CHAPTER XIII.

THE WET SPINNING OF FLAX, HEMP, AND RAMIE YARNS.

The Wet Spinning Frame.—Figs. 61 and 62 show the usual form of wet spinning frame used for spinning flax, hemp, and tow yarn. The bobbins, full of rove, are brought from the roving frame and placed upon wooden or wire skewers A in the creel B C D, fig. 61. Brass or porcelain footsteps are inserted in the planks C and D, which support the skewers and bobbins, in which steps the points of the skewers turn freely, while they are supported in a vertical position by the staples E, or in holes in the plank above. The creel must be made wider if the frame is to be used for spinning "double rove," for in that case double the number of bobbins must be put in the creel at one time in order that there may be two ends per spindle instead of one. The rove passes from the bobbin, as shown, over the brass guide rod F, which should direct it in such a manner that it passes between the back of the trough G and lid H (without rubbing against either) and round another rod, I, which is placed near the bottom of the trough T, containing water at a temperature of from 100° to 170° F. The rod I is placed low in the trough in order that the rove may be kept as long as possible under the action of the hot water and be sufficiently macerated. The trough is supplied with water and steam by feed-pipes connecting it with the main supply pipes which pass above the frames. The proper position of the steam pipe in the trough is shown at J. Since heated water rises, the pipe J must be placed low down and far enough from the line of the rove to prevent the latter from being scorched.

From the rod I the rove is drawn by the feed-rollers K, over the lip L of the trough and rove guide M. The object of the latter, which is given a slow and short reciprocating horizontal motion by an eccentric moved by a worm wheel and worm upon the end of the feed roller K, is to cause the rove to traverse backwards and forwards over the face of the roller so as to distribute the wear pretty equally over its surface, and in this way increase its life. Were the rove to remain in one place upon the roller a track would soon be created which would prevent the roller N drawing as it should. N is the boss or drawing roller, moving at from four to sixteen times the surface speed of the feed roller K, and effecting, by the aid of the pressing rollers O and P, an equal amount of drawing out or drafting. The rollers O K N are all brass covered, but the drawing pressing roller P is of wood, india-rubber or guttapercha. All these rollers are fluted to a pitch varying with the coarseness of the frame, and lying between 20 and 40 flutes per inch in diameter. The quality of the brass which covers these rollers,

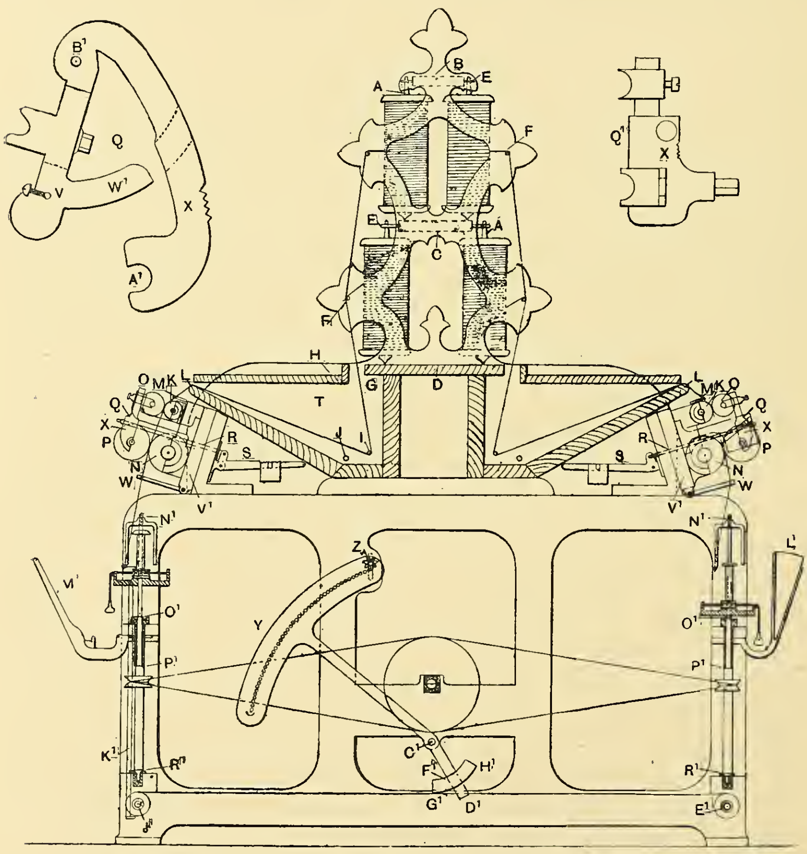

FIG. 61.—Section of wet spinning frame for flax, hemp or tow.

and the method of casting, are of great importance, especially for fine spinning. The metal must be close-grained and of equal density throughout, for blowholes and other flaws cause the flutes to be imperfect and prevent them from drawing properly. Most of the makers have special mixes and methods of casting, while in the same cases the bosses are compressed under great pressure while on the roller. The pressing rollers O and P are in pairs, upon either end of short axles. The means by which they are pressed against the feed and drawing rollers, which are in one long

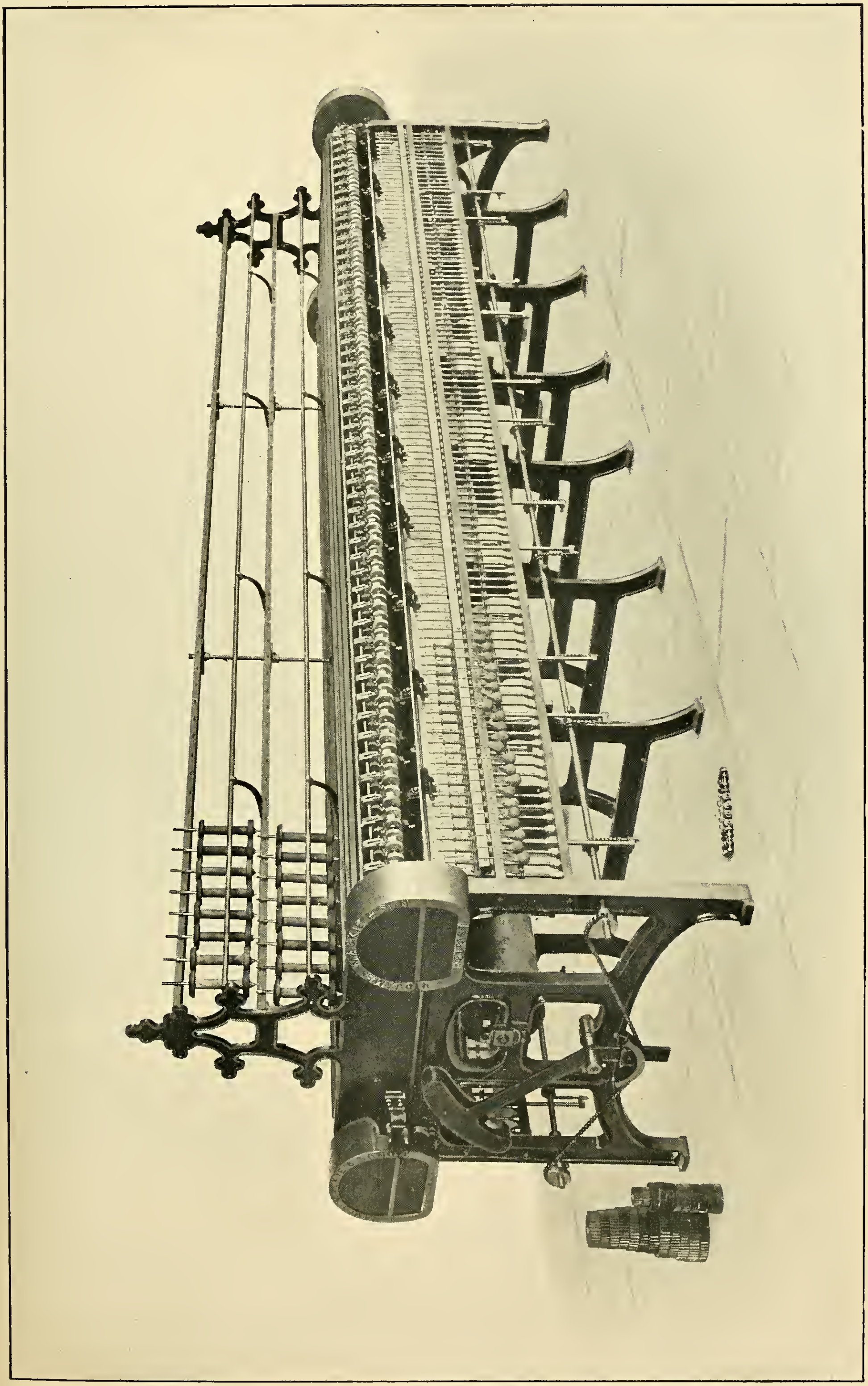

FIG. 62.—Wet spinning frame for flax, hemp or tow, as made by James Mackie & Sons, Ltd., Belfast.

length, is clearly shown. Q is a piece of brass, called the "saddle," having two bearings, which embrace the journals between each pair of pressing rollers. A pull is brought to bear upon it through the wire R, one end of which is attached to the short arm of the lever S, while the other passes through the saddle, which is tightened up by a nut upon the screwed end of the wire R, a washer or collar, called the "humbug," being interposed between the nut and the saddle.

A weight is placed upon the long arm of the lever, as shown, in a position necessary to give the required pressure, which varies from 60 to 180 lbs. The figure shows the frame fitted with rollers of an ideal size, under which conditions the lever is exerting its force most efficiently, the spring wire R being at right angles to the saddle and pressing the feed and drawing rollers directly into their bearings. Under these conditions the force exerted is distributed between the top and bottom rollers in quantities inversely proportional to the length of the perpendiculars let fall from their centres upon the wire. Since the feed roller with its bearing is frequently screwed up and down in order to lengthen or shorten the length of reach, or distance from the nip of the top roller to that of the bottom one, it follows that while the perpendicular distance of the centre of the drawing roller from the spring wire remains constant for the same size of bottom pressing roller, the length of a similar perpendicular from the centre of the feed roller varies with the reach. For this reason the effective pressure upon the feed roller diminishes with the length of the reach, or *vice versâ*, while that upon the drawing roller is increased, or the reverse, in a like degree.

The size of the bottom pressing roller likewise materially affects the distribution of the pressure of the lever and weight between top and bottom rollers, for if the triangle of forces be studied, it will be seen that, the saddle being no longer perpendicular to the spring wire, the bottom roller receives a larger percentage of the pressure applied, part of which, however, is generally lost in pressure of the saddle against its stand. It may be said that, although the saddle and stand have been the subject of innumerable patents, they are a practical detail in spinning machinery which is still open to improvement. We show a few of the leading types in detail. They may be broadly classified into armless and armed saddles, the former being supported and kept in place by a single central stand, while the latter require a double stand, such as is shown on the right hand side of fig. 61. The advantage of an open or single stand is the additional room and freedom secured for cleaning, etc. Many spinners prefer a double or closed stand, because, if the stand be well spaced and the pressing roller axle of an exact length, the wooden or guttapercha rollers cover the brass bosses properly, enabling the boss roller to be run much longer without refluting. The bad practice of side and over the roller piecing, which is quite easy with an open stand, is moreover rendered difficult, and often impossible, with a closed stand. The saddle Q′, shown in detail and detached at the right of the figure, is an armed saddle which is superior to that designed in the right hand side of the frame itself, for the reason that the bearing for the bottom pressing roller may be screwed in and out with the object of keeping the saddle perpendicular to the spring wire with every size of pressing roller, for the reason already given. In both of these saddles the top pressing roller seat may be shifted up or down to keep the point of contact of the rollers constant, whatever may be the length of the reach.

Another advantage which the armed saddle has over the armless one, is that the groove, cast in the stands at either side to receive the ends of the saddle arms, may be made at such an angle or curve that the point of contact of the bottom rollers may also be kept constant, whatever the size of the pressing roller. In all classes of saddles the angle of the spring wire and the saddle itself may be further adjusted, to a small extent, by shifting the point of the humbug in the nicks made to receive it, and shown in the enlarged saddles to the right and left. The small saddle shown to the left, in the frame, is an armless saddle, similarly constructed in other respects to those already described. It has the practical disadvantage of occasionally permitting the rollers to wear to one side or the other. The enlarged saddle to the left is perhaps the best of two-piece saddles. We will describe it rather minutely, as the theory of its leverage is interesting. It is supported in a single stand, in which its short arm is pivoted at V. The short arm carries the top roller bearing, and the long arm is pivoted to the upper extremity of the first, and carries the bottom pressing roller bearing. The spur W′ on the short arm passes through the long arm, and makes the combination more rigid. The spring wire passes through the saddle at X, and is screwed up with a nut and humbug in the usual way. If the combination be studied, it will be seen that in the first instance the long arm acts as a lever of the first kind, the pressure applied at X being distributed between the points A and B′ in inverse proportion to their perpendicular distance from the spring wire. The short arm of the saddle will now be seen to be a lever of the second kind with its fulcrum in the pin V, while the force is applied at the point B′ against the resistance offered by the top pressing roller at a variable distance from the fulcrum V. This saddle has several structural defects which prevent the point of contact of the bottom pressing and boss rollers from being kept constant. Difficulty is also sometimes experienced in working with small pressing rollers, while with a long reach the pressure upon the retaining rollers is frequently insufficient.

Leaving the drawing rollers P and N, the thread passes to the action of the flyer and spindle, being steadied in its passage through the eye of the thread plate W. The thread plate eye is a round disc of brass riveted in a corresponding hole in the cast iron thread plate which is pivoted as shown, to enable the bobbins to be readily doffed from the spindles. A small round hole is bored in the brass disc, into which hole the thread is inserted through a slanting or tangential slot communicating with the outer edge of the plate. This slot is cut in such a direction that the end does not tend to fly out while being twisted. The arrangement of the spindle and flyer is very similar to that of the dry spinning frame described in our last chapter. The flyer is screwed upon the top of the spindle in such a direction that resistance to rotation tends to tighten it. The flyer eye, being quickly cut by the hard and well-dragged thread, is of brass wire soldered into the hollow end of the flyer leg and turned into a curl. The bobbin is placed upon the spindle and rests upon the builder, being "dragged" by a cord which extends across the latter, from back to front, and carries a leaden weight at its extremity, as shown. Either the side or top of the front edge of the builder is nicked to hold the cord in the desired position, the drag being "tempered" or regulated by hand, or by the automatic bobbin dragging motion, fig. 60, as the bobbin fills, causing the drag band to embrace a larger section of the grooved base of the bobbin. The weight of the drags varies from one ounce for the finest yarns to sixteen ounces or more for heavy numbers.

An up-and-down traverse is given to the builders by means of the quadrant Y, turned by the small pinion Z on the end of the long shaft extending from the other end of the frame. The circular segment of the quadrant, which is only a quadrant in name, is set with one row of round brass pins, which serve as teeth, upon either side of which the teeth of the small driving pinions act. A semicircular guide at either end of the row of teeth causes the pinion to move round to the other side, which it is free to do, its shaft not being rigidly held, but moving in a slot, as shown. The quadrant turns upon a stud at C′ and has a tailpiece, C′ D′, which, if the driving pinion cannot be placed in the centre of the frame, must make a suitable angle with the long arm of the quadrant, so that, while in motion, it makes similar angles on either side of a vertical line drawn through its rocking centre. The reason of this condition is that the builder shafts J′ and E′ are given a reciprocating rotary motion by means of adjustable chains attached to bosses upon their ends, and to a circular segment F,′ upon the tailpiece of the quadrant. The simplest way to obtain an absolutely uniform motion for the builder is to have the chains E′ G′ and J′ H′ always horizontal. This, however, is not always practicable, if the traverse of the builder has sometimes to be lengthened or shortened by moving the segment F′ up or down upon the tailpiece C′ D′ of the quadrant.

Inconveniences of this sort may be avoided, or bobbins of special shape built, by the use of cam-shaped pieces or "irons," instead of round bosses upon the end of the builder shafts. Thus, for instance, a bobbin with a large base and a small head may be used, and a large quantity of yarn placed upon it by building the said yarn in a large measure towards the base of the bobbin, by increasing the speed of the builder as it approaches its lower position, and *vice versâ*. In explanation we may say that if the head of the bobbin be too large, the end will rub against it and cause breakages or fraying of the yarn. The capacity of the bobbin may be increased by giving the full bobbin a swell in the middle, by giving the builder a slow motion near its central position, and quickening that motion towards either extremity. The reciprocating rotary motion of the builder shafts is changed into a vertical up-and-down motion and communicated to the builder itself through rods K′, known as "poker rods," one end of each being tapered and inserted in a taper hole in the builder, while the other end is attached to a short chain wrapped round a small boss upon the builder shaft. The reciprocating rotary motion of this latter shaft thus wraps on and lets off the short chains and raises or lets fall the builder, that on one side of the frame rising while the other descends. Flyer frames are at present at work building cops or pirns with a quick and short up-and-down traverse, as in the ring frame described in the last chapter. Two forms of splash boards are shown at L′ and M′. The object of this accessory to the wet spinning frame, the use of which is rendered compulsory by law in some countries, is to protect the spinners from the spray thrown off by the revolving flyers, which in a coarse frame is of considerable density. It consists of strips of sheet iron, etc., supported in brackets of various forms, the chief qualifications of a good splash-board being ease in lifting out for cleaning and freedom to move forward to enable the spinner to reach her creel with facility. The spindles are driven in the ordinary way by bands from a single tin cylinder, as shown. The most suitable banding for wet work is coated with a red composition to protect it from the damp, and is composed of three strands of three to six threads of about $2\frac{1}{2}$'s cotton, made from long-stapled fibre. Tapes are also sometimes used for heavy work. They necessitate the use of a tension pulley and a wharve of different construction to that shown. The proportion of the tin cylinder to the wharve, as regards diameter, is usually about ten to one. To keep the spindle from jumping and the step from being unduly worn, the wharve should be shrunk upon the butt in a horizontal line with the centre of the tin cylinder. A well-proportioned spindle should have the length of its blade, N′ O′, two and a half times the pitch of the frame, or the traverse of its bobbin, or about a third of the total length of the spindle. The length of the neck, O′ P′, should be about half that of the blade. The butt P′ R′ is an inch or two longer than the blade. The diameter of the blade varies from $\frac{1}{5}$ to $\frac{1}{2}$ inch, the neck being about $\frac{1}{8}$ inch larger in diameter and the butt $\frac{1}{4}$ inch more than the blade. The wharve, besides being horizontal with the centre of the tin cylinder, should be upon the balance point of the spindle in order to secure steady running. The angle of the rollers and the position of the latter in relation to the spindle and thread plate are important in consequence of the effect they have upon the strain put upon the yarn while spinning. The distance which the face of the delivery roller N stands back from the line of the spindle is termed the "projection," and varies from $\frac{1}{2}$ to $1\frac{1}{4}$ inch according to the strength and number of the yarn and the pitch of the frame. When the line of the spindle projects much beyond the face of the roller, a considerable strain is put upon the end, and *vice versâ*. The thread plate eye must be absolutely vertically above the spindle top, and the plate itself, which should be high enough above the spindle to permit the spinner to insert her hand between the plate and flyer in order to stop the latter, should also be at right angles to the line of the thread between the thread plate eye and the point of delivery from the roller. The rollers may be advanced or retired with their seats and the beam V′, which extends the whole length of the frame. The following table gives suitable settings for frames of various pitches:—

Pitch of Frame.	Bottom of Spindle Screw to Nip	Distance back from Line of Spindle.	Angle of Beam.	Angle of Rollers.	Distance from Spindle Screw to Thread Plate.
inches.	inches.	inches.	°	°	inches.
4	$9\frac{3}{4}$	$1\frac{1}{4}$	17	19	$3\frac{3}{4}$
$3\frac{1}{2}$	$8\frac{3}{4}$	$1\frac{1}{8}$	17	19	$3\frac{1}{4}$
3	$7\frac{3}{4}$	1	16	18	$2\frac{7}{8}$
$2\frac{3}{4}$	$7\frac{1}{4}$	$\frac{7}{8}$	16	18	$2\frac{5}{8}$
$2\frac{1}{2}$	$6\frac{3}{4}$	$\frac{13}{16}$	15	17	$2\frac{3}{8}$
$2\frac{1}{4}$	$6\frac{1}{4}$	$\frac{3}{4}$	15	17	$2\frac{3}{8}$
2	$5\frac{3}{4}$	$\frac{10}{16}$	15	17	2
$1\frac{3}{4}$	$5\frac{1}{4}$	$\frac{1}{2}$	15	17	2

The pitch of a frame is the distance from centre to centre of the spindles, and indicates the fineness of the frame. The line of angle of the rollers should be a prolongation of that drawn from the thread plate eye to the nip of the drawing rollers, in order that the end as delivered may not rub unduly upon either brass or pressing roller. The points of contact of the top and bottom brass rollers with their pressing rollers should be such that the lines joining their centres may cut the line from the thread plate eye, which touches the surfaces of both top and bottom brass rollers, at right angles.

