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## THE MODERN COTTON SPINNING FACTORY

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Among the mechanic arts that of textile manufacturing is at the same time one of the oldest and the most highly organized. It includes some of the most ingenious mechanical appliances, and its products are at the same time of commercial and artistic value. It is proposed, in the present article and in those which are to follow it, to give the present state of this important art in the district in which it has attained its highest development, and from which the other parts of the world have drawn their experience and success.—THE EDITOR.

THE art of spinning fibres into threads dates back beyond recorded history. Fabrics woven from threads are found in Egyptian and Chaldean tombs, and nothing can be said as to the earliest methods of spinning beyond, perhaps, that the first threads were twisted up by hand from a bundle of loose fibres pulled out by the fingers in a manner but little different from the method of the hand spinners of to-day, and that these threads, in the earliest weaving, were worked much on the system of mat or basket making from twigs or reeds. Until about 150 years ago spinning was carried out on lines but little different from those handed down from remote ages. Mechanically, there was a single spindle revolved by a wheel and band, but there was nothing in the shape of a roving: the thread was drawn out by the fingers from a loose mass of cleaned fibre. The modern cotton spinning factory consists of three departments: (a) a department for cleaning the fibre; (b) a department for spinning this fibre into threads. The latter department is simply a

many-multiplied hand spinning spindle taking its supply of fibre from department (a) through the intermediary of a third department (c), which forms a series of extensions of (a) and (b) towards each other, and gives a more gradual transition of the cleaned loose fibre into the hard-twisted thread. According to the observed law of averages, any hundred casually selected articles will be more nearly the weight of any other hundred, similarly selected, than will two such articles be alike in weight. So in cotton spinning, the final thread produced by the mule or by the ring spinning frame, though primarily the result of the calculated reduction of so many pounds of cotton wool into so many hanks of yarn, is, secondarily, the average of many hundreds, or even thousands, of the primarily calculated threads. Thus, reduced so many times and laid parallel with themselves over and over again, the surplus thicknesses and deficiencies of the different threads average out into the even thread known as twist or as weft. When raw cotton arrives at the factory it is contained in

heavily pressed bales wrapped in coarse sacking and banded with hoop-iron, and it contains some seed, broken leaf, shreds of husk and more or less dirt and sand, not always innocently introduced.

When cotton manufacturing became a growing industry there was, perhaps, no special reason why it should settle in and round Southeast Lancashire; for no doubt the industry was widely spread at first, and we read of Arkwright setting up his mills at Cromford and Belper, for the people of Lancashire did all they could to destroy his machinery. But the climate of the county, its coal and iron, its excellent soft water and a certain energy in the people combined to give to Lancashire a great advantage. Climate particularly favoured the industry, for cotton spins best in a moist climate. In dry air cotton fibre becomes harsh and refuses to lie peaceably with its fellows. If the air of a factory is too dry, it becomes statically electrified, and this causes the cotton fibres to stand out like quills on the fretful porcupine. And so, for good or ill, the industry possessed the County Palatine, and the county possessed the industry, and cotton spinning, weaving, dyeing or bleaching, or the trades attendant on these four branches of the cotton manufacture, make up most of the trade there is in the county. True there is woollen at Rochdale and round about, and there is cotton spinning in the teapot handle of Cheshire, in the northwest corner of Derbyshire, and, indeed, more or less all over the county, and even in Yorkshire and round Nottingham, Leicestershire and in the County of Stafford. But Lancashire is the locus *par excellence*, and, in Lancashire, Oldham stands pre-eminent for the standard yarns of sizes 28 to 32, these numbers, by which yarns are described, signifying the number of hanks of 840 yards contained in one pound of yarn. Cotton is spun as low as No. 4. Nos. 12 to 24 are termed coarse counts. Nos. 28 to 36

are termed Oldham counts. Fine counts are spun in Manchester and Bolton, and may run up to 250 or even 500, though 120 is considered fine. It is said that yarn of over 2,000 hanks per pound has been spun as a curiosity. It would be impossible, in the space of a single article, to give a description of the machinery employed for different counts. Suffice to say that its general lines are very uniform, minor differences in detail not visible to the casual observer alone existing. For example, throughout all operations there is the process of drawing the cotton between rollers, each successive pair of rollers rotating more quickly than the pair before it. According to the count of the yarn so must be the length of the staple employed, and, if the fibre or staple be, say,  $1\frac{1}{4}$  inches in length, it would be broken if an attempt were made to pass it between sets of rollers only 1 inch apart. The roller centre distances must, therefore, approximate to the length of the staple, so that the sliver of cotton may easily be drawn out in passing through.

In this article, therefore, it is proposed to describe and illustrate the buildings and machinery of a modern factory. The size of a mill is always thus stated in terms of the number of spinning spindles it contains. The spindles of the preparation machinery of department (c) are not counted in this statement. Cotton, as it arrives at the factory, is simply a mass of curly, twisted, matted and pressed fibres, and the process of manufacture consists in cleaning these fibres, taking out their twists and curls, laying them all even and straight and parallel, and then twisting them into threads. There are in the main seven processes, and some of these are divided into multiple stages, while others are much alike in their characteristics. Every machine, however, may well be separately described which takes its share in the sequence of mixing, opening, cleaning, carding, drawing, slubbing and spinning.

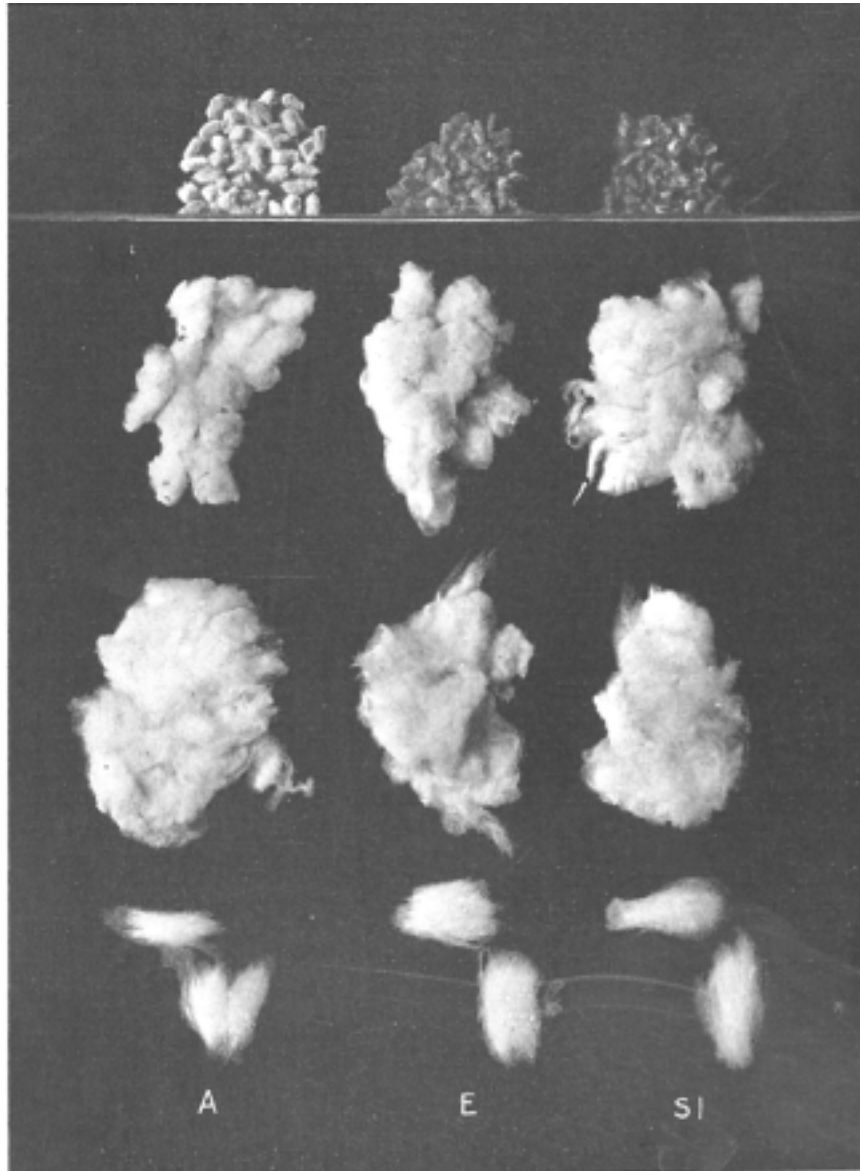


FIG. 1.—SEEDS, SEED COTTON, GINNED COTTON AND STRAIGHTENED FIBRES  
A, American; E, Egyptian; SI, Sea Island Specimens.

