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 re­polished, painted with a chalky mixture to prevent its surface oxidizing and exposed to a red-heat in a box filled with chalk and charcoal; then it is plunged in cold water to harden it and finally tempered to the proper degree of toughness. In this state it forms the "die ” from which the “ mill ” is made. To produce the actual “ mill ” with the design in relief a softened steel cylinder is screwed tightly against the hardened die and the two are rotated under constantly increasing pressure until the softened cylinder or “ mill ” has received an exact replica in *relief* of the engraved pattern. The “ mill ” in turn is then hardened and tempered, when it is ready for use. In size it may be either exactly like the “ die ” or its circumferential measurement may be any multiple of that of the latter according to circumstances.

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

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

Preparation of Cloth for Printing

Goods intended for calico-printing ought to be exceptionally well bleached, otherwise mysterious stains, and other serious de­fects, are certain to arise during subsequent operations. 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 2 ½ 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 lb of wheat starch with a little cold water to a smooth creamy paste ; a little olive oil is then added and sufficient water to bring the whole up to 10 gallons. The mixture is then thickened by being boiled for about an hour and, after cooling, is ready for use.

Starch is the most extensively used of all the thickenings. It is applicable to all but strongly alkaline or strongly acid 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 lb of either in one gallon of water, either by boiling or in the cold by standing.

*British gum or dextrine* is prepared by heating starch. It varies considerably in composition—sometimes being only slightly roasted and consequently only partly converted into dextrine, and at other times being highly torrefied, and almost completely soluble in cold water and very dark in 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 lb of gum to one gallon of water, but the darkest and most highly calcined require from 6 to 10 lb 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