OPENING-MACHINE, OPENING RAW COTTON FROM THE BALE.

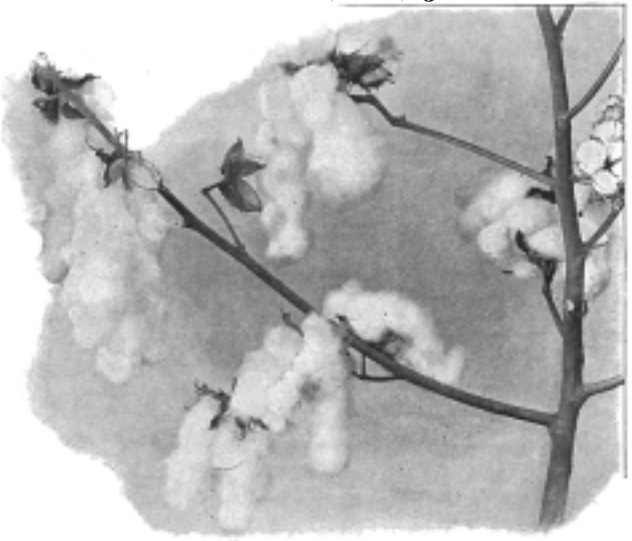
GREAT INDUSTRIES OF THE UNITED STATES.

II.—COTTON AND COTTON GOODS.

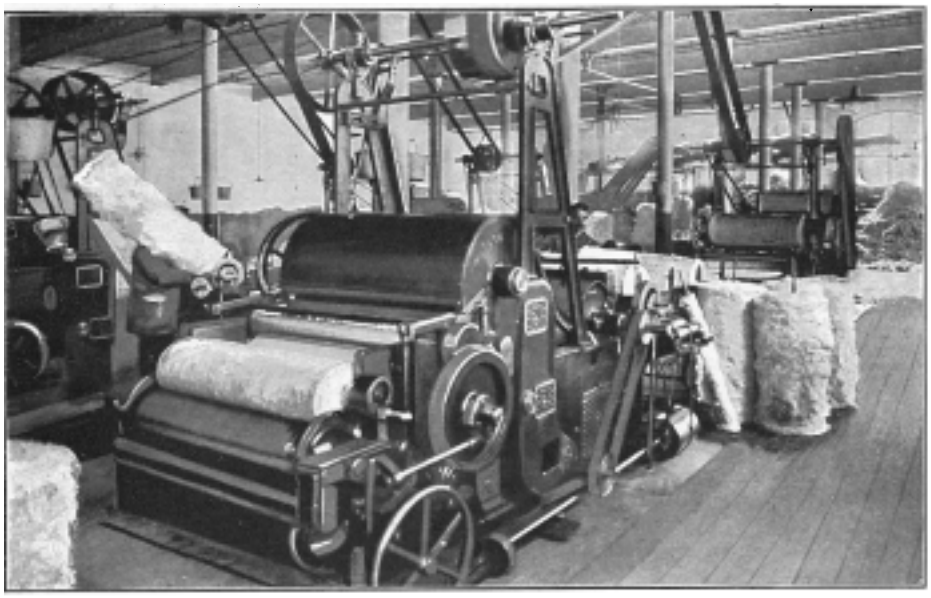
By William R. Stewart.

SITTING under the shade of a tree, on the edge of a hole in the ground, into which are thrust his feet and the lower sections of the few reeds which form his primitive loom, the balances fastened to a convenient branch overhead, and with two loops underneath the gear into which to insert his great toes as treadles, the cotton-weaver of India makes as fine woven fabric as the world knows, with instruments as rude as the flint tools of prehistoric races.

Between the tedious methods of the Indian in the field and the busy whir of machinery in the great cotton-factory of to-day, are only two really original inventions. Yet the two inventions, with the changes which evolution has wrought in the apparatus of prehistoric type, have been so momentous in the saving of labor that twenty million of the present population of the United States, working with hand-cards,



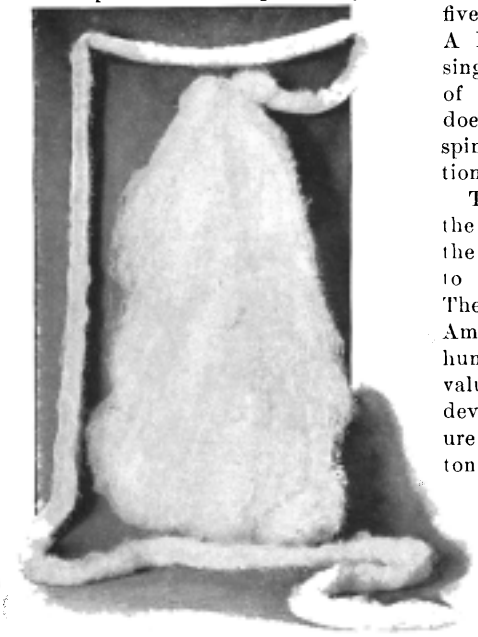
BRANCH OF WOOLLY-SEED COTTON PLANT.



SCUTCHER AND LAP-MACHINE, WHERE THE COTTON IS PREPARED FOR CARDING.

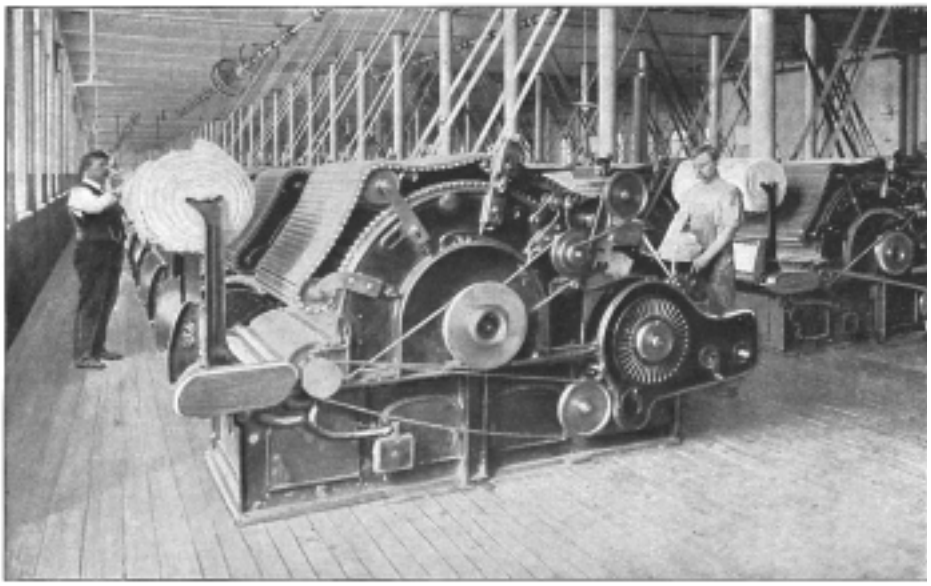
spinning-wheels and hand-looms, would scarcely make the quantity of cloth now consumed in a year by themselves and the other sixty millions.