Cotton fibre differs very much in length or quality. The highest class is the Sea Islands cotton, grown in Fiji, Tahiti, the Bahamas or the Florida coast. Its fibre has a length of  $1\frac{1}{4}$  inches to  $2\frac{1}{4}$  inches, and a diameter variously stated at 0.000833 to 0.00064 of an inch. It is soft and

silky, and is used for the finest yarns. Egyptian fibre is also of fairly soft and silky quality, but is strong and tough, and makes good driving ropes. Its length is from 1 inch to  $1\frac{1}{2}$  inches m., and its diameter about 0.00065 inch m. Brazilian fibre runs from 1 inch to  $1\frac{1}{4}$  inches. American

cotton—the main staple of the industry—varies from  $\frac{3}{4}$  inch to a full  $1\frac{1}{4}$  inches, while Indian cottons may be as short as  $\frac{1}{2}$  inch or less up to  $1\frac{1}{8}$  inches for the better varieties, and useful for the coarser counts of yarn up to about 28's twist. Upon the fineness of the yarn to be spun depends the sort of cotton that must be used, and upon the raw cotton that has to be treated depends the style of the cleaning machinery and the general operation of cleaning, the ratio of the different machines to be employed throughout the whole factory, and the details of the machinery, especially as regards the roller centres distances of all the drawing rollers. Substantially the process is alike for all varieties and all counts. In the finer counts there is introduced the additional process of combing, but this is the only difference of process throughout. Usually all the preparation machinery for three or even four spinning rooms can be contained in one room, extended, it may be, some distance beyond the width of the other rooms by a shed extension beyond one side wall of the mill.

#### GENERAL

Probably in no great industry is the machinery so varied and, in a sense, uneven in its degree of complication as in the machinery of cotton spinning. In the first preparation is found the combination of heavy rotating beaters, with the system of conveyance by a gentle blast of air of the material operated upon. And that very current of air is made to serve not merely as a transporting agent of the loosened fibres, but it is made to do duty in carrying off dust from the fibre, and, as in the scutcher, in effecting an even distribution of the material in the form of a thick blanket, the lap. Then in the carding engine the fibre is somewhat roughly treated by means of a multitude of light wire brushes, and, while the carding is effectually done, it is by no means easy to see just how this is contrived, nor is it very

clear how the shorter fibres are flung off as waste or "fly" while the longer fibres find their way to the doffing cylinder. Consider for a moment the vital operation of drawing. The machinery for doing this is essentially but four lines of rollers easily and simply driven at different velocities. Beyond this there are only the very simple stop motions. The much less important machines, which serve simply to reduce the diameter of the sliver, are provided with most ingenious trains of mechanism—skew or hyperboloidal gears for spindle driving, a differential motion of repeatedly varying degree in respect of the differential of rotation, but of uniform differential of peripheral or surface velocity, and a most ingenious changing motion for the bobbin rail, which determines the double cone winding on the bobbins.

The actual operation of spinning is simplicity itself; yet how complicated is one of the machines by which the operation is carried out, and how very simple is the throstle or water frame of Arkwright, so called because it was first power-driven by waterwheels at Cromford, and because it was compared by the workers, as a singer, with the song thrush known in Lancashire and surrounding countries as a "throstle"! In this machine there are simply rollers, spindles driven from a plain tin roller, drag upon the yarn brought about by the crude expedient of power-wasting friction, and a coping motion given by a heart cam—that refuge of the idea-destitute mechanician.

How very different this from the self-acting mule spinning frame of Crompton as it has become to-day, the premier machine of the whole industry, which, in its one headstock, has gathered up such a collection of gearing, linkage, cams, detents, levers, scrolls, band wheels and other pieces of mechanism as never did before combine in one machine for the apparently simple purpose of turning three lines of rollers and a lot of

identical spindles at certain relative rates of rotation! What this complicated machine does, and does to very great perfection, can be done by a lady's two hands with a bunch of cotton wool and a single spindle. With one hand she will do what the rollers do in the self-actor; with the others she will carry out the work of the simply rotating spindle. The complicated mule will hardly make a better yarn than the lady; but the mule turns 1,000 or 1,400 spindles at one time, and, on each of them, winds identical yarn and produces a cop ready for the weaver's shuttle. A newcomer will need to watch a mule at work for several days before he can get a clear, connected picture of its many movements into his mind and grasp the special co-relation, on a time basis, of each movement, or even find out all there is of hidden details, detents hidden in a rotating box, motions, backing-off or stripping gears, stretch and other movements, all combining for better efficiency and greater output. It may appear wonderful that so complicated a machine as this mule, with its long-moving, spindle-carrying carriage, should be allowed to continue in use in face of the simple throstle or its rival, the ring frame. It does seem strange that, after the thousand or ten thousand foldings of the original scutched lap, there should be any further improvement possible in the evenness of the spun thread. But it is because of this possibility of further improvement that the mule holds its own. It does so because of a special and peculiar property of all twisted fibres. More turns per inch will run into a thin strand of fibre than into a thicker strand, as can very well be shown by taking a foot length of roving and attaching it to the same length of intermediate slubbing, when, by twisting one end with the thumb and finger, the thinner roving will receive by far the larger number of turns in each inch of its length. It is a further property of the fibre that the frictional grip of

the fibres, one upon another, that is given by the twist in the smaller roving is considerably greater than the grip of the larger number of fibres with the smaller number of turns. Thus, if this piece of twisted fibre be pulled slowly out lengthwise, it will first begin to fail by stretching of the thicker portions. But as these pull out and become thinner, more turns run into the thinned places, which cease to extend. Another thicker part now begins to fail, and, assuming that a sufficiency of further twist is added to maintain strength, twist again runs into it and saves it before it breaks. Thus, bit by bit, every part of the thick piece will gradually stretch, by sliding of the fibres longitudinally upon each other, until the whole thread has been drawn out to an even thickness with the thinner length, and with the same number of twists per inch throughout. While still only half spun, a continuation of the stretching will continue to attenuate the thread, and always the most twist will run into the thinnest places and make them the strongest, thus compelling the thicker places to yield.

In a long rope walk, when a man casts a loop of tow over a horizontally revolving hook and pays out tow with his fingers from a bundle of fibre attached to his body, this action is carried out, for the man walks backward faster than he pays out tow, and he stretches the soft spun yarn to render it even. The man represents the traveling carriage of the mule, save that, in the mule, it is the spindles that are carried by the moving carriage, and in the rope walk the creel is on the moving piece and the spindle is stationary in place. This stretching action is one of the grand principles of the mule, its carriage, as elsewhere described, moving out from the roller beam faster than the front roller speed, so that the threads must break or stretch. They stretch, and observation will show the thicker places becoming reduced. Especially will this be ap-

parent when, as occasionally happens, quite a lump of fibre may come out from the rollers. Such lumps will cause breakage if they are short balls of badly-drawn stuff. But if they do not break they will disappear suddenly, having pulled out and taken twist. The machinery of a spinning mill, after the mule, is of no very special complexity. There is the winding frame, on which the small bobbins of yarn, spun on the

has been said it will be clear that there is not any particular relation between the importance of an operation and the complexity of the means of carrying it out. Yet every machine is a survival and a development through many years of invention, improvement and demand, and its mechanism is devised to the best carrying out of an even and regular twisting of parallel fibres. It need hardly be said that every improve-



FIG. 2.—KAGOSHIMA MILL, JAPAN (BUILT BY PRINCE SATSUMA, 1866). THE FIRST MILL IN JAPAN.  
PLATT BROS., OLDHAM

throstle frame, are wound off upon large bobbins, to be set in the creel of the warping mill, which collects hundreds of threads in a certain order to form, in one long length, a band of parallel threads, which, when arranged properly in the loom, form the warp ready to be woven into cloth by the flying shuttle—the invention of Kay, a Bury man. But here the machinery ceases to be that of spinning, and this article is not concerned with weaving. From what ment in the preparation of the fibre

has trenched more and more upon the superiority of the mule. But the mule still stands pre-eminent for the finer counts of yarn, as it stands first as a beautiful piece of mechanism for performing one of the prettiest of operations. Each time the carriage runs out over a mile of yarn is made, and a standard mill of 70,000 spindles averaging 32's will turn out 1,000,000 miles every week, or sufficient to envelop the earth forty times round the equator.

