is then let into the kier A, through the tap G, until the necessary quantity has been supplied, about 20 gallons of caustic soda at 70° Tw., and 400 lb lime for the full charge being used. The steam is then turned on slowly, and by its pressure the liquor in kier A is made to pass with great force through the cloth, and then up the pipe D, through the 3-way valve, into the kier A′. When all the liquor has passed over, the steam valve E′ is reversed, steam is shut off from A, communication is opened to pipe D′, and valve E′ turned so as to admit steam to A′, when the action of forcing the liquor through the cloth up the pipe E′ into kier A is performed. This alternate passing of the liquor backwards and forwards, see-saw fashion, through the cloth, constitutes the operation of boiling. The steam also has great effect if left in contact with the cloth for a few minutes in one kier, after the liquor has gone over to the other kier. This process is continued for eight hours (nearly one-third the time formerly required in what are termed low-pressure kiers), with steam of from 30 to 50 lb, during which time the liquor passes about 16 times from one kier to the other; then the valves H H′ are opened, and all the liquor expelled by the steam from the cloth into a drain. The steam is then shut off, the man-hole lids removed, and the ends of the two chains of cloth taken out and passed through pot eyes, which guide the pieces to the washing-machine.[1]

Washing.—The cloth as it issues from the kiers is found to have assumed a very dirty brown aspect. Formerly, the apparatus used for washing was either the wash-stocks or the dash-wheel, to which allusion has already been made. The machine now generally employed is represented in section in fig. 9. It consists of a pair of wooden bowls

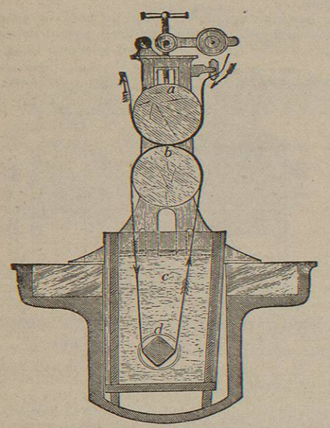

FIG. 9.—Section of Washing-Machine.

or cylinders *a* and *b*, about 9 feet long, mounted in a strong framework, and arranged to press against each other in their revolution. Plane tree is the wood most suitable for making these bowls. Running underneath the whole length of the bowls is a box or trough *c* filled with water, near the bottom of which a rectangular roller *d* is fixed. The water in the box is constantly renewed during washing operations by a current flowing in at the middle and escaping at each end. Two chains of cloth are washed in this machine at the same time, one being introduced at each extremity of the roller. The cloth passes down into the water under the roller *d* and up to the wooden bowls, between which it is caught and nipped, and down again into the water, working its way in a spiral manner from the end to the centre of the machine, passing nine times through the water and between the bowls in its progress. Its course inwards is guided by a strong wooden rail, from which pegs project, arranged according to the number of turns to be given to the cloth. In the centre part of the upper bowl there is a lapping of cotton rope, which projects a little above the surface of the wood, and serves to give the cloth, as it finally issues from the machine, a much stronger squeeze than it would obtain between the long even bowls, and thereby expels a large proportion of moisture. As the cloth travels inwards towards the centre of the trough, while the flow of water is outward to escape at each end, the cloth on each revolution is meeting water more nearly pure, till just at the point where it issues from the trough for the last time, the clean water entering the trough is powerfully spurted upon it, thus giving it a thorough rinse before it is finally squeezed. It is usual to pass the cloth from the lime boil either through a pair of such washing-machines, or twice through the same, in order to expel the last trace of calcareous soap and uncombined lime from the texture.

In addition to this machine various other devices have from time to time been proposed and introduced to perform the important operations of washing. Among these the continuous washer of Mr Henry Bridson of Bolton-le-Moors, Lancashire, patented in 1852, is deserving of notice as a simple and efficient washing-machine. Mr Bridson's washer consists of an oblong tank or trough of cast-iron which, in use, is kept about half filled with water. Within this tank, just dipping into the water, two cross shafts are fixed, which are geared to revolve in the same direction by spur-gearing mounted outside the trough. Each shaft carries a pair of discs of large diameter, and between the discs of the two shafts a pair of bars placed diametrically opposite each other are mounted. These bars form flat winces or revolving frames, by the revolution of which the fabric is not only carried forward, but is in its progress caused to strike with great violence against the surface of the water. The intermittent flapping and shaking motion thus communicated to the material has a powerful effect in detaching adhering impurities from the cloth. Another form of washing-machine in use in Lancashire consists of a row of eight vats or troughs arranged in an ascending series, so that the overflow of water from the highest or last runs into the second highest, and so downwards till it escapes from the lowest or first. The cloth enters at the lowest trough, and is carried by guide-rollers up and down through the entire series, issuing at the top between a pair of squeezing rollers.