The woods most used for pressing rollers are boxwood, willow, pear tree, thorn and beach, the former being suited to fine work, while the latter serves the purpose for frames of coarse pitch. Pure guttapercha, often costing 7s. 6d. per lb., is almost universally employed in the medium and coarse Continental trade, while vulcanised indiarubber forms a serviceable roller for tow spinning. When the brass roller has been well covered by the pressing roller, it should work for seven or more years without refluting. The overlapping edges of the pressing roller soon become high, gather a great deal of dirt, and eventually necessitate the refluting of the boss. Pressing rollers of the same width as the brass bosses will work much longer and produce cleaner yarn, but until some plan is devised to keep top and bottom bosses accurately in position, the old method must continue. This is a detail in which the spinning frame is open to improvement, and we would recommend it to the attention of practical men.

The following table gives the pitch of frames upon which the various numbers may be most conveniently spun, together with the ordinary reaches, diameter of rollers, and flutes per inch in diameter :—

Range of Numbers.	Pitch of Frames.	Range of Reaches.	Top Roller.		Bottom Roller.		
			Diameter.	Flutes per Inch in Diameter.	Diameter.	Breadth of Face.	Flutes per Inch in Diameter.
	inch.	inches.	inch.		inch.	inch.	
8's to 16's lea,	3	5 to $2\frac{3}{4}$	2	16	$3\frac{3}{4}$	$\frac{15}{16}$	20
12's to 25's lea,	$2\frac{3}{4}$	$4\frac{1}{2}$ to $2\frac{3}{4}$	$1\frac{1}{4}$	20	$3\frac{1}{4}$	$\frac{13}{16}$	24
20's to 30's lea,	$2\frac{1}{2}$	$3\frac{1}{2}$ to $2\frac{1}{2}$	$1\frac{1}{2}$	24	$2\frac{3}{4}$	$\frac{3}{4}$	30
30's to 40's lea,	$2\frac{1}{4}$	3 to 2	$1\frac{1}{4}$	30	$2\frac{1}{4}$	$\frac{5}{8}$	32
40's to 60's lea,	$2\frac{1}{8}$	$2\frac{3}{4}$ to 2	$1\frac{1}{4}$	30	2	$\frac{5}{8}$	32
60's to 90's lea,	2	$2\frac{1}{2}$ to $1\frac{3}{4}$	$1\frac{1}{8}$	32	$1\frac{3}{4}$	$\frac{1}{2}$	36
90's to 140's lea,	$1\frac{3}{4}$	2 to $1\frac{3}{4}$	1	36	$1\frac{3}{4}$	$\frac{7}{16}$	40
140's upwards.	$1\frac{1}{2}$	$1\frac{3}{4}$ inches.	$\frac{7}{8}$	40	$1\frac{3}{4}$	$\frac{7}{16}$	40

If the reaches be not too short and the rollers are in fair order, it will be found that pressure varying from 140 lbs. on 3-inch frames to 100 lbs. on $1\frac{3}{4}$-inch frames will give good results. The pressure is usually distributed between the drawing and retaining rollers in the proportion of about 2 to 1 respectively.

The height of the thread plate should be such that when the builder is at its highest point, a line drawn from the flyer eye to that of the thread plate should clear the head of the bobbin. The distance of the point of delivery of the yarn from the eye of the flyer varies from 7 inches in a fine frame to, say, 11 inches in a coarse one. The effective length of the flyer leg should be rather greater than the traverse of the bobbin plus the thickness of its head, and for a similar reason the length of the spindle blade, upon which the bobbin traverses up and down, must be at least equal in length to the over all length of the bobbin plus its traverse.

The flyer is of solid steel. Its head is tapped to screw upon the spindle top. It has two arms or legs, from outside to outside of which must be less than the pitch of the frame, the inside measure being sufficient to clear a full bobbin of yarn. A wide flyer puts additional strain on the end in its passage through the thread plate eye, for which reason, when spinning wefts, it is advisable to use a narrow flyer, and consequently a bobbin with a small head. The top or head of the flyer is either closed or open. Those who believe in the first-named pattern hold that a closed head prevents dirt and water from getting upon the screwed spindle top. An open-topped flyer has the advantage that the head may be more perfectly tapped.

The nature of the material and of the flax spinning frame has prevented the attainment of such high spindle velocities as are now possible in the cotton frame.

Unlike a ring spindle, the flax throstle spindle must be rigid and have a sufficiently heavy butt end to balance it. The spindle "foot" rests in a brass footstep set in the "step rail." The neck works in a long collar set in the "neck rail." That part of the spindle between the neck and step rails is termed the spindle butt, and it is there that the wharve is fixed. The butt is of larger diameter than the neck, so that a collar is formed which, running against the brass tube or collar proper, prevents the spindle bouncing up and down, if it is inclined to do so. If the wharve is placed at a proper height in relation to the tin cylinder, which gives motion to the spindles through cotton bands, there should be no tendency to jump on the part of the spindles. The total length of the spindle is from 14 to 21 inches, according to the pitch of the frame. It weighs 9 to 25 ozs.

The wharve has usually a V-shaped groove for a cotton band, such being quite sufficient for medium and fine frames. Coarse frames, with heavy spindles, are often driven by tapes about an inch in breadth. Such a drive is inconvenient, since it necessitates the use of tension pulleys to maintain the driving tension of the bands. "Capstan" wharves are rather to be recommended for coarse work. Such a wharve is deeper, and has a shallow and broad groove around which the cord is wrapped twice, and in this way insures a good drive.

The tin cylinder which forms the driver of the spindles, on both sides of the frame, is usually 10 to 12 inches in diameter. If the frame be long, or if there be no means of inserting a long length of cylinder when once the frame is erected, it is made in two or more sections which are united together by socket joints provided with projecting lugs which engage and cause the sections to turn together. A few inches are left between each section, the short axle between them forming a journal, which may be supported by a bearing upon a cross beam. Needless to say, these central bearings must be kept well oiled and accurately lined up, or else they will be the cause of many broken cylinders.

The side of the spindle banding running on to the tin cylinder may be placed either to the right or left hand side of the wharve, turning the spindle so as give either right or left hand twist to the yarn. As we have found that the term "right and left hand twist" is not everywhere understood in the same way, we may state that we here understand that the yarn has received right hand twist when the end twisted in the direction of the hands of a clock tends to become harder. In spinning, the yarn is twisted in this direction when the flyer, as looked at from above, turns in a contra-clockwise or negative direction. In ordinary weft spinning, the spindle and flyer turn in a positive or clockwise sense and put in left hand twist. It is only for special purposes that right hand twist is required, such as occasionally for sewing threads, for instance, where it is desired to give the thread its final twist in any special direction. Right hand and left hand twisting can only be done upon the same frame when the spindle tops upon which the flyers are attached are specially provided with a right hand and a left hand thread, the reason being that the flyer must be screwed on in the opposite direction to the revolution of the spindle, otherwise it will fly off.

In setting the traverse of the bobbin to the flyer eye, at the lowest position of the builder, the yarn should be delivered from the flyer eye and wound directly upon the bobbin barrel at a point quite close to the head of the bobbin. Similarly, when the builder is at its highest point, the thread should be wound upon the barrel close to its base. Since with the quadrant there must always be a short "dwell" in the motion of the builder as it changes direction, or as the quadrant pinion turns the last tooth in the rack, it is often found advisable to shorten the traverse by a fraction of an inch, leaving a small clearance space at each end of the bobbin barrel to accommodate the slight accumulation of yarn at this point caused by the "dwell" in the motion of the builder.

The bobbin is of wood such as boxwood, teak, mahogany, sabicú, etc., with top and bottom flanges. The former, or head, is not so deep as the latter, or base, which requires to be grooved for the drag band. The portion between the head and base is called the barrel. It is usually parallel and of a diameter superior to that of the spindle, which passes through it by an amount sufficient to give it resistance without unduly diminishing the yarn-holding capacity of the bobbin. The diameter of the bobbin barrel is sometimes slightly increased just at its junction with the ends, so that if the builder be rather defective through wear, by shortening the traverse slightly, a bobbin is built which may be wound off with an ease which would be lacking were the bobbin of the ordinary form. The bobbin barrel is bored out a close, but easy, fit for the spindle. Its interior is chambered to reduce the bearing and friction surface on the spindle blade. The walls of this chamber must be left sufficiently thick to preserve the requisite strength of the barrel. Boxwood is a fine-grained, hard and heavy wood, almost universally employed for small bobbins for fine yarn. It is too heavy for the larger bobbins, so the lighter woods are employed as the size of the bobbin increases. Teak is a hard wood of rather open and cane-like structure. Bobbins made from this wood are thought to wear the spindle blade more than those of other species. Some spinners attribute this to the presence of sand in the pores of the wood, a supposition we are not disposed to confirm. Boxwood, we believe, gives the best working surface upon the spindle blade, for which reason this wood is often used to "bush" the bore of bobbins made of the lighter and softer woods. The size of the bobbin is proportionate to the pitch of the frame upon which it is to work. As a general rule the length of the traverse or barrel may be equal to the pitch of the frame or the distance from centre to centre of adjacent spindles, while the diameter of the head and base may be taken to be half the length of traverse.

Modification in the form of the bobbin may be made to suit special work, or with a specific object. For instance, if in spinning a weak weft yarn we use narrow flyers in order to reduce the strain put upon the end by the thread plate, we must also have a small-headed bobbin. In order that the bobbin may still contain the same quantity of yarn, we will have to lengthen the traverse or bobbin barrel. Or again, if for strong warp yarns we desire to get an additional drag upon the bobbin, we may provide the latter with an exceptionally large base, giving an increased friction surface for the drag band.

Having mentioned the subject of drag upon the bobbin, we may say that its intensity should be all that the yarn will stand, for besides augmenting the length which may be wound upon the bobbin, it increases the smoothness and strength of the yarn very materially in drawing the fibres into closer contact. If hard fibre be not perfectly drawn by the rollers, a heavy drag will often prevent the presence of "beads" in the yarn. A "bead" is caused by the presence of hard fibre whose component parts the rollers have been unable to draw out and separate. Around the central fibre are gathered others, which form a lump devoid of twist, a weak point and grave defect in any yarn.

Starting and Working a Frame.—Having described fairly minutely the working parts of a wet spinning frame, we will proceed to explain how such a machine is started as a yarn producer. Given a new frame, or one in which the old rove has been broken out for repairs, changing, cleaning, etc., the rove bobbins must be replaced in the creel, the ends drawn over the rove rods, down between the back of the lid and trough, under the bottom rove guide, over the lip of the trough, and placed in position to be inserted in the nip of the feed roller when the frame is started. The water is then turned on and the trough filled to the required level, when the steam valve may be opened and the water raised to the required temperature. The frame may then be started and the ends of rove inserted singly between the rollers by the spinner, "layer" or "piecer-up." The drawn end as delivered laps round either the boss or pressing roller, from which it is easily removed if the latter be kept well moistened.

There are two ways of attaching the newly formed yarn to the bobbin —*i.e.* either by "piecing up" or by "laying on." To accomplish the former, the worker is provided with a bobbin of yarn. Placing her left hand upon the top of the spindle and flyer, she stops them, and taking the end of the yarn with which she is provided, she places it in the flyer eye and carries it through the eye of the thread plate. Releasing the flyer, the end is lapped upon the bobbin, the latter being pulled round at the speed of the spindle as long as the other end is held. Breaking off the thread which she holds, from the bobbin, she transfers the end to her left hand and holds it near the extremity between her finger and thumb. Then with her right hand she takes the waste from the roller, and drawing the drawn and untwisted rove downwards at the speed at which it is being delivered, she adroitly unites it with the end which she holds in her left hand, which end she allows to slip through her fingers and twist in with the rove as delivered. This is practically the method by which the spinner pieces up a broken end in the ordinary way, the only difference being that, instead of placing a fresh end upon the bobbin, she must, if possible, find the broken end and, pulling off a sufficient length, thread the flyer and thread plate eyes and piece up the end as described. Needless to say, the process is much more difficult to execute than to describe, and requires years of practice. Laying on is still more difficult, and is only possible at slow or moderate speeds. It is effected by taking the end of rove as delivered from the boss roller, and by a quick motion of the hands twisting it into a thread between the palms. The thread, when formed, must be quickly put into the eye of the flyer with the right hand while it is held by the left, and both being released, the end is lapped upon the bobbin while the thread is being steadied and guided into the thread plate eye. In spinning superior yarns, laying on is sometimes practised for all ends requiring to be set spinning again, since the reelers can cut off the untwisted ends when they turn up and make a small weaver's knot, which is much superior to even a well-made piecing. When the doff or set of bobbins is full, all the ends should be got up and the frame stopped while the builder is in its middle position, lest the ends when broken off should be lost between the head or base of the bobbin and the yarn upon it. It will save much time and waste if all the ends can be set spinning prior to the doffing of the frame. When stopped, the doffers commence to draw a short length of yarn off the bobbin and to break off the threads, which they throw upon the trough lids. They first remove the flyers from the spindles and then the full bobbins, which they replace by empty ones after the spindle blades have been rubbed with an oily "patch." Replacing the flyers, they bring down the ends again and thread the eyes. The drag bands are put back to their starting position and the frame slowly but steadily started. If all this has been carefully but quickly done, few, if any, ends should be broken. Each doffer should have a certain number of spindles assigned to her, according to her proficiency, so that all may be finished at the same time. If this be well managed, two minutes should suffice to doff a frame of 200 spindles.

The draft and twist may be changed on the wet spinning frame in a similar manner to that described in our last chapter when dealing with the dry spinning frame.

The reach being short, the draft gearing is, of course, more compact, consisting merely of the top roller wheel, draft change pinion, stud wheel on the horse head, and the boss roller pinion. An average draft of 9 or 10 is the rule, but when spinning double rove the draft is usually longer. A short draft always gives a more regular yarn, and is the thing for superior yarns and warps.

The number of turns per inch twist required is usually reckoned by multiplying the square root of the lea of the yarn by $1\frac{1}{2}$ for weft, $1\frac{3}{4}$ for light warp, 2 for full warp, and $2\frac{1}{4}$ or $2\frac{1}{2}$ for thread warp.

The effective circumference of a fluted roller is not the same as that of a plain roller of the same diameter, for the reason that the former develops a greater length when the material it delivers is pressed into the undulations of its surface. The finer the flutes, the shallower they are, and the more the surface of the roller approaches the form of a plain cylinder. The coarser the flutes, the deeper they are, and the greater the effective circumference of the roller. The actual circumference of the boss roller of the spinning frame may be determined by passing a slip of paper through the rollers when the frame is running, then counting off a number of indentations corresponding with the number of flutes in the boss, and cutting off the remainder of the paper. The length of the preserved piece when smoothed out will be the correct circumference of the boss. Carefully measured in this way, it will be found that the circumference of a roller with 20 to 24 flutes per inch is the product of 3·4 and the extreme diameter of the roller. For rollers with 26 to 32 flutes per inch, 3·35 multiplied by the extreme diameter gives the circumference, and similarly for rollers fluted up to 40 per inch their circumference is the product of 3·3 and the extreme diameter of the roller.

This increased development of the boss roller of wet spinning frames must not be lost sight of when making the twist calculation, since the drawing roller delivers a greater length than would a plain roller of the same diameter.

Wet Spinning of Ramie.—Fig. 63 shows the upper portion of a wet spinning frame used for the ramie fibre. The strength of this fibre is due, not, as in the case of flax or hemp, to gummy matter binding the individual filaments together, but to the length of individual filaments themselves, which in order to be spun fine must be entirely freed from all such gummy matter. Hence the length of the reach of even a wet spinning frame for ramie must be from 12 to 20 inches. This distance is divided into three portions by two long rollers with light wooden pressings, which serve to control and render the drafting uniform. The fibre is so clean that the ring system of spinning is usually employed in preference to the flyer.

Before leaving the subject of wet spinning, it will be of interest to mention a way of producing a lumpy yarn for fancy linens upon the wet spinning frame. Fig. 64 shows the means which Mr M'Meekin of Belfast has devised to produce the desired effect. It will be seen that, instead of the speed of the feed roller being periodically increased by means of eccentric wheels, as is sometimes done in a gill spinning frame, the feed or retaining roller is pushed quickly forward at intervals by means of a ratchet and pawl actuated by a connecting rod and a heart wheel. The mechanism consists of a pinion *b*, placed upon a cylinder shaft, which pinion transmits motion to a cam *g* through the wheels *c*, *e*, and *f*. The wheel *e* is a change wheel for varying the speed of the drive. The shaft upon which the cam is mounted is turned down, and enters slots in the two rods *h* and *h'*. Secured to each rod, by means of pins, is a runner or bowl, which is kept in rolling contact with the surface of the cam before mentioned. As the latter revolves, the radial action of the rods operates upon the bell-crank levers shown, and through them causes the pawls *w* to turn the ratchet wheel *o* on the retaining roller shaft *m*. Mounted loosely upon the shaft *m* is a free wheel *p*, which obtains its motion from the draw-roller shaft. This free wheel is provided with a series of driving pawls, which engage with a second ratchet wheel *w* on the retaining roller shaft. The cam *g* is shaped in such a way that at every revolution the arms *h* and *h'* are pushed quickly forward, accelerating for a short time the speed of the retaining roller. The ratchet mechanism referred to, being operated from the drawing roller through the horse-head stud wheel and

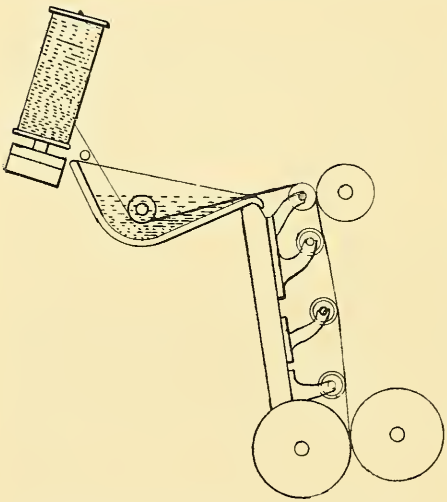

FIG. 63.—Part of ramie wet spinning frame.

draft change pinion, drives the feed roller at the usual speed when not affected by the throw of the cam. The acceleration of the speed of the retaining rollers at regular intervals produces lumps in the yarn at equal

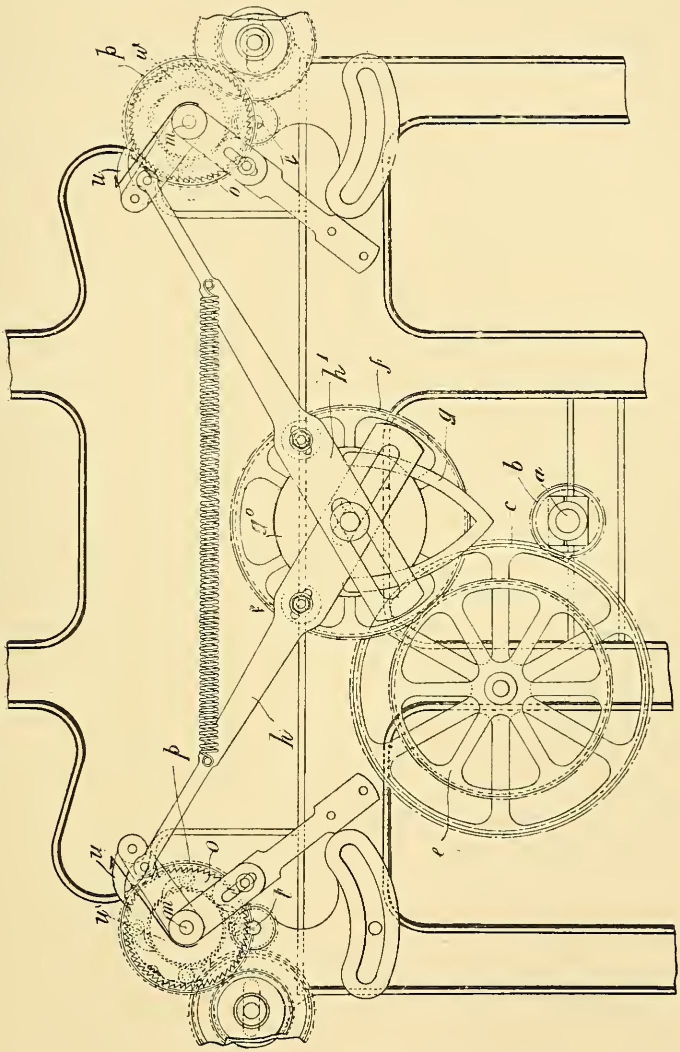

Fig. 64.

distances. Of course the thread plate eyes must be of sufficient size to let the lumps pass to the bobbin.