A hundred years ago, it would have taken one person, working at night in addition to the usual field-work, two years to separate from the seed the quantity of cotton contained in one average standard bale of five hundred pounds. To-day, a battery ginnery, operated by steam, has a capacity reaching to one hundred and fifty five-hundred-pound bales in twelve hours. A hundred years ago, the spinning of a single thread represented as great an output of labor as the spinning of thirty threads does to-day. The cotton-gin and the spinning-jenny have to this extent revolutionized the making of cotton goods.



CARD-SLIVER, BEFORE AND AFTER GOING THROUGH CONDENSING-ROLLERS.

The manufacture of cotton goods was the first and the largest factory industry in the United States, and remains the largest to this day, undisputed in any respect. The present total value of the products of American cotton-factories is about four hundred million dollars annually, and the value of the land, buildings and machinery devoted to the purposes of cotton manufacture is about the same. The value of the cotton crop of the United States—about five billion pounds yearly—nearly seventy per cent. of which is shipped in its raw state to foreign countries—was last year over five hundred million dollars. Twenty-six million acres of land were devoted to its cultivation, valued with their buildings at one billion two hundred million dollars. Of the total

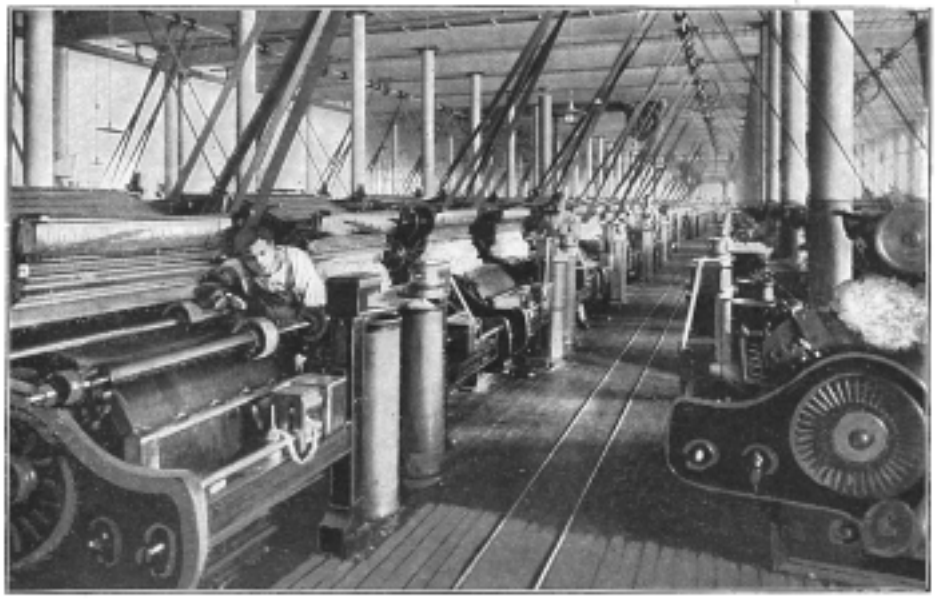


REAR VIEW OF THE CARDING-MACHINES, WHERE THE FIBERS ARE DISENTANGLED FROM ONE ANOTHER AND LAID IN PARALLEL ROWS.

world's production of cotton, the United States now supplies over eighty per cent.

The cultivation and the manufacture of cotton are wholly distinct industries, carried on by entirely separate interests and largely in different localities. So closely are their processes connected, however, so intimately do the gathering, spinning and weaving blend into one another, that no account of cotton manufacture can be complete which should ignore cotton cultivation. The proprietor of a cotton-factory is scarcely

A BALE OF COTTON READY FOR TRANSPORTATION TO THE MILL.



FRONT VIEW OF THE CARDING-MACHINES, SHOWING CANS INTO WHICH THE WEB IS COILED TO BE CARRIED TO THE DRAWING-FRAME.

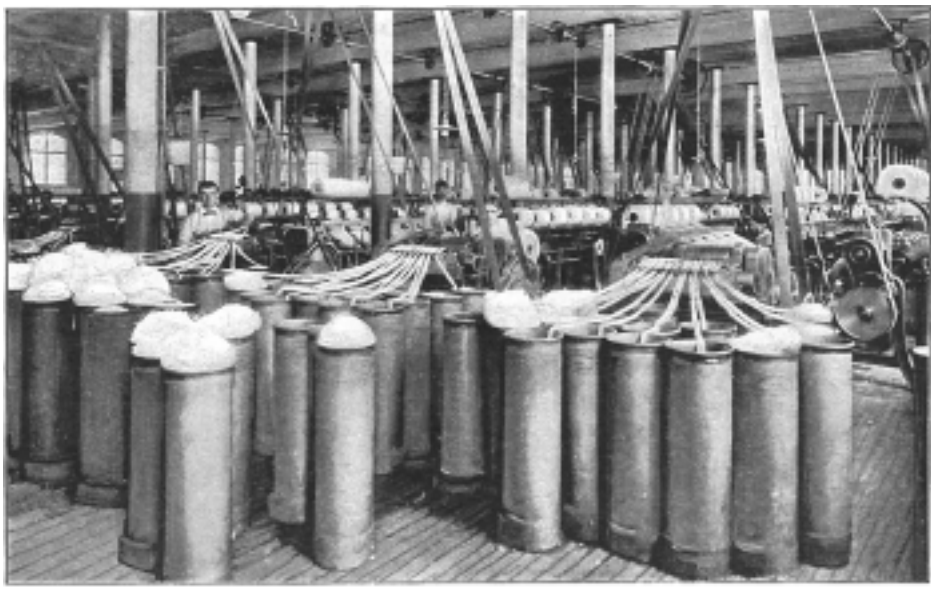
more concerned with the mechanical operation of his plant than with the financial operations of his treasurer in buying cotton. The profits of a mill during a whole year may depend upon the purchasing of the material at the right or the wrong season, and this again depends upon the successful or wrong forecasting of a large or a small cotton crop.

There are upward of twenty varieties of the cotton plant in the world, but only two are cultivated in the United States. These are the woolly-seed cotton, grown throughout the Southern States, which forms the great commercial crop of the country, and the "sea-island" cotton, which is grown on the islands off the coast of South Carolina, in Florida and along the coast of Texas. Sea-island cotton produces a fiber noted for its length and silky quality, and is used in making fine laces, muslins and spool cotton.

The cotton fiber is the "wing" of the seed of the cotton plant. In the unripe seed it is a cell containing a watery sap, but as the seed nears maturity the sap condenses, the fiber, which had been wrapped in many folds around the seed, collapses, and assumes the form of a twisted ribbon, something like a corkscrew or a wooden shaving. As it becomes elastic, it bursts the boll, or pod, and hangs ready to be gathered or to be blown away by the wind.