As already stated, the home of cot-

ton spinning is the County of Lancashire. Owing largely to its climate, the atmosphere being by nature largely charged with water vapour, and to the particular genius of its inhabitants, Lancashire stands pre-eminent in the spinning of the cotton fibre, and the Lancashire machine makers cannot be touched in the excellence of their products. Unlike the machine-tool trade, which shows, generally, firms which make but a

been chiefly felt in the coarser qualities of yarn, and the tendency in Lancashire is towards the spinning of the finer and better qualities. Thus, where the town of Oldham at one time produced yarns from 24 to 36 hanks per pound, it is now quite common to find Oldham mills spinning 120's and 136's, the hank being a length of single yarn of 840 yards and the numbers or counts of the yarn signifying the number of



FIG. 3.—OSAKA MILL, JAPAN (1888). PLATT BROS. & CO., LTD., OLDHAM

few tools, the biggest houses in the textile machinery trade make every machine that is required in a cotton-spinning factory. They have supplied these machines to every country in which cotton spinning is carried on, and Lancashire-made machinery is to be found in France, Germany, Italy, Austria, Spain, India, Japan and America, Brazil and Mexico, and also in China, Russia, Turkey, Greece and Portugal. Competition has, of course, been fostered against the Lancashire spinner; but the effect so far has

hanks per pound weight of yarn.

Whatever the counts spun, the general operations of the factory are identical. The finer counts demand the use of better fibre, and an additional process—combing—is now introduced between the operation of carding and that of drawing. The raw material or cotton fibre varies greatly, and the quality of fibre is very much a matter of the climate in which it is grown. Thus, from India the fibre is short and somewhat harsh, and it suffers also from

admixture of broken leaf and dirt, and this renders the cleaning more difficult. By the use of better seed the fibre can be improved, but the plants gradually deteriorate and the fibre soon falls back to that native to the locality, and cotton, grown in the Surat district from American seed, soon again acquires the characteristics which distinguish it as Surat. Good, fairly clean fibre of moderate staple comes from the United States in enormous quantities. From the littoral of the United States comes the Sea Islands cotton, which is characterized by length of fibre and a more soft and silky nature; and the next, but long, staple fibre, very soft and silky, and suitable for fine spinning, is the product of Egypt.

The cotton fibre, as grown, is enclosed in a husk or pod or shell somewhat like a soft-shell nut, the fibres enclosing a number of seeds, to which they are attached. The pods, when ripe, burst, and the fibre swells up to many times the size of the pod and is picked by hand. It has now to be ginned, to remove the seed. In one form of gin the balls of cotton are fed to a small roller, which drags the fibre from the seeds which cannot be drawn by the rollers into the narrow slit between the roller and a sharp-edged steel plate, which is presented to the rounded seed, while a second reciprocating plate pushes away and assists to strip the seed. The stripped seed falls from the rollers and the fibre passes through. In the saw gin a series of toothed discs, like circular saws, project through a sort of comb or slotted plate through which the fibres are dragged, leaving the seeds on the face of the comb, from which, when stripped, they fall away.

The ginned cotton, more or less mixed with broken seeds, parts of husk, leaf and dust, is then heavily pressed into bales; and this raw fibre, crushed and bent and compressed, is the raw material from which Lancashire manufactures cotton goods to

the value of over £100,000,000 sterling annually for export alone.

Though the raw material arrives nominally graded as to quality, every bale differs somewhat, and, from every pod, fibres more or less short and immature are derived. It is necessary, especially with fine yarns, in order to secure an even product, that the raw cotton shall be blended, cleaned, opened up, and the short fibres removed. The short fibres from long staple cotton are used for the spinning of coarser counts. Thus the fibres rejected from the factory spinning 130's will be good for spinning medium numbers, and the waste from 60's will spin excellent coarse counts, and so on.

It is an axiom in cotton spinning that the biggest possible mixing should be made by mingling as many bales in one bin as can conveniently be done. From this mixing bin the cotton is raked down onto the floor and fed to the opener, which further cleans and separates the fibres, which are next well beaten in the scutcher and drawn clear of dust by a suction fan. Hence the fibre passes to the carding engine, which opens out the cotton into a filmy fleece, with every fibre separate and distinct, but not yet parallel. In spinning the coarser counts, the fibres are made to lie fairly parallel in the next operation of drawing, and no more fibre is usually rejected after the carding operation; but for finer work the carded cotton is combed, the shorter fibres are removed, and the long fibres are laid straight and parallel, and, after combing, there is no more fibre rejected. The operation of drawing ends the first preparation and delivers the fibre in the form of a sliver or loose, slightly twisted, soft round band of fibre about  $\frac{3}{4}$  inch in diameter and just able to hold together. All subsequent operations are of the nature of spinning. Throughout the whole process every endeavour is made to secure an even product. Four of the first-made laps from the opener go to form a similar



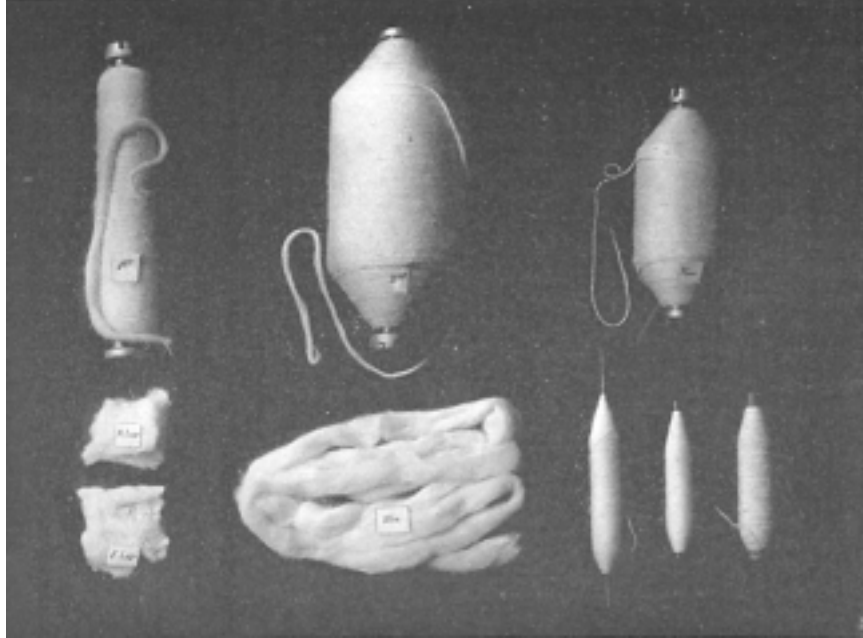


FIG. 4.—FIRST AND SECOND SLUBBINGS, ROVING LAP, SLIVER AND COPS OF MULE YARN  
A, American Lap; E, Egyptian Lap.

lap in the second scutcher. Six slivers from the cards may be combined in a preliminary drawing operation. Eighteen or twenty of these slivers combine to form a sliver lap, and perhaps six sliver laps go to form a ribbon lap. Then the combed ribbon laps unite by sixes to form a fresh sliver, and six such slivers are drawn into one, and these, again, combined in six, and again in six, and, in subsequent operations, there is a series of duplications aggregating, perhaps, sixteen-fold, so that a thread of mule yarn may be the product of  $4 \times 6 \times 20 \times 6 \times 6 \times 6 \times 6 \times 6 \times 16$ , or nearly sixty million doublings of lap, every combination being accompanied by a greater ratio of drawing down, so that there is constant reduction of size, and the final product can only contain a mere fraction of any original over- or under-weight portion of the original feed to the scutcher or of any original lap variation.

So far as the Lancashire industry

is concerned, the cotton fibre is nominally free from seeds, and the gin takes no place in a spinning factory, its use being confined to the country of origin, the seed being crushed for oil. The first operation in Lancashire is, therefore, the opening of the bales and the mixing of their contents preparatory to the cleaning operations, though there is considerable cleaning now done in the very first operation of breaking up the bales.