Cold Water Spinning.—Our chapter on wet spinning would be incomplete if we did not mention cold water spinning, which has within recent years received some attention at the hands of spinners.

Some classes of flax, usually devoid of any great strength, such as some of the dew-retted varieties, will spin very well through almost cold water, and often the water must be kept at a low temperature in order that the rove may draw through the trough without breaking. The harder and stronger the flax, the longer must it be subjected to the action of cold water, in order that the gum binding the fibres together may be softened sufficiently to enable them to be separated or drafted on a short reach.

The rove intended for cold water spinning should be put upon rove bobbins with perforated barrels, and these bobbins of rove steeped in water for some time prior to spinning. The perforated bobbin barrel permits the water to penetrate and act upon the interior layers of rove, so that all may become equally softened. In addition to this preparatory steeping, which should be of constant duration for the same rove, the bobbins, instead of being put in a creel, as in hot water spinning, are placed vertically upon upright pegs in a specially deep spinning frame trough kept full of water. In this trough they revolve quite freely, since the buoyancy of the water supports them and reduces friction. The advantages of this method of spinning, which answers admirably for some classes of flax, are the saving in the cost of steam for heating the troughs, and the cooler, drier, and more healthy atmosphere of the spinning room.

The Use of Alkalies for Maceration.—While the maceration of flax, hemp, or tow fibre is more easily accomplished in soft water than in hard, yet certain alkalies in solution have the effect of softening and eventually dissolving out the natural gum of the fibre. Practical use is made of this fact in the steeping and boiling of linen yarns and cloth in soda lye, which forms part of the bleaching process.

The same alkalies, if used in the wet spinning trough, would no doubt enable the material to be spun on shorter reaches, but the danger of injury to the yarn, as regards both colour and strength, through the alkali gaining in strength as the yarn dries, precludes their use. There is, we believe, but one firm making use of such chemicals, the firm referred to being started and the mill equipped with machinery to carry out the patents of Mr Connor of Belfast. This gentleman proposed to use in the spinning trough a ·5 to ·75 per cent. solution of hydrodisodic phosphate, formed by dissolving 1 lb. of crystallised phosphate of soda in 12 to 15 gallons of water, which might be slightly acidulated with a weak acid, such as acetic or sulphurous. The worst of using any such compound is the injurious effect which it has upon any iron work with which it may come in contact, and the practical impossibility of protecting the journals, etc., of the spinning frame against such injury.

Size in the Spinning Trough.—Other spinners have tried to improve the quality of their yarns as regards strength, suppleness, "skin" gloss or lustre, by dissolving in the hot water of the spinning trough such substances as starch, glucose, Iceland or Irish moss, etc. It has been found that the increased value and quality of the yarn spun in such a fashion does not warrant the increased expense and trouble incurred.

Turn Off and Speed of Spindles.—The quantity of yarn which a spindle can "turn off" in a given time is limited by the quality of the material and the speed of the spindle. If the flax or tow is really good for the number and the rove extremely level, the yarn may be spun with the spindle running at the greatest speed consistent with due wear and tear. If the material is not first-class and the ends break frequently, the yarn must be spun at a speed which will permit a skilful spinner to make good piecings, or, if the ends are laid on, to accomplish that operation.

There is one particular number best suited for each pitch of frame. Other numbers may be spun upon these frames, but at slower speeds, by reason of either the strength or weight of the yarn.

To spin a fine yarn upon a coarse frame, that yarn must be strong enough to pull round a heavy bobbin, and to stand the strain put upon it at the thread plate eye by reason of the "projection" of the rollers and the width of the flyer. To spin a coarse yarn upon a fine frame the speed of the spindles must be low enough to avoid the centrifugal force of the revolving flyer causing the ends to "balloon" out, and, striking one against the other, to break each other down. It is also sometimes advisable to spin a superior yarn at a slow speed to avoid bad piecings, etc.

The question of whether it is advisable to spin at a high speed and get a good turn off even at the expense of making a little extra waste, is an important one for the manufacturer. Its solution depends upon the price of the material being spun, the cost of spinning remaining approximately constant. If flax be very dear, more may be lost by making, say, one per cent. more waste than would be gained by causing the spinner and frame to produce more yarn in the same time by increasing the speed of the spindle. On the other hand, if the material be very cheap it is often more profitable to run at a higher speed and get a good turn off, even if the waste on the spinning does seem a little bit excessive.

Spinning Room Belting.—One of the largest items in the expenditure necessary to keep the wet spinning room running is the cost of belting. A spinning room belt, owing to the conditions of running, and to the excessive and frequent changes of temperature and humidity of the atmosphere of the room, is indeed subject to a severe test. A cotton, canvas or woven belt thoroughly waterproofed or coated with indiarubber is undoubtedly the one best suited to withstand a varying temperature and damp atmosphere. Such a belt is, however, often found lacking in other properties required by the severe nature of the spinning frame drive. Indiarubber belts are heavy and expensive. For cheapness, lightness and durability the author prefers a reliable make of camel's-hair belting, kept in good order by the regular application of a good belt syrup into the composition of which no resin enters.

Textile belts of any description are apt to wear unduly at the edges, owing to friction on the belt fork. This wear and tear may be minimised by having the guide pulleys correctly set, and by the use of porcelain rollers on the arms of the fork.

Arrangement of the Spinning Room.—The spinning room is usually sufficiently wide to take in two frames in width and to give a sufficiently wide passage down the centre of the room between the frames. The iron beams of the fireproof ceiling are supported by columns near the centre of the room and at one or both sides of the central alley. These columns support the brackets carrying the line shaft, which should have a speed of about 200 revolutions per minute and lie at right angles to the tin cylinder or driving shaft of the frame to be driven. The pulley end of the frame is usually kept away from the passage in order to avoid accidents and to give the longest driving belt possible, which is often as much as 50 or 60 feet. It will be easily understood that guide pulleys are required to carry the belt over the top and length of the frame, and to pass it vertically downwards to the driven pulley. These guide pulleys should not be less than 12 inches in diameter, in order to avoid excessive speed, friction, and wear and tear upon the spindles or studs upon which they turn. They should be thoroughly adjustable to any required angle. In setting them it should be borne in mind that the face of at least the one which carries the slack side of the belt must be in a vertical plane at right angles to the cylinder and passing between the fast and loose pulleys, while the centre of the line in which the driving side of the belt leaves its guide pulley must be in a line drawn from the centre of the face of the driving drum at right angles to the line shaft. If these principles be observed, much unnecessary friction upon the edges of the belt will be obviated and its life considerably lengthened.

In starting a frame after doffing, the belt is usually held half on and half off the fast pulley, in which position it slips and gives the desired slow motion. This practice is highly injurious to the belt, especially a textile one, as the edge bears heavily against the fork, and part of the inside face of the belt is heated and burned by friction upon the pulley. If the belt be a canvas or indiarubber one, the solution binding the layers together is often melted and runs, after which the belt soon breaks up.

The small cotton bands which drive the spindles are affected by the damp and changes of temperature in a similar manner as are the belts. They are generally found to contract and tighten up during the night, causing the frame to be heavy to start in the morning, when many bands break, being either rotten or weakened by cutting at the knot. Experiments are now in progress with a swing rail wet spinning frame similar to the dry spinning frame described in our last chapter. The advantage of the swing rail, as before explained, is to overcome this difference in tension of the bands, which is still more marked in the wet than in the dry spinning room.

The make of banding most suitable for flax spinning frames is that composed of three strands—each of three, four, five or six plies of, say, $2\frac{1}{2}$'s cotton yarn, spun from fibre of good long staple. The 3×3 cotton banding is suitable for the finer frames, while the 3×6 is that usually employed upon a 3-inch frame.

Band Tying.—There are two ways of tying the bands around the spindle and the tin cylinder. The first, almost universally practised in Ireland, and the only proper way for fine frames, is by using the flat or intersecting loop knot, which is a very secure one if properly made. As the band is put on when the frame is running, we will describe how it should be done. A small weight, such as a drag weight, is attached by a single bow knot to the end of the band cord which the band tyer has in the form of a ball in the box upon which he sits. Passing his weight in between the spindles to the right or left of that one which requires a band, he follows it up with an iron rod, in the hooked end of which he catches the cord behind the weight, and in this way carries it forward and drops it over the revolving tin cylinder. Withdrawing the rod from above, he uses it to catch the cord again below the cylinder, and drawing it towards him he regains possession of the free end of the cord, from which he releases the weight. He has now one end of the band on each side of the spindle, the side which will run on to the wharve being to the right or left, according as the spindle is required to give left or right hand twist and being inclined upwards or downwards according to the side of the frame upon which the spindle is situated. Crossing and intertwining the ends, he forms a single knot upon the spindle butt below the wharve. Exerting his strength he stretches the band and pulls the knot tight. If the tin cylinder is revolving towards him, he has the short end in his right hand. If he is on the other side of the frame, the tin cylinder appears to be revolving away from him, and he has the short end in his left hand. Since the band is drawn tight upon the cylinder it has a tendency to be pulled round towards the left, but it must be steadily held in place by the long end of the band in the right hand, while the short end is again passed over and looped upon the tightly drawn long end, then passed behind the spindle and both ends drawn tightly *at the same time* into a properly formed flat knot, both ends being then cut off about one inch from the knot with a sharp knife. Care must be taken in performing this operation, which is a rather difficult one to learn, not to hold the band at rest for a lengthened period upon the tin cylinder, for if it should happen to rest upon one of the numerous soldered joints, the heat engendered by friction might, and often does, melt the solder and cause the cylinder to break in two. The knot formed as we have described is much smaller than that made on the Continent, and for that reason is much more suitable for fine spinning, as a large knot causes the spindle to jump, and if, as in a fine frame, there is very little room between the spindle wharve and the poker rods, it may be caught and hold the band. The large knot we have spoken of is made as follows:—The band is passed round the tin cylinder as before and the ends brought out at either side of the spindle. The short end is crossed under the other, and then lapped twice round both sides together and drawn through the loop, forming a slip knot. The long end is then drawn tight and the knot slipped up close against the spindle and below the wharve. A notched piece of iron is then inserted between the knot and the spindle to prevent the band from moving, while the long end is cut to a length sufficient to make a single knot behind the slip knot, when the ends are cut short, the iron removed, and the band sprung upon the wharve.

Tapes for Spindle Driving.—Tape or cotton webbing, about an inch wide, is sometimes used instead of banding, especially for coarse frames. It is generally arranged that a single tape shall drive at the same time one or more spindles on each side of the frame.

The use of tapes necessitates the employment of tension pulleys, which are often a source of trouble. The tapes are cut to the exact length, and the ends joined by sewing or by a patent fastener.

Oiling in the Spinning Room.—Careful oiling is, if possible, more important in the spinning room than anywhere else. The quality of the oil used to lubricate such an immense number of spindles running at a high speed affects, in a marked degree, the power required to keep the roomful of machinery in motion. A spindle oil with too much body makes the frame heavy to drive, while, if the oil be too thin, it is not retained in the brass collar which surrounds the spindle neck. For heavy frames a very good mixed oil may be made by combining four parts of sperm oil with one part of mineral oil; but for fine frames, pure sperm oil is to be preferred. An oil or grease of considerable consistency is required for the slow running rollers working in open bushes, as a light oil would run off immediately.

How Black Threads are Produced.—The greatest care must be taken in oiling the rollers lest any oil should get upon the material being spun. Black threads in bleached yarn are generally caused by oil absorbed on the spinning frame. Black oil will often make its way from a roller bearing under the brass carriage or covering of a roller, and come to the surface through a blow-hole in the metal. The spinning room guide pulleys should be well greased every morning before the mill starts. The spindle necks should be oiled twice per day while at work, and the spindle steps once a week. The boss or drawing rollers should be oiled every day, but once a week will be found sufficient for the slow-moving top or feed rollers. Once a week will also be found sufficient for the builder motion, but both draft and twist gearing had better be oiled twice a week.

Cuts per Spindle.—The rate of production of a spinning frame is usually calculated and compared in cuts or leas of 300 yards obtained per spindle, and per hour or per day.

Degree of Saturation of the Atmosphere of the Wet Spinning Room.—The frequently excessively humid, and, consequently, unhealthy atmosphere of the wet spinning room has led to the introduction of a "special rule" or clause of the Factory Act limiting the degree of saturation of the air in the wet spinning room. The instrument by which this is determined is known as a hygrometer, the most convenient form of which is a wet and dry bulb thermometer, such as is shown in fig. 65. These are two ordinary thermometers, side by side. The bulb of one is covered with muslin, which is connected by a wick with a water reservoir, so that it remains always moist. When the air is fairly dry, or still far from being completely saturated with moisture, evaporation from the muslin covering of the wet bulb is constantly going on, and an amount of heat corresponding with the rate of evaporation or dryness of the air is being extracted from the bulb, causing it to show a lower temperature than its companion or dry bulb. When the air is fully saturated, no water will evaporate, and the two thermometers show

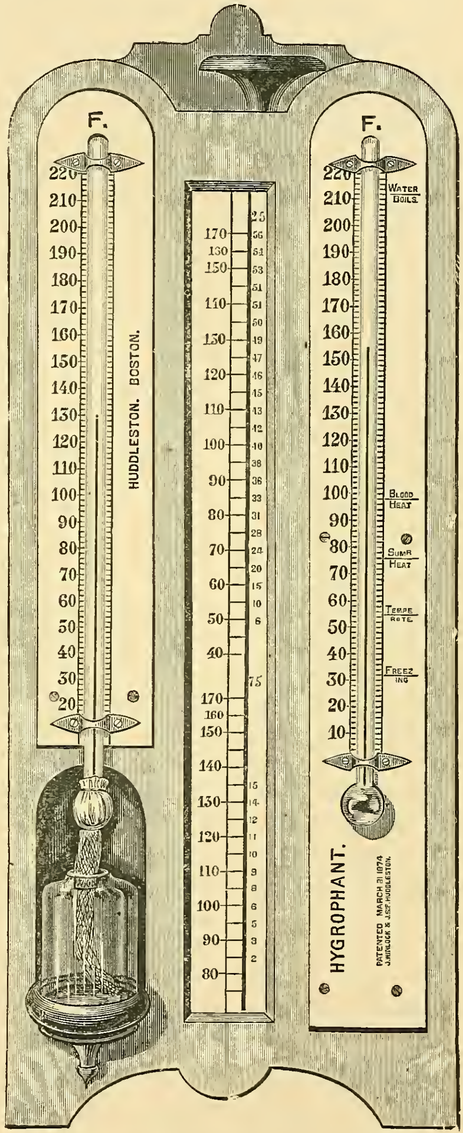

FIG. 65.—Hygrometer, as supplied by The Sturtevant Engineering Co., London.

the same temperature. In order that the air may be sufficiently dry and healthy, the law requires that the wet and dry bulb thermometers show a difference of at least two degrees at the ordinary spinning room temperature. The chief source of the saturation of the air of the wet spinning room is the evaporation which is constantly going on from the surface of the hot water in the troughs. There are several ways of preventing this evaporation to a large extent, all practical ones being based on the reduction of the water surface in free communication with the atmosphere of the room. The apertures through which the steam escapes from the trough are (1) at the front, between the lid and the lip of the trough, and (2) at the back, through which the rove enters. In the first place, the surface of water in direct communication with these openings may be reduced to a minimum by fixing projecting ribs upon the under surface of the trough lid, the said ribs projecting downwards and into the water in the trough, and thus forming an effective steam trap. The means of carrying off the steam, the escape of which cannot be prevented, will be described in Chapter XIX., where the subject of ventilation will be fully discussed. The water surface in contact with the air of the room may be still further reduced by passing the rove into the trough through porcelain tubes, each accommodating two ends, so that, with the aid of one, a broken end, or one which has run through, may be easily replaced.

The quantity of shove and dust thrown off and extracted from the rove and yarn during the wet spinning process is truly surprising, and, especially with some sorts of flax, forms an important part of the waste or loss in spinning. The frames require frequent cleaning, the flyers throw off water and dirt upon the spinner, and the work, especially in coarse rooms, is of so dirty and onerous a character that it is becoming extremely difficult in many places to obtain hands. The spinners should be provided with waterproof aprons, and the frames should be fitted with splash-boards if the spinner's pass is wide enough, *i.e.* not less than 4 feet 6 inches from spindle to spindle. The splash-board, with its accompanying gutter, keeps the floor dry and free from waste, and thus goes a long way towards improving the working condition of the room. The waste is furthermore kept clean, and in a far better state to be utilised, as we will describe in our next chapter. A convenient form of splash-board is that supplied by Mr Wm. Carter, 28 Waring Street, Belfast. This splash-board may be maintained in three positions—*i.e.* its normal position, its forward position, for putting up rove, and its turn-down position, for doffing and cleaning.

The back of the trough and lid should be frequently looked to and cleaned, as short fibre often accumulates upon them, especially if the rove, on entering the trough, is too near to either. These short fibres, if not kept cleared off, are apt to come away periodically with the rove, forming objectionable slubs in the yarn. The water in the trough, as we said, softens the gummy or pectic constituent of the flax, consequently, when the machinery is stopped for twelve or more hours, the rove remaining in the trough is frequently so softened and weakened by the action of the water, which dissolves out the gum, that, upon the frame being restarted, the rove breaks in the trough. If this is found to be the case with any special rove or material, the trough should be emptied of water for a week-end or holiday stoppage. Another frequent cause of trouble in morning starts is the presence of the gum which has been dissolved out from the flax, and which lies like starch upon the surface of the water in the trough. This sticky substance comes away at once in a mass with the rove, and if the yarn be not strong, the ends are broken down. The only remedy is to remove the gum by hand before starting the frame. The watering of the rollers and of the rove between them and between the top roller and the lid of the trough is an essential if a good start is to be made after a stoppage. If any part of the rove remains dry it will not draw freely, and will, in all probability, break. Where wooden rollers are used, they should be watered every few hours during a stoppage of any duration, until the room has quite cooled down. If this be not carefully done, the rollers will, in many cases, crack and break.