Cotton grows in all intertropical and semitropical countries. In the United States the thirty-seventh parallel, which coincides nearly with a line drawn from Old Point Comfort, Virginia, to Cairo, Illinois, marks the northern limit of profitable culture. To the south and southwest

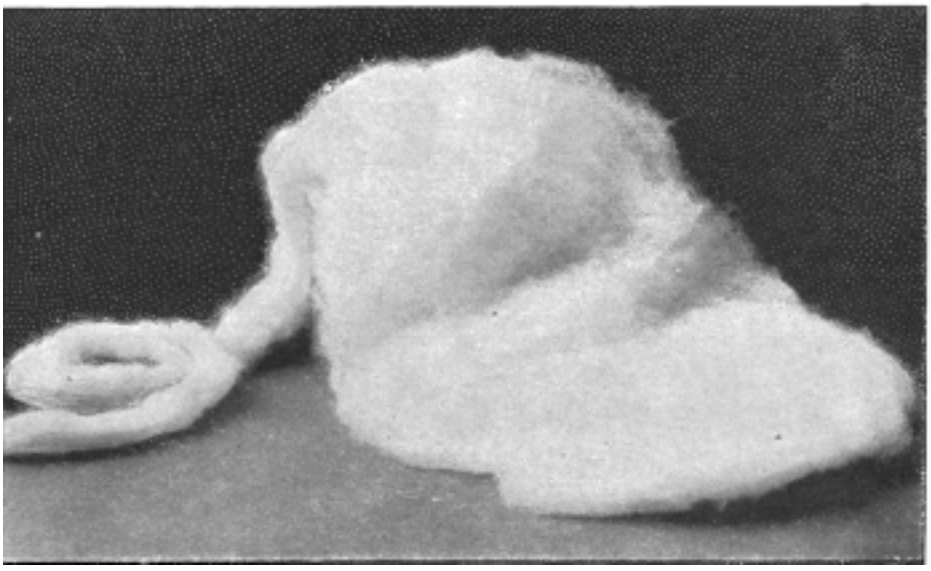
UPLAND OR WOOLLY-SEED COTTON. SEA-ISLAND COTTON.



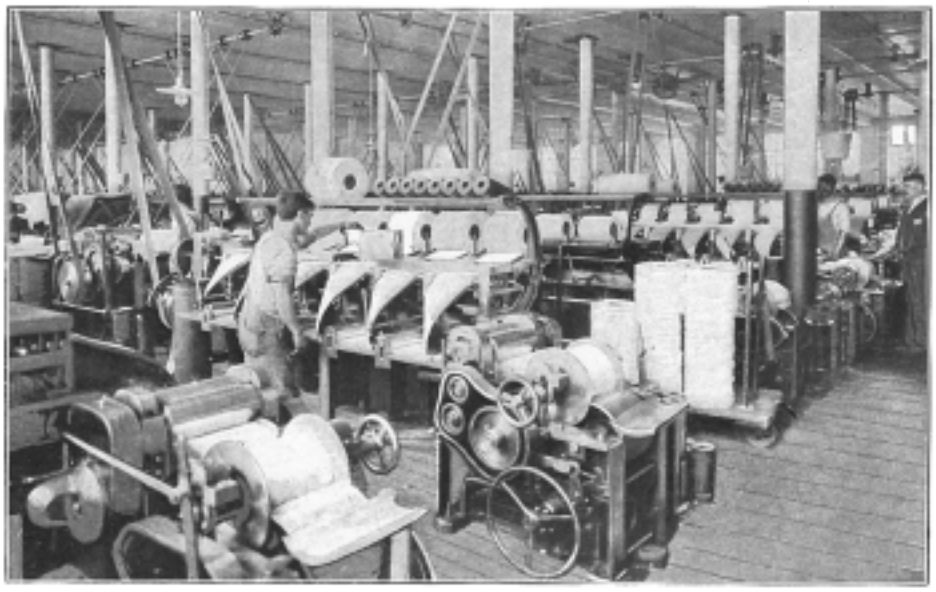
DRAWING-FRAMES, THE ROLLERS DRAWING OUT THE WEBS OF COTTON TO A STILL FINER THREAD.

of this line lies the greatest cotton-producing section in the world, the value of whose exported crop exceeds that of the combined exports of flour, wheat and corn for a year from the whole United States.

Cotton-planting commences in the early part of March and continues till the end of April. The seeds are sown in rows, ten to twenty inches apart, the soil having been plowed and treated with a fertilizer. The picking begins in the late summer, but as the bolls do not all open at the same time, each field has to be picked over many times, and the picking season lasts from August till December. Though many picking-machines have been invented, none has stood the practical test of the field, and cotton-picking is still done, as it was in



DRAWING- OR CARD-SLIVER, SHOWING DEGREE OF COMPRESSION THE FIBER UNDERGOES IN THE CONDENSING-MILLS.



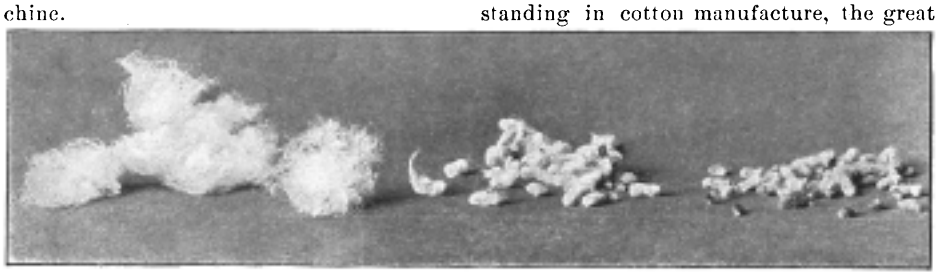
A FRONT VIEW OF THE RIBBON LAP-MACHINE.

the dim past of antiquity, entirely by hand.

The first process to which the cotton is subjected, after being picked and hauled from the plantation, is ginning, by which the fiber is separated from the seed. A century ago, this was performed laboriously by hand, but in 1794 the cotton-gin was invented by Eli Whitney, and the commerce of the staple was revolutionized. Briefly described, the gin is a machine into which the cotton boll is placed, the fiber resting upon or against a grid, or open-work frame, into the openings of which project the teeth of a collection of saws mounted upon a revolving mandrel. As these turn, the teeth catch the fibers, drawing them away from the seeds, which, being too large to pass through the openings, roll downward and out of the machine.

A modern ginnery may contain as many as fifteen gins, of seventy saws each, with a double square-bale press and a suction apparatus attached for carrying the ginned fiber to the press. The ginnery has thus become largely automatic, practically doing away with human labor in its operation. After the cotton leaves the gin, it is shipped to various points for manufacture.