#### MIXING

There are two usual systems of mixing cotton. The object of mixing is to obtain yarn that has the necessary qualities and is made from cottons of a price that will yield a profit. Thus, the spinner can use American cotton, Indian cotton or fly, this latter being the shorter fibres which are carded out of longer staple material, in preparing this for the spinning of finer counts. Fly from good, long staple cotton may thus easily be better material than rough American or

Indian staple. In some mills each class of staple is passed by itself through the processes of opening and scutching. From this last machine the cotton is delivered in the form of a wide, thick, fairly even blanket, and several of these large rolls of blanket are then placed on the feeder of a second similar machine and are delivered from this machine in a final similar blanket, which is passed on to the carding engine. Mixing may be carried out at the scutcher, four American and two Indian rolls,

then raked down vertically from the door of the bin and fed to the opener, where it becomes better incorporated. All the laps fed to the second scutching or lap machine are, therefore, of the same nominal mixture, and such differences as they possess are averaged out by the feeding of several laps at one time to this machine. Probably there is not much to choose between the two methods, but by this latter method it cannot be known how much each particular variety of staple loses in

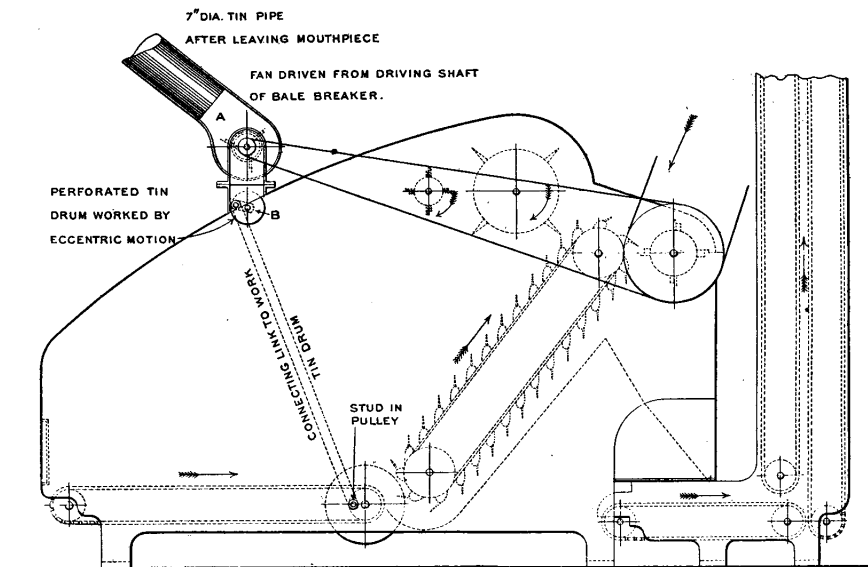


FIG. 5.—HOPPER BALE BREAKER, ASA LEES & CO., LTD., SOHO IRON WORKS, OLDHAM

or any other desired proportion, being passed together through the second scutcher, in which mixture is effected, the result being a lap of mixed cotton containing the desired proportions of each staple. Other spinners have large cages or bins into which, by hand, men fling the slabs of cotton they tear from the packed mass of a bale; but this custom is practically obsolete. They strew the material as evenly as possible over the area of the bin in alternate layers of, it may be, four American bales to one of fly or Surat. Twenty bales may go to a bin or mixing, and the mixed material is

the cleaning processes. By the former method this may be told with fair accuracy from the known weight of bales fed to the opener and the weight of laps delivered from the first scutcher. Some will feed the fibre direct to the opener from the bale; but it is, perhaps, wiser in all cases to break down the bales into a bin, whether for mixing or not; for, after all, this does help to average bales of the same nominal cotton, and it serves to discover stones, knives, matchboxes and sundry trifles not unknown to the cotton-opening loft. Thus there is, first, a loft above the bins, and from the bins the

staple is fed by hand to the opener.

In a recently-built mill, spinning fine counts of 120's to 140's, the cellar of the mill is used as the mixing room. The bales of Egyptian cotton are opened at the end of a machine called a bale breaker, and slabs of the bale are flung into the hopper, Fig. 5. In this hopper there is a traveling lattice band carrying

mainly the whole of the fibre will be disposed of. As the lattice travels over the top roller, the spikes are now pointed downwards and easily part company with the fibre under the persuasion of a second revolving beater, which drives off the loosened pieces of fibre over an open-gridded surface through which dust and dirt fall. The loose cotton then falls upon

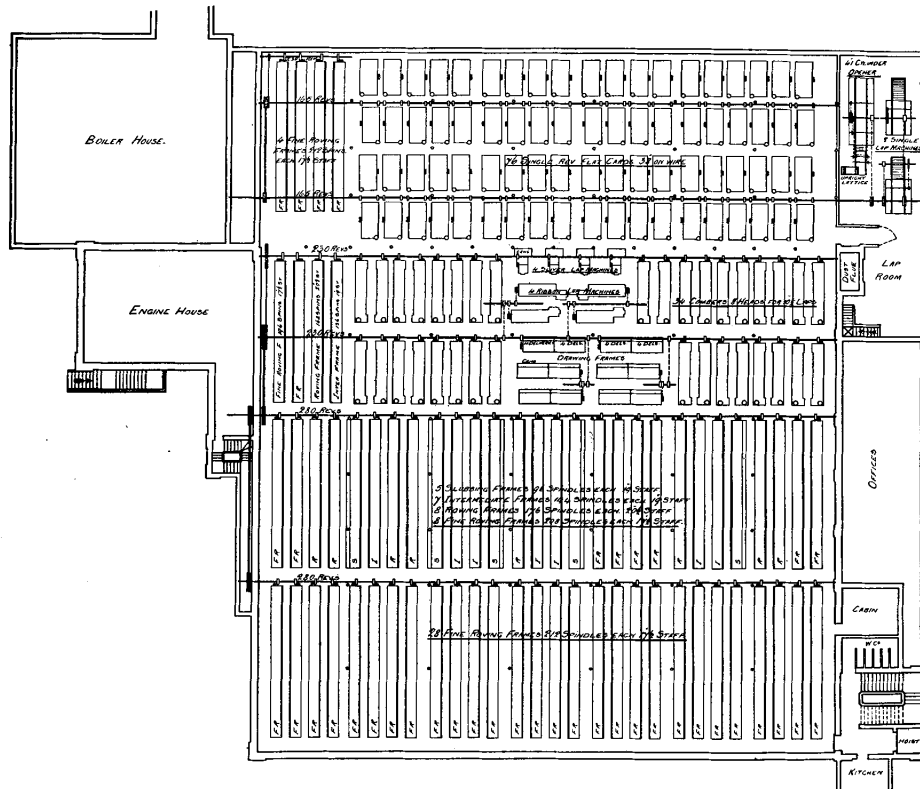


FIG. 6.—CAXO MILL, OLDHAM. MACHINERY BY ASA LEES & CO., LTD.

acutely sloped spikes about 2 inches long. These spikes attack the lumps of matted fibre and carry them upwards. Arrived at the top of the hopper, the band travels under a revolving beater, and this beats off the projecting lumps of fibre and tumbles them back to the hopper floor, which is either sloped forward or has a slow forward movement of a lattice creeper, so that there is a constant supply of fibre pressed against the spiked lattice band; and ulti-

another lattice, which conveys it horizontally to a pair of vertical lattices, between which the fibre is held and raised to other traveling lattices and finally delivered upon a long combination lattice the different lengths of which can be made to move in either direction, thus enabling the fibre to be dropped into any one of several large cage bins over which this long lattice travels. The bale breaker has an exhaust fan above it, and this draws a current of air through the

tumbling cotton and frees it of much dust. The use of the fan is universal through all the cleaning machinery, for the air blast not only carries off dust, but it causes the flying fibres to deposit evenly upon the perforated zinc rotating cylinders in the scutchers, and so helps—indeed, is essential to—the formation of an even lap or blanket, in which form the fibre is delivered to the cards.

In the Cairo mill, Oldham,

being simply a closely-spiked roller, and delivered upon the floor lattice on which the cotton from the mixing bins is hand spread. Thus the waste is evenly distributed among the fresh fibre and travels up with it between the pair of vertical lattices to the floor above or lap room. Here the double upright lattice delivers into a hopper feeder, which delivers to a combined opener and lap machine, and the laps from this