Removing Yarn from the Spinning Room.—There are several methods of sending the yarn from the spinning room to the reeling room. In coarse mills the bobbins are often placed in baskets which are returned with the empty bobbins. A better plan is to provide a set of five or six spiked trays for each side of the frame, the said trays being threaded upon a central rod to facilitate carriage. In this way each doffer may have a tray provided with a number of spikes equal to the number of spindles she is required to doff, while the same trays are a convenience to the reelers in spreading their work over the length of the reel. Another favourite way in fine mills is to have one spiked box or cage for each side of the frame, and to allot to one doffer the duty of collecting the full bobbins from the others, and of caging or placing them upon the spikes in the box, which is then removed to the reeling room.

CHAPTER XIV.

FLAX, HEMP, JUTE AND RAMIE WASTE SPINNING.

Waste Spinning.—The spinning of vegetable stalk and leaf fibre wastes has not until within recent years received much attention nor attained the importance of cotton or woollen waste spinning. The reason of this state of affairs is no doubt the intractability of the material and the consequent difficulty in spinning it. Short fibres which fall or lap, and other wastes made in preparing and spinning hard fibre, such as Manila or New Zealand hemp, may be treated as tow and carded and prepared for a gill spinning frame, such as that shown in fig. 50, and spun into core or inside rope yarns, or into yarn to be used for twine lashings.

American Machinery for Spinning Hard Fibre Waste.—In figs. 66, 67, 68, and 69 are shown a system of machines which is used for treating the above class of waste in some American twine mills.

Fig. 66 is called a duster and cleaner, and is used to separate the waste or tow from the sweepings of the mill.

The sweepings are fed into the machine through the hopper; the dust and dirt is collected underneath, while the clean waste and tow is delivered at the rear of the machine in shape for the picker (fig. 67). This machine takes the clean waste and tow, and opens up the material into a form suitable to be fed in the card. It may also be used to open and pick fag ends of ropes and waste yarns so that the fibre may be utilised. Fig. 68 is the form of card employed. The fibre is fed upon the feed sheet to the right, and is delivered to the action of the cylinder, workers and strippers, which open out and parallelise the fibres, which are taken off by a single doffer and condensed into one narrow ribbon as seen on the left of the figure.

The sliver from the card is taken to the tow spinner (fig. 69), which is built on similar lines to the automatic spinner (fig. 48). The sliver passes between the pinned apron belts shown, which take the place of the chain gill of the latter machine, thence to the calender rollers and flyer, which twists it into yarn and winds it upon a bobbin.

The sweepings of flax, soft hemp and jute mills, as well as long card waste and the dropping from under the hackling machines, may be separated from dust and shove by a passage through the waste shaker shown in fig. 70 and supplied by Messrs Thomas Jennings & Sons, Leeds. After being

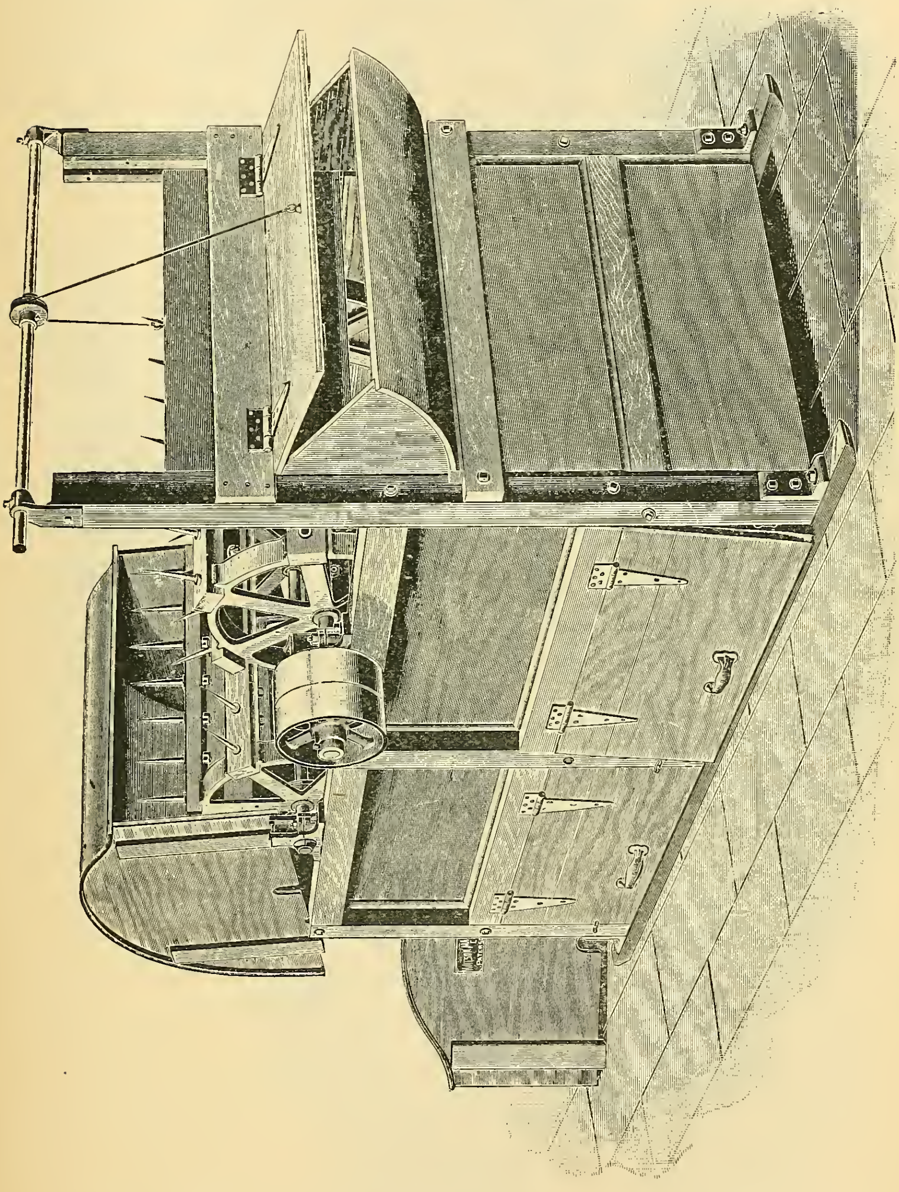

Fig. 66.—Duster and cleaner, as made by The Watson Machine Co., Paterson, New Jersey, U.S.

carefully picked and foreign substances removed, the cleaned fibre may be mixed with a longer material, carded and spun into coarse yarns of low quality.

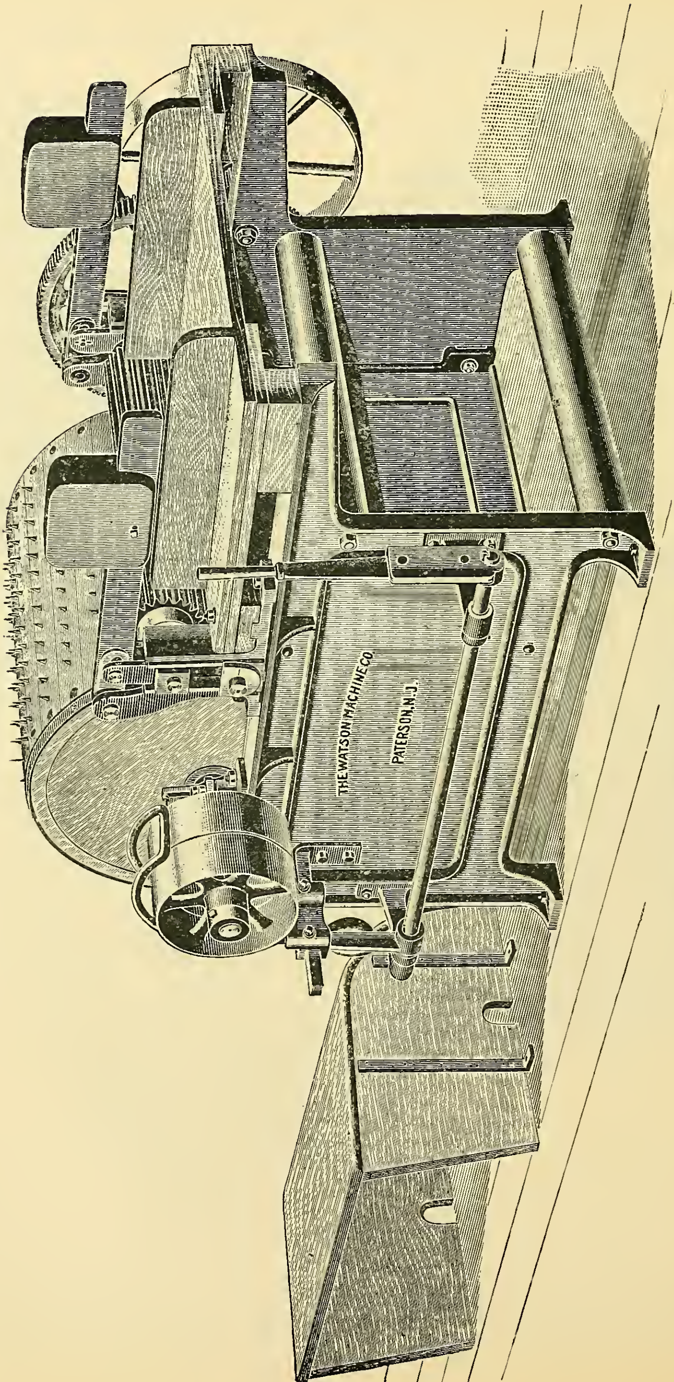

FIG. 67.—Picker for hard fibre waste and tow.

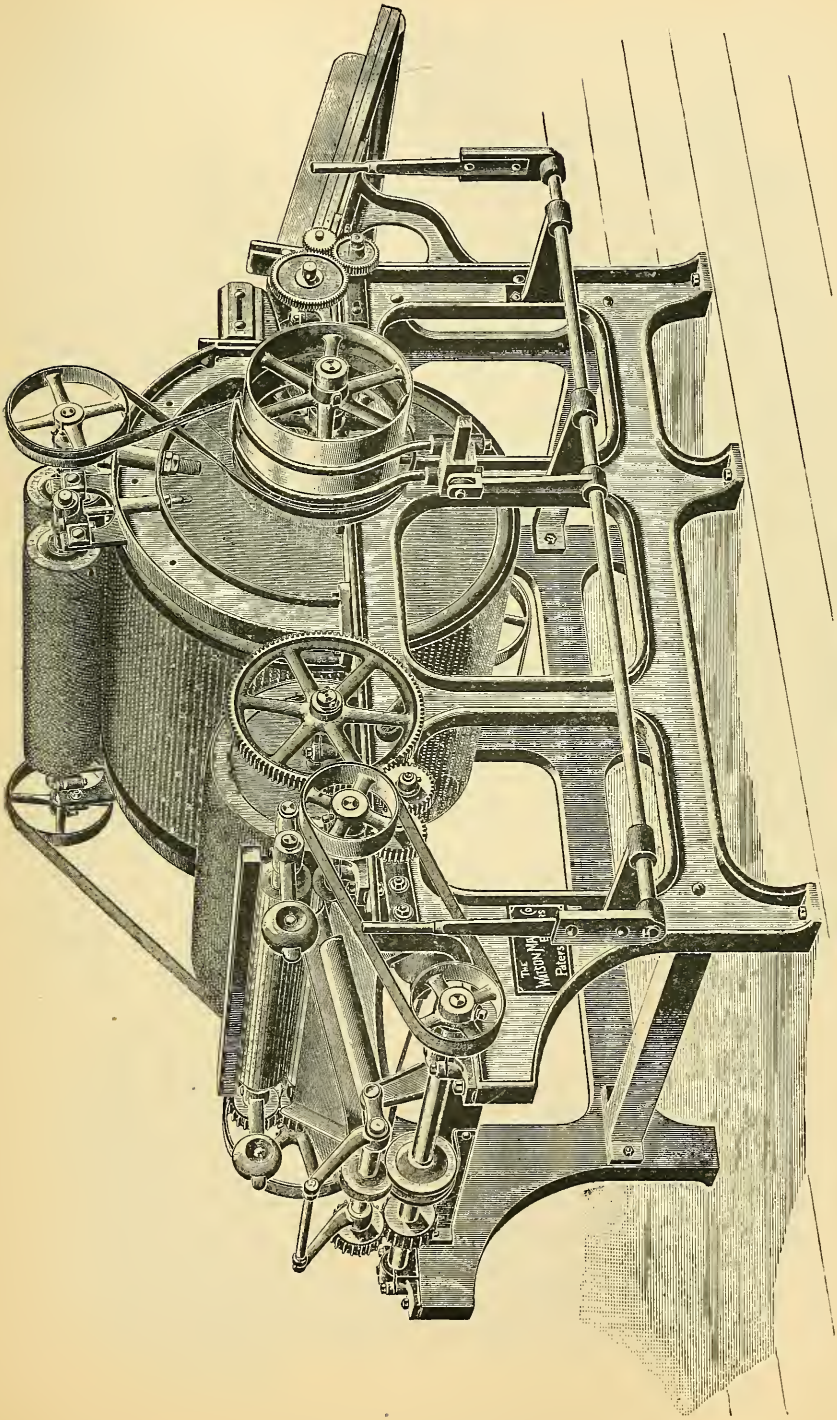

Fig. 68.—Card for hard fibre waste and tow.

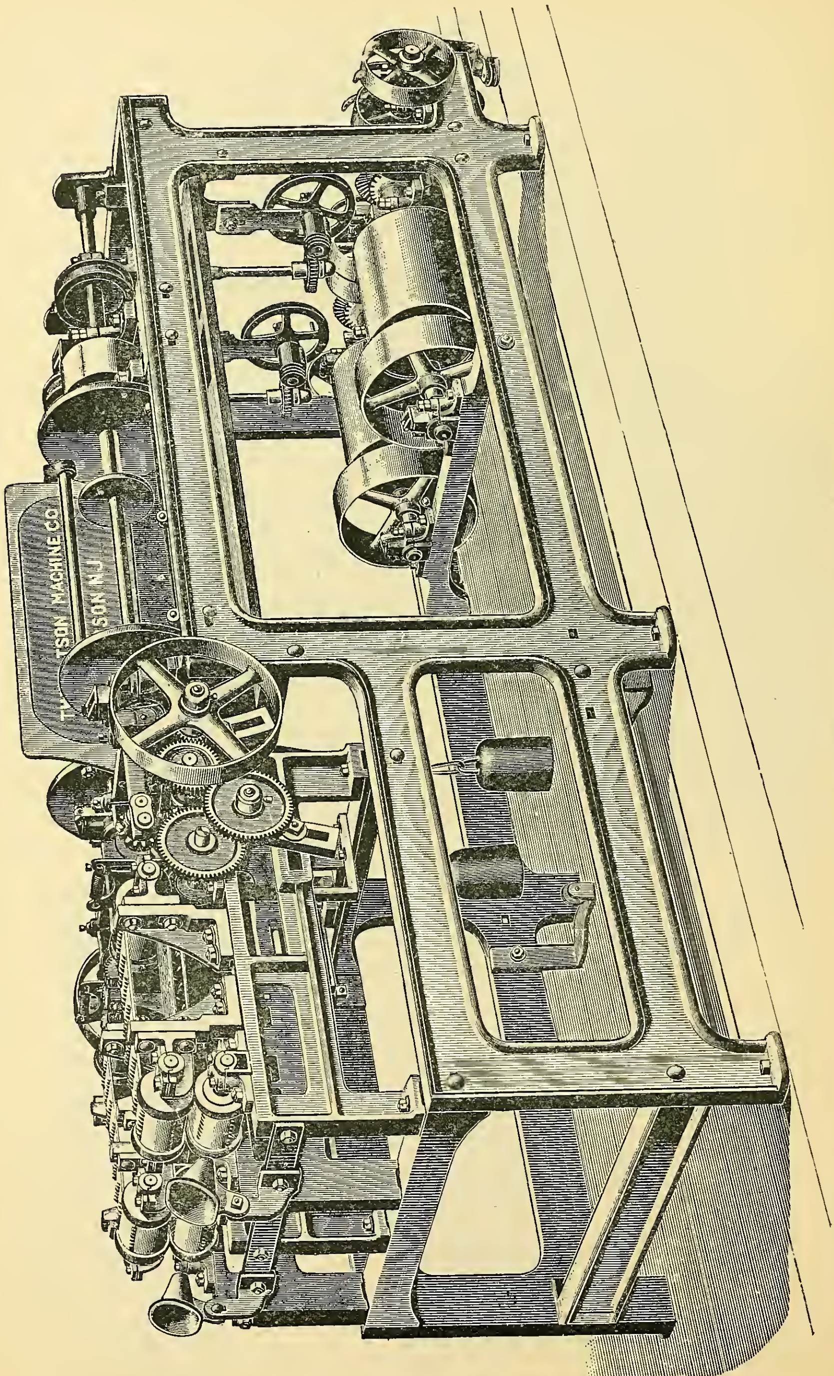

Fig. 69.—Tow spinner for hard fibre waste and tow.

Opening Flax "Bands" and Rope.—The fibre contained in the ropes and bands, which surround the "bobbins" and heads of Russian flaxes, may be utilised in a similar manner. The fibre is either separated by hand or by carding, after the rope has been first cut into short lengths, or by untwist-

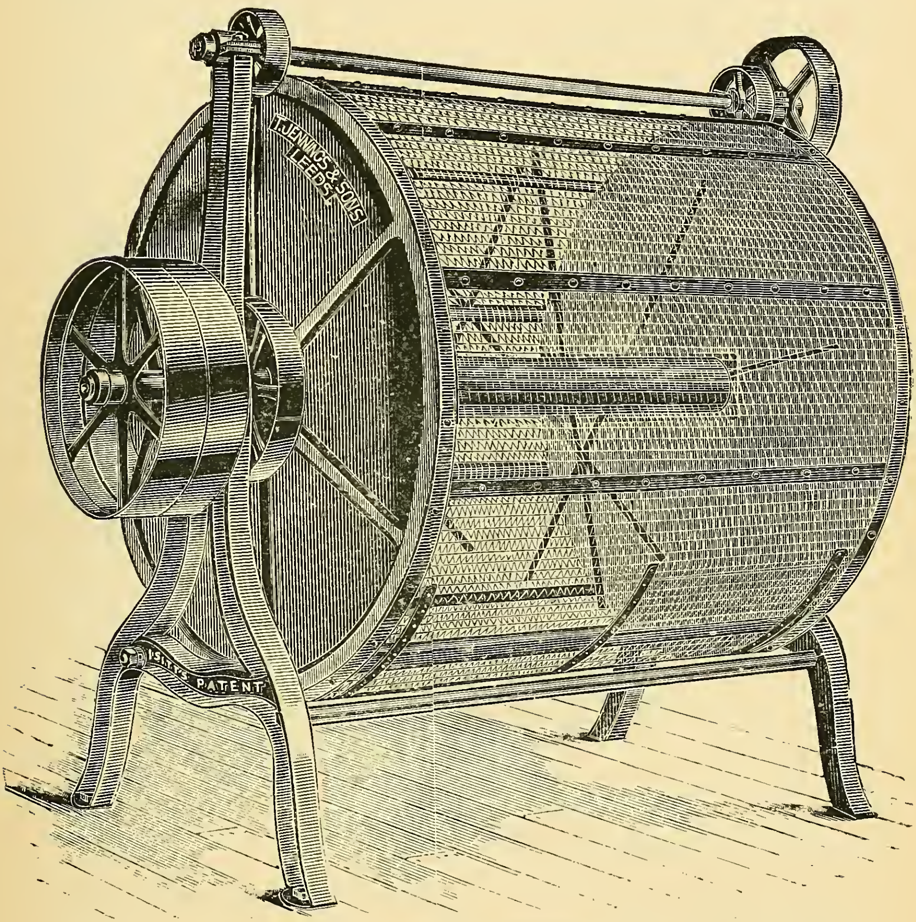

FIG. 70.—Isitt's patent waste shaker.

ing the ropes in the machine shown in fig. 71, which turns off 33 lbs. of excellent tow per day.