Upward of three hundred and fifty thousand hands were employed in the cotton-mills of the United States last year, and nearly one hundred million dollars were paid in salaries and wages to employees. More bales of cotton were consumed in the United States than in any other country. The product, however, was mostly coarse or medium yarns, and Great Britain still maintains its lead of long standing in cotton manufacture, the great



COTTON-SEED: BEFORE GINNING. AFTER GINNING. AFTER LINTING.

COMBING-MACHINES. ONE GIRL CAN ATTEND TO SIX MACHINES.

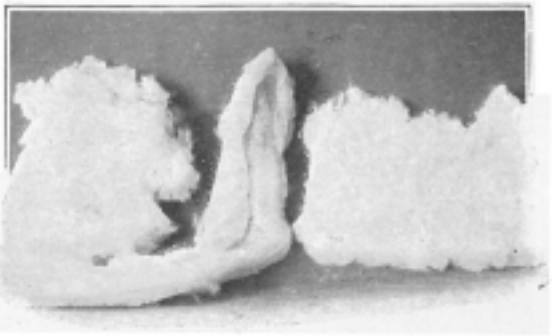
mills at Manchester doing spinning of a much finer kind than is yet accomplished in the United States.

It is interesting to note that the "trust" idea in industry has not yet seriously invaded cotton manufacture in this country. Of the upward of a thousand separate cotton-manufacturing establishments of the United States, only thirty belong to corporations which come within the designation of "trusts." These are divided between three concerns: the New England Cotton Yarn Company, which produces only a small proportion of the yarns made for sale; the Mount Vernon-Woodbury Cotton Duck Company, which manufactures a large portion of the sail duck made in the country, and the American Thread Company, which has combined several of the large establishments which make sewing-thread. The total capital of these companies is less than thirty-five million dollars.

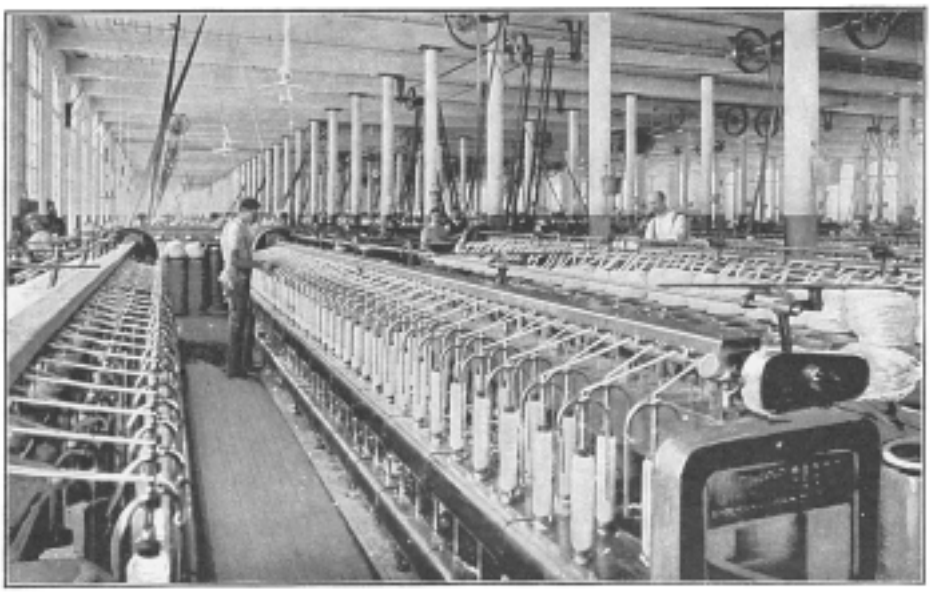
There are almost two thousand different kinds of cotton goods made; different, that is, in at least a sense sufficient to entitle them to distinct classification. In general, they include plain cloths for printing or converting, sheetings and shirtings, ginghams, ticks, denims and stripes, drills, twills and sateens, cottonades, napped and fancy woven fabrics, corduroy, cotton velvet and plush, duck, bagging, netting, tapestries, laces, yarns, sewing-cotton, twine, tape and webbing, batting, and an almost endless variety of other small ware.

The factories in which the various kinds of cotton goods are made produce, as a rule, only certain varieties of articles, but most of them carry through their raw material, cotton, from the baled lint to the woven material.

In England, spinning and weaving are treated as distinct industries, in the sense that both processes are not usually carried



AT THE LEFT, RAW STOCK, OR COTTON AS IT COMES IN THE BALE FROM THE GIN; IN THE CENTER, TOP STRIP FROM THE CARD; AT THE RIGHT, PICKER-LAP.

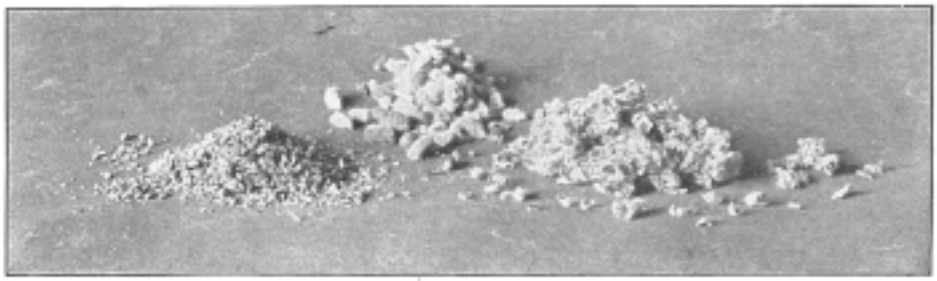


SLUBBING-FRAMES, WHERE THE SLIVER OF COTTON IS TWISTED AND WOUND ON A BOBBIN.

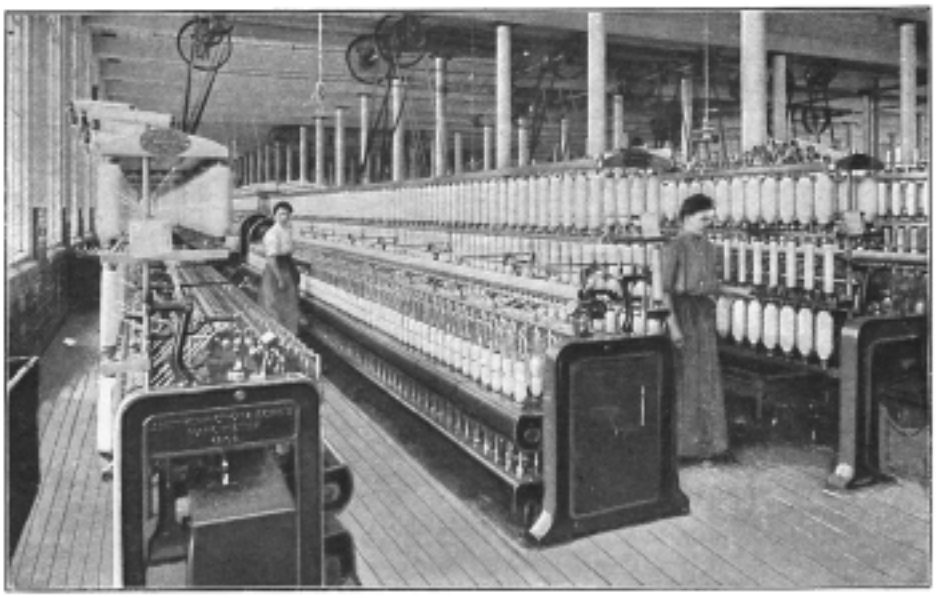
on in one factory. In the United States, there has not as yet been any movement toward this distinction. Nevertheless, cotton-goods mills here are of four general classes: yarn mills; mills which both spin and weave, but do not produce enough yarn to supply their looms; those which purchase fine yarn to be converted into sewing-thread, and those which weave only.