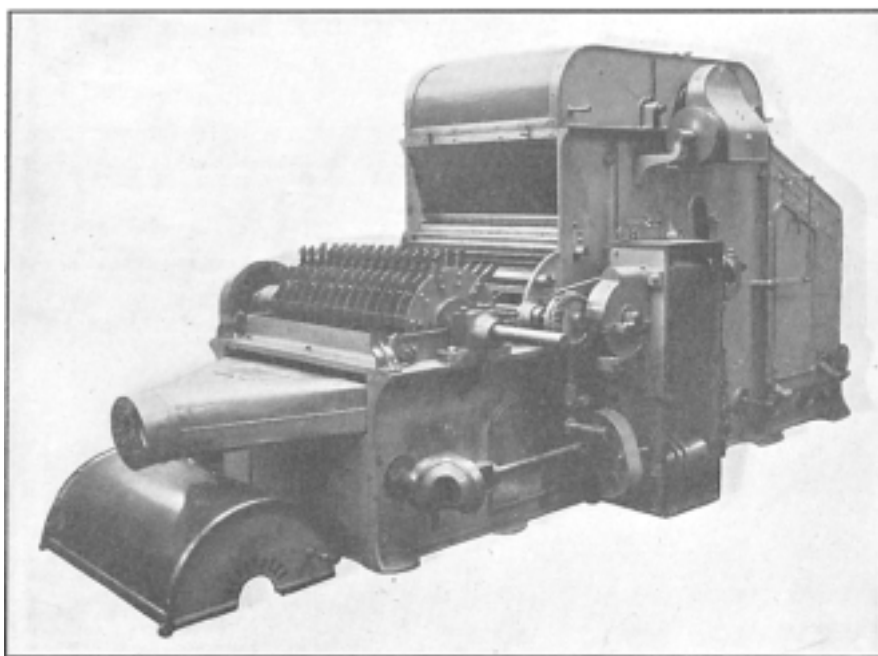


FIG. 7.—HOPPER FEEDER WITH PORCUPINE BEATER. DOBSON & BARLOW, LTD., BOLTON

Fig. 6, spinning fine counts, the machinery in the bale room below the floor illustrated consists of one hopper bale breaker, as above, delivering to upright and overhead lattices, and a breaking-up machine in which the waste of the roving and slubbing frames is torn up again. This waste is merely good material spoiled in the process of manufacture, and not waste in the sense of being inferior material. There is not much of it, and it is spread on a very slowly-moving creeper, passed through the beater cage, the beater

are placed, four together, upon the feed lattices of two lap machines or scutchers (Fig. 18). This completes the outfit of the first series of processes.

The hopper feeder, Fig. 7, above named, is a machine not unlike the bale breaker. In the hopper is a swinging spade or plate, against which the cotton in the hopper presses. According to the pressure, so the position of this swinging plate, which in turn controls conical feed drums and regulates the amount of cotton passing forward. This is

the first regulation of the weight of fibre per unit length. This hopper feeder, Fig. 7 spreads the cotton on the feeder lattice of a combined Buckley opener and lap machine, Fig. 8. In this machine the cotton is beaten by a revolving spiked beater and delivered upon the face of an exhausted zinc cylinder, which passes it on to the scutcher beater. This consists of a pair of, or sometimes three, steel flat bars fixed to the ends of a number of arms, the diameter of the beater being 20 inches. The flat edges of the beater bars strike the cotton as it comes through a pair of heavily weighted, small fluted rollers. The rapid blows knock out any remaining seeds, which are driven through the gridded cage in which the beater revolves, and the scutched fibre travels forward upon an exhausted cage and is finally delivered of fairly even thickness to a set of rollers, which roll the loose blanket of cotton or lap upon a small roller into the form of a cylinder about 41 inches long and 24 inches diameter. These laps, as they are termed, are placed four or five upon one lattice feeder of a second scutching machine and pass through another beating, and this machine delivers a similar finished lap, which is now ready for carding.

#### OPENING

The operation of opening or wil-  
lowing, once performed by beating  
the cotton on an open grid with wil-  
low spikes, was next carried out in  
a machine named a devil, a willow  
or an opener. In this machine the  
fibre is fed steadily and continuously  
into a cage of iron bars, in which  
there is a rapidly revolving cylinder  
covered with projecting round, blunt  
spikes, as in the Oldham willow,  
with horizontal shaft; or the rotat-  
ing beater is built up of a series of  
iron discs armed round the edge with  
flat, projecting steel bars. Fans draw  
a current of air through the cage  
and remove dust, the beaters drive  
out seeds by velocity, or break up

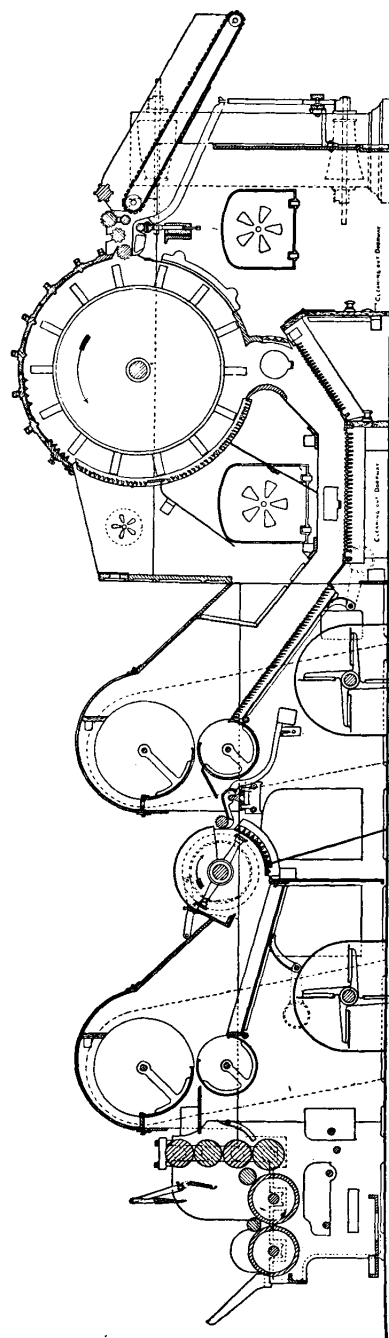


FIG. 8.—SECTIONAL VIEW OF A BUCKLEY OPENER AND LAP MACHINE. HOWARD & BULLOUGH, LTD.

pebbles and drive them through the bars. In the willow the cotton was fed in measured quantity, beaten for a time and turned out through an automatically-opened door loosened and fluffed out into light, clean fibre. The modern opener of the Crighton variety, Fig. 10, feeds the beaten cotton forward up a tapered, barred cage of increasing diameter, and sometimes away to a second beater,

the cotton from the beater cage when the fibre has become sufficiently light and open. Thus when sufficiently beaten, it is drawn away before being injured. Sometimes the opener has been combined with a scutcher beater, a questionable advantage unless combined with regulating apparatus; for if any use is to be made of the lap produced the cotton must be weighed to the opener upon a

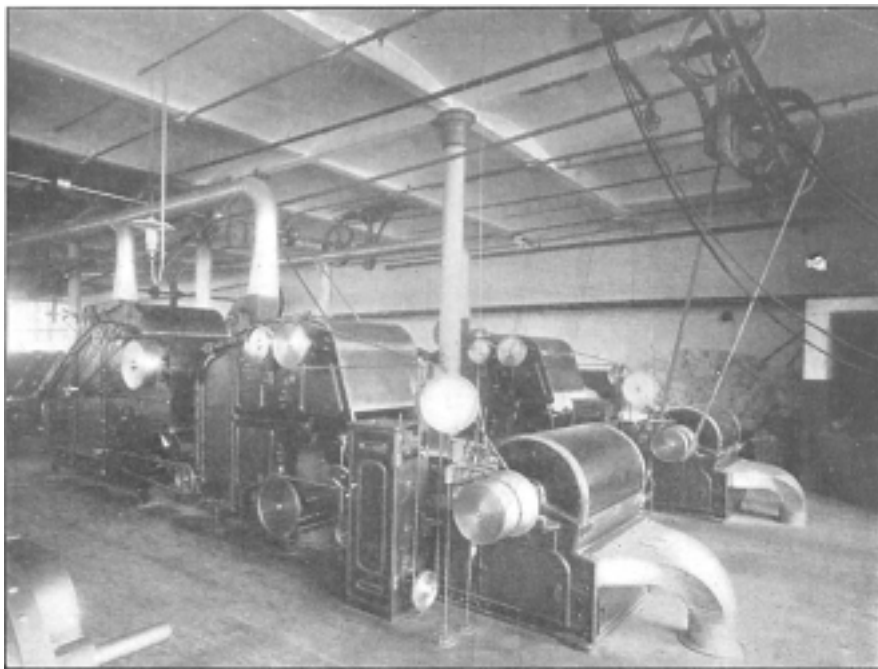


FIG. 9.—COMBINED BALE BREAKER HOPPER FEEDER AND PORCUPINE OPENER WITH REGULATOR.  
ASA LEES & CO., LTD., OLDHAM

and delivers the cleaned fibre ready for scutching.