Noil Spinning.—Noils from the combing machine and hard waste produced in the wet spinning room are of such short staple that they require special machines and treatment. The former, being open and unmatted, is comparatively easily dealt with, although it is only suitable for coarse yarns up to about four leas per lb., which may be used for cords and twines. The latter, which contains all the purest fibre, is so much matted as to require special machinery to open it and put the fibre into a suitable state to spin the fine and level yarns for which it is naturally adapted. We believe Mr Max Raabe and Messrs Porritt Brothers to be the pioneers in noil spinning, while Mr William Carter of Belfast has given the benefit of his lifelong experience in flax spinning to the question of the utilisation of its hard or wet waste in the production of a level and serviceable yarn.

Treatment of Wet Spinning Waste.—Wet spinning waste, after having been dried and picked by hand to separate foreign substances such as flyers,

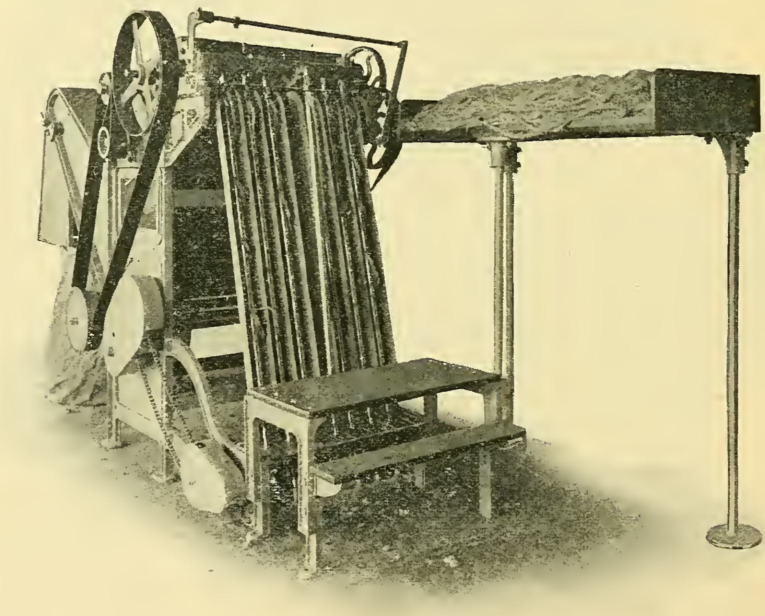

Fig. 71.—Eves' patent rope untwister and opener, as supplied by Mr W. Carter, 28 Waring Street, Belfast.

bobbins, cords, etc., may be roughly opened upon the tenter-hook "willy" as shown in fig. 72. The material to be operated on is spread by hand upon the feed lattice L, which delivers it slowly to the spiked wooden rollers F, which latter hold it against the action of the similarly spiked cylinder C, striking upwards as shown by the arrow. The upper feed roller F is cleared by the wooden brush roller H set with several rows of hair bristles, as shown, similar clearers B acting upon each of the workers W to strip off the material retained by their teeth and deliver it again to the cylinder C. The cylinder itself is stripped by the fan A revolving at a high speed in the direction shown, the roughly opened material being thrown out at the opening E into an enclosed settling chamber of sufficient capacity to allow the air to settle and the flocculent material to fall. The teeth of the workers and cylinder are of flat forged steel about $\frac{1}{8}$ inch in thickness and of cockspur or tenter-hook shape driven into the beech lags, with which these rollers are covered, in rows arranged in such a way in the cylinder and the workers that, although close set, the teeth may not come in contact. Of the wooden staves D forming the rails of the fan, every alternate one is furnished with two rows of straight spikes, and the others have but one row of spikes and a strip of leather which rubs against the teeth of the cylinder and keeps them clean. The upper portion of the machine is enclosed in a wooden cover to prevent dust and waste flying off, while the under covers are in the form of grids, which allow heavy impurities to fall through. The workers are driven slowly round in the direction shown by means of a chain and sprocket wheels, while the strippers and fan are driven at a comparatively high speed by one and the same belt from a pulley upon the cylinder axle.

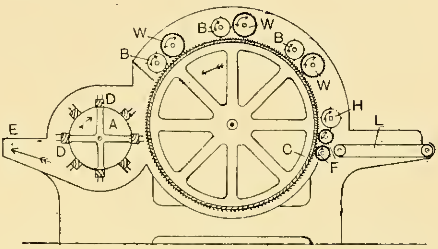

Fig. 72.—Tenter-hook willy for opening hard waste.

The Garnett Machine.—The roughly opened waste from the willy should be more perfectly opened before being presented to the scribbler (fig. 73). The machine best adapted to do this is called a "Garnett" machine, as, besides opening, it breaks up long threads and fibres which would later on cause much inconvenience in the condenser (fig. 75). The Garnett machine is composed of swifts and workers, and resembles very much in general arrangement the scribbler shown in fig. 73. The machine is very strongly built, the cylinders and rollers being of cast iron turned up true. Its chief feature is the clothing, which is in reality a continuous strip of steel ribbon with saw-tooth edge, lapped on edge spirally round the rollers. Applied in this manner it is extremely strong, as indeed it requires to be. The material is spread upon a feed sheet, passed in through feed rollers, and doffed from the last doffer in an open condition by an ordinary doffing knife. When the teeth of the Garnett machine get choked up with waste and dirt, they must be cleaned by taking out the rollers, putting them in a frame, and while turning them round, passing a clearing tool across the face of the roller in the spiral groove formed in the clothing.

Opener and Knot Breaker.—Sykes' opener and knot breaker, which are of similar construction, but coarser than the Garnett machine, may be used instead of the willy (fig. 72).

The perfectly opened waste from the Garnett machine is next batched. Instead of oil and water alone, an emulsion is formed by mixing a vegetable oil, such as olive, either alone or with oleine, with a solution of an alkali.

Batching.—A good mixture consists of 75 parts of olive, rape, castor or colza oil, 25 parts of alkaline solution containing 5 to 10 parts of caustic potash and 100 parts of cold water. A decoction of Irish or Iceland moss may be used instead of pure water. This emulsion is used, not so much as a lubricant, as to reduce the quantity of imperceptible waste, to increase rubbing in the condenser, and make a stronger slubbing and yarn. The batch should lie for at least twenty-four hours in order to let the lubricant, which has been put on with a watering can, permeate and diffuse itself throughout the mass, before the fibre is used to supply the hopper feeder shown to the left of fig. 73. This feeder is Tatham's "Rochdale" pattern, and similar in every way to the machine described on p. 81, fig. 32.

The Scribbler.—Leaving the lattice feed sheet of the automatic feeder, the material transfers itself to that of the scribbler proper, which delivers it into a pair of feed rollers M, about 3 inches in diameter, generally clothed with leather filleting set with steel points. The larger roller N, similarly clothed, is the "licker in," which takes up the fibre as delivered by the feed rollers and carries it forward towards the first cylinder or "breast," as it is often called. The fibre is not delivered direct to this cylinder by the licker-in, but is transferred to it by an "angle" stripper, as shown.

Three pairs of workers and strippers are shown upon the upper portion of the breast. These, together with the cylinder, turning in the direction shown, do their work of straightening out the fibre in a similar way and upon the same principles as the same organs of the ordinary tow card. The roller O is peculiar to this class of card. It is called the "fancy roller." Its work is to raise the fibres which are imbedded in the cylinder clothing so that they may be deposited upon the doffer Q. The "fancy" is covered with leather sheets, set with long and limber steel wire, considerably knee-bent in the reverse direction from that in which the roller revolves, as shown by the arrow. Its surface speed is slightly greater than that of the cylinder, so that the pins of these rollers slightly intersect one another, those of the fancy passing through those of the cylinder, raising the material imbedded in the latter, and keeping the cylinder clothing keen and in good condition. The doffer Q receives the material from the breast and carries it forward towards the next cylinder, to which it is transferred by another angle stripper, as shown. The same operations are repeated over the back and front swifts before the doffer R is reached, and the now attenuated web or fleece is doffed from it by a comb S, which is given a rapid vibratory motion by means of an eccentric and rod, as shown. A lancewood lath attached to the comb stock and pedestal supporting the doffer, forms a radius bar which keeps the knife at its proper distance. The small roller shown on the top of this doffer R is placed there for the purpose of keeping the clothing of that roller clean and in good keen condition.

The fleece as doffed from the last doffer of the scribbler is carried away upon a narrow lattice which runs parallel and close up to the face of the doffer. This lattice runs round the lower of the three condensing rollers T, so that the scribbled material is formed into a sliver some 4 inches wide,

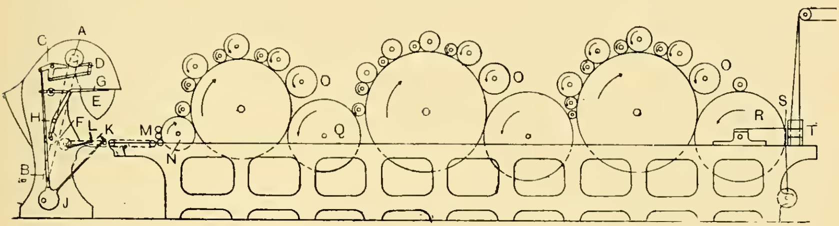

Fig. 73.—Scribbler with hopper feeder for flax waste spinning.

compressed and strengthened in passing between the heavy rollers T. This method of taking the fleece off the scribbler forms part of what is known as the Scotch feed arrangement, by means of which the material is transferred from the scribbler to the carder. Another and more complete view is given of this arrangement in fig. 74. Taking both together, it may be seen that the sliver passes from the calender rollers T to the lattice carrier U V, and thence over the swinging arm W to the feed lattice or sheet of the carder (fig. 75), upon which it is spread in a regular manner by the travelling carriage Y. This carriage, which runs upon grooved pulleys and rods, as shown, is carried backwards and forwards across the face of the card, by means of the endless strap Z, upon which is riveted a stud which engages with the slotted piece A B of the carriage. A pair of tin rollers C are contained in the carriage in order to deliver the sliver properly downwards to the sheet below. Motion is given to these rollers by means of a pinion D compounded with a small grooved band pulley, around which the cord E F passes once. Since this cord is kept tight by the weight F, suspended upon one end, the pinion D is forced to turn as the carriage moves backwards and forwards, first in one direction and then in the other. Each of the tin rollers has a pinion upon the end of its axle which engages constantly with its fellow and alternately with the pinion D, the disengagement

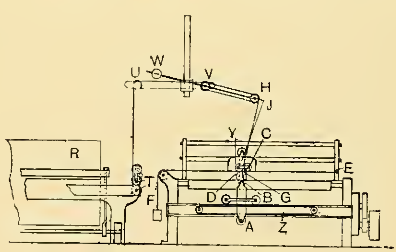

Fig. 74.—Scotch feed.

of one pinion and the engagement of the other being effected at the extremity of each traverse by the contact of the T-piece G with a stop, adjusted in the correct position at either side. The pinions, once changed, are kept in gear by the overlapping of the wedge-shaped ends of the pieces B and G, the latter being pressed downwards by a spiral spring enclosed in a chamber recessed in the piece G. In order that the Scotch feed may work smoothly and correctly, it is advisable to have the pulley V vertically above the rollers T, and the centre of the arc, in which B swings, vertically over the carriage when in the centre of its travel. The end H is pulled downwards, and all strain kept off the sliver by attaching the end of the rod J to the carriage by means of a cord. The speed of the carriage, and the rollers which it contains, must be made to correspond with the rate of delivery of the rollers T, so that the sliver may be kept tight without being broken. The surface speed of the feed lattice of the carder must likewise be so made to conform with the speed of delivery of the sliver

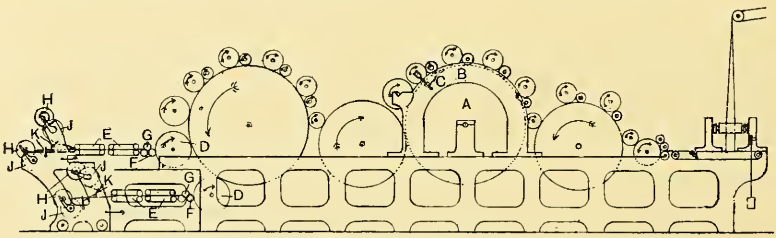

Fig. 75.—Carder and condenser for preparing slubbing from short waste.

to it that its entire surface may be equally covered without interruption, the edge of one row of sliver overlapping the one preceding in a regular manner. Until we come to the last swift of the carder, fig. 75, the arrangement of feeds, licker in, angle strippers, breasts, swifts, workers, strippers, doffers and fancies is similar to that already described for the scribbler. The manner in which the swifts and their surrounding rollers are supported by means of "bends" is shown in connection with the swift A, fig. 73. The bends B are castings of semicircular or horseshoe form bolted to the sides of the framing. The fancy is supported upon a projection, as shown, while the workers and strippers work in brasses socketed upon the ends of screwed spindles, held in a position quite radial to the swift by means of metal straps. These screwed spindles, traversing a block C bolted upon the inside of the bend, may thus be screwed in and out to adjust the distance apart of swifts and rollers, which in a fine card is infinitesimal, although no roller, except the fancy, should actually touch the swift. The workers and strippers may be brought into light contact occasionally in order that the latter may keep the former keen; but, generally speaking, the clothing of both swifts and rollers should be regularly ground and sharpened by means of emery rollers, in a manner to be described. The apparatus joined to the carder, to the left of fig. 75, is a condenser of the system known as a double doffer, tandem rubber, six or eight bobbiner. Such a machine is capable of making as many as ninety-six good threads and two waste threads from the fleece taken from a carder 60 inches wide, each thread frequently weighing no more than 300 yards per ounce. The way in which this is accomplished is as follows:—The doffers D are ringed, that is to say, their clothing is put on in perfectly parallel rings, alternating with spaces, the rings in one corresponding with the spaces in the other. One outside ring of each doffer is much broader than the others, its object being to take off the fibres on the edges of the swift which are defective, and to form them into a waste thread. As a general rule the rings upon the bottom doffer are slightly broader than those upon the top doffer, since the latter, meeting the fully-laden swift first, is apt to rob its comrade, causing the threads from the latter to be lighter, if the collecting surface of the rings be not increased. The ring doffers are stripped by small stripping rollers F covered with fine filleting, which are in turn stripped by smaller but similar stripping rollers G. Dividing rollers are now often introduced between the stripper and the rubber leathers, especially in fine machines, where difficulty is often experienced in keeping the threads apart by reason of long fibres and threads which unite them. The dividing roller should revolve at the same surface speed and in the same direction as the narrow ribbons of sliver and have as many V-shaped grooves as there are slivers passing over it. If the rubber leathers be given a slight lead, the ribbons may be drawn down into the grooves and kept separate. The rubbers E are leather aprons stretched over rollers as shown. They lie one on top of the other, almost or quite in contact, and having a reciprocating horizontal motion in different directions given to them by means of eccentrics, they rub the narrow slivers, which pass between them, into round and comparatively strong rovings or slubbings, at the same time delivering them forward to be wrapped upon the condenser bobbins H, which lie upon and are turned by the surface drums I. Wire guides K, with a rather quick horizontal traverse, build the slubbing into compact cheeses lying close together, but quite distinct, upon the barrel of the same bobbin. The prepare with which the material is impregnated keeps the rubber leathers soft and in good working condition. The leathers are usually plain, but occasionally, where difficulty is experienced in getting the stuff to turn over and rub into a strong slubbing, scored leathers of various makes are employed. The stripping roller F, working against the ring doffer, should be given a very slow backwards and forwards traverse to avoid being marked by the constant wear of the rings always in one place.

The presence in the material of long fibres and threads, and consequent difficulty in the separation of the threads of slubbing, renders the use of the tape condenser preferable in some cases. In machines of this type, the division of the web from a plain doffer is effected by means of leather, tape or steel bands crossing each other and pressing against the rubber leathers. In condensers of the roller type which are suitable for fine slubbings, leather-covered rollers take the place of endless leather aprons. A series of these rollers are placed in pairs, fairly close together, one advantage of the arrangement being that with certain materials a lighter slubbing and increased production may be obtained by arranging the surface speeds of the rollers in such a way that a slight draft is obtained between each succeeding pair of rollers.

Card Clothing, or "Cards."—The clothing of cards for this description of work is put on in leaves or filleting, and is of the same class as that used for woollen, cotton or cotton-waste carding. It is extremely fine as compared with the ordinary clothing for flax, tow, hemp or jute cards, having from 100 to 600 pins per square inch. Its closeness and fineness, if kept keen, enable it to hold the short fibre, so that a very small percentage of waste is made; but, on the other hand, necessitates the use of the rollers called fancies, whose work is to raise the material, embedded in the pins, in such a manner that it is caught and carried off by the doffer. Were these rollers not employed upon the swifts, the pins of the latter would, in less than an hour, become so choked up with the fibre that they could no longer do any work. Even as it is, the cards must be stopped for "fettling" once a day, and even more frequently, when working dirty material. Fettling consists in clearing dirt, dust and short fibre out of the teeth of the card clothing by means of a species of comb known as a "fettler." The card clothing consists of staples of steel or iron wire set in leather or cotton cloth with indiarubber foundation. When set in leather, the leather should be of the best elastic calf hide, and put on in sheets about 5 inches wide, and in length equal to the width of the card. Filleting has almost invariably a foundation of cotton and indiarubber, and is put on in long strips from 1 inch to 3 inches wide, and wound spirally round the roller to be covered. In filleting, the pins are set in one of two different ways, known as "ribbed" and "twilled." The latter always shows a spiral groove when wrapped round the roller, while ribbed filleting joins up close. The leaves of clothing are tacked upon the surface of the roller, being well stretched the while. Filleting is also held by tacks at the ends, and at intervals in its length. There must, of necessity, be a space between the leaves of card clothing, but filleting is continuous, and for that reason is to be preferred, especially for the last swift and doffer, so that a continuous fleece may be obtained. The keenness of the clothing and the setting of the rollers are points of the utmost importance in carding fine material on cards of this description. If the clothing be not keen and the rollers sufficiently closely set, the material will be rolled into balls and drop to waste below the card or be spewed out at the outside edges of the card. The finer the material, and the greater the number the threads of slubbing to be taken off the condenser, the closer must the cards be set. Although fine gauges are useful in setting or "keying" a card, yet, in many cases, the ear and eye can only be relied upon to insure that the rollers are not actually in contact. If light can be seen between the rollers, and no sound of brushing be heard, the rollers are out of contact. Such fine setting as we have described renders it absolutely necessary that the rollers should be perfectly cylindrical, and the pins of uniform length. To this end, the rollers are ground by emery rollers of equal breadth brought in contact with the pin points, and turned in either or both directions. In the case of workers and strippers which can be lifted out, this operation is accomplished in what is known as the grinding frame. For the swifts and doffers, the emery roller must be put in the place of the worker or stripper, and the swift or doffer and grinding roller turned in the desired direction. A little sharpening may be done at any time by means of a piece of wood covered with emery and known as a "strickle." This grinding puts a chisel point on the pins or wire, the same being frequently burred, which prevents the card working very well until the burrs have worn off, by use, or, in the case of the swifts, by the action of the fancy roller, and a more or less perfect needle point been formed. The fancy roller, at least, should be covered over, as this roller often throws out loose fibre. The waste shown will be lessened by covering in the cards completely, as in cotton waste spinning, but for fine work a smoother yarn will be obtained if the cards be left uncovered, for the flowings are apt to accumulate in the covers and get away in lumps.

