper sulphide, vanadium chloride or potassium ferrocyanide. Copper and vanadium blacks are usually developed after printing by being aged in a moderately warm room for a day or two, when they become converted into "emeraldine," at which stage they are taken down, and passed through a hot solution of bichromate of potash to complete the oxidation of the aniline. Great care is required in printing these two blacks, as if overdried they take fire and have occasionally caused considerable damage to buildings in consequence. The blacks made with ferrocyanide, on the contrary, may be printed in conjunction with "steam" colours, and, after a preliminary passage through a rapid steam ager, and an ammonia "gassing" box, will withstand the long steaming necessary for alizarine colours.

A copper aniline black may be made as follows:—

15	lb	starch.
8	lb	British gum or dextrine.
5¼	gals.	water.
4	lb	chlorate of soda.
¼	gal.	olive oil.

Boil, cool and add:

8	lb	aniline salt.
3	lb	aniline oil.
5	lb	sulphide of copper (precipitate pressed to a 30 per cent. paste).
1	gal.	water.

This black may be either hung to develop, which is the safer course, or, if printed in fine shirting patterns, it may be "aged" through steam for 2 to 3 minutes. Whichever method is adopted the printed cloth must afterwards be passed through hot bichromate —"chroming"—and then well washed.

The following ferrocyanide black works well in practice:—

10 lb starch.
2 lb British gum.
6 lb yellow prussiate (ferrocyanide) of potash.
7 gals. water.

Boil, turn off the steam, and add:
$2\frac{3}{4}$ lb chlorate of soda in powder.

Cool and add:
$8\frac{1}{4}$ lb aniline salt.

Print, age 4 minutes through the rapid ager, chrome, wash and soap. If printed with alizarine steam colours it must be passed through ammonia vapour after "ageing," and then be steamed for one hour before chroming and washing. Sometimes the chroming is omitted, but the colour is then apt to become green after a short time owing to the action of sulphur dioxide present in the air.

Aniline black is now used almost exclusively for printing along with mordants for the madder style, and for black ground goods that were formerly dyed with logwood on an iron mordant. Shirtings and all single-colour black dress goods are also executed in aniline black, which is faster to light, washing, and perspiration than any other black except some of the sulphur blacks.

(2) *Printing of Mordants.*—This, the second of the great styles of textile printing, was, at one time, the most extensively practised of all, and is still the most important for all classes of work where the fastest colours are required. It may be conveniently divided into two branches: (*a*) the madder style, and (*b*) the printing of other mordants such as chrome, tannic acid, β-naphthol, &c.

(*a*) *The Madder Style.*—In this style the only mordants used are those of aluminium and iron.

Aluminium alone yields various shades of red and pink when dyed up in madder, or its artificial competitor alizarine. Iron alone yields with the same dye-stuffs shades varying from black to the palest lavender. Iron and aluminium mordants in combination yield colours ranging in shade from claret through all gradations of bordeaux and maroon to the deepest chocolates, according to which of the two mordants predominates in the mixture. Browns and allied colours may be dyed on the same mordants with either nitroalizarine alone, or with alizarine itself mixed with dyewood extracts—logwood, Persian berry or quercitron bark, &c.

Both aluminium and iron mordants consist of the acetates of their respective metals. The iron mordant which gives the best results is known as "black liquor." It is a crude acetate containing a good deal of organic matter which appears to regulate the speed of its oxidation and so produce much more level colours than have ever been obtained from any other iron mordant.

Aluminium acetate in the pure state is also rarely employed, the crude commercial "red liquor" being found in practice to yield the best results, both as regards colour and ease of working. The "red liquors" vary considerably in composition, some being normal acetates, others basic acetates, some normal sulphate-acetates, others basic sulphate-acetates, but their mode of application is always the same, that is, they are thickened, printed, aged and dyed in alizarine. If they are too basic they decompose on boiling, or on dilution, and become utterly useless; but this rarely happens nowadays and need not be further gone into. Many difficulties occur in the printing of mordants and their subsequent dyeing, but if the following points are observed most of them may be surmounted; (1) after printing the cloth must be gently dried, otherwise the mordants become dehydrated or "burnt," and instead of dyeing up evenly they appear patchy and very light in the over-dried parts; (2) the dye-stuff must not be used in excess; and (3) the temperature of the dye-bath must be kept as low as is consistent with the fixation of the colour. If these last two points are neglected the unprinted parts of the cloth, which should remain a pure white when it is finished, will be soiled beyond repair unless indeed the "whites" are cleared at the expense of weakening the colour. Iron mordants especially are liable to unevenness due to the oxidation being too rapid; and as this defect is most noticeable in purples and lavenders, the pyrolignite of iron or "black-liquor" is frequently boiled for half an hour or more with 1 per cent. of its weight of arsenious acid, or "white arsenic," a substance which retards its oxidation. For this purpose the goods are printed with either aluminium or iron acetates, and hung or "aged" for 2 to 3 days in a brick chamber containing moist air at about 30° C. dry bulb, and 27° C. wet bulb thermometer. In this operation the "ageing" (which is really the volatilization of the acetic acid, leaving the hydrated oxide on the fibre) goes on slowly and evenly. After hanging, the last traces of acid are removed and the hydroxide thoroughly fixed by "dunging," a process in which the goods are passed through a mixture of cow-dung and chalk at a temperature of about 50° C. In this "dunging" bath they are worked altogether about $1\frac{1}{2}$ hours, at the end of which the mordants are thoroughly fixed, and all the thickening agents perfectly eliminated, thus leaving the cloth in the best condition to absorb the dye-stuff. The dyeing is carried out by working the goods at 60° C. in a mixture of alizarine, a little chalk, and glue size for 1 to $1\frac{1}{2}$ hours. They are then well washed, soaped, and the whites cleaned by a passage through weak bleaching powder solution, followed by a passage through steam. Further soaping and washing is then resorted to until the goods are quite clear and bright.

In the case of cloth dyed in red and pink alone the goods after dyeing are well washed, passed through a bath of alizarine oil containing oxalate of ammonia, and then steamed for one hour at 15 lb pressure. This brightens the colours by removing the brown appearance they possess after dyeing. When reds are associated with chocolates and purples, however, the oiling process must be carefully conducted, otherwise the two latter suffer; frequently it is omitted altogether, the brightening being effected by vigorous soaping.

By printing the following mordants a six-colour design may be produced with a single dye-stuff and in one dyeing:—

	Red.	Pink.	Chocolate.	Dark Purples.	Violet.	Black.
Aluminium acetate, 6° Tw.	12 gals.	3 gals.	$10\frac{1}{2}$ gals.	..	..	..
Black liquor, 24° Tw.	..	..	$1\frac{1}{2}$,,	1 gal.	$\frac{1}{2}$ gal.	8 gals.
Water	..	8 gals.	..	11 ,,	$11\frac{1}{2}$,,	4 ,,
British gum	..	36 lb	..	..	36 lb	..
Acetic acid	..	1 gal.	..	..	..	..
Tin crystals	$1\frac{1}{2}$ lb	$\frac{3}{4}$ lb	..	..	..	..
Cotton-seed oil	$\frac{1}{4}$ gal.	..	$\frac{1}{4}$ gal.	$\frac{1}{4}$ gal.	..	$\frac{1}{4}$ gal.
Starch	16 lb	..	16 lb	16 lb	..	16 lb

The above mordants are printed on white bleached cloth, dried, hung 2 to 3 days, "dunged," dyed, washed, well soaped and washed again; then "chemicked" through weak bleaching powder solution, and finished.