The growth of cotton-manufacturing in the South, principally in the four states of North and South Carolina, Georgia and Alabama, has been one of the most notable features of the industrial growth of the United States during the past ten years. In 1893, there were fewer than two hundred and fifty cotton-goods factories in the South; in 1903, there were almost five hundred separate establishments, an increase of nearly one hundred per cent. The increase in the number of spindles was twice as great. In the four states named, the industry is now important enough to consume almost one-half of the crop of cotton grown within them, and the employment which they afford has gone far toward solving the "poor white" problem in the South.

The densest concentration of cotton-manufacturing in the United States, however, is now, as it always has been, in southern New England. Within a radius of thirty miles of Providence, Rhode Island, are factories containing one-third of all the spindles in operation in the entire country. Fall River, Massachusetts, is the great print-cloth center, almost one billion square yards of cloths having been



THE COTTON SEED FROM WHICH COTTON-SEED OIL IS MADE: AT THE LEFT, THE RAW KERNELS; IN THE CENTER, THE SEED AFTER GINNING AND LINTING; AT THE RIGHT, THE HUSKS.



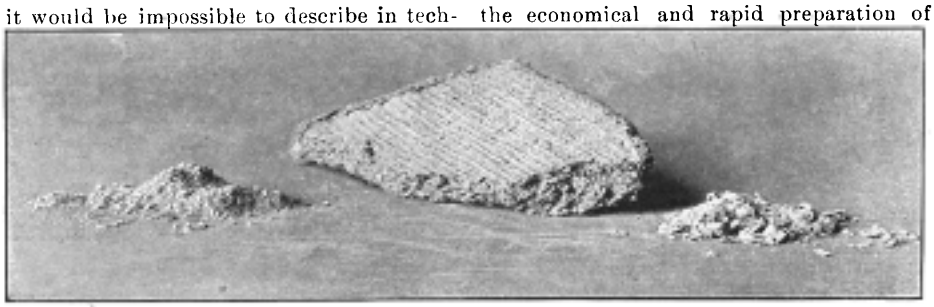
INTERMEDIATE AND ROVING-FRAMES, ON WHICH THE COTTON IS STILL FURTHER TWISTED.

for some years its mills' annual production.

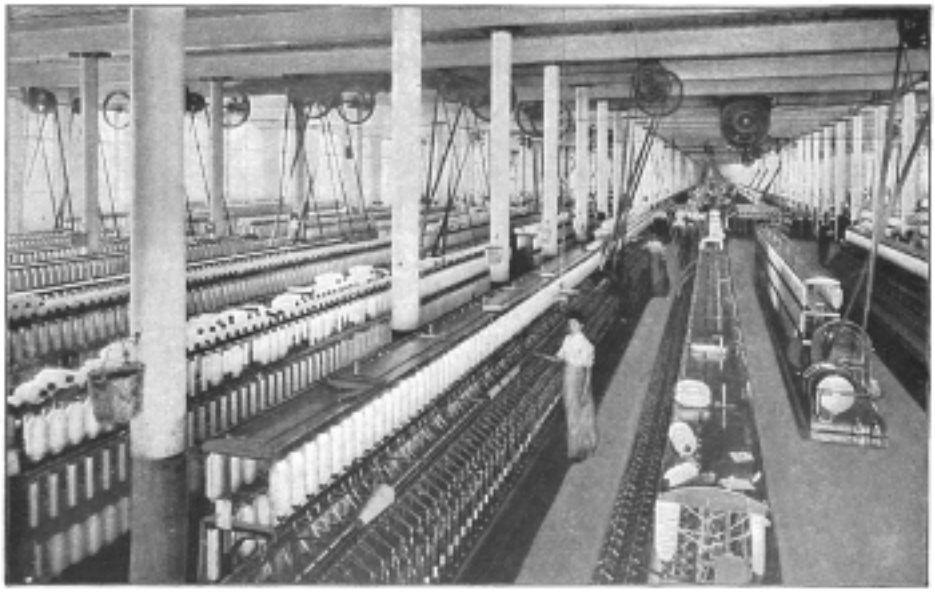
Upward of one million horse-power was used to operate the machines in American cotton-factories last year. The principal machines now in use comprise—giving them the names by which they are technically known—the opener, scutcher and lap-machine, the carding-engine, drawing-frame, slubbing-frame, intermediate frame, roving-frame, throstle, self-acting mule, hand-mule, and doubling-frame, or mule doublers or twiners, all used for spinning; and the loom and its adjuncts for weaving.

So varied and complicated is the series of machines by which the raw cotton is now turned into manufactured cloth, that it would be impossible to describe in technical detail yet in popular form. The whole operation, however, is almost exactly like hand-spinning and hand-weaving, except that in regard to the former a large number of rovings (slivers of cotton fiber) are operated upon at once instead of a single one; and in the latter, machines instead of hand weave the weft into the warp.

The fundamental contrivances of which all modern spinning and weaving machines are but adaptations and improvements were invented by two Englishmen, Hargreaves and Arkwright, during the latter part of the eighteenth century. These were the spinning-jenny, the spinning-frame and the power-loom. The improvements since made in these, however, and another series of inventions directed to the economical and rapid preparation of