Gray Sour.—From the washing-machine the chain of cloth is passed through a pair of squeezers, by which a large proportion of moisture is expelled. The operation of souring, which comes next, is performed in an apparatus of the same construction as the washing-machine, the trough under which contains the souring liquor. For white bleaching a solution of hydrochloric acid of a strength of 2° Twaddle (sp. gr. 1010) is used, and for print bleaching the solution is made up to 4° Tw. Through this the cloth is passed up and down twice by the revolution of the bowls, and piled up in the sour in stillages for some hours. The object of the souring is to dissolve any traces of free lime which may have been left in the washing, and to decompose the calcareous soap.

Second Boil.—After having lain in the sour for a sufficient length of time the cloth is passed through squeezers to expel as much as possible of the acid, and again washed in the machine. It is next passed into a kier or set of kiers, precisely as after liming, for the second boil, which in the

[1] For this description of the Barlow kiers we are indebted to Mr William Mather

case of print bleaching is done with a solution of soda-ash and rosin. For a pair of Barlow kiers boiling 12,000 lb of cloth, the quantities used are 350 lb of soda-ash and 200 lb of rosin dissolved with 30 gallons of caustic soda at 70° Tw. The boiling is carried on for ten hours, in a like manner and at the same pressure as in the case of the lime boiling. The soda-ash and rosin form a soap, which dissolves out the free fatty acid in the cloth, and acts on the calcareous soap remaining by forming carbonate of lime and a soluble soda soap. In the white bleaching of 2700 lb of cloth, the boiling solution is 8 gallons of caustic soda at 70° Tw., but by some bleachers soda-ash is employed in the proportion of 80 lb to 2700 lb of cloth. From this boil the cloth is passed on to the washing-machine, and then squeezed, when it is ready for "chemicking" with the bleaching-powder solution.

Chemicking.—When the previous processes have been efficiently carried out, the cloth will, at this point, have attained a considerable appearance of whiteness and purity. The "chemicking" or liquoring with bleaching-powder which it now undergoes is conducted in a similar manner to the souring already described. The chemick is used as weak as possible, the solution varying from $\frac{1}{8}$° to $\frac{1}{4}$° Tw. (sp. gr. 1·000625 to 1·00125) according to the weight and condition of the cloth under treatment. It is run through this liquor, gently squeezed, and piled up for four or six hours. It is then squeezed and washed; and at this stage the bleacher has to judge whether the cloth requires to be chemicked a second time, which, in the case of heavy goods, is frequently necessary. If a repetition of the process is required, the cloth is again passed into the kiers, boiled with a solution of soda-ash, and the other processes repeated as before.

White Sour.—After lying in the chemick the goods are again washed and squeezed, and afterwards soured in machine with sulphuric acid, used at a strength of about 4° Tw. (sp. gr. 1·020), and piled up for a period of at least three hours. Thereafter, in order thoroughly to expel all acid the goods are twice washed, and finally squeezed, which concludes the operation of bleaching proper. The calico should now present a snow-white aspect, and should be fit to take the most delicate shades of colour when it is to be used for printing purposes.

Opening.—In passing through the numerous processes detailed in the foregoing statement, the cloth has been always in the form of a coil or loose rope. In the drawing from one machine to another it has been also pulled somewhat to the length at the expense of breadth, and in places it is likely to have become a little twisted. The pieces have therefore now to be opened out to their full width, and, if necessary, evened. The opening out is effected by passing the pieces to a winch placed at a considerable height when the weight of the cloth itself in passing upwards unfolds it, and the selvedges are caught and extended by a boy just before it passes on to the winch. When necessary it is caught beyond the winch by an opening-machine, such as that patented in 1871 by Mr Wm. Birch of Salford. It is a complex apparatus, working by endless bands, on which are toothed projections, and these, travelling from the centre to the sides in opposite directions, open and spread out the cloth before it passes over the roller which is mounted on the machine. From the opener the cloth passes at once to the drying-machine (hereafter described), after passing over which cloth intended for printing is folded or batched on rollers, and its further treatment belongs to the art of calico-printing.