The "dunging" is performed in vats through which the cloth circulates continually during the operation. As a rule dunging is done twice, the second bath being weaker than the first. The vats or "becks" contain a mixture of:—

100 gals. water, 10 lb chalk, 50 lb cow-dung — 1st dunging.
at 60° C.

100 gals. water, 5 lb chalk, 25 lb cow-dung — 2nd dunging.

Wash well after "dunging" and dye in alizarine, &c.

The dyeing is carried out in large becks over which a roller or bowl revolves, equal in length to the beck. Over this roller the cloth is wound spirally in large loose loops so that one end of the loop is on the roller and the other dips into the dye liquor. When about 700 yds. of cloth have been entered in this way the two ends of it are knotted together, thus forming an endless rope which circulates continuously in and out of the dye-liquor. The vat or beck is then charged with alizarine, chalk and glue, the proportions varying according to the amount of space covered by the mordants on the cloth. If, for instance, half the surface is printed then the dye-liquor might be made up as follows, the quantities being calculated on the weight of the cloth:—

$4\frac{1}{2}$ per cent. alizarine (blue shade), 20 per cent.
$1\frac{1}{2}$,, acetate of lime, 28° Tw.
10 ,, glue solution, or size, 15 per cent.
— in a sufficiency of water.

The goods are entered into this solution cold. The temperature is gradually raised to 60° C., and the dyeing continued at this for one hour or more. The goods are then washed in a similar machine, soaped well and finished off by drying.

Aniline black may be printed along with "red liquor" and iron liquor, and many other modifications also employed, but the principle of dyeing is always the same.

(*b*) *The Printing of other Mordants.*—Of these the most important are tannic acid, chrome mordants and β-naphthol.

For printing tannic acid the following is used:—

5 lb tannic acid dissolved in
1 gal. acetic acid and added to
9 ,, starch and tragacanth paste.

The goods are simply dried after printing and the tannic acid immediately fixed by passing through a solution of—

2 oz. tartar emetic.
1 oz. chalk.
1 gal. water at 60° C.

After washing they may be dyed up in any of the basic aniline colours.

Various chrome mordants are employed in printing, amongst which may be mentioned chromium chromate, and chromium acetate. The former is thickened with starch or gum, printed, and fixed by being passed through boiling sodium carbonate. The latter is applied in the same way but, after printing, is steamed before the carbonate treatment. Both these mordants are suitable for dyeing with any of the dyes mentioned under the direct printing of mordant colours, such as alizarine, alizarine bordeaux, coeruleine and the natural dye-wood extracts. They are dyed similarly to the madder colours, with an addition of glue size to preserve the white of the unprinted parts of the cloth.

(3) *The Discharge Style.*—This style is now one of the most important produced. Its range is so extensive, and its modifications so numerous, that it is impossible to mention more than a few of its chief applications. It may be used for locally destroying either the colours dyed on cloth, or the mordants with which they have been previously prepared. In both cases the resulting pattern appears in white, or colours, on a full rich ground the beauty of which cannot be equalled by direct printing.

The discharging agents consist of organic acids, caustic alkalis, oxidizing agents and reducing agents, each used according to the kind of colour or mordant to be discharged.

(*a*) *Discharge of Iron and Aluminium Mordants.*—The cloth is padded with a solution of these mordants, dried in hot air, and then printed with thickened citric acid or acid citrate of soda mixed with china clay to prevent the pattern running. It is then passed through the rapid ager once or twice, "dunged," washed, and dyed in the usual way for madder colours. Wherever the discharge has been printed the mordant is dissolved out, leaving a white pattern on a dyed ground.

(*b*) Tannate of antimony mordant is similarly discharged by printing on caustic soda. The goods are passed in like manner through the ager, well washed in water, and dyed-up in any basic aniline dye.

(*c*) The chrome discharge is produced by padding the goods in chromium bisulphite; then drying them, and printing-on citric acid, or chlorate of soda and yellow prussiate of potash. They are then steamed, passed through chalk and water, well washed and dyed up in any mordant dye.

(*d*) Turkey red may be discharged in both white and coloured patterns by either oxidizing agents or caustic alkalis. (1) The dyed cloth is printed with strong citric acid, or arsenic acid, at 180° Tw., and then run through bleaching powder solution, whereby the printed parts are completely decolorized. If colours are required, the citric acid is mixed with lead salts and Prussian blue, and the fabric after passing through the bleaching powder solution, is further treated in a bath of bichromate of potash which forms with the lead salts the insoluble chrome yellow. Green is obtained by the combination of Prussian blue with the chrome yellow.

Examples:—

White. 6 lb citric acid or tartaric acid.
1 gal. water.
4 lb British gum or dextrine.
Boil together.

Yellow. 15 lb British gum.
$1\frac{1}{2}$ gals. dark British gum paste, 30 per cent.
$2\frac{1}{2}$,, water.
20 lb tartaric acid.
12 lb nitrate of lead.

Print, dry, discharge through bleaching powder solution, 18° Tw., and chrome.

(*e*) The dyed cloth is printed with strongly alkaline discharge pastes, passed through the "ager" two or three times, and then washed off in silicate of soda. If blue, yellow and green discharges are desired the dyed cloth must first be passed through glucose solution, well dried, printed with the colours, "aged," passed through silicate of soda, chromed in bichromate, well washed and dried. Examples:—

White. 10 lb stannous chloride dissolved cold in
8 gals. alkaline thickening.
2 ,, silicate of soda, 70° Tw.

Blue. 15 lb indigo pure 20 per cent. paste.
$\frac{1}{32}$ gal. turpentine.
$\frac{1}{16}$,, glycerin.
$1\frac{1}{2}$,, British gum paste.
7 ,, alkaline thickening.

Green. 8 parts of the yellow without silicate.
1 part of blue.

Yellow. 30 lb lead hydrated 50 per cent.
2 gals. water.
$\frac{3}{4}$,, silicate soda.
$5\frac{1}{4}$,, alk. thickening.

Alkaline Thickening.
15 lb yellow dextrine.
8 gals. caustic soda, 100° Tw.

(*f*) *Paranitraniline red* is discharged by means of the new hydrosulphite-formaldehyde compounds. The dyed cloth is printed with the following:—

25 lb hydrosulphite N.F. conc., or hydraldite conc.
$1\frac{1}{2}$ gals. British gum paste.
Heat till dissolved and add—
$\frac{1}{32}$ gal. glycerin.
$4\frac{1}{2}$,, starch-tragacanth thickening.
After printing, age twice for 4 minutes through dry steam at 220° F., then wash well and soap.

Coloured discharges are obtained by mixing hydrosulphite, tannic acid, aniline or phenol, and basic colouring matters together. Mordant dyes fixed with chromium acetate may also be used.

On α-naphthylamine maroon the above discharge white requires the addition of induline scarlet, patent blue or anthraquinone, before it becomes effective, otherwise the procedure is the same as for paranitraniline red.

(*g*) Indigo is usually discharged by oxidation. For this purpose the dyed cloth is printed in two different ways. Firstly, with chlorate of soda, and red or yellow prussiate of potash together with a little citric acid or citrate of soda; secondly, with chromate of potash. In the first instance, the cloth is "aged" through the rapid ager after printing, and, in the second, is passed through a vat containing hot sulphuric acid and oxalic acid. Coloured discharges may be obtained in both methods by adding albumen and pigment colours to the discharging agents.

