THE MODERN COTTON SPINNING FACTORY

By W. H. Booth

III. THE FINAL OPERATION OF SPINNING. INTERIOR ARRANGEMENTS OF A STANDARD MILL

This is the last of a series of three articles on the cotton-spinning factory. The final operation, that of spinning, is here described and descriptions of a few typical machinery lay-outs of up-to-date mills given. The first article, besides being of an introductory nature, described the processes of mixing and opening, the second one treating on the subsequent operations of carding, combing, drawing, slubbing and roving.—THE EDITOR.

SPINNING

The final operation in a spinning mill is that of spinning, for no notice need be taken in this article of the subsequent operations of winding the yarn upon larger bobbins and converting these into warps; for these operations, though often carried out in spinning mills, are properly preliminary processes in weaving.

Spinning is carried out on two varieties of machine, the mule and the throstle.

The latter is now practically obsolete, the ring frame having taken its place.

The throstle spinning frame was to the last no way different in principle and but little in mechanism, except in style and finish, from the original water frame as invented by Arkwright, and so called because it was driven by water power at the Cromford Mills, in Derbyshire, whither Arkwright fled from the machine smashers of his own county.

Arkwright's frame was simply a little roving frame, in which there was no positive geared driving of the bobbin. This was simply dragged round by the thread, and the thread was wound on the bobbin at the tension required to pull the bobbin round at its high velocity of several thousand turns per minute. Friction of the bobbin was purposely made large by interposing a strip of felt between the copping rail and the base of the bobbin. Thus, every bobbin was a little brake, and the power to turn one hundred throstle or flyer spindles was much greater than that required for the same number of mule spindles. But this clumsy frictional device made the machine very simple, and it consisted only of the three rows of draught rollers, a long tin roller carrying tapes or small cotton bands to drive the spindles, and a rising and falling rail driven by a heart-shaped cam, which caused the fully wound bobbin to be slightly barrel-shaped. The yarn spun on these frames could be spun hard, and was known as twist and made into warp. It could be hard spun because it was always under tension and could not snarl up. To-day the throstle frame does not appear in makers' catalogues. It has been superseded by the ring spinning frame Fig. 1. In this frame the yarn may either be twist or weft, for to a large extent the ring frame has displaced the mule also. Weft is spun upon wood pirns or upon paper tubes placed on the spindle. Twist is spun upon a pirn or headless bobbin, and the yarn comes off the full spindle in the form of a long, thin, barrel-shaped cop.

Upon the copping rail is a ring about 1½ inches diameter encircling the spindle, and round the edge of this ring fits loosely a little steel wire traveler through which is looped the yarn as it passes from the front roller to the spindle. The yarn drawn round by the rotation of the spindle drags the little traveling wire ring rapidly round the edge of the ring, and the resistance thus set up gives the required drag upon the thread. This drag may be made slight by the use of light travelers, and soft yarn may be spun upon a ring frame. Since there is only a few inches interval between the spindle and the front roller, each bit of drawn roving, as it comes through the rollers, is promptly twisted into yarn. There is no draw between the two points, as in the mule, so that the evenness of the yarn depends entirely on the operations that have preceded spinning; and in modern mills, with their ex-dle and grips it above the top of the sleeve bearing, and the pirn comes down over this tube and grips it at the top of the spindle, so that pirn and spindle turn together.

Ring spinning frames are very narrow, and do not require wide passages between them. Consequently, as may be judged from the various illustrations, a very large number of spindles can be put upon a given floor space. In most mills it is usual to build the mill of such a breadth that two ring frames, of about 400 spindles each, will extend across the mill from passage to passage. The ring

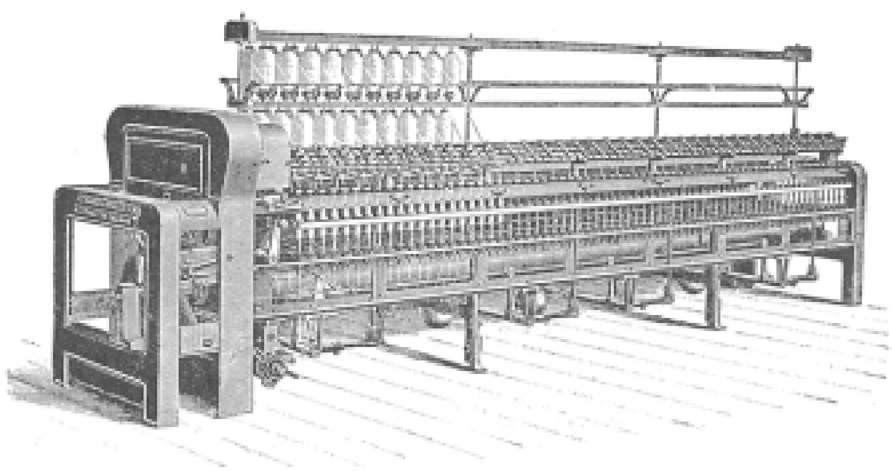

FIG. 1.—RING SPINNING FRAME. HOWARD & BULLOUGH, LTD., ACCRINGTON

cellent preparation, the roving is of such even thickness that ring yarn is practically perfect, and what more can mule yarn be? Still, for the finer counts the mule still holds its own as a more delicately-worked machine. Much ingenuity has been expended upon the spindles of the ring frame, their bearings and the attachment of the little wharve or driven pulley, by which a little cotton cord communicates motion from the long tinplate roller that extends all the length of the frame. The spindles are carried in a combined footstep and long collar oil-bath bearing screwed to the spindle rail. The wharve is attached to a tube which extends to the spin-

frame is a double-sided frame, there being about 200 spindles on each side driven from the tin rollers.

There are two of these rollers, each of which is encircled by the spindle band, and a single band drives one spindle, the band making the circuit of the tin roller farthest away from the spindles it drives, and both entering and leaving each spindle wharve nearly horizontally. When a single tin roller was employed the angle of the band as it left the spindle wharve was very acute, and it was necessary to make the frames wider to reduce this. The double roller enables the frame to be made of minimum width, so that more spindles can be got upon