Finishing.—So far as regards bleaching proper the process is now at an end, and the further operations which white calicoes undergo have only for their object the improvement of their appearance for the market. But although the finishing adds in no way to the quality of the material, it is regarded as of great value by the merchants, and the finish of a bleacher is of more importance than his bleaching. A great variety of finishing operations have to be employed, according to the different qualities of textiles, and the purposes to which they are devoted. Finishes are "beetled," "calendered" (either "stiff," "medium," or "soft," or "glazed,") and, for dress muslins, &c., "elastic." As the processes and appliances for these finishing operations are very numerous and varied, they cannot here be described in detail. In most cases they are the same as used in the finishing of calico prints, and more information will be found under that head. We shall here confine our remarks chiefly to the finishing of ordinary white beetled calicoes.

Water Mangle.—The cloth, when brought into the finishing-room, is passed over a stretching rail into a trough of boiling water and between a series of calender rollers, in which it is powerfully pressed. A common arrangement of the cylinders of the water mangle is to have a series of four, two of small diameter being made of copper, and two larger of condensed cotton; but wooden bowls are also sometimes employed with only a single intermediate copper cylinder. By this mangling process the water is equalized throughout the whole piece, the threads are flattened, and the cloth stretched, smoothed, and wound upon a roller, and thus rendered fit for receiving the *starch*.

Starching.—It is in this stage that so much is done by some bleachers to give cloth a factitious appearance of weight and bulk by filling up the interstices between the fibres with compounds which have no other object than to please or deceive the eye, and some of which have a decidedly deleterious influence on the tissue they are intended to improve in appearance. A great variety of mixtures, both cheap and nasty, are used by some finishers in place of starch with a view to produce weight and appearance, but, naturally, as little information as possible on this point is permitted to leak out to the public. What ought to be, and by reputable bleachers really is, used is pure starch, either of Indian corn or wheat, or both, made up into a stiff mucilage and blued with ultramarine or indigo. The cloth passes over a stretching rail into a trough of this starch, in which a roller is mounted. As it comes out of the starch it is caught between a pair of bowls, by which the superfluous starch is squeezed out and thrown back into the trough, the cloth passing on to the drying-machine. The starching mangle and drying-machine are seen together in fig. 10

Drying.—The drying-machine (fig. 10), consists of a

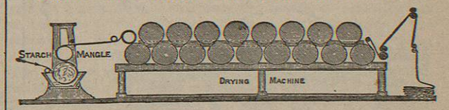

FIG. 10.—Starching Mangle and Drying Cans.

number of cylinders made of tinned iron or copper, and filled with steam of low pressure. The cloth passes alternately back and face over one and the other, and emerges to be placed down at the end perfectly dry. This system of drying was introduced among the first mechanical appliances used in calico-printing, and has not as yet been superseded by any other plan. Various improvements in detail, we learn from Mr William Mather, as to the construction of the cylinders and the mode of applying steam to them have been recently introduced, but the machine remains the same. One important defect has been recently

removed by an alteration in the construction of the cylinders, to prevent collapse, in case a vacuum were formed by the rapid condensation of the steam. A spiral rib or stay is made to run from end to end of the body of the cylinder, giving support uniformly the whole length, and serving at the same time as a screw to drive the condensed water, as the cylinder revolves, to one end, where it is ejected through a nozzle. The steam enters at a nozzle, from the framing which is cast hollow, and serves as a pipe to distribute the steam to all the cylinders in the machine, while the framing on the other side serves in like manner to receive and discharge the water.

Damping.—From the drying cans the cloth is passed on to the damping-machine, where it is uniformly moistened by an exceedingly fine spray of water thrown upon it. The spray is thrown up by a circular brush, the tips of which are allowed to dip into water in a trough over which it revolves. Mather and Platt have introduced a manifest improvement on this plan by throwing the water in fine jets on the brush from a pipe which runs parallel with it. By this means the quantity of water and degree of moisture can be regulated with the utmost nicety. Fig. 11 shows the damping-machine in section as modified by

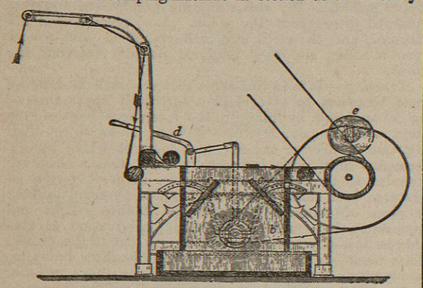

FIG. 11.—Damping-Machine.