In the course of the passage of the beaten fibre through an opener there are revolving cages of perforated sheet metal from which the fan exhausts air, and the beaten fibre, driven in a cloud from the beater cage of bars, settles on the perforated cylinder cage and parts with its dust, the cage carrying forward the cotton to the delivery point. Cotton must not be beaten too much. In the Crighton opener the draught of the fan is so regulated that it only draws

brattice, a brattice being a traveling chain of wooden laths or "lats," one lat painted black every four or five feet, and between such painted lats a given weight or fibre being spread. Thus the opener is given a continuous feed, and, while this is good in its way, there is always the greater variation of error, owing to dirt, than when the first weighing is performed on the brattice of the first scutcher after most of the dirt has been removed in the opener.

These remarks apply rather to coarser counts and older methods.

With the preliminary bale breaker and the hopper feeder with the swinging spade feed regulator, the combination of opener and a single beater scutcher appears to have become established practice, especially for fine counts, as previously described.

While the various machines illustrated are those made by different makers, it is not usual to fit up a factory with machines of different makers. Thus, the Cairo mill, of which Fig. 6 is the card room, was fitted throughout by Asa Lees & Co., of Oldham. Similarly, Platt Bros., of Oldham; Dobson & Barlow, of Bolton; Howard & Bullough, of Accrington, and John Hetherington

usually obtained from more than one firm.

In passing through both lap machines the weight of fibre per unit of length of lap is regulated by means of a motion known as a piano motion, and consisting of a series of levers or pedals, Fig. 14, which press up against a roller just behind the feed rollers to the beaters. The cotton passes between these pedals and the roller above, and the pedals are more or less depressed from the roller, according as a thick or thin layer of fibre is coming through. To each pedal pad hangs a rod, Fig. 12, at the lower end of which is a tapered length, and all these tapered rod ends

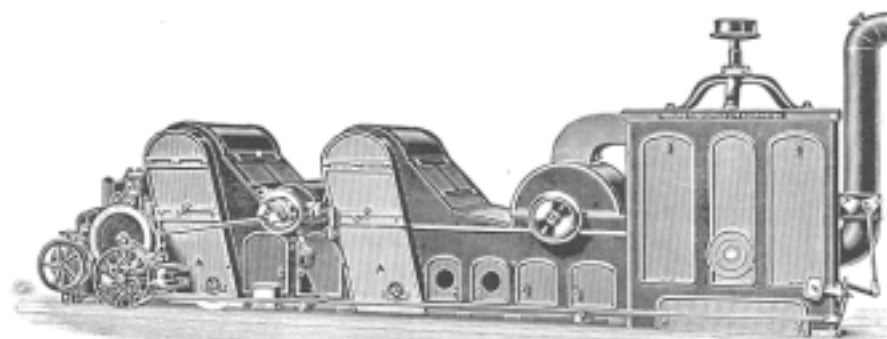


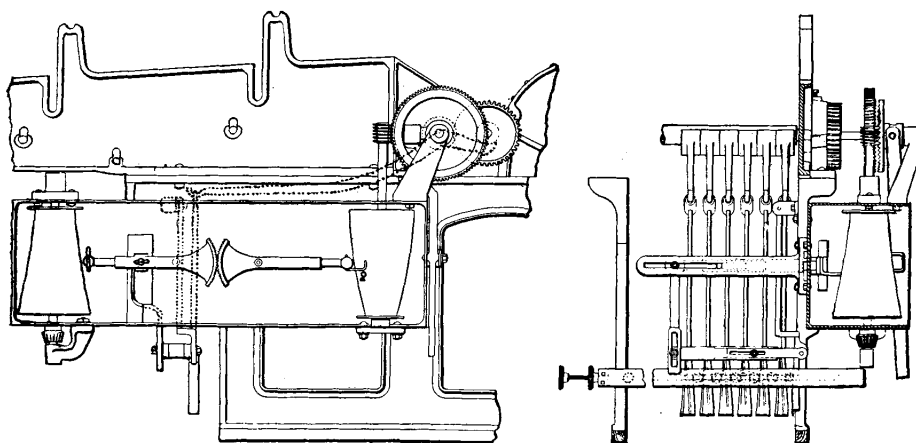
FIG. 10.—CRIGHTON OPENER; HOWARD & BULLOUGH, LTD., ACCRINGTON

& Sons, of Manchester, fit up mills complete.

Other firms, like Brooks & Doxey, of Gorton, and Tweedales & Smalley, of Castleton, do not make every machine, nor do Lord Bros., of Todmorden, or Taylor, Lang & Co., of Staleybridge.

Every machine maker has some special machine in which it is customary to say among spinners that special excellence is reached. Then, again, while it would be unusual to find two different makers of, say, mules or of speed frames, in one mill, it will be quite usual to find one maker fitting up all preparation machinery, while another puts in the mules and a third, perhaps, supplies the ring spinning frames. But machinery of the same order is not

are packed side by side in a narrow frame with roller divisions, Fig. 13. Thus, if all the rods are lowered at once, the length occupied in the frame will be considerably altered, and similarly, but in the opposite sense, if all rods are raised at once. As the 41 inches of roller breadth is divided up into a large number of pedals, each little section of lap is taken care of by its own pedal, and some pedals are up and others are down, and the end movement of the frame is only the algebraic sum or difference of the various rod end breadths at the roller centres in the frame. The device integrates the many movements of the rod ends, and the net end movement of frame is a mean of the whole up-and-down movements of the many pedals, and



FIGS. 11 AND 12.—IMPROVED SELF-ACTING "PIANO" FEED REGULATOR WITH COMPOUND GEAR FOR FEED ROLLERS, AND TRIPLE ANTI-FRICTION BOWLS FOR REGULATOR. HOWARD & BULLOUGH, LTD., ACCRINGTON

this end movement shifts a belt on a pair of small cone drums, Fig. 11, and changes the rate of feed. Howard & Bullough do not use two feed rollers next the beater, but make the lever pedals act the part of the lower roller, thus getting the regulation action right up to the beater, as in Fig. 14.

thoroughly beaten. The seed is less liable to be crushed than when the feed is through a pair of rollers, cleaning is better done, and the cotton rendered more fleecy, which, of course, eases the work to be done in the subsequent operation of carding. The system of Fig. 14 is modified to Fig. 15 for long staple cotton, but

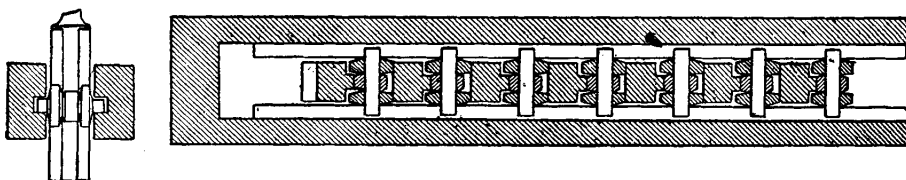


FIG. 13.—FRAME WITH ROLLER DIVISIONS, SHOWN ON LARGER SCALE. HOWARD & BULLOUGH, LTD.

They also employ the method of Fig. 16, which they term the tandem or double grip. In this device the cotton is held by two sets of pedals or holders. From one the fibre is beaten. From the other, which is set behind, there is no beating of the fibre, but these rear grippers are connected with the regulating gear and serve to shift the cone belt just about the time that that part of the lap arrives at the beater which has influenced the moving of the belt. The double grip is also claimed to prevent plucking in of lumps of fibre before they have become properly and

Fig. 16 is regarded as offering considerable advantages in good regulation. It will be noted that the shock of the beater does not come upon the regulating pedals, and this serves to prevent plucking in of tufts of unbeaten cotton.

Asa Lees & Co. employ a different combination in their regulator. Each pair of pedal rods is attached to the opposite ends of a short lever or link, and the middle points of the links of two pairs of pedal rods rest on the two ends, respectively, of a similar link of twice the length, and again two of these double-length



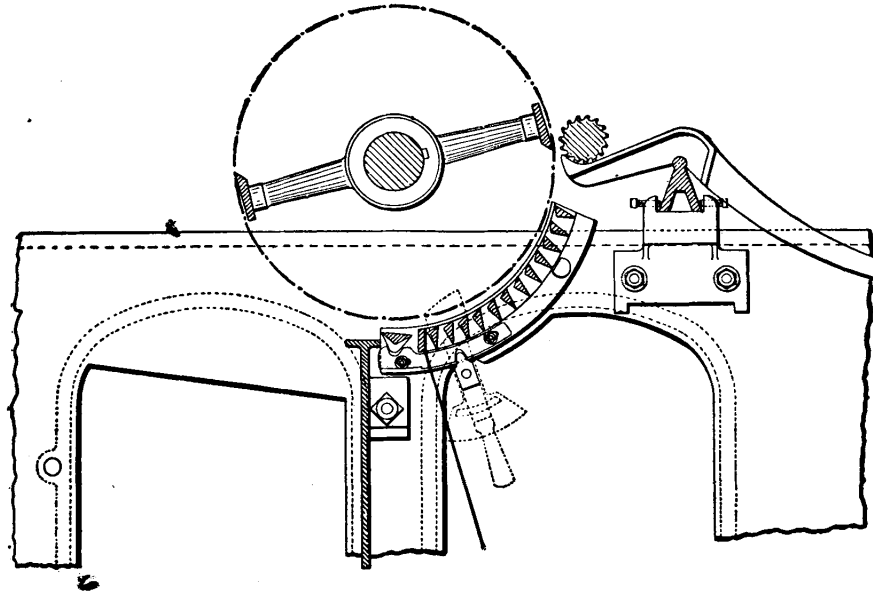


FIG. 14.—ARRANGEMENT OF FEED ROLLERS AND COTTON HOLDERS FOR SHORT AND MEDIUM STAPLED COTTON BEATEN FROM PEDAL NOSE, SHOWING ALSO ADJUSTABLE AIR GRATE UNDER BEATER. HOWARD & BULLOUGH, LTD.