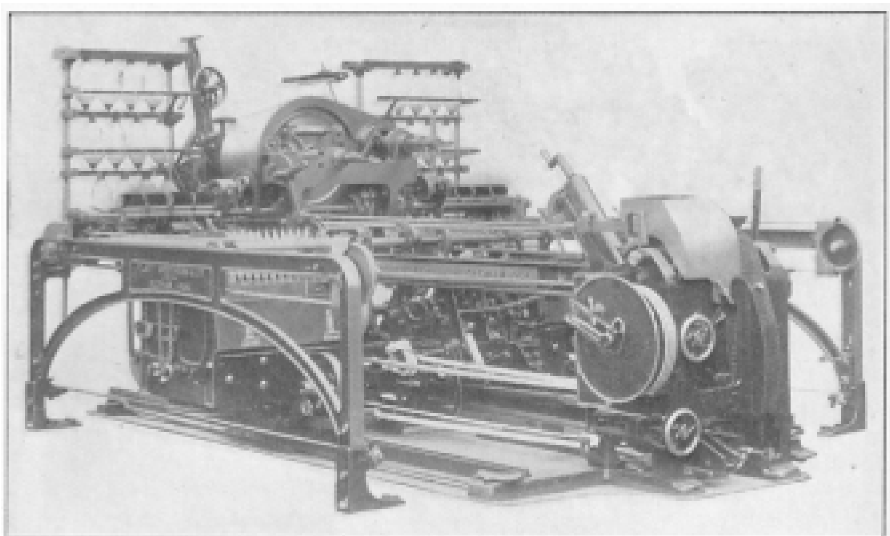

FIG. 2.—HEADSTOCK AND SELF-ACTING MULE. PLATT BROS. CO., LTD., OLDHAM

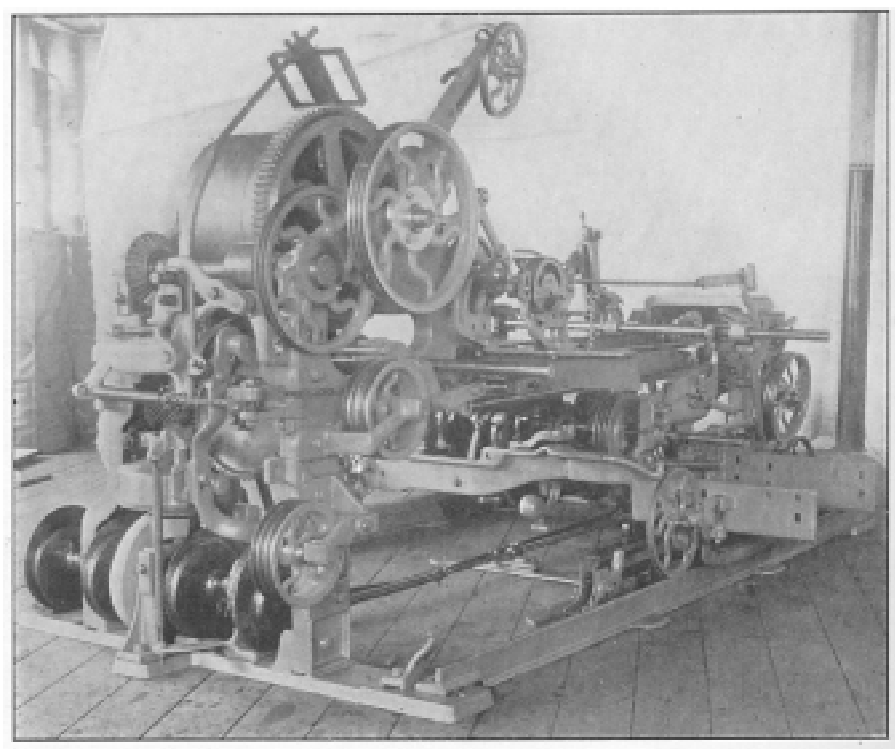

FIG. 3.—HEADSTOCK AND SELF-ACTING MULE. ASA LEES & CO., LTD., OLDHAM

a square foot of floor surface. The ring frame appears to be of American origin, devised to enable women to spin weft yarns; for, at least at one time, men could not be got to spin in America, and women could not spin on the mule. But though of American origin, the ring frame was brought to perfection in England, where it was introduced by Howard & Bullough, of Accrington, and Brooks & Doxey, of Gorton. Like the throstle, the ring frame is a continuous spinner, and the roving receives its twist as it issues from the front rollers. These are inclined forward towards the spindle tops, so that the issuing roving does not pull over a part of the circumference of the lower roller, as in the throstle. If it did so the twist could not run freely right up to the nip of the rollers, and the soft stuff would break easily. With the nip directly facing the spindle top the twist can run right up into the nip, so that the issuing roving is at once spun and does not break. This was a great improvement and made for the complete success of the ring spinning process.

The mule, Figs. 2, 3, 5, and 6, spins on a somewhat different principle. This machine was invented by Samuel Crompton, of Bolton, Lancashire, and it is not a continuous-acting machine. It draws out and spins about 5 feet of yarn, winds this upon the spindle, and proceeds to draw out another length of 5 feet, alternately spinning and winding up in turn. To effect this the bobbins of roving are carried, as usual, on light wooden pegs in a frame or creel behind the roller beam, and one or two threads of roving go to each thread of yarn. The rovings are led through wire eyes to the back pair of three pairs of rollers, the top rollers of each two back pairs being frequently plain metal and the front top roller being leather covered, all much the same as in slubbing and drawing frames, wherein, however, the top rollers are leather covered.

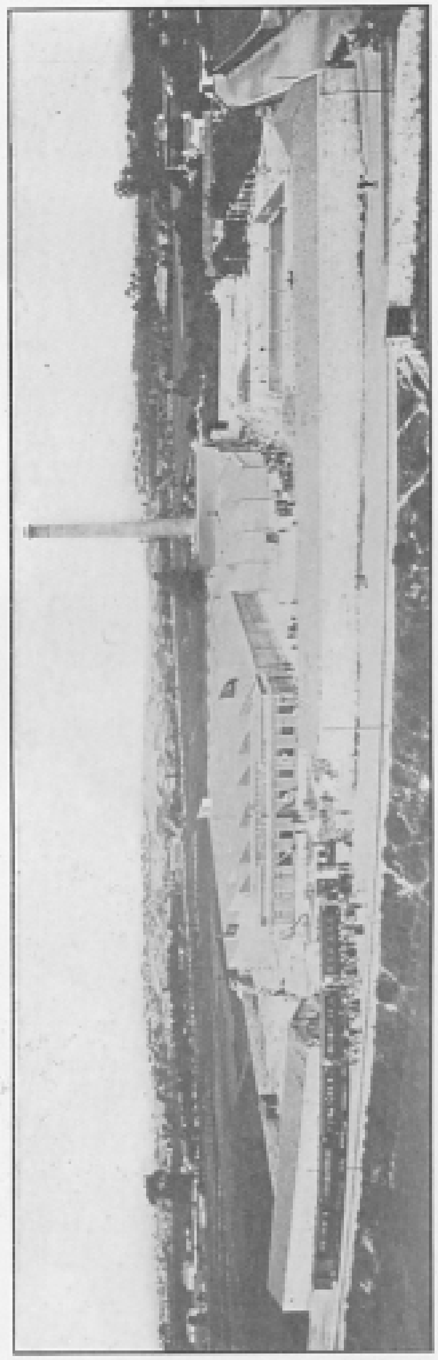

FIG. 4.—TYPICAL COTTON MILL IN BRAZIL. MACHINERY INSTALLED BY DOBSON & BARLOW, LTD., BOLTON

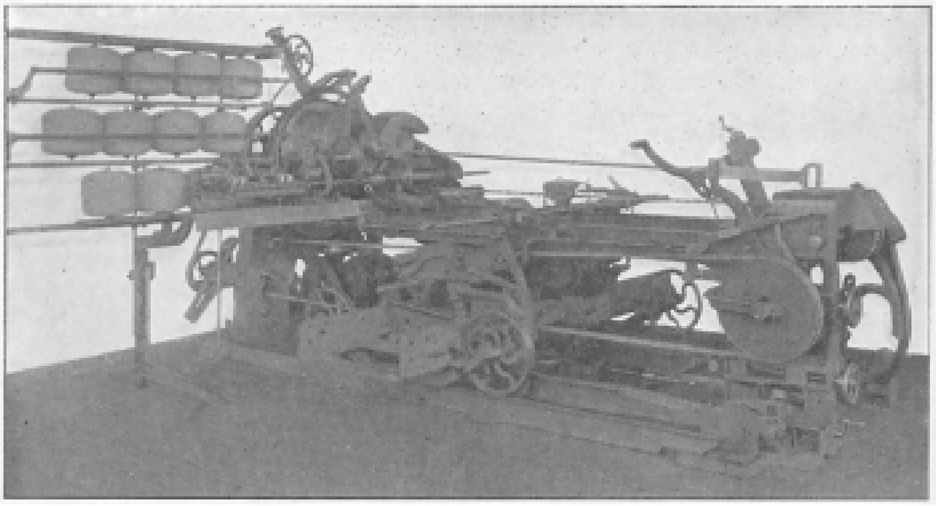

FIG. 5.—HEADSTOCK OF WASTE SPINNING MULE. ASA LEES & CO., LTD., OLDHAM

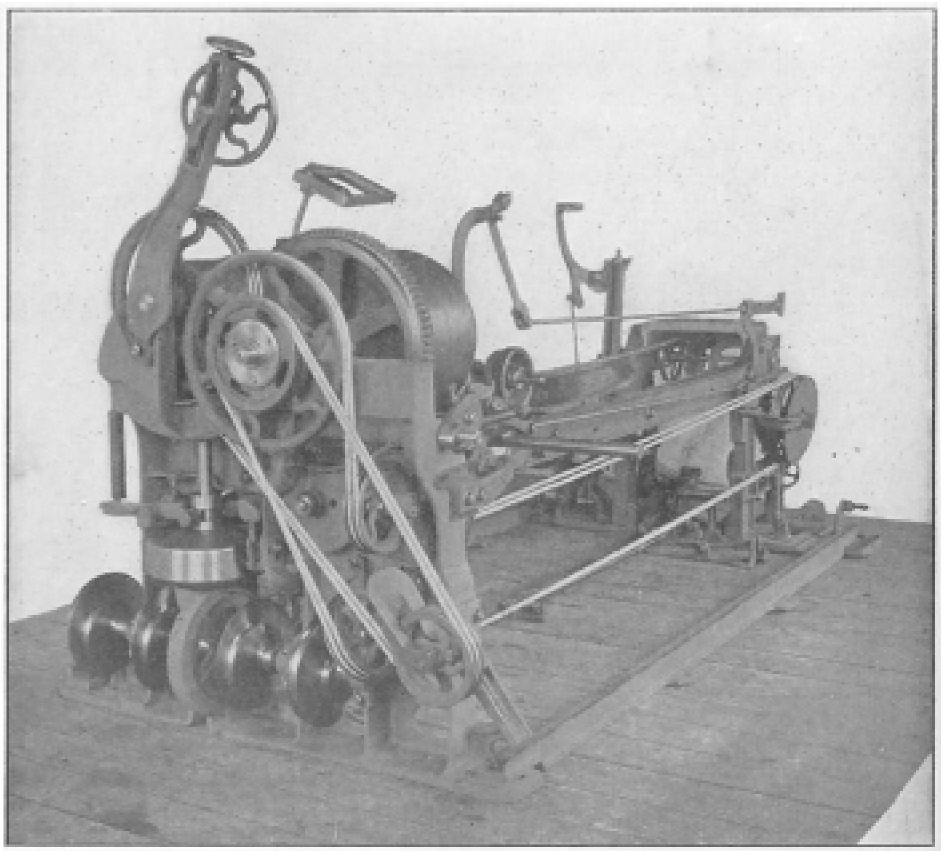

FIG. 6.—ANOTHER VIEW OF A WASTE SPINNING MULE HEADSTOCK

In the slubbing and roving frames all top rollers are leather covered and held down with weights slung over their spindles.