(1) Discharge by steaming:—
12 lb citric acid, dissolve in:
7 lb caustic soda, 70° Tw., and add:
12 lb sodium chlorate.
5 gals. British gum paste.
Heat till dissolved, cool and add:—
$1\frac{3}{4}$ gals. British gum paste.
2 lb yellow prussiate of potash.
Print, steam and wash.

Chlorate of aluminium is also used for this process, but it acts very energetically and is apt to tender the cloth.

(2) Chromate discharge:—
White. $8\frac{1}{2}$ gals. British gum paste.
12 lb bichromate of soda.
$\frac{1}{2}$ gal. turpentine.

Yellow. 32 lb chrome yellow pigment.
3 gals. 50 per cent. albumen solution.
$\frac{1}{2}$,, thick tragacanth mucilage.
$\frac{1}{4}$,, oil (vegetable).
12 lb bichromate of soda neutralized with
$\frac{3}{4}$ gal. caustic soda, 70° Tw.
$\frac{1}{2}$,, water.

Print, dry, pass through a "beck" (*i.e.* a bath) containing:—
100 gals. water.
50 lb sulphuric acid (168° Tw.).
50 lb oxalic acid.
Then well wash and dry.

With these oxidation discharges it is impossible to prevent the fibre being attacked in the discharged portions, with the result that it is partially converted into oxycellulose. Recently a method has been brought out for the production of a white discharge on indigo which is said to do away with the formation of oxycellulose and which consists in printing on a thickened solution of sodium nitrate and, after drying, running through sulphuric acid of 50° Tw.

Another method of producing white discharges on indigo consists in printing the dyed cloth with hydrosulphite N.F., then steaming and running through a boiling solution of caustic soda. Good whites are thus obtained without the formation of oxycellulose, but the process is expensive.

(*h*) *Direct dyeing* or *substantive colours* can be easily discharged with the hydrosulphite discharge used for paranitraniline red (see above). It must be reduced in strength to about one-fourth for dark shades, and much weaker for lighter colours. Direct colours were formerly discharged by stannous chloride or acetate, but the hydrosulphite has almost entirely displaced these salts for white discharges.

(*i*) Discharges on manganese bronze are of little importance at the present time. They are effected by means of stannous chloride, colours being obtained by the addition of basic dyes and dyewood extracts.

(*j*) Sulphur-colours, dyed basic colours, and some alizarine colours, are discharged with chlorate and prussiate like indigo.

(4) *The Resist or Reserve Style.*—Reserves are substances which, when printed, prevent the fixation or development of mordants and colours subsequently applied, and are used to produce effects similar to those obtained by discharge printing.

The principal reserves are those used for madder dyed goods, steam alizarine reds and pinks, steam basic colours, vat indigo blue, insoluble azo colours, sulphur-colours and aniline black.

(*a*) *Reserves under Aluminium and Iron Mordants.*—For the production of this important class of goods, use is made of the fact that alkaline citrates prevent the fixation of the mordants. The cloth is first printed with citrate of soda (or sometimes citric and tartaric acids for iron mordants), then dried, and again printed over the previous impression, with either a fine "all over" pattern or flat uniform ground, in iron or aluminium mordants. The fabric is then aged, "dunged," washed and dyed as already described, with the result that wherever the "reserve" of citrate or acid was printed a white pattern is left on a figured or plain ground. The fine patterns printed over "reserves" are called "covers" and the plain grounds "pads," hence the name "cover and pad" style in cases where, as frequently happens, a dark "cover" and a light "pad" are both printed over a white "reserve." The "cover and pad" style is, for the most part, restricted to dyed alizarine purples under which red, black, dark purple and white can all be reserved at the same time, thus giving rise to very pleasing effects. For example: white cloth is first printed with four "colours," viz., citrate of soda and citric acid for the white; logwood and iron for the black; strong iron mordant for the purple; and aluminium acetate at 6° Tw. with 8 oz. per gallon of stannous chloride for the red. (The stannous chloride acts as a resist for iron mordants.) The whole is then "covered" in a fine pattern printed in a fairly strong iron mordant, dried, and again printed, in a very weak iron mordant, with a pad roller, that is, a roller which prints a uniform ground over the whole surface of the cloth. After this last printing, the cloth is "aged" for a day or two, by being hung as previously described, then "dunged," washed and dyed in a blue shade of alizarine. When finally washed, soaped and "cleared" in bleaching powder solution the first printed pattern in white, red, black and purple is seen to stand out, clearly and sharply, from a figured background in two lighter shades of purple. This "cover and pad" style of reserve printing constitutes one of the staple processes of nearly all print-works, and is produced in enormous quantities for both home and foreign markets. Red is not often introduced as in the above example, the usual colours being white, black and two purples. The same method of working can be adopted with aluminium mordants for red and pink covers and pads, but they are better produced with the steam alizarine colours as below.

(*b*) *Reserves under Steam Alizarine Red and Pink.*—In this case a reserve composed of citrate of chromium alone, or in conjunction with citrate of soda, gives the best results. The goods are first prepared in alizarine oil and then printed with the following:—

10 ℔ china clay.
½ gal. citrate of soda, 54° Tw.
½ ,, citrate of chromium, 42° Tw.
½ ,, water.
2½ ,, British gum paste.

After printing the above, the goods are dried and again printed either with "cover" or "pad" or both, in alizarine pink, dried, steamed for 1½ hrs., well washed and soaped. On leaving the steamer the parts printed with the resist are yellow, but become quite white on soaping. Like the purples, the alizarine pinks can be reserved in colours. For blue, green, yellow and violet the ordinary steam basic colours are used with additions of citric or tartaric acid.

Example:—

{ 7 ℔ china clay.
{ ½ gal. water.
6¼ ,, British gum paste.
2 ℔ methylene blue.
1 ℔ citric acid.
1 gal. acetic acid.

Boil, cool, and add:—

1¼ gals. 50 per cent. tannic acid solution in acetic acid.

Red with steam alizarine red; yellow with thioflavine in place of methylene blue in above; green a mixture of blue and yellow. These colours with the white reserve may all be printed at once. Then steam as usual, pass through a solution of tartar emetic and chalk, wash well and soap.

(*c*) *Reserves under Insoluble Azo-Colours.*—These are based upon the action of stannous chloride, which prevents the combination between the β-naphthol and the diazo bodies by reducing the latter to hydrazines. The β-naphthol prepared cloth is printed with the following colours, then dried and passed through diazotized solutions of paranitraniline for red grounds; α-naphthylamine for maroon; ortho-nitrotoluidine for orange, &c., &c. The cloth is then washed and soaped until the "whites" are clean.

White Resist. 5 gals. gum senegal solution.
30 ℔ tin crystals.
5 ℔ tartaric acid.

For heavy rollers this may be reduced with more gum.

	Blue.	Yellow.	Green.	Pink.
New methylene blue N.	2 ½ ℔	..	..	..
Auramine G. (B.A.S.F.)	..	..	2 ℔	..
Brilliant green	..	..	1¼ ,,	..
Theoflavine T.	..	2 ℔	..	..
Rhodamine 6 G. (extra)	..	..	..	1 ℔
Acetic acid	2 gals.	2 gals.	2 gals.	2 gals.
Citric acid	2½ ℔	2½ ℔	2½ ℔	2½ ℔
Starch	10 ,,	10 ,,	10 ,,	10 ,,
Water	2 gals.	1½ gals.	2 gals.	2 gals.
Tragacanth mucilage	1 ,,	1 ,,	1 ,,	1 ,,
Tannic acid sol., 50 per cent.	1½ ,,	2 ,,	1½ ,,	2 ,,
Tin crystals	20 ℔	20 ℔	20 ℔	20 ℔
Make up to	10 gals.	10 gals.	10 gals.	10 gals.