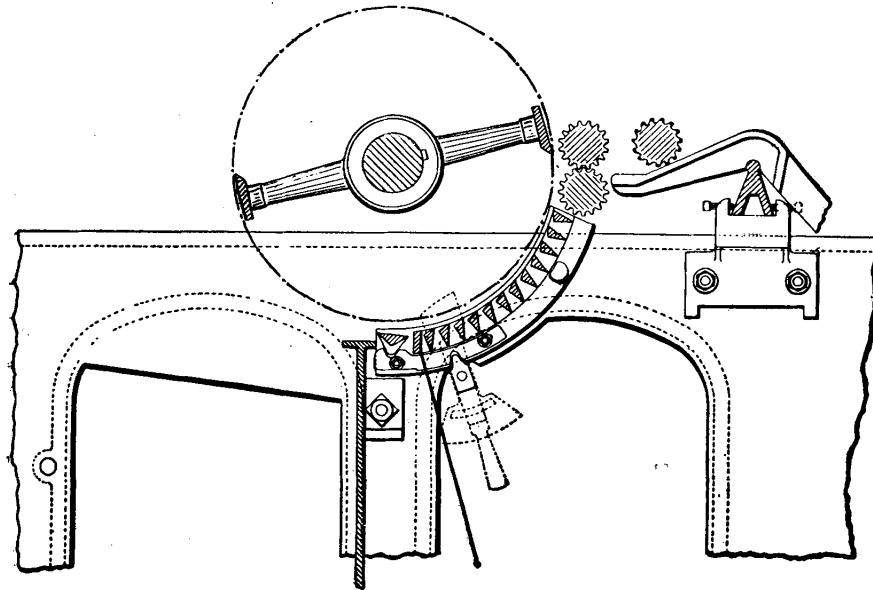


FIG. 15.—ARRANGEMENT OF FEED ROLLERS AND COTTON HOLDERS FOR LONG STAPLED COTTON, BEATEN FROM FEED ROLLERS, SHOWING ALSO ADJUSTABLE AIR GRATE UNDER BEATER. HOWARD & BULLOUGH, LTD.

links rest respectively on the ends of a link of double their length, and this final link, as seen in Fig. 17, couples direct to the strap shifter of the small cone drums. In the illustration, Fig. 17, the traveling feeder lattice is removed, the four carrier rollers appearing above the regulation levers. One blade of the beater is seen beyond the roller, and below this roller are visible the top faces of the piano lever pedals, the link connections hanging below and their arrangement being clearly visible, together with their coupling, up to the

These motions do not regulate the evenness of the lap as regards its thickness right across, but they regulate the amount of material which is fed to form a given length of lap. Regulation of the thickness equality at all points is fairly well carried out by the exhaust cages or drums on which the fleecy fibre settles in proportion to the amount of air tending to each part of the cage. Naturally, the air rushes to the least thickly covered areas and carries the fleece with it. When coarser counts are spun, the scutchers may each

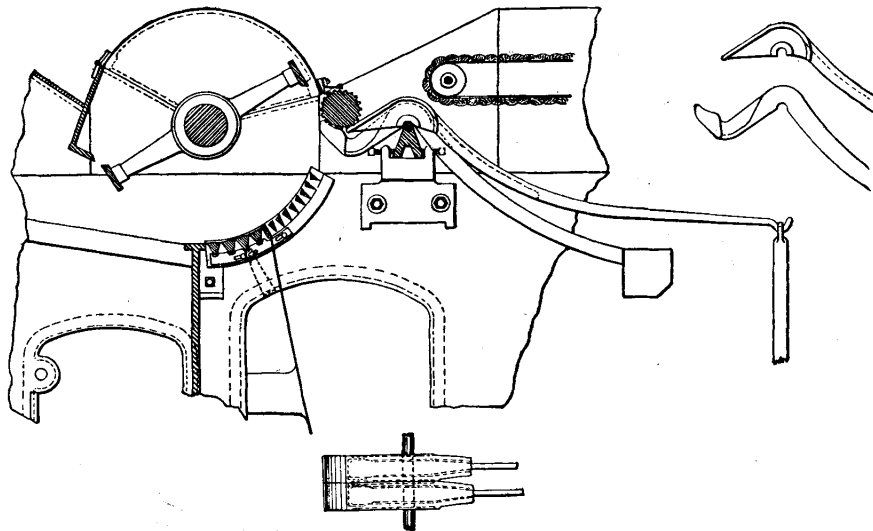


FIG. 16.—DOUBLE-GRIP COTTON HOLDERS TO REGULATOR. HOWARD & BULLOUGH, L<sup>td</sup>, ACCRINGTON

weighted lever which shifts the belt on the cone drums which drive the feed roller. The grip roller is not merely fluted, it is also toothed.

Again, this is simply an integrating device, and the same result is obtained by John Hetherington & sons by means of wires instead of rods, a looped wire round a small pulley being attached by its two ends to the ends of two adjoining pedal levers. Each link carries two wire pulleys or bowls, and is pivoted at its centre to a larger frame, which carries two bowl frames, and so on to the final frame, which is connected directly to the cone box.

have two beaters in series; and, for very dirty cotton, such as some of the Indian cottons, the fibre is cleaned in a Crighton opener, which contains one or two vertical conical beaters in grid cages. These machines are not so suitable for long staple cotton, and much less beating is, of course, required by clean cottons, such as Egyptian. It is not desirable to do more beating to any cotton than is necessary to clean it. With fine counts the output per spinning spindle is so comparatively light that the blowing-room machinery is relatively very small in quantity, as compared with coarser count blowing rooms,

where not only must more cotton be worked, but it must be worked to a greater extent than necessary with cleaner raw material.

The foregoing sequence of operations, as carried out by Asa Lees & Co.'s machinery at the Cairo mill, may be somewhat modified in other mills by different arrangements of openers and scutcher beaters, but substantially it represents ordinary modern practice. The main difference between a coarse and a fine mill is in the ratio of the machin-

ing 62's, 19,440 twist averaging 46's, and 23,760 averaging 45's weft, the finer counts in each case being spun from Egyptian and the coarser from American cotton. These mules occupy three floors of the mill and all the preparation goes upon one floor. In a coarser mill spinning 27's, the 55,600-ring frame spindles are almost all contained in the space of one floor, and all the preparation, except mixing, occupies one floor and includes 2 bale breakers, 3 hopper feeders, 3 openers, 24 scutchers, 106

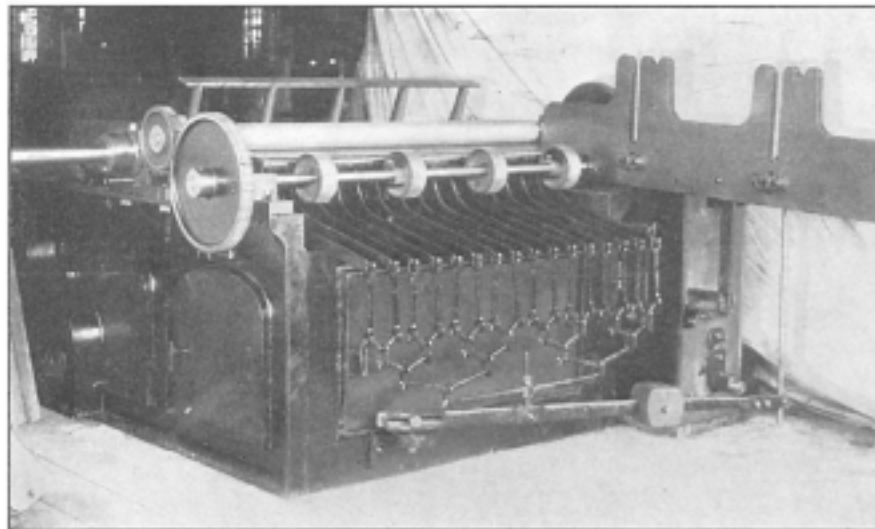


FIG. 17.—"PIANO" REGULATING MOTION AS ARRANGED BY ASA LEES & CO., LTD., FOR LAP MACHINES

ery. Here, for example, is a list of the machinery in two mills of finer and coarser counts.