In all machines the bottom rollers are all fluted with narrow flutes, and, as they run against the upper leather rollers, these become marked by the flutes.

This marking may be prevented by fluting the bottom rollers somewhat unevenly in the pitch of the flutings, so that every part of the top roller some times takes the fluting and then does not take it, wear being even all round.

The drawn roving is delivered by the front pair of rollers and extends from them to the point of the spindle. It is an axiom with some spinners that, to increase production, the rollers should never stop moving. To secure this they are rotated quickly during the run out of the carriage, slowly when the carriage stops, and slowly during the run in of the carriage towards the rollers. The carriage carries the spindles, and there will be from 1,000 to 1,400 spindles in a mule, according to the gauge of the spindles or distance apart, which may be 1⅛ inches to 1⅝ inches. The carriage is moved out 64 inches, more or less, during which time the rollers turn out a somewhat less length of roving. The carriage also may move out some three or four inches while the front roller is practically standing still near the end of the draw. This carriage movement is called stretch. It is during this movement that the half-twisted yarn is stretched out so as to pull out all the softer parts and render the yarn even. In the spinning of the finer yarns the carriage must also stand still at its extreme outward run, while the spindles continue to rotate and put into the yarn the necessary number of turns. The number of turns per

FIG. 7.—INTERIOR OF PREPARING ROOM OF MILL SHOWN ON PAGE 585

inch of length varies as the square root of the counts of the yarn. Thus, a yarn of 16's counts will have fifteen turns per inch and yarn of 64's counts will have thirty turns for the same degree of hardness. The standard twists is $3\frac{3}{4}\sqrt{\text{counts}}$ for American twist and $3.606\sqrt{\text{counts}}$ for Bolton counts.

A yarn of 120's has nearly forty turns per inch, so that with a stretch of 64 inches the spindle must rotate turn and wind up the yarn, the said wire moving upwards so as to wind evenly on the cop. Some allowance is made by the fact that the yarn passes over another long horizontal wire similarly held, but on weighted arms. This wire gives a uniform tension to the wound yarn, and is free to move and yield to excess tension or take up undue slack. But the point end of the cop is conical, and the winding of the yarn upon it

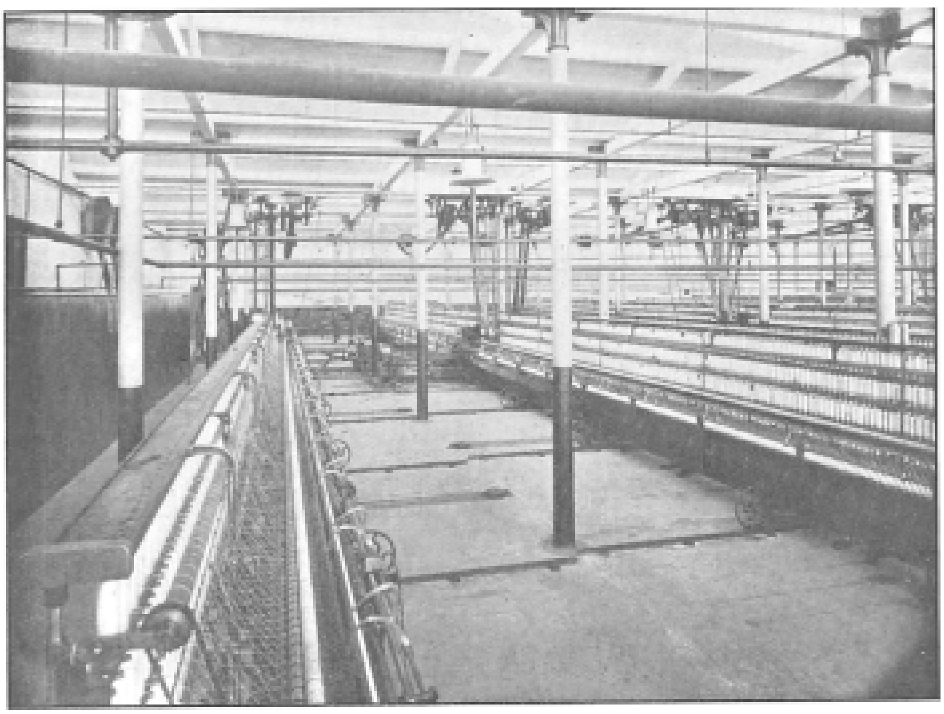

FIG. 8.—SPINNING MULES. DOBSON & BARLOW, LTD.

2,560 times for each draw-out of the carriage, and some of this has to be put in after the carriage has run out. Spinning completed, there are a few turns of yarn on the bare spindle between the top of the cop and the spindle point. This must be removed, and it is removed by causing the spindles to turn backwards. Next the yarn must be wound on the cop nose. A long wire descends on the stretch of yarn and the carriage begins to run in and the spindles has to be regulated so that, as the winding approaches the smaller diameter of the cone, the spindles shall turn correspondingly quicker. Further, until the cop has been formed to its full diameter, the winding has further to be adjusted so as correctly to form the cop shape from the start upon the bare spindle. Now all this has to be, and is, automatically effected by the mule itself, and the slight play of the top tension wire is all that is permitted from perfect action of the mechanism. The cop is formed, and the machine varies itself to do this. Arrived at full nose shape, the machine then becomes practically of equal winding action after each draw, except that, as the cop grows towards the thinner diameter of the spindle, a certain additional small winding speed of the spindles must be given to compensate for this. For very fine counts this complete automaticity of the mule in winding has only lately been perfectly secured, and the faller wire which regulates the winding is operated by hand, and is a very skillful bit of work. But in ordinarily fine counts the operative has no special skill of hand to display. The machine does everything but piece up broken ends.

The long carriage is divided into two nearly equal halves, the two together about 130 feet long, and these two long carriages run on wheels upon rails laid on the floor, and are drawn equally to and fro by ropes worked over scrolls on a shaft behind the roller beam, which shaft extends to the central headstock, in which is concentrated all the gearing and movements by which the above complex series and combinations of operations are effected. It would require many pages adequately to describe the self-acting mule, so called because this invention of Crompton—an ancestral relative of the present writer—was a sort of hybrid between the water frame of Arkwright and the spinning jenny of Hargreaves.

FIG. 9.—ELECTRICALLY-DRIVEN SPINNING FRAMES. DOBSON & BARLOW, LTD.

Crompton left the mule somewhat as it is used to-day—for very fine spinning. It is to Richard Roberts, of Manchester, that the fully automatic or self-acting mule is due. Hargreaves employed a stationary frame of spindles, and the rovings were run out from a fixed creel and through a bar, which nipped them after a

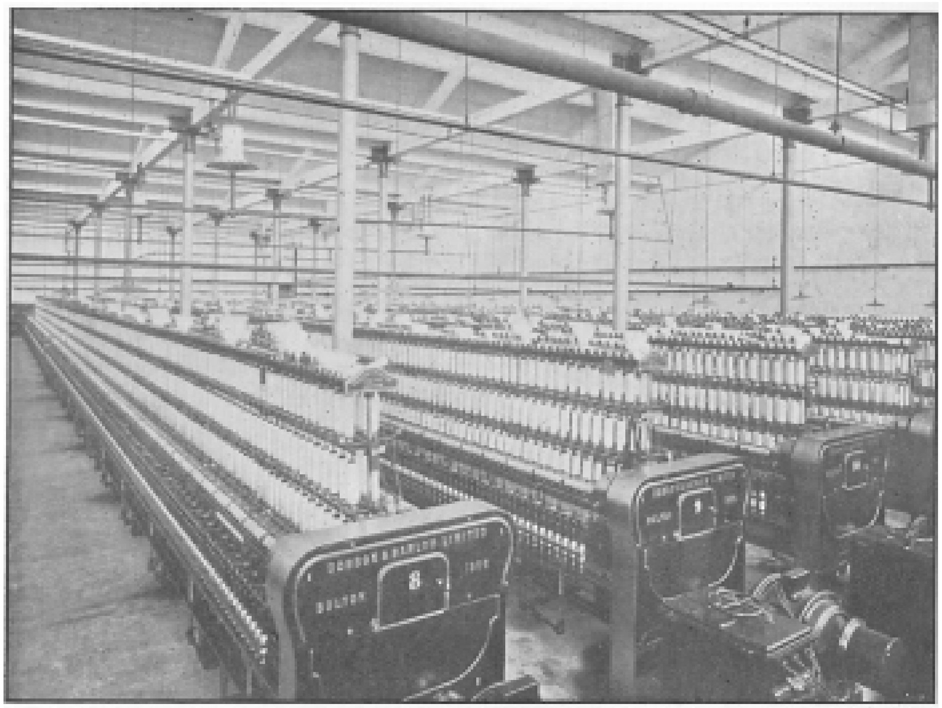

FIG. 10.—ELECTRICALLY-DRIVEN RING SPINNING FRAMES. DOBSON & BARLOW, LTD.