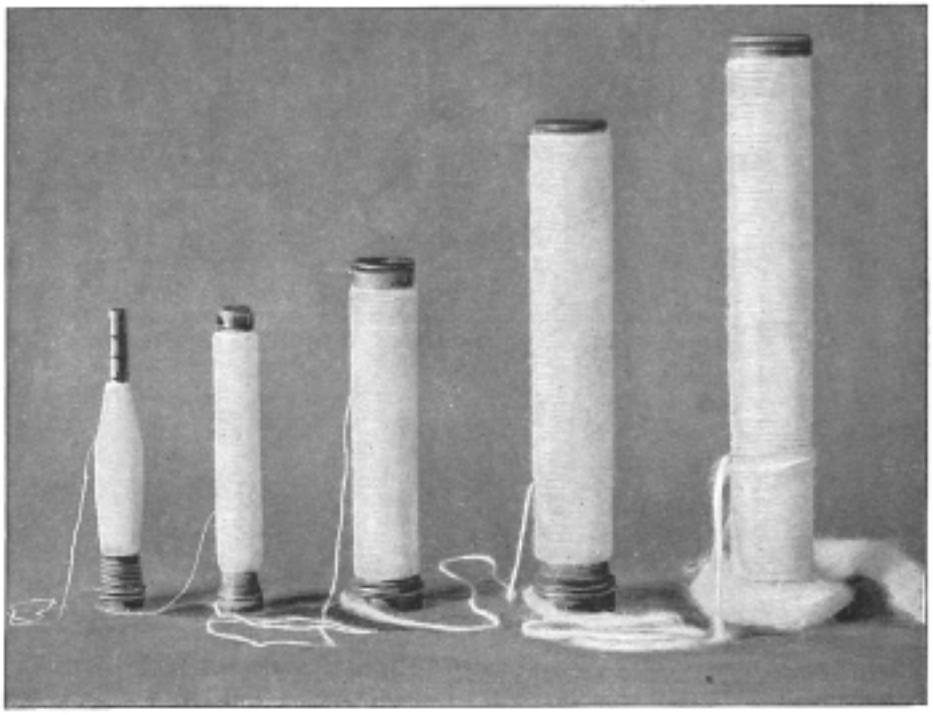


IN THE CENTER, COTTON SEED AS IT COMES PRESSED; AT THE RIGHT, THE KERNELS AFTER CRUSHING BY ROLLERS PREPARATORY TO EXTRACTING THE OIL; AT THE LEFT, GROUND MEAL FROM THE COTTON SEED AFTER THE EXTRACTION OF COTTON-SEED OIL.

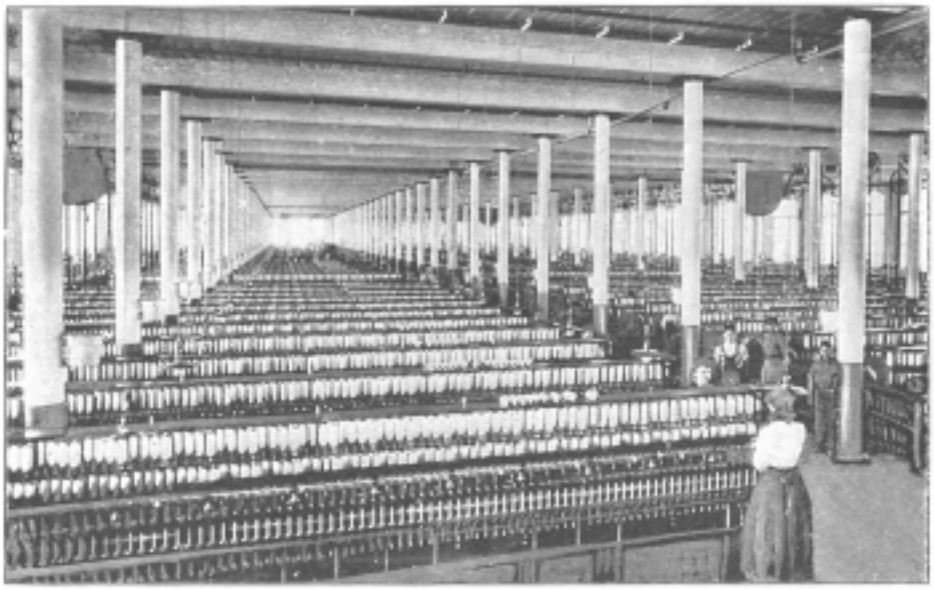


A GENERAL VIEW OF THE CARDING-ROOM OF A MODERN FACTORY.

the cotton for spinning, and in the final processes of the manufacture, have multiplied several hundred fold the efficiency of the industry. Spindles in the great factories of to-day reach the almost incredible speed of ten thousand turns a minute.



FROM RIGHT TO LEFT: (1) SLUBBER-ROVING, (2) INTERMEDIATE ROVING, (3) FINE FRAME-ROVING, (4) WARP YARN, (5) FILLING YARN.



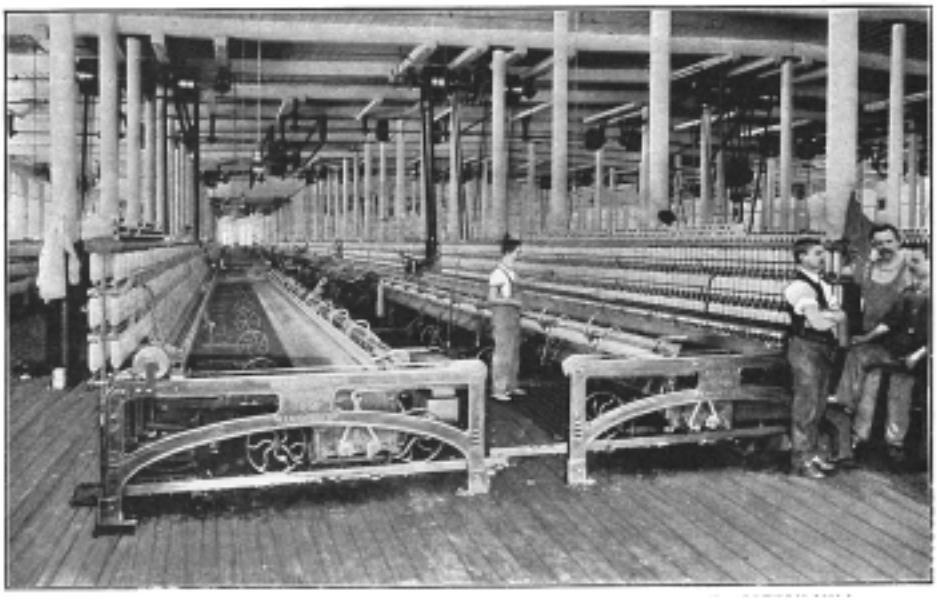
SPINNING-ROOM, SHOWING ROWS OF THROSTLES WITH SPINDLES AND FLYERS.

The principle of the spinning-frame—which spins a vast number of threads of any degree of fineness or hardness—is not difficult to understand. It consists of two pairs of rollers, turned by means of machinery, the lower roller of each pair being furrowed longitudinally, and the upper one covered with leather to make it take hold of the cotton. With only one pair of rollers, a carding of cotton, passed between them, would be drawn forward by the revolution, but would only be compressed by the action. With two pairs of rollers, however, no sooner has the cotton, or roving, as it is technically termed when in that form, begun to pass through the first pair of rollers than it is received by the second pair, which are made to revolve with three, four or five times the velocity of the first pair, according to the fineness of the yarn, or thread, desired. In this way the roving is drawn out to the requisite degree of tenuity, a twist being given to the thread by the adaptation of the spindle and fly of the common flax-wheel to the machinery.