Mather and Platt. *a* represents the circular brush revolving in a trough, and *b* is the pipe from which the water is squirted on the brush. The spray from the brush is confined by two sloping boards *c*, *c*, which work on quadrants, and the lever *d* raises or depresses the brush at

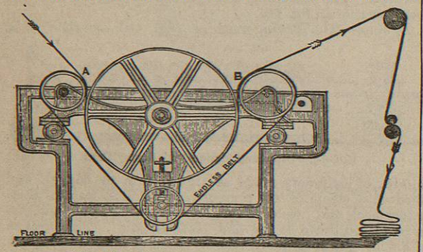

FIG. 12.—Elevation of Belt-Stretching Machine.

pleasure. The course of the cloth over the machine is indicated by arrows, and after damping it is batched on an iron or wooden beam *e*, when it is ready for the process of beetling. When goods are to be finished of any particular width, they are at this stage breadthened by such an apparatus as the belt-stretching machine of Mather and Platt shown in elevation in fig. 12 and in plan in fig. 13. In

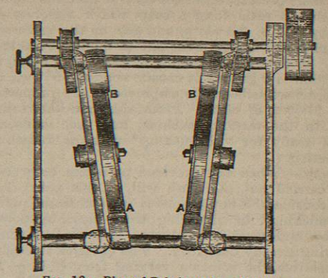

FIG. 13.—Plan of Belt-Stretching Machine.

this machine the full width of the cloth is obtained by the selvedges being held firmly by a belt and pulley on each side, the pulleys revolving at such an angle that the stretch on the cloth has to compensate for the difference in distance between these pulleys at A and B.

Beetling.—The beetles ordinarily employed are a series of long heavy wooden piles arranged in a frame. These piles are alternately raised and allowed to fall with their full weight against the beamed cloth by the revolution of roller having a spiral series of notches, which catch a corresponding range of projections on the piles. The beam with the cloth is made to revolve gently by a ratchet motion as it is submitted to this hammering, which goes on for two or three hours. Recently Mr John Patterson of Belfast has patented and introduced a form of beetling-machine (fig. 14), which from its highly effective action

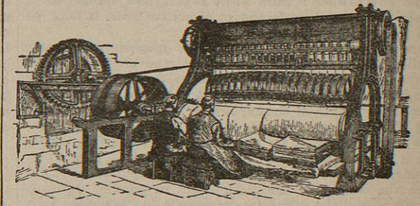

FIG. 14.—Patterson's Patent Beetle.

is likely to come into very extensive use. The advantages claimed for his machine over the common beetle Mr Patterson thus states: "Heretofore, the beetling of textile fabrics has been done by means of beetles, or stampers, falling upon the fabric by the action of gravitation, each stamper or beetle falling 55 or 60 times per minute through a space of 13 to 15 inches. This rate of speed cannot be accelerated by gravitation, and the consequence has been that in order to increase the quantity of work done by the ordinary beetles, very bulky and massive machinery has been employed, requiring large and expensive buildings and driving gear. The new beetling-machine requires not one-tenth of the space, very much lighter gearing, and

instead of making 60 blows per minute, each beetle makes from 420 to 500 blows per minute. The blows are not by the action of gravitation, but are actuated by a series of cranks cut upon a solid steel shaft. There are connecting rods from the steel cranks to semicircular springs. The beetles are attached to, or suspended between, the points of the semicircular springs by means of leather straps. When the crank shaft is set in motion the beetles are snatched up in regular sequence by the upward motion of the cranks, and the springs are compressed by the weight of the beetles, as in fig. 15, and by the combined upward motion of the cranks and the springs the beetle is thrown upwards with great impetus. The upward motion is stopped as the cranks pass the top centres, and the beetles are thus met by the springs and thrown violently into them, causing them to be again compressed, as in fig. 16.

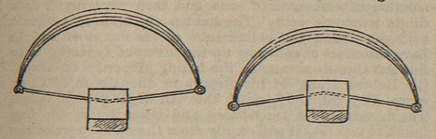

FIG. 15 FIG. 16.
Hammers of Patterson's Beetle.