The Drury Spinning Apparatus.—For very coarse yarns the slubbing may be spun directly and wound upon bobbins in the condenser itself by the use of a machine invented by a Mr Drury. As it is only suitable for very coarse work, a short description will suffice. The ribbons are stripped from the ring doffer by means of a specially shaped needle, then passed through an eye and caught between two revolving endless tapes, which, turning in contact and in opposite directions, impart twist and form a thread, which is then wound upon bobbins in the ordinary way.

Porritt's Spinning Frame for Short Waste Fibre.—Fig. 76 gives a view of a special spinning frame patented and successfully used by Messrs Porritt Brothers, for spinning flax noils into yarn up to 4 leas per lb. when the author was in Leeds some years ago. Its leading feature is the arrangement A, for putting in twist while drafting is going on—a course rendered necessary by the shortness and irregularity in length of the staple. This shortness and irregularity, combined with smoothness and inelasticity of the fibres, are the chief difficulties to be overcome, to which must be added, in the case of hard waste, the presence of pieces of thread twisted in the wet state. Like Mr Raabe, Messrs Porritt Brothers formed their roving or slubbing by carding the material upon a scribbler and carder, such as are

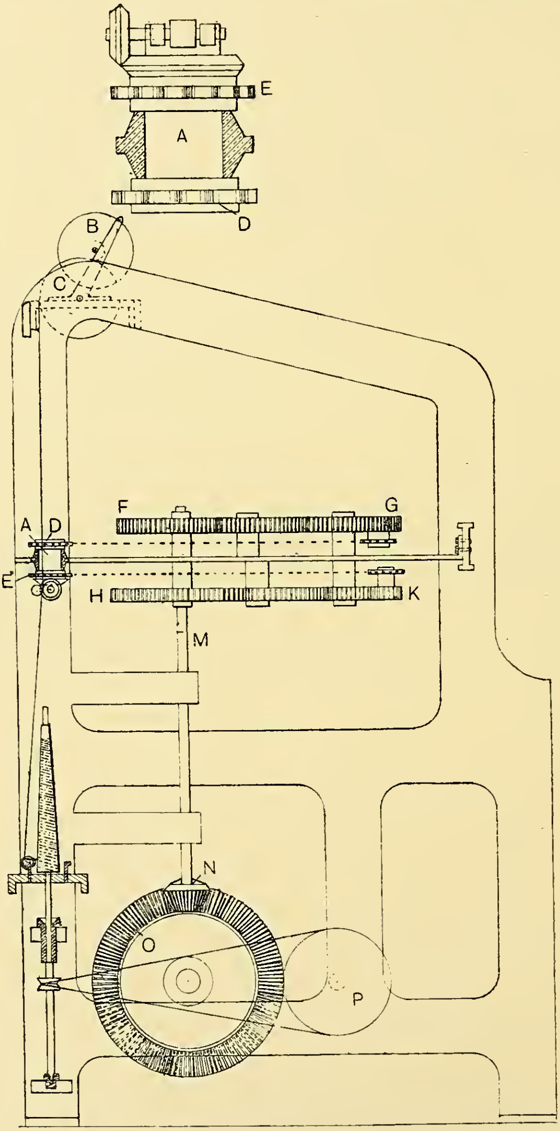

Fig. 76.—Porritt's dry spinning frame to spin slubbing of flax noils or waste from the condenser bobbin.

used for wool, and which have been shown in figs. 73 and 75. The fleece from the doffer of the carder was divided into narrow ribbons by means of a condenser, such as has been described, which rubbed the said ribbons into a round slubbing that was wound upon the condenser bobbin shown at B, fig. 75, resting upon the surface drum C, the revolution of which causes the weak slubbing to unwind and pass down to the drafting and twisting apparatus A. The latter consists of a tubular boss A, turning in bearings fixed in one of the frame rails, as shown. At the upper end of this tube a sprocket chain wheel D is fixed. The lower portion of the tube A forms a bearing for two horizontal spindles, a boss on each of which forms the drawing roller. They hold and draw the slubbing by reason of pressure applied to them by springs. One of them is the driver, receiving its motion through a pair of bevel wheels, one fixed on the end of the roller and the other keyed on the pap of another sprocket wheel E, both turning freely upon the end of the tube A. It will be seen that the two together form a species of epicyclic gear, for the effective speed, and consequently, draft, imparted to the roller is materially effected by the direction in which the tube A is turned by the sprocket wheel D. The sprocket wheel E and bevel wheel must be driven in a contra-clockwise direction, in order to cause the rollers to draw the material downwards. If left hand twist is being put into the yarn, the tube must be driven in a clockwise direction by the sprocket wheel D, in which case the rollers gain in speed, since they are carried round their driver, while if the tube be turned in the opposite direction the rollers lose in drafting power. To modify these conflicting elements and to attain any desired result, the change gearing F G, H K is provided, both lines of gearing being driven by the vertical shaft M, turned by the bevel wheels N and O. The spindle, ring rail, ring and traveller are arranged in the manner shown and as previously described, the spindle being driven by the tin cylinder P.

The Celestin Martin Twist Tube Frame.—One of the best machines for fine waste spinning, and as regards production, is that made by the Société Anonyme Celestin Martin of Verviers, Belgium. It is a ring spinning frame, constructed in a somewhat similar fashion to the frame shown in fig. 76, and drafts and spins the slubbing from the condenser bobbin.

The drawing out or drafting of roving composed of the material of which we are now treating, which, unlike cotton, has no natural adhesion, is a most difficult matter. It cannot be done on a short reach on account of the presence of occasional long fibres. Upon a longer reach it cannot be satisfactorily accomplished without keeping the slubbing bound together, by means of twist, with the aid of a twist tube, an ingenious form of which is an important feature of the Celestin Martin frame. This tube, situated between the feed and drawing rollers, puts a sufficient degree of false twist into the slubbing to bind the fibres together and prevents the drawing away of short fibres from the long, which would occur were no such arrangement introduced. The theory of the twist tube is somewhat similar to that principle of the woollen mule by which a draw is given to the slubbing, after it has got a little twist, through the stoppage of the rollers before the carriage has reached the end of its outward run. It is well known to woollen spinners that, if this slubbing has any irregularities, the twist will always run into the thin places, first leaving the slubs or thick places still soft and susceptible of elimination by a draw. In this way woollen yarns are frequently rendered more regular than the slubbing from which they were spun, and so, in this Belgian frame, there is a chance of a thick portion of the slubbing getting more than its share of the draft and being in consequence considerably reduced in size while the yarn gains in levelness.

The Waste Mule as used for cotton waste spinning may also be employed in spinning flax-waste and noils. Its chief disadvantages are—small production, impossibility of drafting, and difficulty in avoiding snarls.

On account of the non-elasticity and the immediate setting of the thread undergoing twisting, it is impossible to give any "gain" to the carriage. For the latter reason there is more yarn to be "backed off" the spindle top—hence the snarl, if the ends be not lifted off the spindle tops by a special motion before the end of the draw. Lack of elasticity in the thread also renders a "checking up" motion imperative to prevent snapping of the ends through contraction by twist. There should be two lines of bottom delivery rollers and one of top self-weighted rollers lying between them, in order that the slubbing may be firmly held. For 5 to 10 lea yarn, a mule of $2\frac{1}{2}$ inch gauge, and for 10 to 20 lea yarn a mule of $1\frac{3}{4}$ inch gauge, will be found suitable. Since the mule is not a constant spinner, its production is comparatively small for the large floor space occupied; hence a ring frame with twist tube is to be preferred for cheap production.

Ramie Waste Spinning.—Short ramie waste and noil is usually carded on a cotton card, and spun in the usual way.

CHAPTER XV.

YARN REELING, WINDING, DRYING, COOLING, AND BUNDLING.

Wet Warp Winding from the Spinning Bobbin. — Under ordinary circumstances most of the yarn from the spinning room is reeled into hanks, which is the form in which spinners usually sell to the weavers. If the spinners are weavers in addition, they may wind their warp yarns directly on to tin spools, upon a frame similar to fig. 80, and their wefts on to pirns or paper tubes upon a pirn-winding frame. It is every day becoming more common for spinners to sell their yarn in the workable form of cheeses and cops, and really, except when yarn is to be bleached, dyed, or boiled, there is no use in going to the expense of the intermediate process of reeling.

In the process of reeling, hanks are formed by winding the thread from the spinning bobbin round the circumference of the swift or fly, forming a continuous length 3600 or 1800 yards long, subdivided for convenience into twelve parts, each 300 or 150 yards in length. When made in the former way, the swift is $2\frac{1}{2}$ yards in circumference, 120 turns being consequently required to form each cut or lea of 300 yards, twelve of which cuts form the hank. If made up in the second way, the yarn is said to be "short reeled," for the swift has a circumference of only $1\frac{1}{2}$ yards, or the same as that of the swift of the cotton reel. Unlike the cotton standard, however, 100 threads or rounds of the reel go to make a cut or lea, twelve of such cuts forming the hank, which is consequently equal in length to one-half of a long-reeled hank. Flax and hemp yarn reels are generally double—that is to say, the same gables support two swifts, each of which gives employment to a reeler. The centre of the swift should be about 20 inches from the ground for the long reel and 26 inches for the short reel. The shifter or bobbin carrier, which extends the length of the reel, should lie close to the top of the swift, projecting backwards from the centre line. As the strain put upon the yarn, and consequently the ease with which it may be reeled, depends very much upon the construction of the reel itself, we will try to describe the principles to be borne in mind in designing a good reel.

The swift should be light and well balanced, so that it will remain at rest in any position, and never turn backwards of its own accord. In order that the periphery of the swift may be nearly circular, the latter should have a sufficient number of rails and spokes, twelve being the most suitable number for the long reel and eight for the short reel. If the swift has a less number of spokes than that named, the segments formed between the rails will be too great, and will cause the yarn to be drawn irregularly from the bobbin and subject the thread to jerks and strains, causing excessive breakages in fine and weak yarns. If, on the other hand, the rails be too numerous and consequently close together, they are liable to injure the fingers of the operative and retard her progress when putting in the leasing. The standard sizes are, as we have said, $2\frac{1}{2}$ yards or 90 inches and $1\frac{1}{2}$ yards or 54 inches, being known as the 90-inch and 54-inch reel respectively. The actual circumference may be made rather less than this, however, say $\frac{1}{16}$ inch for the short reel and $\frac{1}{8}$ inch for the long reel, for the reason that the threads, lying more or less one on top of the other, increase the effective diameter of the reel. The swift is made collapsible in order that the hanks of yarn may be taken off it. A flange screwed to one pair of spokes is firmly secured by set-screws to the hollow barrel upon which the swift is built. The others may be freely moved round upon their axle or barrel. The swift is distended while at work, and the rails kept in place and at equal pitches by means of tapes attached to the inside of each, and to the fixed rail by means of a ring and screw. When the yarn is tightly lapped round the swift, the latter could not be conveniently caused to collapse were not one set of spokes arranged in such a way that they may be shortened and the rail at that end brought in towards the centre, and the yarn sufficiently slackened to admit of the other rails being brought together.

In order that the rail may be brought in towards the centre in the way we have described, it is either attached to slotted brackets clamped to the spokes by means of thumbscrews, or else to a bracket turning upon a pivot on the shortened end of the spokes. The swift turns upon ends shrunk in the barrel, and either turns in open bearings so that the end may be lifted out and the yarn passed over it when doffing, or in closed bearings, in which case a half-moon arrangement is required in order that the yarn may be passed round the centre.

A double-power reel is most conveniently turned by means of friction bowls, of leather or paper, on either end of a short shaft, driven at a slow speed by a belt from the line shaft. Friction plates are pressed against the bowls by means of footboards, connecting levers and rods, so that the reel may be started at will and stop of its own accord when the reeler removes her foot. Reels propelled by hand, and power reels with a handle and fast and loose pulley, are still at work, but are becoming rarer.

Upon the other end of the swift axle to that at which the yarn is usually taken off, is a worm working into a bell wheel upon a vertical or horizontal spindle. A pin in the bell wheel presses back a spring, upon the end of which is a brass bell, which is thus caused to sound at each revolution of the bell wheel. Theoretically the bell wheel should have 120 teeth for the long reel and 100 teeth for the short reel, but usually one to four extra teeth are given in order to make up for any short count caused by broken threads. The worm upon the axle end is single-threaded, so that every time the swift completes 120, 100 or more revolutions, the bell rings, showing that a cut of yarn has been reeled.

Upon modern reels the rotation of the upright spindle carrying the bell wheel is used to give the bobbin carrier or shifter the lateral motion necessary to spread and build the yarn properly upon the swift. The shifter is of wood, about 6 inches in breadth and rather shorter than the swift. It has two cast iron ends, upon which it slides in the gables of the reel. The inside of one end piece forms a rack into which works the shifter pinion, upon the elongated pap of which is a worm wheel actuated by the worm upon the upper end of the bell wheel spindle already alluded to. Starting close up against one gable of the reel, the shifter is thus moved, either to the right or left, a distance of some 3 or 4 inches, while the bell wheel makes twelve revolutions. After each hank has been completed the shifter must be lifted out of gear and put back into its starting position to the right or left. We have seen shifters moving both to the right and to the left, it being a matter of indifference when the reeler is once accustomed to it.

Yarn is said to be cross-reeled when the shifter has a quick backward and forward traverse across the face of the hank. Leasing is dispensed with for cross-reeled yarn, which is more easily wound again from the hank. The shifter should make four complete traverses for each revolution of the swift, cross the threads four times, and thus form complete diamonds in the round of the swift. The required motion may be easily given to the shifter by means of an eccentric driven from the axle of the swift and actuating a bell-crank lever by means of a connecting rod.

The bobbins of yarn are usually placed upon brass sockets which turn freely upon iron pins set at suitable distances along the shifter. In an old-fashioned reel of Continental make, the bobbins are placed upon short spindles turning freely in collars and steps fixed in a stationary rail, but in order that the tension of the yarn being reeled may remain as constant as possible, it is advisable that the bobbin should be actually upon the shifter in order that it may always maintain its position relative to the wire guide upon the front edge of the shifter.

Twenty to forty bobbins are usually carried upon the shifter at a distance of from 3 to 5 inches apart, according to the coarseness of the yarn being reeled and giving to the shifter and swift a length of from 8 to 10 feet. A 20-hank reel of 5-inch pitch is suitable for the coarser yarns up to 16 leas; a 25-hank reel of 5-inch pitch for yarns 16 to 30 leas per lb., a 30-hank reel of $3\frac{1}{2}$-inch pitch for yarns of 30 to 100 leas, and a 40-hank reel of 3-inch pitch for all finer yarns.

The traverse given to the shifter must be rather less than the pitch of the bobbins in order that there may be a small space between the completed hanks. Thus a 23-worm wheel compounded with a 20-shifter pinion working into a rack of three teeth per inch will give the $\frac{120 \times 20}{23 \times 3} = 3\frac{1}{2}$-inch shift suitable for a reel of 5-inch pitch.

Reels are still at work without automatic shifters, but the quality of the work which they turn out is inferior, because the yarn in each cut is built too much in one place and not properly and evenly spread. The number of revolutions per minute which a 90-inch and a 54-inch swift may make is about 70 and 100 respectively, but naturally depends very much upon the quality and strength of the yarn. The length of yarn between the bobbin and the point where the thread first touches the swift should be as short as possible in order to reduce breakages to a minimum; and although the pins upon which the bobbin socket turns should be well oiled, care must be taken that the wooden shifter does not get so much saturated with oil as to run a risk of staining the yarn upon the swift, as sometimes occurs, especially in summer.

Having described the reel itself we will now speak of the manner of reeling, and draw attention to some important points which must be carefully watched if the hanks are to be easily rewound without excessive waste, in the factories of the weavers, upon the warp drum winder or the pirn weft winder.

The first operation of the reeler is to place and distribute her cages or trays of bobbins before her upon the box or reel which separates her from her comrade opposite. She may then place a bobbin upon each spindle or socket and bring the ends, four or six at a time, through their respective guides and attach them to one rail of the swift, which she has previously distended to its full circumference. Having satisfied herself that both bell and shifter are in their starting positions, she may now put the swift in motion by hand, or, if it be a power reel, by placing her foot upon the footboard, or by putting on the handle, if there be one. She must, while finding the ends and preparing fresh bobbins, keep a good look-out for a broken end or empty bobbin, and when such occurs stop the reel immediately, replace the bobbin, find the end and unite it with that upon the swift. She must find this latter, as when a bad reeler breaks a whole thread and joins it up, or puts her end between a hank and the rail without knotting the ends together, she adds to the labour of the winder and perpetrates the faults of cross-reeling and broken threads of which the winder reasonably complains. When the first cut or lea is completed, the reeler cuts off the starting ends, which she ties to a rail of the swift and ties each of them in two loops round their respective cuts, drawing the latter at the same time slightly to one side at that place, in order to leave a small space between it and the following cut, which she then proceeds to wind in a similar manner. When the bell rings for the second cut, the reeler must first see that all the ends are whole and then commence to put in the "leasing." The object of leasing is to maintain each cut separate, in order that they may be easily counted and the broken threads easily found in winding.

Leasing is a fine twine of linen or cotton yarn about 1200 yards per lb. It should be cut in lengths about two and a half times as long as the breadth of a completed hank, or 8 to 12 inches. The middle portion of the short length of leas-band is placed round the first cut, the ends crossed and placed around the second cut, then crossed again and doubled into the threads upon the swift, ready at hand to continue the operation when the third and following cuts are completed. When the last or twelfth cut or lea is finished, the two free ends of the leas-band are made into a knot along with the end of the yarn, and all cut off short. The leas-band must not be tightened up too much, confining the cuts too close together, as in this case, if the yarn is to be boiled, bleached or dyed, difficulty will be experienced in obtaining good results, as the chemicals or colouring matter will be unable to penetrate between the threads where they are closely held together by too tight leasing.

The reel being finished, the swift may be collapsed and the hanks of yarn removed in one or more bouts, each of which should bear a ticket giving the number of the frame, yarn, and reeler.

To prevent mistakes, it is also advisable to have tickets of special colour for each mark of yarn. The knot used by the reeler in joining her ends should be a small one, known as a weaver's knot. It is made by holding an end in either hand, crossing them the right under the left, passing the long end in the right hand round the back of its own extremity, and in front of that of the end held in the left hand, forming a loop, which is held in place between the first finger and thumb of the left hand until the short end of the thread held by that hand is passed backwards through it and held under the thumb while the loop is drawn tight, forming a fast knot. All other knots which bad reelers like to make, such as overthumb or granny's knots, bunch knots, etc., must be rigorously suppressed, as they are too bulky, showing up badly in the cloth, if they do not break the thread by sticking in the shuttle or heedle eye or reed of the loom.

Odd hanks of yarn should be counted regularly, to prevent the reeler giving too many threads under or over count, and to detect and punish double cuts and faulty reeling.

Double cuts occur when the reeler, through negligence, forgets to insert her leasing at the completion of a cut, in order to separate it from the one following. The appearance of the yarn will be much improved by forcing the reelers to throw the short ends or cuttings which they make, well behind them, and not allow loose threads to become mixed with those upon the reel.