The two machines which are first employed in the process of cotton manufacture are the opener and the scutcher. By these the raw cotton is cleaned and opened out, ready to be put into flat folds by the lap-machine. The opener is fed with the raw cotton by means of a pair of feeding-rollers, the cotton as it enters being subjected to the action of a beater. This consists of a cylinder, revolving when in operation at a rate of fifteen hundred turns to a minute, and having four or six rows of projecting teeth which open up the cotton fibers. A strong draft of air is, by an ingenious contrivance, made to play through the newly opened cotton, cleaning from it the dust and other foreign particles. One machine will open about eight thousand pounds of cotton in twenty-four hours.

The scutcher and lap-machine, which are combined, resemble the opener, and simply continue the process of opening begun by the latter. The cotton is further cleaned and carried forward on rollers, making laps for the second or finishing scutcher, and going from this to the carding-engine.

The carding-engine, by which the fibers of cotton are disentangled from one another and laid in parallel rows, consists of three cylinders—the smallest called the taker-in, which receives the cotton from the scutcher by a pair of feed-rollers; a main cylinder covered with cards, which is surmounted by small ones called rollers, also covered



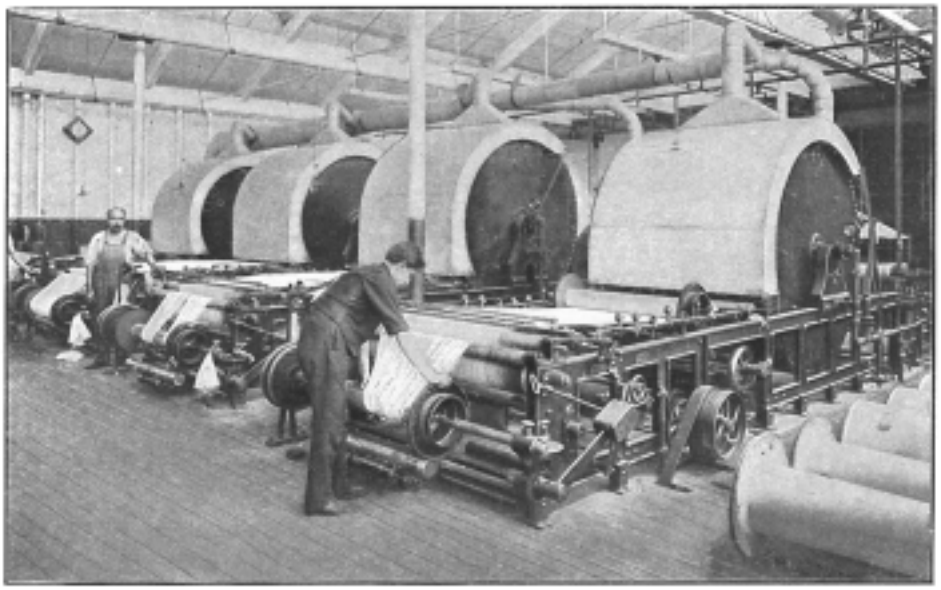
SELF-ACTING MULES, THE MOST HIGHLY PERFECTED MACHINERY OF THE COTTON-MILL.

with cards, and which, revolving in opposite directions to those of the large cylinder and in opposite directions, card the cotton; and a doffer, into which the cotton passes from the main cylinder in the form of a very light fleece. This fleece is drawn together into a funnel, which forms it into a narrow web. Then it passes through two pairs of calendar rollers, and is coiled into a can. The cans are carried to a drawing-frame, which is provided with successive pairs of rollers, the operation of which draws out the webs of cotton to a still finer thread.

The slubbing-frame is the next machine to which the cotton, now in the form of slivers, is subjected. In the slubbing-frame the sliver has a certain amount of twist imparted to it, and it is then wound on a bobbin. The twist is given to the thread as it emerges from the rollers by the action of vertical spindles and flyers, which at the same time wind the ends upon bobbins in successive layers.

WARPING-FRAME, WHERE THE THREADS ARE ARRANGED FOR THE FIRST OPERATION OF WEAVING.

The ingenious character of the mechanism used in modern cotton manufacture is illustrated in the method by which the winding of the bobbins is accomplished. It is plain that as the bobbins fill and increase in diameter the rate of speed at which the strands of cotton will travel on the growing ball will likewise increase.



SLASHING, OR DRESSING THE THREADS FOR THE WARP.

This, after a few revolutions, would draw out the yarn to an extent where the thread soon would break. To prevent this, a piece of mechanism has been invented, called appropriately "the sun and planet motion," consisting of a large wheel within which two other wheels are made to work, with the result that the "sun" wheel decreases in speed with every layer of cotton wound.

From the slubbing-frame the cotton goes first to the intermediate frame and then to the roving-frame, where it is still further twisted. The operations of these machines need not be described. When the thread comes from the roving-frame, it is not yet yarn, but it has reached its final stage of preparation and is ready for the operation of spinning, strictly so called. Spinning is accomplished on either a throstle-frame or a mule, the former being chiefly used for coarse warps, while on the latter, which is rapidly supplanting the throstle, both coarse and fine yarns are spun.

The self-acting mule of the modern cotton-factory is so perfect a machine that further improvement in its construction seems impossible. A slight touch of the hand on the part of the spinner, to shift a belt or move a wheel, is sufficient to set in motion parts which seem endowed with almost human intelligence. Hundreds of swiftly working spindles, mounted on movable carriages which, their draft finished, return automatically to their places, again to receive their charge of roving, form a picture of factory activity not soon to be forgotten by a visitor to a cotton-mill.

In the self-acting mule all the movements of spinning are so regulated as to succeed one another in their proper order, the end of one operation being the beginning of the next. In its structural features, the mule contains, first, a system of drawing-rollers, and the attenuated roving as it issues from between them is twisted by the action of spindles mounted on a movable carriage that recedes from the rollers a little faster than the roving comes from them. The manner in which the twist is imparted by the spindles is not very different from that of the old spinning-spindle.

About one-half the labor-cost of converting a pound of raw cotton into cloth is represented by the operation of weaving. Eight years ago, it was much larger. The decreased expense is due to new inventions and improvements in regard to the loom, which shows the most important recent advance of all cotton machinery.

The power-loom was invented by Arkwright in England in 1785, and reinvented

A ROOM FULL OF POWER-LOOMS IN A NEW ENGLAND COTTON-MILL.

in the United States by Lowell in 1814. But the problem of the loom still bothered manufacturers. The capacity of a shuttle must always remain limited, and at the speed at which modern looms are run the yarn in the shuttle-box is exhausted in from seven to eight minutes. The solution of the difficulty lay in some method which would prevent the loss of time occupied in changing shuttles, and this has now been accomplished by a device which gives the shuttle a fresh supply of weft without removing it from the loom. By a warp-stopping device, also, the machine is stopped instantly on the breaking of a single thread. It is now customary in many factories for the weaver, on quitting his work for dinner, to leave all his looms running, and the filling-magazines all full. If there should be any breakage of the warp in any machine, that machine at once would stop, and no imperfect cloth be woven.