Potassium sulphite is also used as a white reserve under insoluble azo-colours with good results.

(*d*) *Reserves under Steam Basic Colours.*—The white cloth is printed with:—

20 ℔ china clay.
2½ gals. water.
15 ℔ British gum.
20 ℔ sodium tartar emetic.
20 ℔ zinc sulphate.

All boiled well together,

and then covered, or over-printed, with any steam basic colour—steamed one hour, passed through tartar emetic, then washed and soaped, when the reserve white above comes away, bringing along with it the colour printed upon it and leaving a white pattern on a printed ground.

(*e*) *Reserves under Vat Indigo Blue.*—This was formerly a very important style, but at present is only used in special cases. Resist or reserve effects are obtained by printing the white cloth with oxidizing agents, &c., and subsequently dyeing it in the indigo vat. In addition to oxidizing agents the reserve pastes contain lead sulphate, barium sulphate, resins, fats and thickenings in various proportions. The following is a good white reserve:—

15 ℔ flour.
6 gals. water.

Boil, cool a little, and add—

18 ℔ copper sulphate powdered.
2½ ℔ copper nitrate, 90° Tw.
1 pint alizarine oil.

Yellow. 2¾ gals. British gum paste.
33 ℔ lead sulphate, 66 per cent. paste.
18 ℔ zinc sulphate.
22 ℔ lead nitrate.

Print the white and yellow, dry, dye in the indigo vat—sour slightly in sulphuric acid, wash, and pass into a hot solution of bichromate of soda, which develops the lead yellow. Reserve whites also contain lead salts when used for white alone, but obviously the white given is best suited to white and yellow reserves, as its soluble copper salts wash out before the "chroming" stage is reached.

(*f*) *Reserves under Sulphur Colours.*—These are obtained with zinc chloride. They are not much used, but are capable of yielding fine effects.

(*g*) *Reserves under Aniline Black.*—Reserves under aniline black are produced with caustic alkalis, alkaline carbonates, silicates and sulphites, sulphocyanides, oxide of zinc and the acetates of magnesia, zinc and soda. The white and coloured resists may be printed upon either the undeveloped black or upon the cloth before the black is applied.

In the former case the cloth is slop-padded through a mangle-box with the following black:—

7½ ℔ aniline hydrochloride.
3½ ℔ sodium chlorate.
4 ℔ potassium ferrocyanide.
10 gals. water.

It is then very carefully dried in hot air so that it becomes no darker than a pale yellow; if it is green before printing, the white is sure to be bad.

The dried padded cloth is then printed with the "resist" colours, dried and steamed 3 to 4 minutes in a rapid ager, chromed through warm bichromate of potash, and finally washed and soaped. During the steaming the black is developed all over the cloth except where the colours are printed. Here its development is prevented by the alkali or the reducing agent, whichever may be present, in the colour, and instead of a plain black dyed piece a coloured design on a black ground is produced. The following formulae may be employed for white and coloured resists:—

White. 8 lb starch.
8 lb British gum.
30 lb potassium sulphite, 90° Tw.
3 gals. water.
15 lb soda acetate.
10 lb bisulphite of soda, 66° Tw.
¼ lb ultramarine blue.

Boil together.

	Red.	Pink.	Blue.	Yellow.	Green.	Violet.
Rhodamine 6 G. (100 per cent.)	2¼ lb	1 lb	..	..	..	..
Auramine O	¼ ,,	..	..	..	..	..
Acridine yell. G.	..	..	..	2 lb	2¼ lb	..
Thionine blue O.	..	..	2 lb	..	..	..
New solid green 2 B.	..	..	..	..	1 lb	..
Methyl violet, B. x.	..	..	..	..	..	2 lb
Water	1¾ gals.	1¾ gals.	1½ gals.	1½ gals.	1½ gals.	1½ gals.
Tragacanth mucilage	1 ,,	1 ,,	1 ,,	1 ,,	1 ,,	1 ,,
Glycerin	..	..	¼ ,,	¼ ,,	¼ ,,	¼ ,,
Albumen, 40 per cent. solution	1 gal.	1 gal.	1 ,,	1 ,,	1 ,,	1 ,,
Resist paste	6 ,,	6 ,,	6 ,,	6 ,,	6 ,,	6 ,,

Print on the padded cloth, age, chrome and wash. The resist paste is as under:—

Resist Paste. 10 lb zinc oxide.
1½ gals. magnesium acetate, 40° Tw.
2½ ,, tragacanth mucilage (dragon).
1 ,, starch paste.

For reducing the colours take 6 parts resist paste.
4 ,, starch paste.
4 ,, white resist.

Very good results can be obtained by the alternative method, *i.e.* printing the resists on white cloth and applying the black afterwards. The basic colours are chiefly used, though chrome yellow and ultramarine are also employed for some styles. The following formulae will serve as types of the composition of white and colours:—

White. 20 lb precipitated chalk.
5 lb potassium sulphite, 90° Tw.
5 lb acetate of soda.
½ lb ultramarine blue for sightening.
1 gal. water.
6 ,, starch paste.

The whole ground together in a mill.

Colour. 2 lb basic dye-stuff.
1 gal. water.
2¼ ,, starch paste.

17 lb zinc oxide.
1 gal. water.
¼ ,, glycerin.
¼ ,, turpentine.
¼ ,, bisulphite of soda.
3 ,, starch paste.

Print on white cloth, allow to lie a day or two, then slop-pad in the Prud'homme black already given, dry, age, chrome and soap.

Pigment colours may be applied on black padded cloth as follows:—

Yellow. 40 lb chrome yellow, &c. &c.
2½ gals. 40 per cent. albumen.
2½ ,, tragacanth water, 6 oz. per gal.
6 lb soda ash.
1 gal. citrate of soda, 40° Tw.

Other methods, varying in detail, have been used from time to time, but the above two are at the present time generally employed —especially the former, by which many fine patterns have been produced in all sorts of delicate and artistic shades.

The Treatment of Cloth after Printing.

After printing, the various classes of goods undergo many different treatments according to the character of the colours printed. These treatments include steaming, hanging in the ageing chamber, passing through tartar emetic, the chalk bath, washing, soaping, "chemicking" or clearing and finishing.

(1) The operation of steaming is necessary for all styles except those with the insoluble azo-colours, vat dyes discharged, and some colours that are precipitated on the fibre. The short steaming necessary for most discharges, indigo blue prints, and aniline black is effected in the Mather and Platt ager, of which a sketch is here given (fig. 2) showing its principle.

It consists of an iron box A A A through which the goods (indicated by the dotted line) pass in the direction of the arrows. They enter at B, and traverse the whole chamber over a series of top and bottom rollers C C C, finally emerging at the same point B, whence they are drawn forward, by mechanical means, and plaited down on a waggon placed conveniently near. Steam enters the chamber A A A by the steam pipe D at the bottom, and escapes through the same slot (B) that the cloth enters and leaves by. An engine or electric motor drives the gearing, and the whole process is continuous.

This ager affords quite a sufficient steaming for aniline blacks, printed indigo, chlorate discharges, and for some mordants, but alizarine reds and pinks, mordant dyes generally, and basic colours require much more than the 2 to 3 minutes' exposure to steam which is all that can be given in the ordinary Mather-Platt ager, although they are frequently passed through it to eliminate the greater part of the volatile acids they contain. Paranitraniline red discharged with hydrosulphite also requires a modification of the ager for its success—for the steam must be very hot and very dry if any of the azo-colours are to be effectively discharged by the hydrosulphite method.