What is known as chain leasing is sometimes employed to provide half hanks to be used as bands in the bundling process, which we will describe later on. Chain leasing consists in tying two knots, about half an inch apart, upon the leas-band between the sixth and seventh cuts. The hank is thus easily separated into two parts when such are required, by cutting the band between the knots referred to.

A reel to be found in some German mills is designed to obviate the necessity of stopping the whole machine when a thread breaks or runs out, and to work more or less automatically. The swift is divided into sections long enough to accommodate ten or twelve hanks. The threads, when running, pass over and depress levers which, when released by the absence of the thread, rise and allow their tailpieces to engage with and stop the motion of an oscillating bar or revolving shaft, stopping one section of the swift in the same way and by similar means as in a cotton drawing frame, to which one of the older mechanical stop motions is applied.

It is a good idea to keep the greater part of the swift running while an end is being knotted, but the difficulty in keeping the automatic stop motion in order takes away any advantage, and shows once more that a simple machine is often the best.

Although the usual method, reeling is not the only way in which flax, hemp, and jute yarns are prepared for market.

Cop Winding.—It is becoming day by day more usual to sell fine flax wefts upon paper tubes which may be put directly into the weaver's shuttle, or from which the yarn may be pulled off endwise. The yarn is wound upon these tubes either on the spinning frame, in the manner described in Chapter XII., in which case it is also dried upon them, or it is dried on the bobbin and then wound upon the tube on a cop-winder, such as Boyd's.

In Boyd's cop-winder the spindles lie almost horizontally and are pressed into conical cups by means of a lever. The end of the spindle, which passes through the cup and upon which the empty tube is placed, is removable, and is driven by a clutch from the butt of the spindle which passes on a feather through a bevel pinion which drives it from the spindle shaft pinion. The thread guides are fixed upon an oscillating shaft, and have a traverse about equal to the height of the cone inside which the cop is formed. When the tube is empty it protrudes through the cop, and the yarn is lapped upon its base until it accumulates to such an extent that its diameter becomes greater than the diameter of the cone, and it is forced backwards with the spindle which drives it.

In this way, the base of the cop being formed, the sides are kept perfectly parallel, the nose of the cop being always of the same conical shape as the interior of the forming cone or cup. An ingenious stop motion is arranged in such a way that when the tube becomes full the lever which pushes the spindle forward overbalances itself and draws the cop back, when the clutch disengages itself and motion of that spindle ceases. The firmness or hardness of the cop depends upon the tension of the yarn as it is drawn off the bobbin, upon the pressure with which the nose of the cop is pressed into the cone, and upon the length of the thread guide traverse. The thread is better bound together with a long traverse, a short traverse tending to make the cop brittle. Most cop-winders are built upon somewhat similar principles, but the spindles are vertical in many cases.

Fig. 77 shows a double cop-winding machine to wind flax, hemp and jute yarn direct from the bobbin and form cops 1 to $2\frac{1}{4}$ inches in diameter and from 6 to 12 inches long.

Yarn Drying.—There are several ways of drying yarn which has been spun wet or demi-sec. Weft yarn spun upon paper tubes for direct weaving, yarn upon the spinning bobbin and intended for the pirn or cheese winder, and warp yarn which has been wound wet on to tin spools for the warping machine, is generally put to dry in a hot chamber or "stove" in which the bobbins, tubes or spools rest upon iron plates, forming the lids of flat chests heated by steam. The difficulty of this sort of drying is the property which the yarn has of becoming slack upon the paper tube or bobbin, and of "drying away" from the head and base of the bobbin or spool upon which it is wound.

In the case of tubes, improvements have been made in their construction which remove this difficulty to some extent, but the difficulty of winding from wooden or metal bobbins without waste still remains, together with the inconvenience caused by the warping by heat of spinning bobbins dried in this way. Wooden bobbins which have been warped by heat may be brought back into shape by mixing and covering with damp sawdust and turning once or twice in the course of a few days.

As regards the drying of yarn in hanks, the reels of wet yarn should be collected from the reelers several times daily and handed over to the drying-loft men.

While it is being removed a note should be taken of the quantity of work turned off by each reeler, as the piecework system of payment is the most satisfactory, and almost universal.

Of the various methods of hank drying, the author believes that natural air-drying is the means best calculated to retain the "nature" in the yarn.

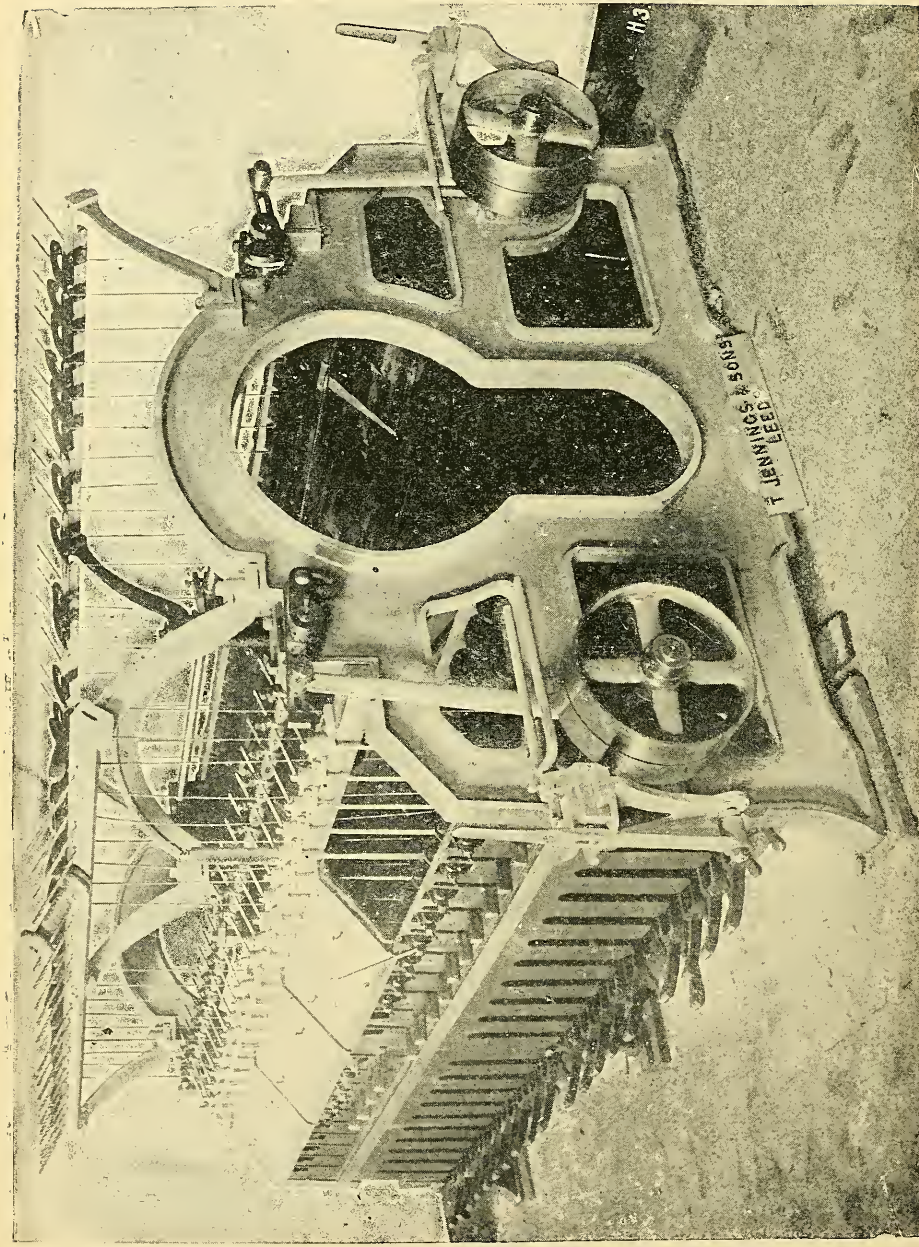

FIG. 77.—Double cop-winding machine.

Most mills lack space to dry their yarn in this fashion, even if the winter temperature and climate were suitable. Of quick methods of drying, that in which a current of dry and warm air is drawn through the yarn by a fan approaches most closely to the ideal.

The theory of all drying is, of course, the absorption of the moisture in the yarn by the dry air with which it is brought in contact. Since hot air can absorb and hold more moisture than can cold air, the former is usually employed, being removed or allowed to escape while still warm in order that it may carry its moisture with it.

In order that the yarn may be brought into intimate contact with the drying medium, the hanks should be well spread out upon poles long enough to contain, say, one reel of yarn. A second pole is usually suspended in the hanks to keep them straight and prevent their twisting round while drying, as they are inclined to do. The drying poles are supported in racks at either end, and when covered with yarn should be placed about 6 inches apart. Since the yarn actually touching the poles is prevented more or less from drying, when half dry the hanks should be rolled round, changing their position and exposing that portion of the hank.

Next to natural air-drying, perhaps the most economical method is to employ the heat thrown off by the boilers, which is considerable, even if they be covered with a nominally non-conducting composition. This is often done by constructing the drying loft immediately over the boiler house, in a series of flats and stages with openwork floors to allow the heat to ascend. To minimise the risk of fire, the structure should be almost entirely of iron laths and girder beams, supported by columns. A fire, if it occurs, may be quickly extinguished if a means be provided to allow a quantity of live steam to escape into the loft from the boilers underneath in case of need.

If the wet yarn be spread upon the poles during the day and all the windows shut at night, the air will, if of sufficient volume, absorb the moisture and dry the yarn. The hot and moisture-laden air is allowed to escape in the morning through the open windows, or is drawn off by a fan.

Fans are being employed more and more every day to assist drying. This they do by causing a current of air to circulate among the yarn, thus carrying off moisture-laden air and causing it to be replaced by dry air, which is more efficient as a dryer if it has been heated in circulating round the chimney or flues, as can easily be arranged, or drawn from the boiler-house, if that building be not immediately under the drying loft.

There are at least two other methods of hank drying in use. That known as the Scotch system is still at work in some Continental mills. Under this system the hanks of wet yarn are stretched in frames, which are placed in a vertical or horizontal air passage, which they completely fill.

Air, heated by a system of steam pipes, is drawn rapidly through the yarn by the aid of a fan.

The frames of yarn are put in at one end, moved onward automatically, and taken out at the other end, the operation being almost continuous.

Another system of hank drying consists in the use of a drying machine composed of a number of copper cylinders heated by steam which passes in through the hollow axles. These cylinders revolve, while round and between them are passed the hanks of damp yarn, linked together by rods, the whole machine resembling in principle the drying portion of a slashing or yarn-dressing machine. By using this method, the hanks are well stretched and the yarn has a more warpy and smooth appearance, which may in some cases add to its value. The greatest care is required in the use of this machine lest the yarn be scorched. The heat of the cylinder must be kept regular and the machine run through before a stoppage. Drying-loft men are generally paid piecework, *i.e.* per 100 hanks. One penny farthing per 100 hanks with an average lea of 75's will be found about right. If the average lea be lower the rate should be proportionately higher, since the work is heavier, and *vice versâ*. As regards the dimension of an ordinary drying loft required to dry a given daily production of yarn, it will be found that a loft of 100,000 cubic feet capacity, divided into four storeys, with 9 feet head room and openwork floors, closed up and heated during a period of five to eight hours per night by 500 feet of 8-inch piping, filled with steam at an initial temperature of 300° F., will dry 1600 bundles of yarns averaging 75 leas per lb. The duration of steaming depends very much upon the weather and the arrangements of the loft with regard to fans or other means of producing a draught through it during the day-time, while the loft men are engaged in taking off and spreading the yarn upon the poles.

Yarn Cooling.—The complement of yarn drying is yarn cooling. To dry out the moisture from the core of heavy yarns, especially in a short time, by air at a high temperature, the outside of the thread is overdried and the yarn is in a harsh and brittle condition unfavourable to weaving. In this state the yarn must be allowed to absorb, with uniformity, about 5 to 8 per cent. of moisture, which it will do naturally if exposed to the outside air for a sufficient length of time. Want of space to accomplish this exposure forces most mills to water their yarn with a watering can and then to pile the damped yarn in order that the moisture may spread through the whole, as it will eventually do if the pile be frequently turned over. A cooling shed, with openwork sides and roof, in which the yarn is hung on poles as in the drying loft, is much to be preferred, especially if the air be kept moist and cool by a humidifier, such as is shown in figs. 135 and 136. Another good way to cool yarn is to spread it upon an earthen floor, covered with bass matting, or even upon a tiled ground floor.

Yarn Proofs.—In order that yarns being spun may be kept to their exact number or lea, proofs of reliable exactitude as to count, etc., are almost indispensable, and certainly advantageous. For this reason, every mill should have a small sample reel of twelve spindles, upon which a careful reeler should daily make a proof of twelve cuts of the yarn being spun on each frame. As there is no reason why one of these twelve threads should fail while a cut is being reeled, a bell wheel of the exact number of teeth, 100 or 120, for short and long reel respectively, should be provided, its efficiency being further enhanced by supplementing the bell by a hand or marker, which, after the ringing of the bell as a warning, may be slowly brought round to an exact spot and the correct number of threads obtained. Again, as there is no reason why the threads should not be well spread upon this reel, the circumference of the swift should be absolutely exact, that is to say, $1\frac{1}{2}$ yards $= 1{\cdot}372$ metres for the short reel, and $2\frac{1}{2}$ yards $= 2{\cdot}286$ metres for the long.

Since the number and weight of the yarn is most conveniently ascertained in the yarn department, we will here make a few remarks upon a subject which affects, perhaps more than any other, the value of a spinner's yarn and the profit which he may make through spinning it.

In the first place, the uniformity in weight or "grist" of the yarn from bobbin to bobbin and from day to day, although seldom obtained by the consumers, is appreciated by them, since it affects the uniformity of their cloth. If, for instance, instead of a bundle of 30, a weaver is supplied with a bundle of the same weight, really composed of a half-and-half mixture of 28's and 32's, he will find his cloth correspondingly uneven in weight from yard to yard and piece to piece. The sewing-thread maker must be even more particular than the weaver, since two threads of dissimilar weight and diameter will not twist properly together, the smaller always trying to twist around the heavier, forming an unsightly thread, which is weaker than it would be were the strain equally divided among its component parts. For the convenience of those engaged in the trade at home and abroad we give the weight in lbs., ozs., and drams, and also in grammes, of a long reeled hank of flax or hemp yarn, corresponding to that of two short reeled hanks, both in the stove-dried state and under the atmospheric conditions prevalent in the British Isles. The author, after long experience and many experiments, believes that yarn in a stove-dried condition absorbs 8 per cent. of moisture if allowed to do so under natural conditions, and consequently holds that it is the amount of moisture which linen or hempen yarns should honestly contain. If they are sold drier, the spinner gives away an unnecessary quantity of material and a more brittle and less sightly yarn. If, on the other hand, the spinner sells a damper yarn, he may, in certain cases, make money by giving water instead of yarn, but is liable to have to pay compensation through the yarns arriving at their destination light in weight through "drying in." The weights of the yarn given in the subjoined table are calculated upon the Irish linen yarn table. We should observe, however, that in the north of France, for

Lea.	Weight in Grammes of 1 Hank = 3600 yards.		Weight in lbs. and ozs. of 1 Hank = 3600 yards.						Weight in lbs. and ozs. of 1 Reel.					
	Cool.	Stove Dried.	Cool.			Stove Dried.			20 Hanks.		30 Hanks.		40 Hanks.	
			lbs.	ozs.	drs.	lbs.	ozs.	drs.	lbs.	ozs.	lbs.	ozs.	lbs.	ozs.
6	906	839	2	0	0	1	13	10	40	0	60	0	80	0
8	679	629	1	8	0	1	6	4	30	0	45	0	60	0
10	544	504	1	3	3	1	1	12	24	0	36	0	48	0
12	453	419	1	0	0	0	14	13	20	0	30	0	40	0
14	388	359	0	13	11½	0	12	11	17	2	25	11	34	4
16	340	315	0	12	0	0	11	2	15	0	22	8	30	0
18	302	280	0	10	11	0	9	14	13	5½	20	0	26	11
20	272	252	0	9	9½	0	8	14	12	0	18	0	24	0
22	248	229	0	8	11½	0	8	1	10	14½	16	5¾	21	13
25	217	201	0	7	11	0	7	2	9	9½	14	5¾	19	3
28	194	179	0	6	14	0	6	6	8	9	12	13½	17	2
30	181	168	0	6	6½	0	5	15	8	0	12	0	16	0
32	170	157	0	6	0	0	5	9	7	8	11	4	15	0
35	155	144	0	5	7½	0	5	1	6	13½	10	4½	13	11
40	136	126	0	4	13	0	4	7	6	0	9	0	12	0
45	121	112	0	4	4½	0	3	15	5	5½	8	0¼	10	11
50	109	107	0	3	13½	0	3	9	4	13	7	3¼	9	10
55	99	92	0	3	8	0	3	4	4	6	6	9	8	12
60	91	84	0	3	3	0	2	15	4	0	6	0	8	0
65	84	77	0	2	15	0	2	12	3	11	5	8½	7	6
70	78	72	0	2	12	0	2	9	3	7	5	2½	6	14
75	73	67	0	2	9	0	2	6½	3	3¼	4	13	6	6½
80	68	63	0	2	6½	0	2	4	3	0	4	8	6	0
85	64	59	0	2	4	0	2	2	2	13	4	3½	5	10
90	60	56	0	2	2¼	0	2	½	2	10½	4	0	5	5
95	57	53	0	2	¼	0	1	14½	2	8½	3	12¾	5	1
100	54	50	0	1	14¾	0	1	13	2	6½	3	9¾	4	13
110	50	46	0	1	12	0	1	10	2	2¾	3	4	4	5½
120	45	42	0	1	9½	0	1	8	2	0	3	0	4	0
130	42	39	0	1	7½	0	1	6	1	13½	2	12¼	3	11
140	39	36	0	1	5¾	0	1	4½	1	11½	2	9¼	3	7
150	36	34	0	1	4½	0	1	3¼	1	9½	2	6¼	3	3
160	34	32	0	1	3¼	0	1	2	1	8	2	4	3	0
180	50	28	0	1	1	0	1	¼	1	5¼	2	0	2	10½
200	27	25	0	0	15½	0	0	14½	1	3¼	1	13	2	6½
250	22	20	0	0	12½	0	0	11½	0	15¼	1	7	1	14½
300	18	17	0	0	10¼	0	0	9½	0	12¾	1	3	1	9½

instance, the spinners, although nominally following that table, spin some of their numbers rather heavier. Thus, for instance, Lille spinners spin their 14's to weigh 40 kilogrammes per paquet, or 400 grammes per hank instead of 388. It is interesting here to notice the ease with which, under the metric decimal system, the weight of a French paquet or six bundles may be calculated from the weight of one hank, for since there are 1000 grammes in a kilogramme, and 100 hanks in a six-bundle bunch or paquet, the weight in kilos of one hank of 14's lea is ·388 kilo, and of one paquet 38·8 kilos.

The yarn table as used in the Scotch dry spun trade is as follows :—

Spyndle.	Hanks.	Heers.	Cuts.	Threads.	Yards.
0	0	0	0	1	$2\frac{1}{2}$
0	0	0	1	120	300
0	0	1	2	240	600
0	1	6	12	1440	3,600
1	4	24	48	5760	14,400

Another handy way of checking the number or lea of any linen yarn is to find the number of yards which weigh $\frac{1}{300}$ part of a pound avoirdupois. Such a number of yards correspond with the lea, since there are 300 yards in a cut.

The degree of twist in any given sample of yarn may be tested and found by the use of a handy little instrument in which a given length of thread, say 6 inches, is firmly held at one end, while the other end is turned in the reverse direction to that in which the thread was originally twisted, taking out the twist and registering the number of turns given, by a worm actuating a worm wheel, pointer and dial.