given length had been given out, and this bar was moved still further from the spindles after the rovings were nipped fast. Thus there was the drag or stretch on the soft, partly-twisted yarn. But Crompton fixed this bar and added draw rollers upon it, and put the spindles on the moving carriage and produced the hybrid mule which Roberts perfected and placed much as it is to-day, a very marvel of mechanism.

Asa Lees & Co., Platt Bros. & Co. and other makers now make the mule to spin counts as fine as 300's from Sea Island or Egyptian cottons and to be automatic. Such fine counts were once spun only on hand-winding mules.

In this complex machine, a part of which is moving to and fro upon the floor, movements of several orders have to be communicated to the spindles and faller wires on this running carriage from the fixed part of the machine. This is effected by rim wheels, with rope bands so arranged that the carriage rims run in a reduplication of the rope bands, and thus are self-compensating for carriage movement as regards tightness. All other movements and compensations of speed for different speeds of the spindles are made in the fixed headstock gearing. Very various are the mechanical means by which the many different movements are effected. There are scrolls of increasing diameter on which are wound the ropes which haul the carriage in and out at the proper speeds, starting gently and stopping gently, owing to the varying spiral of the scroll. These are variously-sloped rails on which run the rollers of the levers which move the faller wires. There are other scrolls for spindle winding, varied in the copping motion by a peculiar quadrant gear with a winding chain of varying length, and there are numerous clutches and other involved movements for the many motions required.

The illustrations of parts of the

mule will serve to tell of its complexity, even though not readable by the non-expert. See Figs. 2, 3, 5 and 6.

The relative proportions or numbers of the various machines in a factory is most important. A thousand spinning spindles turning out so many hanks of yarn consume so many hanks of roving, and this is made from a nearly equal weight of slubbing, of drawing sliver, of combed sliver, carded sliver or scutcher lap. Each process must turn out the same weight of stuff as the next following process plus a small percentage for waste or spoiled material. Properly proportioned, there is very little stock of material between each process. No machine ought ever to stop for lack of following supplies of what to it is its raw material. Machines are designed to produce certain average weights, and their average hourly output can be closely foretold. But any lack of proportion can readily be corrected. Thus, if we suppose that there is a shortness of supplies for the first slubbing operation, a very slight variation can be made in the velocity with which cotton is fed to the first scutcher. This will produce a somewhat heavier lap, and the following carded sliver and drawing sliver will, in turn, be heavier per card. The back roller of the slubbing frame can then be made to run rather less quickly, when it will still supply an equal weight to the second roller; but the draft between the two rollers will be slightly greater, so as to counteract the heavier sliver. At every process corrections can be made for slight discrepancies, but the general lay-out of a mill to spin 50's would be quite wrong for a mill intended for 20's. As an example of machinery required for spinning such yarns as average 30's on self-acting mules or ring frames, with the approximate calculated production at each process, the sliver weight, spin-

FIG. 11.—FINISHING ROOM. THE PROCESSES OF WARPING AND BEAMING

TABLE I.—LIST OF SPINNING MILL MACHINERY

	Hank of Roving.	Speed.	Production per Week of 55½ Hours.
108 single cards 45 inches wide on wire 50-inch cylinder, 106 flats 1⅜ inches wide..........	0.15	170 revolutions, cylinder.......	774 lbs. per card. = 116 hks. per card.
27 drawing frames, 2 heads of 4 deliveries = 72 finishing deliveries......................	0.13	350 revolutions of front roller 1½ inches in...........	1,150 lbs. per delivery per spindle. = 149 hks. per delivery per spindle.
9 slubbing frames of 96 spindles 10 x 5½-inch bobbins, 19-inch staff..................	0.625	600 revolutions of spindle.....	94.8 lbs. = 59.2 hks.
17 intermediate frames, 140 spindles, each 10 x 4¾-inch bobbins, 26⅜-inch staff........	1.60	750 " "	34.1 lbs. = 54.5 hks.
42 roving frames, 180 spindles, each 8 x 3⅝-inch bobbins, 20½-inch staff..................	4.25	1,100 " "	10.6 lbs. = 45.1 hks.
72 S. A. mules, 1,100 spindles each, 64-inch stretch.................................	30's av.	10,000 " "	1.03 lbs. = 31 hks.
or,			
120 ring spinning frames, 440 spindles each, 2½-inch pitch, 1⅝-inch rings, 6½-inch lift....	30's	9,000 " "	1.5 lbs. = 45 hks.

dle speeds, etc., let it be assumed there are 79,200 mule spindles for 28's to 32's (average 30's) twist-spun counts at 31 hanks per spindle, calculated to produce 79,566 pounds of yarn per week of 55½ hours' working, from American cotton and single roving of 4¼ hanks.

Or there would be 52,800 ring spindles for the same counts producing 45 hanks per spindle, or 79,200 pounds of yarn, from the same roving. This production would require three hopper bale breakers 36 inches wide; three hopper feeders with filling apparatus, 36 inches wide; three single Creighton cylinder openers with pipe connection to the exhaust opener or bale machines; also three in number, 48 inches wide, for 46-inch laps, with lattice feeder 4 feet centres and patent dust trunks.

Following these come seven single scutchers 46 inches wide for 45-inch wide laps, and a feeder lattice for four laps. The finished lap will

TABLE II.—LIST OF MACHINES FOR A STANDARD MILL FOR OLDHAM COUNTS

Quantity of Machines.	Kind of Machine.	Spindles, etc., per Frame.	Gauge, etc.	Total Number of Spindles, etc.	Production per Spindle in 10 Hours.	Total Production in 10 Hours.
1	Bale opener, with mixing lattices, etc.					
4	Combined exhaust openers with porcupine feed table and hoppers.					
7	Intermediate scutchers.					
7	Finisher scutchers.					
140	Revolving flat carding engines	....	37 inches on the wire.....	....	125 lbs. per card.......	17,500 lbs.
30	Drawing frames............	2 heads each 5 deliveries	16 inches.....	100 finishing deliveries...	175 lbs. per delivery....	17,500 lbs.
10	Slubbing frames............	104 spindles.	4 spindles in 17½-in. gauge, 10-in. lift....	1,040 spindles.	16.82 lbs. per spindle of 0.6 hank.........	17,500 lbs.
20	Intermediate frames.........	142 spindles.	6 spindles in 19½-in. gauge, 10-in. lift....	2,840 spindles.	6.16 lbs. per spindle of 1.5 hank..........	17,500 lbs.
56	Roving frames.............	180 spindles.	8 spindles in 20½-in. gauge, 7-in. lift.....	10,080 spindles	1.73 lbs. per spindle of 4.5 hank..........	17,500 lbs.
175	Ring frames...............	400 spindles.	2¾ gauge, 1⅝ ring, 5-in. lift	70,000 spindles	0.25 lbs. per spindle of 30's counts.........	17,500 lbs.