A longer exposure to the action of steam is obtained by means of the *cottage steamer* and the *continuous steamer*, in both of which goods may be steamed for any length of time. The cottage steamer consists (1) of a cylindrical iron box or chamber fitted with a false bottom on which rails are laid, and under which lie the pipes for the admission of steam, and for the drawing off of the condensed water; and (2) of a carriage or iron framework mounted on wheels and furnished with a series of removable rods capable of being revolved by means of spur-wheel gearing. Convenient lengths of the cloth to be steamed, together with a "back grey" (a piece of unbleached calico) are then wound in the open width, into a sort of broad hank on a folding frame. As each hank, so to speak, is completed it is removed from the winding frame and hung over one of the rods, which is then placed in position on the carriage.

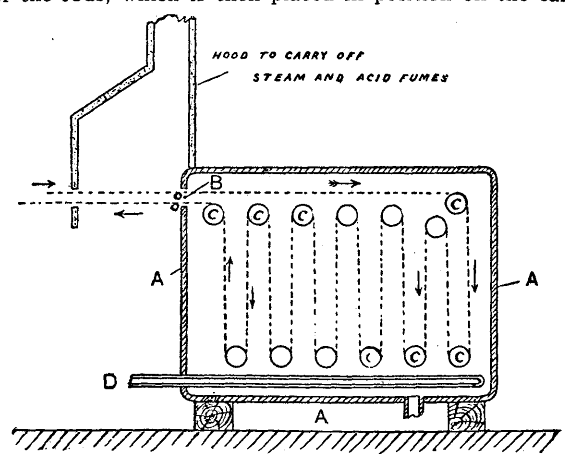

FIG. 2.

When the latter is fully loaded in this way it is run into the "cottage," the doors are closed, and steam turned in. The steaming is continued for various periods of time—from ¾ hour to 2 hours—according to the style of work in hand, and either with or without pressure, as may be required. The carriage is then withdrawn and the goods unwound in readiness for subsequent operations.

The object of enveloping the printed goods in a "back grey" is to prevent the colour from marking off from the face of one fold on to the back of the next, and also to minimize the risk of damage from drops of condensed water. This latter defect is further guarded against by heating up for an hour or so every morning before any goods are introduced.

In works where the modern continuous steaming apparatus is installed the cottage steamer is reserved for the treatment of dyed alizarine reds and for goods, such as heavy printed velvets, which are difficult to manipulate in the continuous steamer.

The continuous steamer was originally invented by Cordillot, but its present efficient form is due to Messrs Mather and Platt, who have continually improved it, so that now it bears but little resemblance to Cordillot's original machine. Its construction is too complex to be adequately described without the aid of detailed sketches. Generally speaking, it may be said to consist of a long, high, narrow chamber of brick, through which the cloth passes continuously in the form of long loops suspended from rods resting upon, and carried forward by travelling chains, situated at the top, and close to the sides, of the chamber. Steam is admitted to this chamber through a series of pipes at the bottom, and the cloth enters and emerges through slots at the top of its opposite ends. On entering, the cloth falls over one of the slowly travelling rods and continues to run downwards until a sufficient length to form the loop has run in. By this time the first rod has moved forward and a second taken its place, with the result that the cloth now falls over the second rod and commences to form the second loop. At this point—the commencement of a second loop—the second rod comes in contact with a brass bar carried by arms pivotted above. The object of this bar, which clips the continuously entering cloth firmly between itself and the rod until the second loop is complete, is twofold, namely (1) to prevent too much cloth being fed into the first loop, and (2) to prevent the weight of the first loop from pulling the cloth over the second rod during the formation of the second loop. By the time this latter is complete the second rod has moved sufficiently far forward to escape contact with the pivotted brass bar, which thereupon swings back and takes up a similar position on the third rod. In this way each rod is supplied with cloth, which it carries forward continuously until the other end of the steamer is reached, where both cloth and rods emerge—the former through the top of the chamber and the latter through a slotted opening at the top of the end wall. Through a similar slot, at the beginning end of the steamer, the rods are fed in automatically as long as any cloth remains to be steamed.

The usual time occupied in passing the goods through a "steamer" of this description is one hour, but it may be shortened or prolonged at will, and, if desirable, the goods may be allowed to remain in it for any length of time.

The room used for *ageing* is lofty and is furnished near the top with suspending rods of wood, and at the bottom with a series of steam inlet pipes through which thin streams of free steam may be introduced into the chamber, as required. Its temperature is generally kept about 36° C. on the dry-bulb thermometer and 32°–33° on the wet-bulb thermometer.

"*Dunging*" is carried out in a series of becks provided with rollers at the top and bottom, and heated by steam pipes. It may also be performed in becks through which the cloth passes in rope form.

Many attempts have been made from time to time to replace cow-dung by sodium silicate, phosphate, arsenite and carbonate of ammonia, but none of them yield results quite so good as cow-dung.

The tartar emetic treatment is only used for the fixation of tannin mordants, and of basic aniline colours printed with tannic acid. It is performed by passing the cloth in the open width over and under a series of wooden rollers arranged in a water-tight box—a beck—containing the following solution:—

2 ℔ tartar emetic.
2 ℔ chalk.
16 gals. water at 60°–70° C.

The chalk is added simply to neutralize the acid salt produced in the bath—a salt which exerts a solvent action on the basic colour tannin lakes and utterly spoils any ultramarine blues that may have been printed in combination with them.

Chroming is only applied to a few styles, such as aniline black, catechu brown, and colours containing salts of lead which have to be converted into chrome yellow. "Chroming" is carried out in a beck similar to that used for tartar emetic. The cloth runs continuously through a 3 to 4 per cent. solution of bichromate of potash at 60° C.; the excess is squeezed out in a mangle, and the cloth then passes directly into a washing machine to clear it completely of the chrome. When alizarine reds, and other colours susceptible to chrome, are present, the chroming must be either omitted altogether or the operation conducted cold with a very weak solution.

Washing is a very important process, and upon its proper performance depends a good deal of the final success of the work. It may be carried out in several different ways according to the different styles of work to be treated. Alizarine reds and pink, both printed and dyed, dyed chocolates, purples, &c., aniline black, indigo blue, &c. &c., all very fast colours, are usually washed and soaped in the rope form in machines like that described for madder-dyeing. Other colours, especially pigments, must be washed, in the open width, through a series of wash-boxes furnished with rollers over which the cloth passes. In these boxes the water usually enters where the cloth leaves, thus ensuring that the cleanest cloth gets the cleanest water. Some of the boxes are occasionally fitted with heaters and others again with "spirt pipes" through which the water is forced at a high pressure for the purpose of causing it to pass straight through the cloth. Other types of machine are also used, for details of which some technical work must be consulted.

Soaping is also an important factor in the production of the best work. It clears the white parts of the goods, brightens the colours and generally improves the whole appearance of the cloth. The strength and temperature of the soap solution, the duration of the soaping and the type of machine used are all varied according to the fastness of the colours to be soaped. As in washing, the alizarine dyed colours, alizarine "steam" reds and pinks, aniline black and the ice-colours, will not only withstand a long, hot and strong soaping, but are greatly brightened and enhanced in beauty thereby. On the other hand, direct dyeing colours, basic colours, pigments and a few others require only a moderate soaping and that in the open width. Colours which will stand a drastic soaping are usually soaped, in spiral becks, in the rope state, and pass from one to another of these becks, going through as many as half a dozen times before being washed off in water. Goods requiring to be soaped in the open width are treated in a special soaping machine known as the "open soaper." In principle this is simply a range of watertight boxes each fitted with rollers at the top and bottom. The first two or three boxes contain hot soap solution and the rest hot or cold water or a series of "spirt pipes" to better wash out the soap. Very frequently open soapers are supplied with "tartar emetic" and "chroming" boxes, so that the goods can go through two or more processes directly and without any intermediate handling.