Thus if a hank of yarn be found to weigh 7 ozs. 11 drs. ; or if 25 yards be required to balance a small weight equal to $\frac{1}{300}$ part of a lb., the yarn is known to be 25's lea ; and if it be tested for twist and found to have 60 turns in 6 inches, or 10 turns per inch, it may be considered to have been twisted for warp on the basis of two upon the square root of the number, or $2\sqrt{25} = 2 \times 5 = 10$ turns per inch.

Yarn should be tested for strength frequently and regularly in order that its quality may be maintained and faults due to bad spinning detected and remedied.

The most convenient yarn tester for ordinary numbers is the "Porter." It consists of a plank, to the upper portion of which a Salter's spring balance is attached. At a distance below of about 34 inches is a plunger or piston, working in a vertical cylinder kept full of oil. The thread to be tested is attached to the hook of the spring balance and to the upper portion of the piston rod in such a way that the thread may not cut itself. The marker of the balance being at zero, the piston is allowed to descend in the cylinder, which it does very slowly and regularly, for there is a small hole in the piston head through which the thick oil must pass as the piston descends. A gradual strain without jerk is thus put upon the yarn, and when it breaks the indicating finger is held in place upon the graduated scale by means of a rack and pawl arrangement, until the reading be taken, when it is put back to zero, the piston raised and another thread tried. Another yarn tester, as made by Mr Wm. Bywater, Leeds, is shown in fig. 78. It is very suitable for coarser yarns and twines, as it is made in various sizes and tests up to 1200 lbs. The strain is applied to the yarn by a hand wheel and screw as shown.

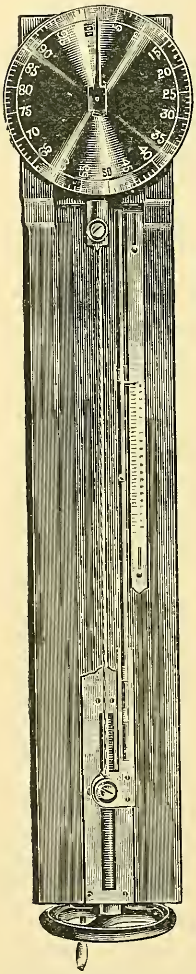

Fig. 78.—Yarn and twine testing machine.

Not less than ten threads of each sample should be tested to get a good average.

Bundling and Bunching Yarn.—There are two ways of making up hanks of flax, hemp and tow yarns for market: that is to say, they may be made into either long or short bundles or bunches. In length the long bunch is almost as long as the hank, say 40 inches, while the short bunch is only about half that length, or 20 inches. Yarns reeled on the 54-inch swift and short bunched, produce bunches about 13 inches long, resembling the cotton bunch. Scotch dry spun flax, hemp and jute yarns are almost invariably made up in long bunches, while coarse yarns in general are cheaply bundled in this way, which serves very well for any yarn which is to be delivered straight away to a neighbouring manufacturer or bleacher. If yarn is to be baled or sent long distances by rail or sea, it will arrive in a much better state if press bunched.

Long bundles are made in the bundling stool, which is a heavy and solidly-built stool about 46 inches long and 10 inches broad. Four or eight pegs form the sides of the stool at either side, leaving it an inside width of 8 to 10 inches. Twenty-five hanks or $1\frac{1}{2}$ bundles of coarse yarn, such as from 6 to 12 lea, will form a bundle of the dimensions given, while 50 hanks, or three bundles, may be united in a bundle of 14's to 25's lea, and 100 hanks or six bundles when dealing with finer yarns. In making a 25-hank stool bundle, four $\frac{1}{4}$ hanks should be used as bands, and being slightly twisted, laid across the stool at regular intervals; $1\frac{1}{2}$ hanks of yarn are then twisted into a head and laid lengthwise in the stool on top of the bands. Four such heads form a row, and four rows of $1\frac{1}{2}$ hank heads, together with the bands, complete the 25-hank bundle, thus, $(16 \times 1\frac{1}{2}) + (4 \times \frac{1}{4}) = 24 + 1 = 25$.

The following table gives the ordinary range of breaking strains, in ounces, for ordinary wet spun numbers in flax line and tow yarns, while a good demi-sec spun line yarn in, say, 18-lea can stand a strain of 6 lbs., 8-oz. binder twine 100 lbs., 11 oz. binder twine 110 lbs., and so on.

Line Yarns.		Tow Yarns.	
Lea.	Breaking Strain in ounces.	Lea.	Breaking Strain in ounces.
10	56 –76	10	46–56
12	46 –65	12	42–49
14	44 –62	14	37–45
16	42 –56	16	33–43
18	40 –52	18	30–42
20	39 –49	20	26–40
22	35 –42	22	24–38
25	32 –37	25	22–35
30	29 –34	30	20–27
35	25 –30	35	19–25
40	22 –26	40	18–23
45	19 –25	45	17–21
50	18 –22	50	16–19
55	16 –18	60	15–18
60	14 –17		
70	12 –16		
80	11 –15		
90	10 –14		
100	9 –13		
120	8 –12		
130	7 –10		
140	6 – 9		
150	5 – 8		
160	4 – 6		
180	$3\frac{1}{2}$ – $5\frac{1}{2}$		
200	3 – 5		
250	3 – 4		
300	2 – 3		

When his rows are complete, the bundler tightens the bands around his bundle in passing one end through the loop of the other, applying his knee and pulling tight, securing the end by tucking it once or twice under the tightened band. Fifty or 100 hank stool bunches are made in a similar manner, the former being composed of sixteen heads of three hanks, together with four half-hank bands, and the latter of sixteen heads of six hanks each, together with four one-hank bands.

Short bunches may also be made upon the stool, but the use of the bundling press is now almost universal, and "pressed" yarn is preferred by manufacturers, since it is less tossed and broken, and the heads, if properly made, more easily opened out by the bleacher or winder.

A press suitable for a 25-hank bunch in 8's to 20's lea, 50 hanks in 20's to 40's lea, 100 hanks in 42's to 80's lea, and 200 hanks in 80's to 160's lea, may be conveniently 21 inches long, 8 inches wide and 12 inches deep when open, inside measurements. It is constructed of cast iron with side supports, between which the bands are placed, and corresponding hinged caps with clasps of various construction. The bottom is movable, and is raised to compress the bunch either by an Archimedean screw, with a nut, in the form of a bevel pinion, fixed in position and turned by another bevel upon the spindle of the hand wheel, with which the bundler applies the pressure without much labour; or by means of a spur pinion and cam wheel, the latter connected to the movable bottom by links, the lower ends of which embrace a stud fixed eccentrically in the cam wheel. Pressure is usually applied by hand in turning a capstan or hand wheel, upon the spindle of which, in the case of the screw press, is the endless worm actuating the worm wheel or nut block or the spur pinion giving motion to the cam wheel in presses of that construction; but power presses are not unknown in which the hand wheel is replaced by a fast and loose pulley and belt. A power press of this description should be provided with a knocking-off motion to shift the belt on to the slack pulley when the bunch is sufficiently pressed.

In making a 25-hank press bunch, four $\frac{1}{4}$ hanks are used as bands, each being separately and well twisted by a quick motion of the thumbs and fingers, while the hank hangs upon the "horn," a round bar of wood firmly fixed at one end. The bands are placed in position between the side supports and over the bottom of the press, which should be of wood and grooved to receive the bands. The heads are then formed, in the case in hand, 16 in number, each of $1\frac{1}{2}$ hanks laid in four rows of four heads each. To form the heads the bundler places a reel or half a reel of yarn upon his horn, and untwisting the hanks, separates the number required per head from the others. These he should turn round upon the horn to stretch and straighten the threads, pulling them tight occasionally with a jerk, which will cause some shove to fall. The "leasing" of the several hanks being in line and in view a few inches above his hand, he gives that portion of the hank about two turns of twist by a dexterous movement, and removing them from the horn, doubles the length exactly in half and twists the double into a head between his fingers, or in throwing the end twice under his arm. The head thus formed he places evenly and squarely in the press, taking care that, for the first and last row and the outside heads of each row, the leasing is always turned inwards and thus hidden in the completed bunch. The last row being complete, the bundler secures the caps of the press, screws it up as described, and secures his bands in a similar manner as in the stool bundle. Releasing the press which was held by a ratchet and pawl, he allows the bottom to sink, and opening the caps lifts out the completed bunch. A 50-hank bunch may be made in a similar manner with 16 heads of three hanks each and four half-hank bands, and a 100-hank bunch with 16 heads of six hanks each and four one hank bands. Short-reeled yarn is pressed in a similar manner in a press of proportionate dimensions, which are those of a cotton yarn press. This yarn is usually tied with cord.

In this way a six-bundle bunch may be built of five rows of five heads, each head having eight short hanks, or 200 hanks in all. The following table gives particulars of press bunches built in the ordinary way :—

Leas.	English Bundles.	Belgian Paquets.	French Paquets.	Hanks in Bunch.	Heads in Bunch.	Hanks in Head.	Number of Bands.	Hanks in Bands.
Up to 20's lea, . .	$1\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{4}$	25	16	$1\frac{1}{2}$	4	$\frac{1}{4}$
20's ,, 30's lea, . .	3	1	$\frac{1}{2}$	50	16	3	4	$\frac{1}{2}$
35's ,, 45's lea, . .	6	2	1	100	24	4	4	1
50's ,, 70's lea, . .	6	2	1	100	16	6	4	1
75's ,, 160's lea, . .	12	4	2	200	24	8	4	2
100's ,, 140's short reel, .	6	2	1	200	40	5	4	cord
160's upwards short reel, .	6	2	1	200	25	8	4	cord

The building of the bunches of yarn in compact piles in the yarn store requires a little practice. Rectangular piles covering various areas may be arranged with a given number of bunches per layer, so that the number of bunches in a pile is easily reckoned in estimating the number of bunches in a layer and multiplying by the layers in the pile. The number of bunches per layer, if not known, may be found by multiplying the number of times the length of the bunch is contained in one side of the pile by the number of heads or bunch ends which might be contained in the length of an adjacent side. To render the pile solid and firm, the bunches in one layer should cross, as much as possible, those in the layer underneath binding all together.

Weight of Bundles.—The following table gives the commercial weights of the English bundles, Belgian and French paquets in the various leas. It will be seen that the Belgian weights correspond with the English standard, while the French, through local custom, vary slightly in several numbers. Yarn should be put into store a few ounces heavier than its standard weight, lest it should become too light in hot weather. For the same reason the yarn store should be dry, yet cool, and the sun's rays excluded. Buyers will seldom object to heavy yarns, say under 60's lea, being more than their standard weight, while they do object to the finer yarn, say above 100 leas, being heavier than they should be.

Leas.	English Bundle.		Belgian Paquet.	French Paquet.
	lbs.	ozs.	kilogrammes.	kilogrammes.
6	33	4	45·32	90·0
8	25	0	34·00	68·0
10	20	0	27·20	54·0 or 55·0
12	16	10	22·66	45·0
14	14	4	19·43	40·0 or 38·5
16	12	8	17·00	34·0
18	11	1½	15·11	30·0 or 31·0
20	10	0	13·60	28·0
22	9	1	12·36	25·0
25	8	0	10·88	22·0
28	7	2	9·71	20·0
30	6	10½	9·06	18·0
32	6	4	8·50	17·0
35	5	11¼	7·77	16·0
38	5	4	7·15	15·0
40	5	0	6·80	14·0
42	4	12	6·48	13·0
45	4	7	6·04	12·0
48	4	2½	5·66	11·5
50	4	0	5·44	11·0
52	3	13½	5·23	10·5
55	3	10	4·95	10·0
60	3	5¼	4·53	9·0
65	3	1	4·20	8·5
70	2	13½	3·88	8·0
80	2	8	3·40	7·0
90	2	3½	3·02	6·0
100	2	0	2·72	5·5
110	1	13	2·48	5·0
120	1	10½	2·27	4·5
130	1	8½	2·10	4·25
140	1	6¾	1·94	4·0
150	1	5¼	1·81	3·6
160	1	4	1·70	3·5
180	1	1¾	1·51	3·0
200	1	0	1·36	2·7

Balling.—Dry spun shoe yarns are generally balled from the spinning bobbin upon a hand balling machine such as is shown in fig. 100. Reaper yarns are balled from the automatic bobbin upon a two-spindle automatic machine such as is shown in fig. 79. In this machine each spindle works independently of the other, the formation of the balls being regulated by cams which ensure all balls being alike as to shape, weight and length of material.

Baleing yarn for exportation or transport to a considerable distance is most conveniently accomplished with the aid of a hydraulic press. The bands of hoop iron with which the bale is to be secured are placed in grooves in the bottom of the press. A piece of hessian or other bagging, a little wider than the bale to be made and in length a little bit longer than the sum of three sides of the same bale, is next laid over the hoop iron band, and upon this the bunches of yarn are built in square layers, one layer binding the other. When the desired quantity of yarn has been built into the press another piece of hessian of similar length to the first is laid over the top layer in the reverse direction, and the hoop iron bands being passed through suitable grooves in the top of the press, the pumps are set going and the platform raised until the desired degree of compression is obtained, when the canvas is sewn strongly together and the bands pulled tight and riveted. When this is done and the water released, a compact and well-secured bale is obtained.

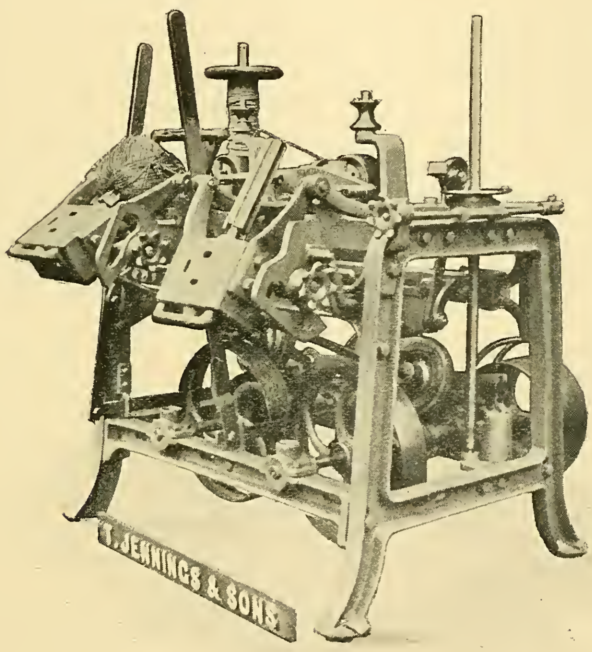

Fig. 79.—Baleing machine.

The prices of wet and dry spun flax and hemp yarns and long line and carded jute yarns were at the time of writing—*i.e.* February 1904—as follows :—

Jute Yarns.

Lea.	Weft Carded.		Warp Carded.		Line.	
	Centimes. Kilos.	Pence. Pounds.	Centimes. Kilos.	Pence. Pounds.	Francs. Paquets.	Pence. Pounds.
1	42	1·90	...	...	...	...
2	43	1·95	...	...	...	...
3	44	2·00	...	...	...	...
4	53	2·40	54	2·45	...	...
5	54	2·45	55	2·50	...	...
6	55	2·50	57	2·60	...	...
7	56	2·55	...	...	...	...
8	59	2·68	...	...	...	...
10	...	3·33	...	...	45	3·73
12	...	3·7	...	...	39	3·93
14	...	...	...	...	37	4·20
16	...	...	...	...	38	5·00

Hemp Yarns.

Lea.	Line (Wet).		Line (Dry Spun).		Tow (Dry Spun).		Tow (Wet Spun).	
	Francs. Paquets.	Pence. Pound.	Francs. Paquets.	Pence. Pound.	Francs. Paquets.	Pence. Pound.	Francs. Paquets.	Pence. Pound.
5	197	8	...	...	161	6·6	172	7·1
6	166	8·5	165	8·3	136	6·8	146	7·3
7	142	8·4	150	8·8	118	6·9	126	7·4
8	127	8·4	134	8·9	106	7	109	7·6
10	106	8·9	108	9	90	7·5	93	7·8
12	95	9·5	95	9·6	82	8·2	81	8·2
14	85	9·6	88	10	77	8·7	77	8·7
16	80	10·6	78	10·4	73	9·7	70	9·3
18	76	11·5	75	11·3	...	...	64	9·7
20	70	11·4	...	...	...	...	62	10

The French paquet is equal to six English bundles or 360,000 yards. Ten centimes are about equal to one penny. One franc equals about 9½d. Irish yarns are subject to a 9 per cent. discount when sold to weavers and to 11 per cent. discount when sold through a commission house. The usual French terms are 6 per cent., 30 days.

French Dry Spun Flax Yarns.

Lea.	Tow Warp.		Tow Weft.		Line.	
	Francs. Paquets.	Shillings. Bundles.	Francs. Paquets.	Shillings. Bundles.	Francs. Paquets.	Shillings. Bundles.
		s. d.		*s. d.*		*s. d.*
6	135	18 9	124	17 3	...	...
8	116	16 0	96	13 1½	...	...
10	95	13 1½	78	10 9	...	...
12	86	12 0	72	10 0	102	14 1½
14	78	10 9	65	9 0	92	12 9
16	69	9 7½	59	8 1½	86	12 0
18	...	..	58	8 0	75	10 4½
20	...	...	57	7 10½	72	10 0
22	...	...		...	69	9 7½
25	...	..	...	..	68	9 6

Lea.	Wet Spun Flax Lines.						Wet Spun Flax Tows.			
	Weft.		Warp. Superior and Medium.		Light Warp.		Warp.		Weft.	
	Francs. Paquets.	Shillings. Bundle.	Francs. Paquets.	Shillings. Bundle.	Francs. Paquets.	Shillings. Bundle.	Francs. Paquets.	Shillings. Bundle.	Francs. Paquets.	Shillings. Bundle.
		s. d.		*s. d.*		*s. d.*		*s. d.*		*s. d.*
6	...	...	...	...	...	...	150	...	134	...
8	..	...	...	..	...	...	125	...	104	...
10	...	..	...	...	...	...	109	...	87	...
12	..	...	142	...	...	...	99	...	76	...
14	90	...	128	...	98	...	86	8 7½	69	8 4½
16	79	...	110	...	87	...	77	8 0	61	7 9
18	72	...	98	...	79	...	70	7 7½	56	7 1½
20	67	8 3	90	...	72	...	66	7 4½	53	6 7½
22	61	7 6	82	...	65	...	61	6 10½	49	6 4½
25	54	7 0	78	..	59	...	57	6 7½	47	6 1½
28	51	6 6	74	..	55	...	54	6 4½	46	5 10½
30	49	6 3	70	...	51	...	49	6 1½	44	5 6
35	45	5 9	68	...	48	....	47	5 9	43	5 1½
40	43	5 4½	68	...	46	...	47	5 4½	42	4 10½
45	40	5 1½	68	...	45	...	...	5 1½	...	4 7½
50	39	4 10½	67	5 6	44	...	...	4 10½	...	4 6
55	38	4 9	67	5 3	42	...	...	...	...	4 4½
60	36	4 7½	67	5 1½	42	...	...	...	...	...
65	35	4 4½	67	5 0	41	...	...	...	...	...
70	34	4 3	67	5 0	41	...	...	...	...	...
75	33	4 1½	67	5 0	...	4 6	...	...	...	...
80	33	3 10½	69	5 0	...	4 6	...	...	...	...
85	33	3 9	70	5 1½	...	4 6	...	...	...	...
90	33	3 9	...	5 3	...	4 7½	...	...	...	...
100	33½	3 9	...	5 6	...	4 10½	...	...	...	...
110	34	3 9	...	...	...	5 0	...	...	...	...
120	...	3 9	...	...	...	5 1½	...	...	...	...