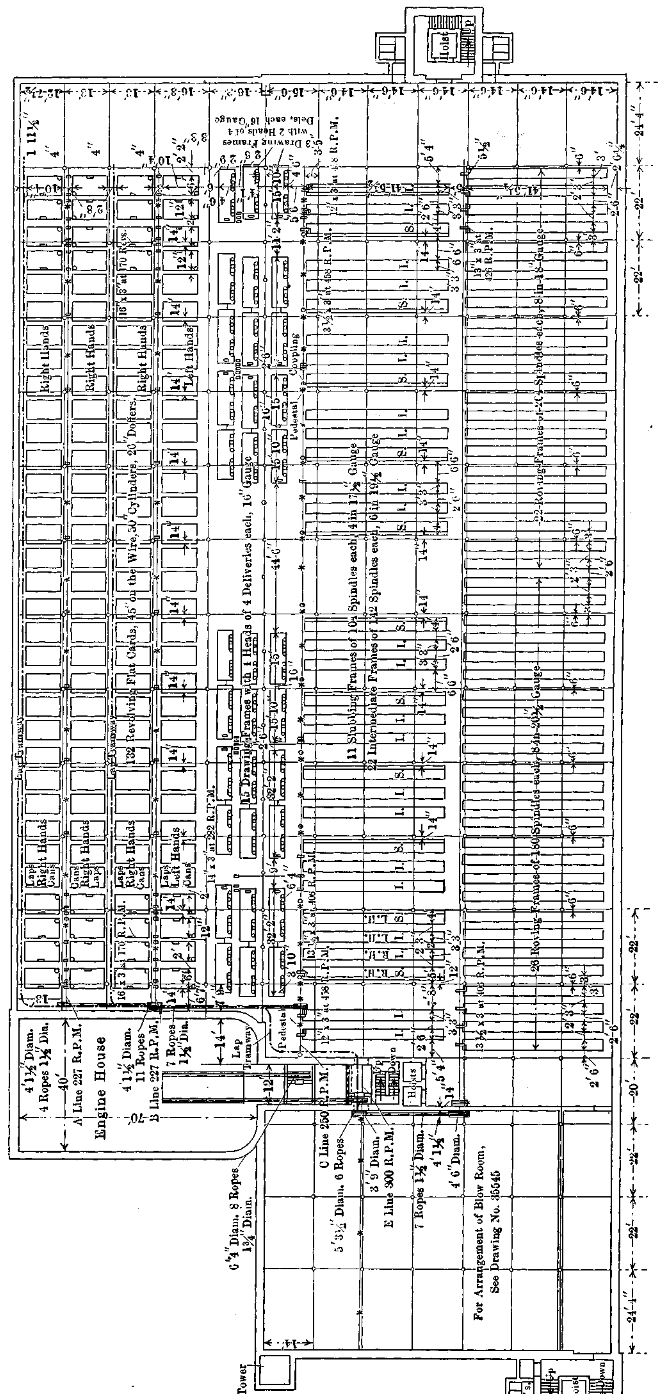

FIG. 12.—CARD ROOM, FIRST FLOOR OF THE STANHILL MILL AT OSWALDTWISTLE, FITTED UP BY HOWARD & BULLOUGH, OF ACCRINGTON

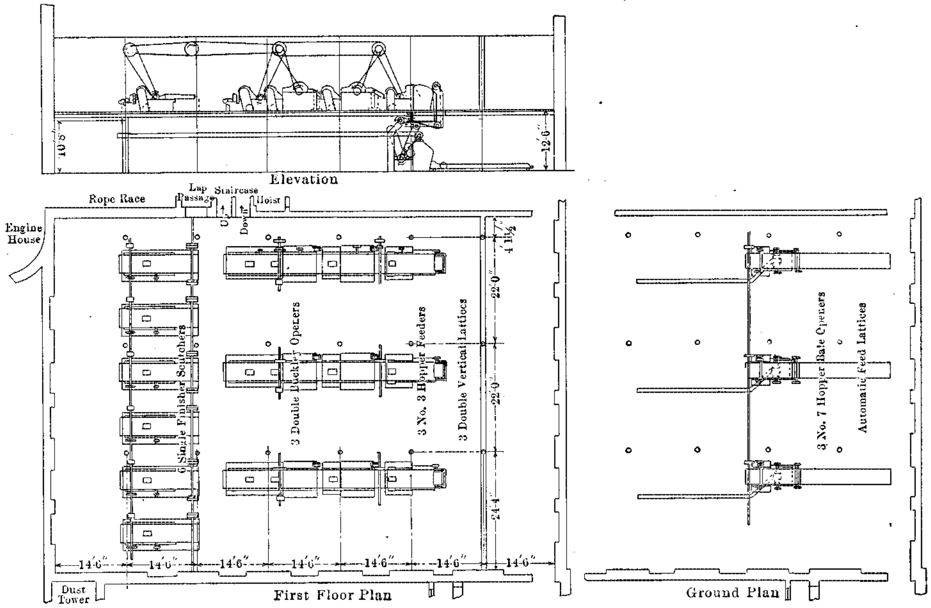

FIG. 13.—GROUND PLAN, FIRST FLOOR PLAN AND ELEVATION OF THE STANHILL MILL AT OSWALDTWISTLE. FITTED UP BY HOWARD & BULLOUGH, OF ACCRINGTON

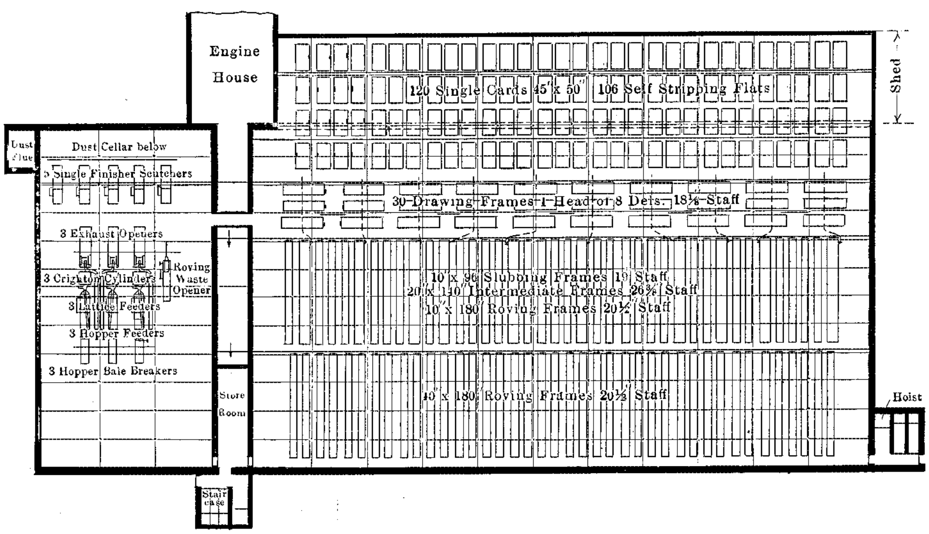

FIG. 14.—MODERN MILL TO CONTAIN 106,176 MULE SPINDLES AND PREPARATION FOR COUNTS 30'S TO 40'S TWIST AND WEFT, FROM AMERICAN COTTON. PLATT BROS., OLDHAM

First spinning room contains 28 x 1,344 S. A. mules, 1⅛" distance, 64" stretch. Second spinning room contains 28 x 1,344 S. A. mules, 1⅛" distance, 64" stretch. Third spinning room contains 28 x 1,104 S. A. mules, 1⅜" distance, 64" stretch.

weigh 14 ounces per yard length. With this will go the roving waste opener and feeding machine. This completes the blowing room machinery, after which comes the machinery as per table 1.

Each process is allowed on the above 1 per cent. loss from the card sliver to the spindle point as a suitable allowance for waste.

is nominally 96,000 pounds. Since the output of a spinning frame is the product of the counts' weight and the front roller speed, the general output of a mill varies inversely as the counts, and the output of a very large factory spinning fine counts is quite moderate in weight. The labour cost of yarn must vary also very closely directly as the counts, as also must

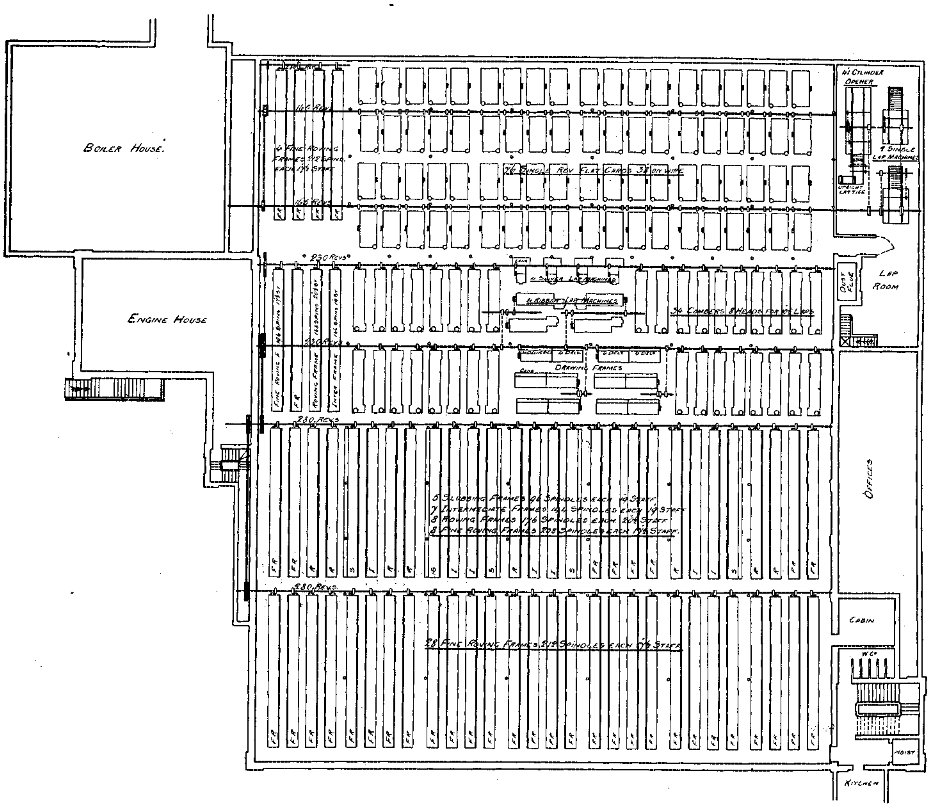

FIG. 15.—CAIRO MILL. MACHINERY BY ASA LEES & CO., LTD.