In the finer mill the blowing room contains one bale opener, two hopper feeders, two openers with attached lap machine and six scutchers, with 108 cards, 9 drawing frames, 794 slubbing spindles, 2,558 intermediate and 10,552 roving spindles. This preparation machinery supplies 101,608-mule spinning spindles in three rooms producing 45,000 pounds of yarn per week. Of these there are 36,848 spinning weft averaging 85's counts, 21,560 twist spindles averag-

ing 62's, 19,440 twist averaging 46's, and 23,760 averaging 45's weft, the finer counts in each case being spun from Egyptian and the coarser from American cotton. These mules occupy three floors of the mill and all the preparation goes upon one floor. In a coarser mill spinning 27's, the 55,600-ring frame spindles are almost all contained in the space of one floor, and all the preparation, except mixing, occupies one floor and includes 2 bale breakers, 3 hopper feeders, 3 openers, 24 scutchers, 106

cards, 15 drawing frames, 1,000 slubbing spindles, 2,272 intermediate, and 7,200 roving spindles. The weekly output of the 55,600 spinning spindles is 96,000 pounds, as compared with the 45,000 pounds from the 101,608 spindles of the fine-counts mill. Thus from about one-third the space filled as compared with the preparation, there is turned out over double weight of yarn, and, as between the two mills, each coarse spindle turns out nearly four times as much yarn as does a fine spinning spindle.

In still finer mills it is found necessary to add to the area of the room

containing the preparation machinery in order that this may all be contained on one floor.

To this end there is a shed extension of the ground floor room made beyond the general plan of the floors above.

This extension is made beyond one side wall of the mill, the lower part of the wall being omitted and replaced by heavier columns of iron. The extension is usually occupied by the cards, which do not require so much light, and the roof of the extension is unglazed, so that there is no risk of drip, which would ruin the card wire. Where the extension joins the main body, however, a single high-pitched shed, saw-tooth light is introduced to throw light across the ground floor so as to compensate for the light lost in the extra breadth of floor.

In a mill spinning 36's on mules, such a card room, with extension, serves four rooms of mules with 112,284 spindles.

As regards the general dimensions of a mule mill, a very usual breadth is 135 feet, divided into bays of 22 feet 6 inches, 22 feet 6 inches, 15 feet 0 inches, 15 feet 0 inches, 15 feet 0 inches, 22 feet 6 inches, 22 feet 6 inches by rows of pillars as shown in the Cairo mill, Fig. 6. This enables the line shaft in the mule room to be carried by one of the two middle rows of pillars, while the countershafts lie exactly in the centre line of the mill and drive right and left down to the mule headstocks at equal angles of belt.

A spinning mule has all its driving mechanism near its mid-length, there being at the Cairo mill in one mule of a pair 602 spindles on one end of the carriage and 546 on the other end, and in the other 616 and 532, respectively. Since, in a pair of mules, each mule carriage faces its fellow, this unequal carriage length throws the long ends of each carriage opposite the short ends of its fellow and the two headstocks are thus displaced seventy pitches from

each other. In this mill the pitch, or gauge, as it is termed, is 1 and  $\frac{5}{16}$  inches, and there are 1,148 spindles across the mill. The passage at one end is only 11 $\frac{1}{2}$  inches, that at the other 3 feet 2 inches. The same effect in placing the driving of each side of a mule at an equal angle may be obtained by making the inequality of spindles alike and varying one of the central bays.

The mill breadth is thus fixed by the machinery itself: the length of the mill may be anything in reason and depends upon the number of the machines. A simple extension of length by any fraction adds an equal proportion to each floor. Similar differences occur in the other floors, on one of which the spindle gauge is 1 $\frac{1}{8}$  inches, and the difference or displacement of the headstocks is 7 feet, or 84 spindles. This headstock displacement is necessary, because the projection of each headstock is more than half the floor space of a pair of mules.

The 1,338 spindles of 1 $\frac{1}{8}$ -inch gauge of the Cairo mill may be compared with the 1,350 spindles of the No. 2 Marlborough mill fitted by the same firm, Asa Lees & Co., in a mill 1 foot wider, viz., 136 feet.

Before leaving the subject of the blowing room, however, it may be pointed out that the whole of the fans in the different machines discharge their dust-laden air into sheet-metal pipes, which conduct it into a dust chamber, from which there is a large sieve-protected outlet area to a dust tower. The heavier dust is chiefly sand, dirt and small fragments of bad fibre, leaf and bits of husk. Seeds and heavy dirt collect in the base of the machines below the grids of the beaters and are removed as they accumulate. At the point where this digression was made, the fibre had been followed to the time when it leaves the blowing room and is ready for carding. In the best appointed mills these laps, with an iron rod through their central axes, are placed vertically in a carriage,

which runs on a single floor rail and on an overhead guide rail and carried through a passage, closed by fireproof doors, into the card room, which is best on the same floor as the scutchers. The laps are laid horizontally to the cards and here begin the finer processes of the art, though it is not to be thought that the rougher processes already described are not fully as important, for on good mixing and careful regulation of weights the final accuracy of the yarn much depend.

and drawing operation, the several laps being drawn down to one, and their irregularities averaged out to the beater. As in the first beater, the feed apparatus is a traveling lattice on which the various laps rest and are unwound at the speed of travel of the lattice. All wastes, such as the ragged ends of laps, are, of course, returned to the feed of the first scutcher.

Regulation of the feed to the second scutcher was performed mechanically and automatically with

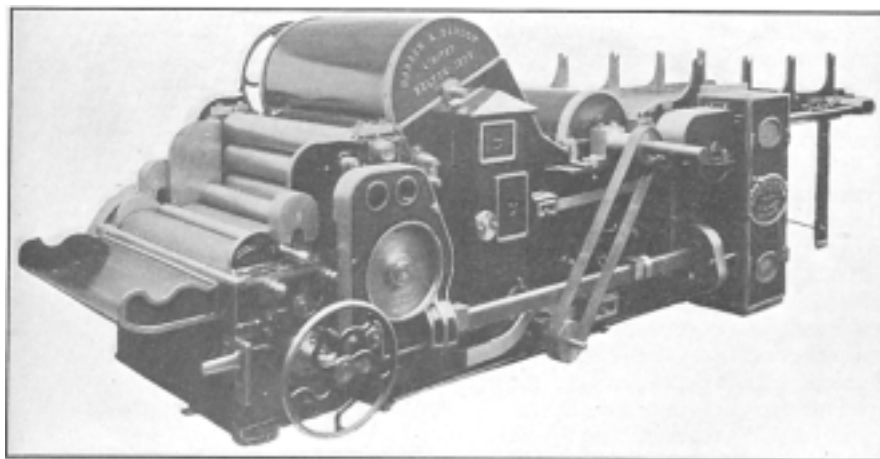


FIG. 18.—SINGLE-BEATER SCUTCHER. DOBSON & BARLOW, LTD., BOLTON

In the old system the opened cotton was weighed out, as already described, upon even lengths of a traveling lattice. This weighing and spreading was an arduous operation and was the first operation in determining the final counts of the yarn to be spun. The hopper feeder has dispensed with hand weighing, and, combined with the piano-motion feed roller regulator, secures correct weights of lap. On the old as in the new system, the finisher scutcher, Fig. 18, was fed with several laps from the first scutcher and delivered one lap ready for carding.

Finishing scutching was once practically the first mechanical averaging

much more ease than with the hand-spread fibre of the first operation, for the several laps are fairly even and of themselves give a fairly even average layer through the fluted feed rollers, especially since the universal adoption of the piano motion. Essentially the blowing room is as it was thirty years ago. Openers and scutchers are identical in principle and general appearance.

Improvements are there by the hundred, but the main principles survive. The chief changes are the bale breaker and hopper feeder. These machines are additional upon old practice and are now almost universal.

(To be continued.)