"*Chemicking*."—In this process all traces of colour still remaining after soaping are removed from the white parts of the printed cloth, by a weak solution of bleaching powder. Two methods are used in applying the "chemick," or bleaching powder solution, to the cloth. In the first the cloth is passed between a pair of squeezing bowls the lower of which is of wood, and revolves partly immersed in a solution of bleaching powder or "chemick" varying in strength from ⅛° Tw. to ½° Tw. This lower bowl carries the chemick to the cloth, the excess is then squeezed by passing between the two, and the cloth goes forward over a set of steam-heated drying cylinders, during its passage over which the bleaching properties of the chemick effectually remove the last traces of colour on the white parts of the cloth and leave it perfectly clean and bright.

The second method of "chemicking" is employed when the cloth is too deeply stained to be successfully "cleared" by the first. All madder-dyed goods, and goods printed in strong heavy dark-coloured patterns, are liable to attract, to their white parts, a considerable amount of colour during the dyeing, washing and soaping operations. They therefore require a stronger "chemicking" to clear them, and this the second method supplies. The goods are passed successively through (1) a trough containing "chemick" at about ¼° Tw.; (2) a pair of squeezing rollers; (3) a small steam chest fitted with half a dozen guide rollers top and bottom, and a steam admission pipe; (4) a series of "spirt pipes" to wash out the bulk of the lime salts; and (5) through a washing-box and squeezing rollers, whence they go directly to a drying machine.

In both methods the strength of the "chemick" depends upon the power of the resistance to its action of the colours printed, and great care must therefore be taken to keep it weak enough.

Occasionally a little ultramarine blue is added to the chemick for the purpose of correcting the yellowish tinge usually possessed by bleached cotton.

From the fact that two or more styles can be combined in one pattern it is obviously impossible to formulate any general rule for the practical application of any of the foregoing after treatments.

For example, in aniline black resists the black ground will stand any amount of soaping, but the basic colours which constitute the pattern are only moderately fast to soaping, and, consequently, this process must be so regulated as to yield the best possible results. The same may be said of alizarine reds and pinks printed in combination with basic or pigment colours, and of paranitraniline red and other ice-colours associated with basic colours.

Finishing.—In this process the cloth undergoes various operations of softening, stiffening, embossing and polishing or smoothing, according to the requirements of the customer. The following substances are chiefly employed for the above purposes:—

Softening Agents.—Turkey red oil, tallow, paraffin, stearine, wax and certain soaps.

Stiffening Agents.—Starch of all sorts, dextrine, gum tragacanth, vegetable gelatine or Blandola, glue size, various preparations of soluble starch, lichens, &c. &c., all of which are applied on special finishing mangles, and either to one or both sides of the cloth.

Hygroscopic substances, such as zinc chloride, glycerin and glucose are added to the stiffening pastes for the purpose of softening the feel of the cloth without detracting from its "body."

The smoothing, polishing and embossing of the fabric are all performed on various types of calenders. Smoothing and polishing calenders have highly polished steel "bowls" which may be heated by steam or gas, embossing calenders have an engraved steel or brass bowl working against one of compressed paper, or one in which depressions are engraved to exactly correspond with the projections on its fellow. The cloth is run between these various kinds of bowls according to the effect desired. In the finishing process all creases are smoothed out of the cloth, and it is stretched to its proper width (and its weft straightened if awry) on special

FIG. 1.—Linen, dyed blue, the "reserved" parts represent the Annunciation; above the reclining figure of the Virgin Mary is the word MAPIA. Coptic, probably 5th or 6th century. 18 in. × 2 ft. 5 in.

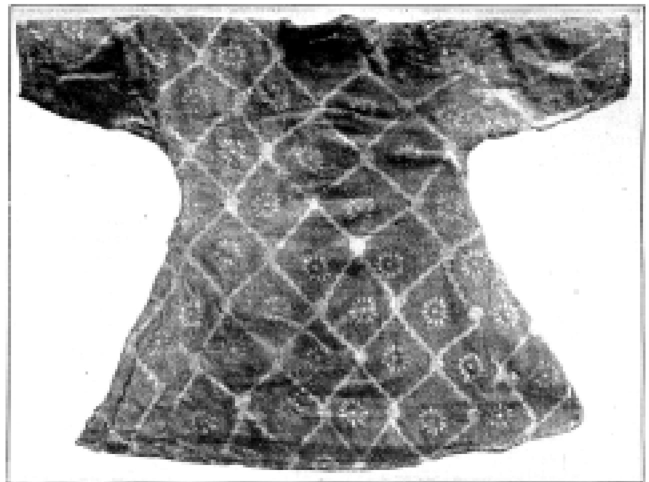

FIG. 2.—Child's Tunic of linen dyed blue, the pattern being "reserved." Coptic, 4th century (?). $18\frac{1}{4}$ in. × $23\frac{1}{2}$ in.

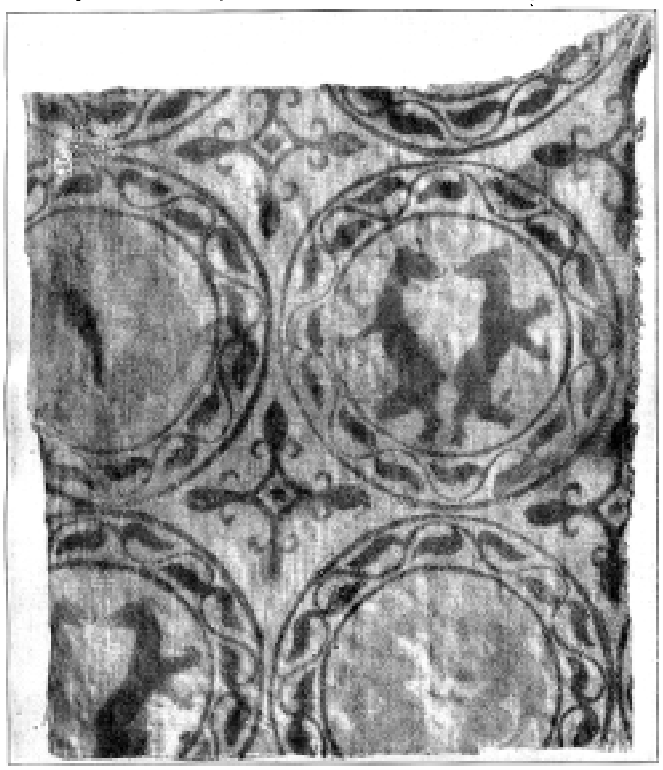

FIG. 3.—Piece of red silk, printed in red, green, and black from wood blocks, with a repeating pattern of black circles or rounds containing pairs of animals and dragons; floriated crosses in the interspaces. Rhenish, 12th or 13th century. $15\frac{3}{8}$ in. × $12\frac{3}{4}$ in.