When by the downward motion of the cranks the springs are allowed to throw the beetles on the cloth beam, a rapid forcible whipping blow is imparted to the cloth, which does not cut or injure it in the manner often done by the slow dropping blows of the ordinary beetles. The weight of the blows can be instantly varied by varying the speed of the crank shaft, from the slightest touch to the heaviest penetrating blow. It is found that twice or thrice the number of folds of cloth can be beetled effectively on the cloth beams more than can be done on ordinary beetles, that is, instead of 200 folds on the beam, 400 or 600 folds can be equally well beetled on the new machine."

Calendering.—When it is desired to finish cloth with a stiff or with a glazed finish, instead of being submitted to the operation of beetling, it is finished in the calender. The calender, as its name κύλινδρος implies, is a series of cylinders mounted above each other in a strong frame-work. The number of cylinders and the material of which they are constructed vary. In some only three cylinders or bowls are employed, and in others they are four or five. One or two of the bowls are made of metal, and two or three are either of wood, of condensed cotton, or of paper, and they must always be turned with great accuracy and be free from all warping. Cylinders of paper or condensed cotton have a very smooth surface and a considerable amount of elasticity. Between these cylinders the cloth as it comes from the damping-machine is passed, and twice, thrice, or four times, according to the construction of the calender, it is powerfully pressed. The pressure gives the cloth a very even surface, condensing the fibres, and produces a shining lustre. When the cloth is submitted to friction, as well as to pressure in a heated calender, a glazed finish is produced. The frictional effect is produced by the cylinders being geared to move at different rates of rapidity, so that in their revolution they rub over the surfaces of each other in addition to communicating pressure. Fig. 17 shows a finishing or friction calender in section. The metal cylinder *a* is made hollow so that it may be heated by the introduction of steam or gas, *b* and *d* are of compressed cotton or paper of the same diameter as *a*, and *c* is a smaller metal cylinder. The pressure of the cylinders is regulated by means of the screw *e*, and the compound lever *f*, which is adjusted by the double screw on the connecting rod at *g*. The cloth enters over stretching rails and rollers, passes through the calender in the manner indicated by the arrows, and is batched on roller *h*.

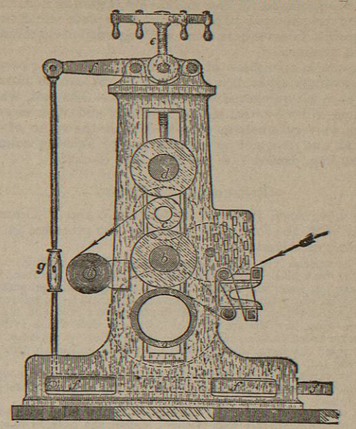

FIG. 17.—Section of Calender.

Elastic Finish.—This particular kind of finish is applied to muslins and similar thin fabrics, and has to be done in highly-heated apartments called stentering stoves. Formerly the work was entirely done by manual labour, and consisted in holding the fabric by the selvedges, and pulling it forward and backward while it was drying in the heated air. In this way the threads were made to rub against each other, and the cloth was thus deprived of the hard, stiff board-like appearance it would have possessed if left motionless when drying. Mr Ridgway Bridson was the first who introduced a machine which successfully supplanted hand labour in producing the elastic finish in muslins. His stentering frame is thus described:—Two horizontal rails or frames extend side by side the whole length of the machine, carrying at each end a large wheel or pulley, with small pins fixed at equal distances in its periphery. These pins pass through corresponding holes in an endless band which passes round the pulleys. On the surface of the endless bands are fastened very fine needle or tenter points to hold the selvedges of the fabric as it passes through the machine. The horizontal rails can be moved away from each other laterally, so as to stretch the fabric breadthwise. The rails are of equal length with the fabric to be treated, which is fastened by the selvedges at one end to the centre pins, and the pulleys being set in motion, the entire piece is carried on and stretched out over the machine, and the rails are then moved outwards to breadthen the fabric. The elastic finish is given by communicating alternate vibrating motions to the two rails, by which a diagonal stretching is given to the muslin while in the process of drying.

At the conclusion of any of these various finishing processes, the goods are folded either in a plaiting-machine or by girls hooking plaits of definite length by the selvedges on steel spikes. The end of each separate piece is then stamped with some device or motto intended to serve as a trade-mark. After the goods have been regularly folded, they are placed piece by piece, separated by sheets of