Different machine makers have their different ways of solving the problem of a factory equipment, but they do not differ very far in their proportions as to machinery and output.

In the second table are given the similar estimates of another firm of machine makers. This latter also may be described as a standard mill for Oldham counts, so called, though Oldham has taken to finer counts now to a very large degree. For this mill the weekly production

general charges, fuel and other labour. The price of yarn when spun is, therefore, made up of the cost of cotton per pound plus, approximately, $\frac{C\,x}{10}$, where C is the counts and x is the total mill cost of No. 10's. In very fine yarns the latter item may very much exceed the former. In coarse counts the cost of the cotton itself remains the chief expense. Hence the coarse spinner is more heavily hit when prices of raw cotton go up than is the fine spinner, and the coarse spinner must also be more on the alert in respect of loss of weight by dirt and waste; for this will affect his profits more than it would where the labour forms a greater proportion of the cost of a pound of yarn.

The Stanhill Mill, at Oswaldtwistle, Figs. 12-13, has been fitted up throughout by Howard & Bullough, of Accrington. It contains 70,584 ring spindles spinning counts from 10's to 50's. The top floor contains, besides ring frames, warping and winding machinery, which does not come into the purview of this article. The second floor contains only ring spinning frames; the first floor contains the cards, 132 in number, 88 finishing drawing-deliveries, 11 slubbing frames of 104 spindles, 22 intermediate frames of 142 spindles, 26 roving frames of 180 spindles, and 22 of 204 spindles. In the blowing room, on the first floor, are 3 openers, with hopper feeders and 6 finishing scutchers, and on the ground floor the hopper bale openers, 3 in number, and a large cotton store. The counts spun average about 30's.

In order to place all the carding engines and speed frames on one floor, a very considerable shed extension of the first floor has had to be made; this is shown beyond the row of half-spaced pillars, the cards being under the unlighted shed roof. It will be noted that the drawing frames are spread along the front line of the cards, so as not to involve too much movement of sliver cans. The slubbing and intermediate frames are similarly interspaced, one and two along the line of drawing frames, and the roving frames then form a third long line.

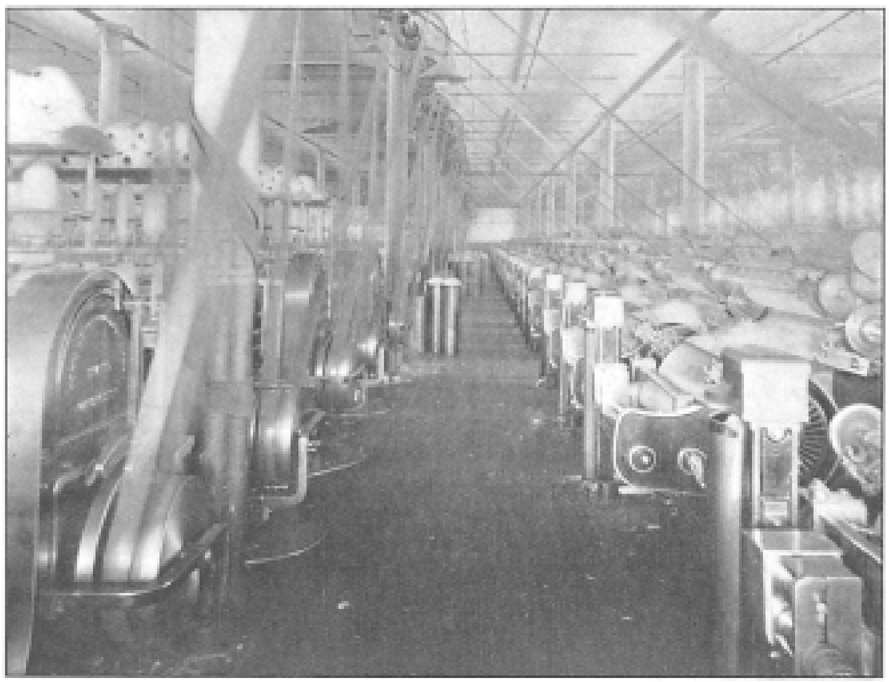

FIG. 16.—CARD ROOM OF CURZON MILL, ASHTON-UNDER-LYNE. MACHINERY BY JOHN HETHERINGTON & SONS, MANCHESTER

The laps travel in from the blowing room on a single-line train, the blowing room being on the same floor beyond the rope race and small hoists and subsidiary stairway. The unoccupied spaces serve for accumulations of sliver cans, skips of slubbing or roving bobbins, full or empty, and as passageways. The spinning room, nearly 102 feet wide, provides for two frames of rings across it of 432 and 408 spindles, respectively, with a double tram line between the frames, the spindles running at 9,000 revolutions per minute and the frames being all driven from a single line shaft with gallows frame pulleys.

The different length of the two rows of frames is to suit the plan of the mill, the long row extending to the face of the hoistway and the tramway track being in one straight line throughout the length of the building.

Arrangements of machines may be varied according to opinion. In one card-room arrangement the drawing frames are placed differently, and so that the material travels from right to left through the first head, or, *vice versa,* left to right, through the second head placed in the same line as the first and third head; whereas in Fig. 15 or Fig. 12 the three heads are in series, one behind the other. The third draw of the alternative is again opposite way from the second, so as to deliver just behind a group of slubbing and intermediate frames.

A few intermediate frames are also interspaced with the fifty roving frames.

The engines are of 1,520 horsepower, or sufficient for about 72,000 ring spindles.

As a modern Oldham mill for fine counts with combed sliver, the Cairo mill, Fig. 15 was fitted up by Asa Lees & Co., Ltd. This is a mule spinning mill, as may be inferred from the counts, which vary from 120 to 136, as seen at the time of the writer's inspection. The drawings show well the shed extension of the ground floor for the accommodation of the whole of the preparation machinery on one floor. The small amount of blowing room machinery indicates the comparatively small consumption of cotton by the 72,268 mule spindles.

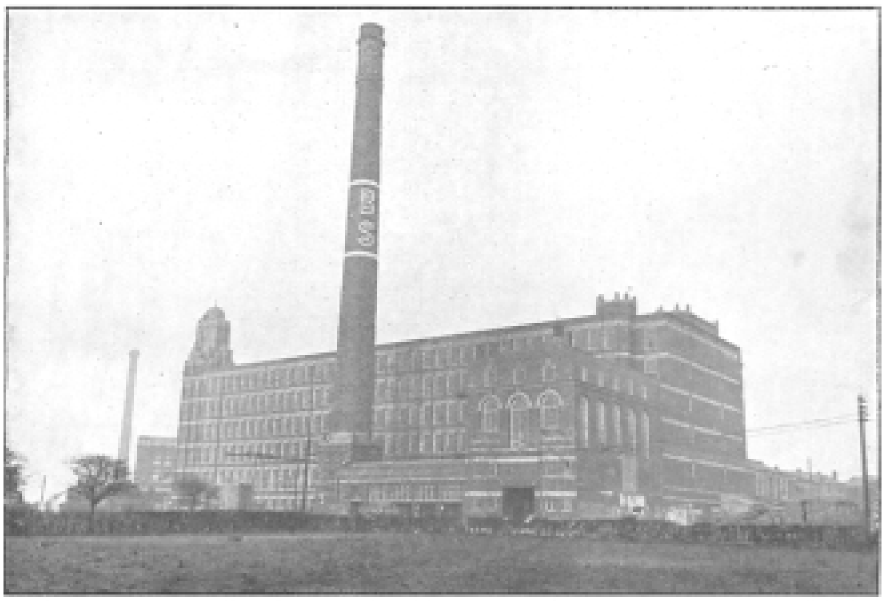

FIG. 17.—BROADSTONE MILL, REDDISH; 125,000 MULE SPINDLES, COUNTS 40's TO 110's. MACHINERY BY JOHN HETHERINGTON & SONS, MANCHESTER

The sliver lap machines, ribbon lap machines and combers are seen arranged between the seventy-six revolving flat cards and the drawing frames. The speed frames, as slubbing frames and others are called, are of four sizes, namely, 4 first, 7 second, 11 roving and 38 Jack or fine roving frames for reducing down to about 16 hank for the finer counts spun. There are only 32 finishing deliveries of drawing, and there are 24 combers with 4 sliver and 4 ribbon lap machines; but there are 72,268 mule spindles made up of 18,732 spindles of 1⅛ inches gauge in each of the first, second and third spinning rooms, and 16,072 spindles of 1 5/16 inches gauge in the fourth spinning room.