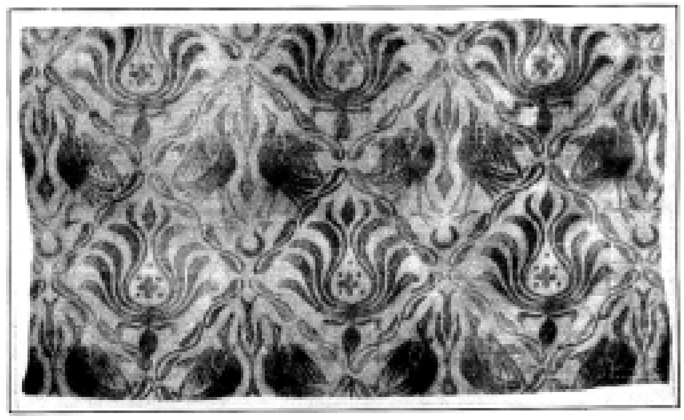

FIG. 4.—Piece of red silk, printed in black from wood blocks, with a trellis pattern enclosing pairs of birds and anthemions. Rhenish, 13th or 14th century. $8\frac{5}{8}$ in. × $13\frac{3}{4}$ in.

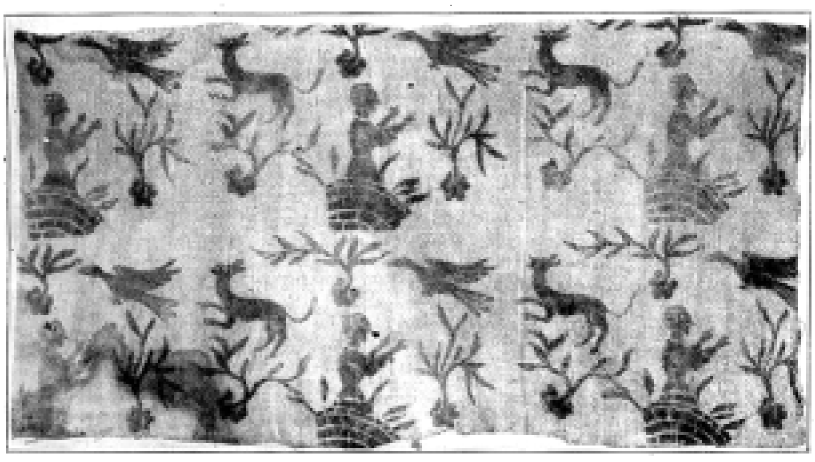

FIG. 5.—Piece of linen, printed in black from a wood block, with a pattern composed of repetitions of a lady on a turret, leafy sprays, a hound, and a bird on the wing. Rhenish, 14th century. $9\frac{1}{2}$ in. × $19\frac{3}{4}$ in.

FIG. 6.—Strip of linen printed in deep purple from a wood block, with a repeating pattern of eagles and conventional leaf and fruit forms. Rhenish, 14th or early 15th century. $20\frac{1}{4}$ in. × $6\frac{1}{2}$ in.

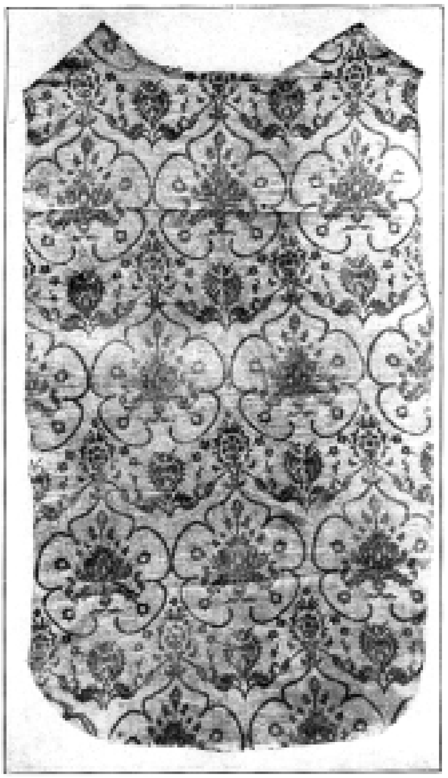

FIG. 7.—Portion of reddish linen lining for a chasuble printed in black from wood blocks, with a repeating pattern composed of five-lobed shapes enclosing conventional fruit device surrounded by small blossom and leaf forms. Rhenish, 15th century; from the neighbourhood of Düsseldorf. 3 ft. 8 in. × 24½ in.

FIG. 8.—Cotton print in colours. Dutch, 17th century. About 14 in. × 9 in.

FIG. 9.—Part of a coverlet of cotton, printed at Genoa in colours, from metal plates engraved with trees, flowers, birds, and animals in the style of Indian palampores or printed calicoes. 19th century. About 6 ft. × 3 ft.

FIG. 10.—Part of a hanging of cotton, printed in red from metal plates engraved with repetitions of pictorial scenes. At the bottom is printed "D 5 T. P. Meillier & Cᵉ de Beautiran près Bordeaux Bon Teint. MF. 3 X. Comm. 19." French, second half of 18th century. 4 ft 6 in. × 3 ft. 4 in.

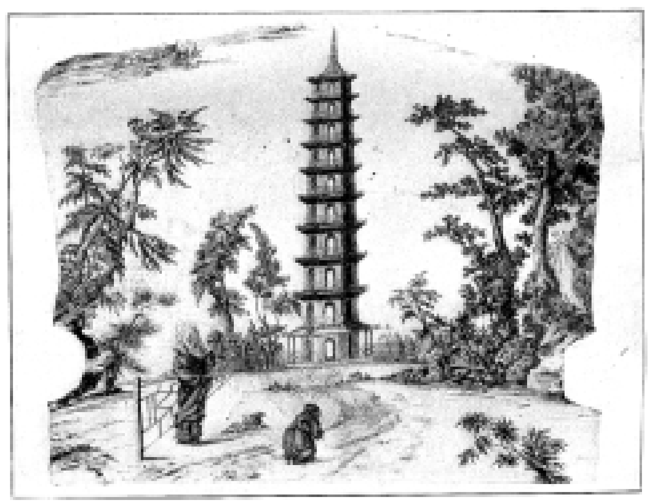

FIG. 11.—Part of a cotton chair back, printed in red from a metal plate engraved with a Chinese pagoda in a landscape; in front is a woman kneeling on the ground, while a priest stands to the left holding up an image. Marked "Collins Woolmers." English, dated 1766. 24 in. × 24¼ in.

FIG. 12.—Linen panel, with a stipple engraving printed in colours, for use as a small fire-screen. English, late 18th century. 2 ft. 4½ in. × 2 ft. 3½ in.

"stentering" machines. On these machines the damped cloth is carried forward, over steam-heated drying plates, by two travelling endless chains, each link of which is constructed to clip the selvedge of the cloth. The distance apart of these chains can be regulated to suit various widths of cloth and in travelling forward they diverge, so that as the cloth advances it gradually becomes stretched out to the required width and is dried at the same time to prevent it contracting when it is released from the pull of the chains, as it leaves the machine.

Finally the goods are cut into certain lengths, wound round flat boards, tied up, ticketed and packed.

Wool-Printing.

The printing of wool differs little from the printing of cotton in general. Most of the colours employed in the one industry are used in the other, and the operations of steaming, washing and soaping are almost identical.

Unlike cotton, however, wool requires to be specially prepared, after bleaching, if the full tinctorial value of the colours is to be obtained.

Two quite different methods of preparation are resorted to, namely (1) the chlorination of the wool; and (2) the precipitation of stannic acid on the fibre. In the first method the woollen fabric is first passed through a solution of bleaching powder, then well squeezed and passed, without washing, into dilute sulphuric or hydrochloric acid, squeezed again and well washed in water, after which it is dried. Great care and experience are demanded in this operation to prevent the wool from becoming hard and yellow.