Plain cloth, such as a piece of calico, consists of two sets of threads, the one intersecting the other at right angles, each single thread passing alternately over one and under the next. To make such a web, the weft thread is passed over and under each alternate warp thread in the breadth of the loom. This operation, and the beating, or closing up, of each successive warp thread, so as to make an even and close cloth, necessitate a rather complicated series of operations.

The actual weaving of the cotton is preceded by warping, which is an arrangement of all the longitudinal threads for the chain, or warp, of the web in a plane of parallel threads. This is done in a warping-frame, which consists of a large reel on which separate threads drawn from a range of bobbins are wound together in a spiral form to the required length of the web.

The power-loom has the same three principal motions—shedding, picking and beating up—that characterized the old hand-loom, with which, it will be assumed, the reader is more or less familiar. Motion is communicated to the working parts of the power-loom by a main shaft provided with two cranks which give an oscillating motion to the lay. Double cloth, in which the ground may be of inferior material and the surface of fine texture, may be woven in three ways: by having double warp surfaces, with the weft in the center; a warp center, with two weft faces, and distinct warps and wefts throughout.

In gauze-weaving, in which effects intermediate between lace and plain cloth are

produced—that is, where the warp and weft do not intersect at right angles—the warp threads are made to intertwist more or less among themselves. This results in the production of light, open textures.

WEAVING ON A POWER-LOOM.

After a piece of cloth leaves the looms, it is passed to the printing establishment, there to receive the colored impression which will mark the final stage in its evolution and in which form it will find its way to the counter of the merchant.

Printing is a branch of the textile industry in the United States which is of comparatively recent development. Until a few years ago, American manufacturers were unexpert with dyes and their patterns were seldom attractive. Now there are elaborate printing establishments, which employ expert dyers, whose whole work is to contrive popular designs and pleasing combinations of color. The fabrics which issue from them are equal in beauty and in permanence of color to any produced abroad.

Probably a million miles would not be too large an estimate of the length which the quantity of calico now turned out in American mills in a year would measure. A single piece—twenty-five yards—can be printed by machinery in less than one minute.

Before being printed, the gray calico is subjected to an elaborate process of bleaching. Here the skill of the inventor in devising means for decreasing the manual labor and hastening the completion of the various operations is conspicuously noticed. Formerly, each piece of goods was treated separately, being carried by hand from one stage to the next. Now many hundreds of pieces are connected, end to end, measuring perhaps thirty miles, and operated upon in one stretch.

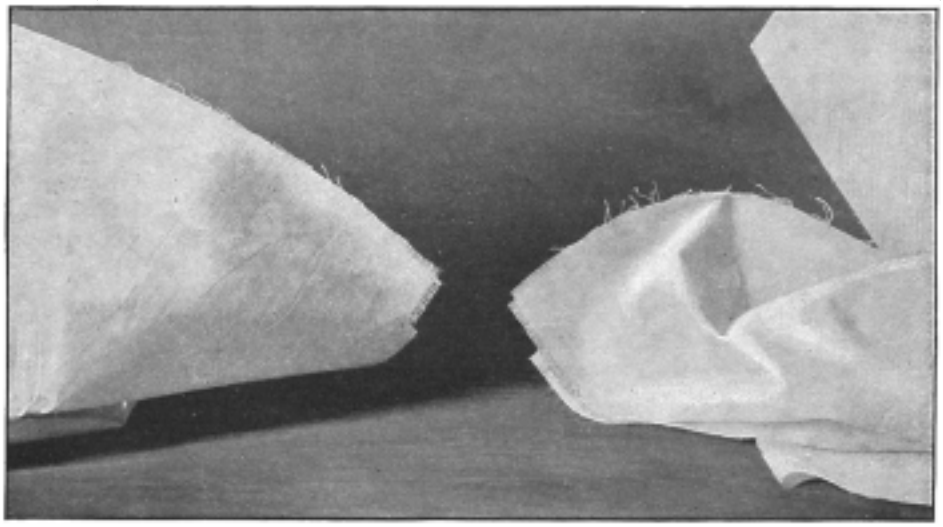
INSPECTION-ROOM : GOODS READY TO BE BALED FOR THE MARKET.

Two methods are employed in bleaching, according to whether the operation is a preliminary to printing the calico or whether the goods are to be printed white or unprinted. In the latter case only the eye of the purchaser needs to be considered, while in print-bleaching the material must be rendered chemically pure so that the colors may not be dull and blotchy.

A description, even in outline, of the several processes in the operation designated as bleaching would be unduly long. It will suffice to say that the cloth is first singed, which removes the downy thread from the surface; that it then is boiled and afterward washed; from the washing-machine it passes through a pair of squeezers, which expels a large portion of the water; it then is run through a souring solution to dissolve any remaining traces of free lime and to decompose the calcareous soap; after lying in the "sour" for sufficient time, it undergoes a second

boiling, and then is opened out and dried.

The printing of calico now is accomplished by means of cylinder machines, much in the same way as color-work in newspapers and magazines is done. The impression is given by one or a series of engraved copper cylinders, a different cylinder being required for each separate shade in the pattern. Many thousands of cylinders are kept constantly in stock in every large printing-establishment. Machines for printing calico are arranged to print with as many as twenty or twenty-five cylinders if necessary, though in ordinary practise few machines carrying more than eight or ten are used. The cloth is



THE FINISHED FABRIC—COTTON CLOTH.

fed to the printing-machine over tension rails, or rollers, and passes between the engraved copper cylinder and a large central "bowl," the cylinder being supplied with the printing material by means of furnishing rollers revolving in the several color-boxes.

A modern development of color-printing is the use of what are called topical or steam colors, with which there is no limit to the number and variety of shades which may be obtained. Each color-box on the cylinder printing-machine, according to this method, contains all the ingredients necessary to the production of a distinct color.

The preparation of the colors for calico-printing requires the exercise of much care. The substances to be printed on the surface of the cloth must be brought to a proper consistency for printing by means of thickeners, with which they are mixed together in color-pans. Wheat flour and starch, potato starch, dextrin and gum-senegal are among the thickeners employed.

The appearance of weight and bulk which many kinds of cotton goods have when they reach the counters of the merchant, is given by a process of starching by which the interstices between the fibers are filled up with compounds which serve no other purpose than to deceive the eye. Starch, either of corn or wheat, is used, made up into a stiff mucilage, into which the cloth is dipped, afterward to be squeezed through rollers and dried.

Yet this stiff, somewhat heavy cloth is made from the same cotton fiber which the hand-workers of Bengal spin and weave into a muslin so fine that when it is laid on the grass and the dew falls upon it, it is no longer discernible. "Webs of woven wind," this Dacca muslin is poetically called, and it has been a prized article of apparel among the Indian potentates. It sells—when it sells—at two hundred dollars the piece. But machinery, which makes the same quantity for two dollars, has played sad havoc with the poor Bengalese weaver.