As an example of general construction may be cited the Imperial Mill, Blackburn. Fireproof throughout, the floors consist of steel beams with a brick vaulting covered with spruce boards, and carried by cast-iron columns and brick walls. The windows are large in area. The cellar serves as a cotton store, warehouse, yarn cellar, dust and waste chambers, general storeroom, and as a reeling room. There is a loading way which admits lorries under a projection of the blowing room in the centre of the mill. On the first floor is the card room, extended on the south side by a narrow shed building, as elsewhere described as being usual practice to enable all preparation machinery to be placed on one floor. The second floor is filled with ring frames, as also a part of the top floor, which contains winding, warping and beaming machines.

The engine house is projected beyond the south wall, and measures 77 feet 6 inches by 36 feet wide, with a rope race projecting into the mill and extending to the roof. The engine room walls and floors are tiled.

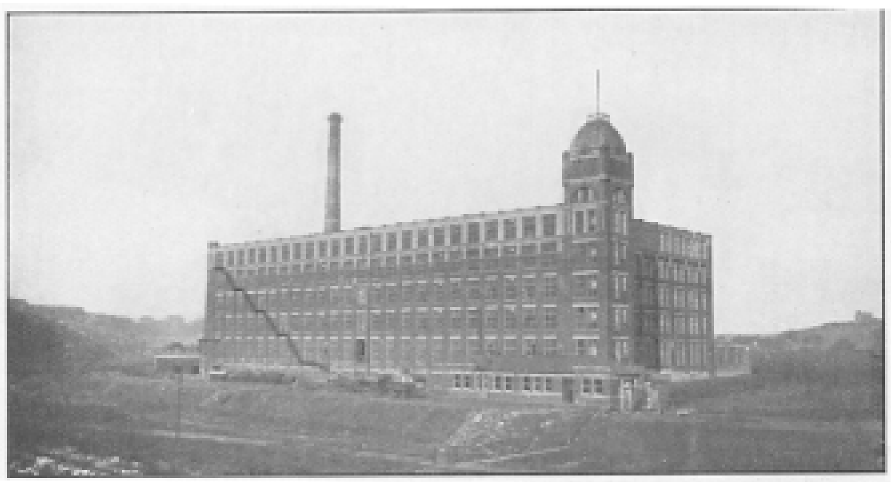

FIG. 18.—KEARSLEY SPINNING CO., LTD., BOLTON; 120,000 SPINDLES, 60'S TO 120'S COUNTS. MACHINERY BY JOHN HETHERINGTON SONS, LTD., BOLTON

The boiler house is alongside, and contains four 30 ft. × 8 in. Lancashire boilers and a Green's economizer of 384 pipes. The pump house adjoins. The chimney is 210 feet high and 9 feet inside diameter.

There are in the blowing department 3 hopper bale openers, 3 hopper feeders, 3 exhaust openers, in the cellar; 6 intermediate and 6 finisher scutchers. In the card room there are both fine and coarse preparation machines, namely, on the fine side 52 revolving flat carding engines, 15 drawing frames, 5 first slubbing, 8 second and 20 roving frames; and on the coarse side the same numbers; while in the fine spinning department there are 44 twist frames of 400 spindles each and 44 with 420 spindles, the gauge being 2⅜ inches with 1½-inch rings. On the coarse side there are 36 ring frames of 420 spindles and 36 of 400 spindles and 4 of 384 spindles, with a gauge of 2⅜ inches and rings of 1⅝ inches. There are 14 winding frames and 19 beaming frames.

The course of the fibre is from the bale openers to the hopper feeders, thence to the exhaust openers, where the first laps are made. There is no handling of the cotton after it is pitched in bulk into the bale opener. The laps are run on a tram car to the rear of the carding engines. The rope race divides the card room into two distinct halves, fine and coarse. The rovings are raised by a lift at each end of the mill into the spinning rooms.

The exhaust openers have each a combined scutcher beater and produce laps which are placed on the intermediate scutchers, which form laps for the finishers.

In the carding engines 43 of the 110 flats of each engine are always working; there is a slow motion for use when grinding the cylinder and doffer wire clothing and for slowing when piecing sliver. The three heads of draw frames are in series, one frame behind another, and all have the makers' electric stop motion.

The speed frames have three rows of rollers and a full bobbin stop motion, and the ring spinning process have the Rabbeth flexible spring spindles, tin rollers carefully balanced and sliver traverse motion for equalizing wear on the leather rollers, anti-balloon apparatus and girder section spindle rails. All wheel teeth are machine-moulded or cut, and the machinery is made throughout to

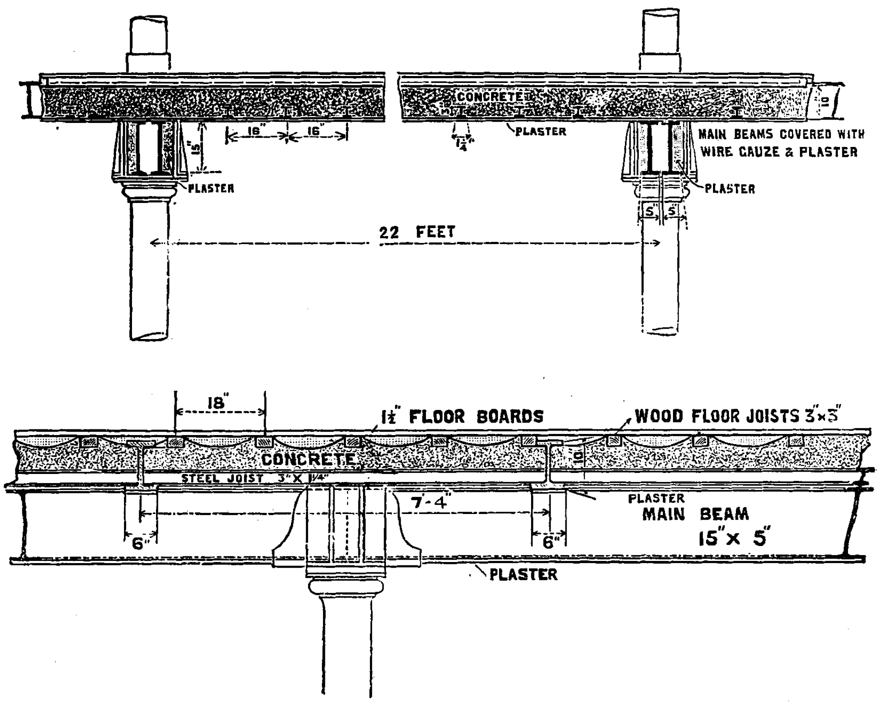

FIG. 19.—CEILING WITH STEEL GIRDERS, AND FLAT CONCRETE CEILING WITH SMALL STEEL JOISTS, BAYS 22 FEET X 14 FEET. PLATT BROS., OLDHAM

gauge and template, with interchangeable parts.

The engines required to drive this mill of 66,736 ring spindles, preparation, etc., have an economical capacity of 1,700 horse-power, and are of horizontal, four-cylinder, triple-expansion type, capable of 2,000 horse-power if required. They are of two-crank, double-tandem type with cylinders 23 inches, 38½ inches and two 42½ inches diameter with a 66-inch stroke, the two-horse-power cylinders being placed in the rear. The speed is 60 revolutions per minute and the boiler pressure 180 pounds. The first two cylinders are jacketted, and there is a steel-plate jacketted reheater between them.

The rope rim is 27 feet diameter, is grooved for 38 ropes 1¾ inches diameter, and weighs 65 tons. There is a jet condenser and an air pump to each side, worked by the usual lever from the tail rod, and the engine can be stopped from any room in the mill in case of accident.

The shafting consists of a line in the cellar with two ropes; two card-room shafts, each with six ropes; one spinning-room shaft with eighteen ropes, and a six-rope line in the top room.