In the second method the cloth is padded in stannate of soda, well squeezed, passed into dilute sulphuric acid, well washed and dried. For certain styles of work it is necessary to combine both preparations.

Although alizarine, mordant colours and dyewood extracts can be used on wool, the vast majority of patterns printed on wool are executed by means of acid dye-stuffs and basic colours, for both of which this fibre possesses a natural affinity. In most cases therefore these colours are simply dissolved in a little acetic and citric acids, thickened with gum and printed without any further addition. The addition of tannic acid, however, can be made to, and considerably increases the fastness of, the basic dyes. Mordant colours like logwood black are applied in the usual way.

The printing of wool is carried out exactly as for cotton, but if the best results are to be obtained, the engraving of the rollers must be deep, the blanket on the machine as soft as possible, and the drying of the printed cloth very gentle. After printing, the goods are steamed in moist steam or wrapped between moistened "greys" and steamed in a "cottage" steamer. If too little moisture is given, the colours lack both strength and brilliancy; if too much they run. The correct degree of dampness can only be determined by experience of the work, combined with a special knowledge of the particular apparatus employed.

After steaming, the printed goods are washed in plenty of water, then dried up and finished with a little glycerin or some waxy preparation.

Discharges may be very easily obtained on wool dyed in acid dye-stuffs, by means of stannous chloride and basic colours for the coloured effect, and hydrosulphite for the white.

Silk-Printing.

Silk-printing calls for no special mention. The colours 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 rôle in silk-printing, which for the most part is confined to the production of articles for wearing apparel—dress goods, handkerchiefs, scarves, &c. &c. —articles for which bright colours are in demand. Alizarine and other mordant colours 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 colours 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 fibre for basic and acid dye-stuffs enables it to extract colouring 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 colour not fixed on the fibre, and then in hot water or benzene, &c., 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 colours and soften the material. (E. K.)

II. 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 and 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 practised at a very early period.[1] Nevertheless, highly skilled as the Chinese are, and 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 (Akhmîm 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 zig-zags, 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 B.C., 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 colouring of tissues. After pressing the material, which is white at first, they saturate it, not with colours, but with mordants that are calculated to absorb colour." 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 coloured." "It is a singular fact, too, that although the dye in the pan is of one uniform colour, the material when taken out of it is of various colours according to the nature of the mordants that have been respectively applied to it." Egypto-Roman bits of printed stuffs from Akhmîm 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

[1] When Cortes conquered Mexico he sent to Charles V. cotton garments with black, red, yellow, green and blue figures. The North American Indians have a mode of applying patterns in different colours to cloth (see Parnell's *Dyeing and Calico Printing*, p. 12).

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, Neuchâtel, Zürich, 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 Mulhouse 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.

Towards the end of the 18th century a revolution in the British manufacture of printed textiles was brought about through the invention of cylinder or roller printing from metal plates. This is usually credited to Oberkampf of Jouy, but it seems to have also occurred to a Scotsman named Bell, and was successfully applied in a large way about 1785 at Monsey near Preston. From this and the calico-printing works at Manchester in 1763, and in Scotland in 1768, the present huge proportions of the industry in the United Kingdom have grown.

Illustrations accompanying this brief account merely indicate a few types of patterns used in various European countries up to the beginning of the 19th century. Typical specimens of East Indian painted and printed calicoes for coverlets and other draperies are shown in the Indian division of the Victoria and Albert Museum. These are *sui generis*, and therefore differ from the bulk of Western prints on chintz, cretonne, &c., which together with a less quantity of printing on satin, silk, velvet, crêpe and the like are principally from adaptations of weaving patterns. An interesting series of over 2500 patterns, chiefly of this character, was made by M. Corimand between 1846 and 1860, and is preserved in the National Art. Library at South Kensington. For many years of the latter part of the 19th century, William Morris designed and produced attractively ingenious floral and bird patterns, admirable in contrasts of bright colours, frequently basing his arrangement of crisply defined forms in them upon that of Persian surface ornament. His style, which on its appearance struck a distinctive note, has very considerably affected numbers of British and foreign designers of printed patterns whether for textiles or wall papers.

The portion of linen hanging or valance given in fig. 1 (Plate I.) comes from an ancient cemetery at Akhmîm in Upper Egypt. The linen dyed blue bears ornamentation with figures undyed or "reserved," through the previous application to it, by means of an engraved block, of some such saturating fluid as that mentioned by Pliny. The design and cutting of the block were no doubt the work of Coptic artificers, the style of the composition being Egypto-Roman of the 5th century A.D. On the child's tunic dyed blue (fig. 2) the simple trellis and blossom pattern is similarly produced by the "reserve" process, and the specimen is of the same *provenance* as that of fig. 1. It is perhaps rather earlier in date, *i.e.* 4th century A.D. Fig. 3 is from a fragment of red silk printed in red, green and black from wood-blocks, thus illustrating another method of applying colours to textiles. It is probably of Rhenish work in the 12th or 13th century, and came from the Eifel district. The ornament, however, is a survival of a scheme of pattern which was in use in Perso-Roman weavings as early as the 7th century A.D. Fig. 4 shows a piece of red silk printed with a Rhenish adaptation of a 13th-century North Italian weaving pattern possessing earlier Byzantine features. The design in fig. 5 is another Rhenish version of a richer style of 14th-century North Italian weaving. An advance in refinement of block-cutting is seen in fig. 6, a Rhenish adaptation of a 14th-century North Italian pattern often employed in brocade weaving of that period. The pattern in fig. 7 (Plate II.) is typical of a style introduced during the 15th century in sumptuous damask satins, and velvets woven at Florence, Genoa and Venice. Very different is the style exemplified in fig. 8, taken from a Dutch 17th-century "Indienne," the trade name for such prints. The repeated wide and narrow stripes recall a scheme of design which the Siculo-Saracens of the 11th century employed for brocades; the intertwining floral ornament closely resembles such as occurs in 16th-century Indian painted and printed cottons. Fig. 9 is a 19th-century Italian reproduction of the Persianesque spreading tree device often used in Indian palampores from the 16th century onwards to the present day. These, however, were either painted or printed from wood-blocks, whereas for this Italian copy engraved metal plates were used, after the manner of the process which was started, as already mentioned, by Oberkampf and Bell in the 18th century. The remaining figures 10, 11 and 12 are from stuffs metal-printed with subjects of a pictorial character which had a vogue for some time. In fig. 10—a French print—are family groups: shepherds and shepherdesses with their flocks; children at play; buildings, rocks, trees, &c.; the decorative effect of which, for the purposes of curtains and furniture covers, resulted mainly from the ordered repetition of these somewhat unrelated details. A landscape with a Chinese pagoda was repeated in lengths of the English cotton print, a piece of which was cut to fit the back of a chair as in fig. 11. Fig. 12 is from a linen panel printed in colours with a stipple engraving to be used as a small fire screen. The style reflects the pseudo-classical taste of the end of the 18th century in England. Beneath the group of figures in the original is an inscription, "London, engraved and published, August 1, 1799, by M—Bost No. 207 Piccadilly." This sort of printing has practically disappeared: it was unsuitable for manufacture on a large scale.

AUTHORITIES.—J. Persoz, *L'Impression des Tissus* (Paris, 1846, see vol. i. Preface); E. A. Parnell, *Dyeing and Calico Printing* (London, 1849); W. Crookes, F.R.S., *Dyeing and Calico Printing* (London, 1864, see Introduction); Dr R. Forrer, *Die Kunst des Zeugdrucks* (Strassburg, 1894). (A. S. C.)