The shafting is all steel, and has ring lubricated bearings. The two lighting dynamos are rope-driven from the card room shafting, and fitted with friction clutches for starting and stopping. The ropes are of the Lambeth type, with a cover of ten twisted cords of cotton yarn. The peculiarity of the Lambeth rope is its four strands, with a small central core on which no stress comes. Ropes are usually three-stranded.

Throughout the mill is a full system of automatic sprinklers fed from a fly-wheel pump, and there is a water tank of 7,500 gallons capacity in the dust tower. This also sup-

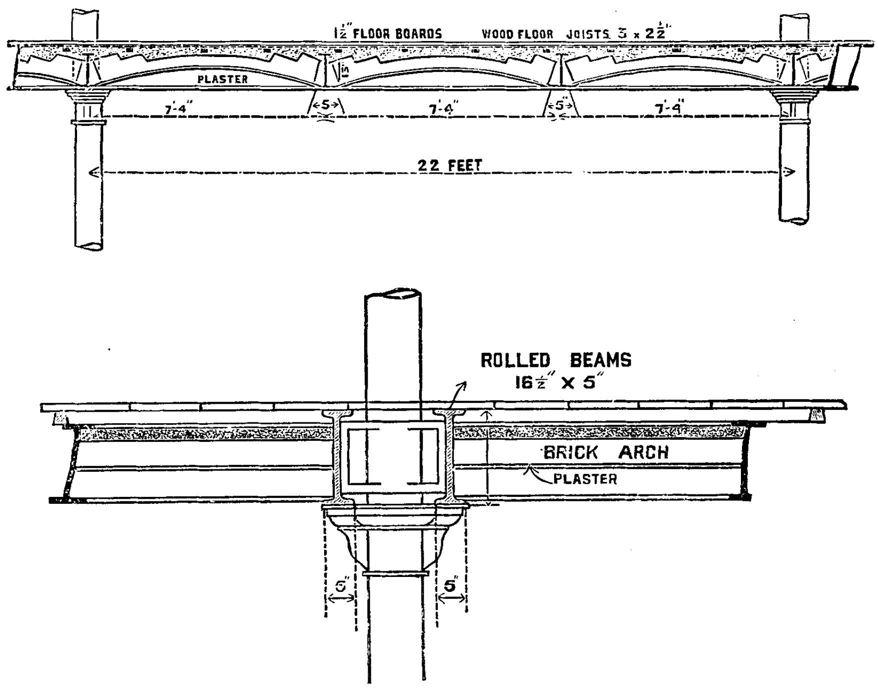

FIG. 20.—CEILING WITH STEEL DOUBLE MAIN GIRDERS, STEEL CROSS BEAMS, AND BRICK ARCHES, BAYS 22 FEET X 22 FEET. PLATT BROS., OLDHAM

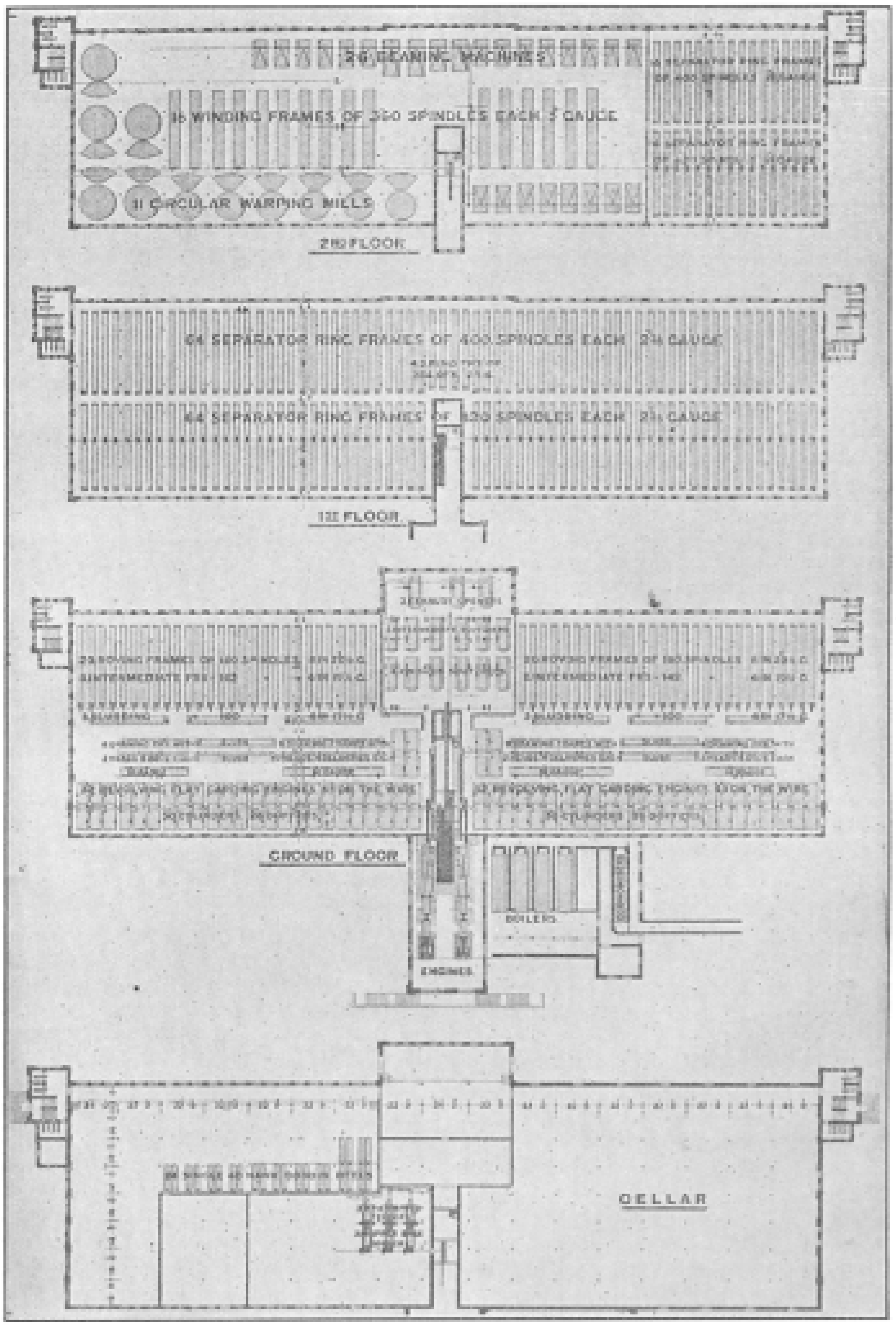

FIG. 21.—MODERN LANCASHIRE RING SPINNING MILL, 67,136 SPINDLES. HOWARD & BULLOUGH, LTD., ACCRINGTON. ENGLAND

plies the sprinklers. The pump also supplies hydrants at points round the mill and on each landing of the staircases. All necessary pressure gauges, valves and name plates are supplied.

There are three lighting dynamos, two driven off the main engine and one driven by a separate small engine. There are two circuits, a main and a pilot, the main current only being put on for working hours and the smaller circuit for lighting the employees in and out.

This mill may also be taken as a fair example of the modern mill. The machinery throughout was supplied by Messrs. Howard & Bullough, of Accrington, to whom the author is indebted for drawings and information in preparing this article. Since the Imperial Mill was built the top room has been filled with preparation and spinning machinery, so that the mill now contains 90,812 spindles, and a shed has been erected outside for the displaced machinery.

Messrs. Platt Bros., of Oldham; Messrs. Dobson & Barlow, of Bolton; Messrs. Asa Lees & Co., of Oldham, and Messrs. John Hetherington & Sons, of Manchester, all supply machinery of similar high class for the complete equipment of mills throughout, and have, equally, placed the author under obligation by their supply of illustrations and information.

In the limit of a brief article it has been impossible to do more than make selections for illustrations, one machine from one firm, another from a second, and so on; and there are, in addition to the above-named firms who make the whole range of machines, such firms as Messrs. Lord Bros., of Todmorden, who originated the piano-regulating motion; Messrs. Taylor, Lang & Co., of Stalybridge, who made a specialty of the mule and of blowing-room machinery; Messrs. Tweedales & Smalley, of Castleton-by-Rochdale, who make carding-room machinery and ring frames; Messrs. Brooks & Doxey, of Manchester, who make almost the full range of spinning and doubling machinery; while there are scores of firms making a few machines or one class of machine or accessories, such as spindles, bobbins, card wire cloths, and the thousands of small details which appertain to the spinning industry, which has now extended until there are probably 55 million spinning spindles in Great Britain.

And to drive all this machinery there are boilers and steam engines made by numerous world-known firms, such as Hick Hargreaves, Musgraves & Woods, of Bolton; Yates & Thom, of Blackburn; Saxons and Buckley & Taylor, of Manchester and Oldham, and many others, consideration of which properly belongs to a special article.