CHAPTER XVI.

THE MANUFACTURE OF THREADS, TWINES AND CORDS FROM FLAX, HEMP, JUTE, AND RAMIE YARNS.

Twisting and Cabling.—Threads, twines, cords, and ropes in the true sense of the term are composed of two or more single yarns twisted together.

If threads, twines, cords and strands thus formed are again twisted together, they are said to be "cabled." The operation of cabling is resorted to when a specially hard-surfaced thread, cord, or rope is required, as, for instance, some sorts of sewing thread, whipcord or driving ropes.

The first process consists in putting the yarn into a suitable form to commence the twisting operation.

If it be dry spun yarn, it may for cheapness sake be twisted from the spinning bobbin, although that way is not to be recommended for first-class work. If excellence is aimed at, the yarn should be re-wound on to larger bobbins or spools, or upon a winding frame of the sort shown in fig. 80, which is even more used for cotton.

In this machine the top spindles are fixed in a double row with brass bolsters and footsteps, the back row has larger wharves than the front row, and the bobbins should be changed from front to back when half filled. This equalises the speed of the yarn and renders a higher average speed of winding possible. In the illustration a creeper motion is shown in the centre of the frame. Its object is to automatically carry away the empty bobbins and deposit them in a basket at the end of the frame. If the yarn has been spun wet or demi-sec, or if it has been bleached or dyed, it must be wound from the hank upon spools before it can be twisted. Fig. 81 shows a single drum winding frame upon which fine yarns may be wound from 54-inch hanks, and figs. 82 and 83 winding frames which are suitable for the coarsest yarns. In this class of machine the flanged wooden spools upon which the yarn is to be wound rest upon the winding drums, so that the speed of winding is constant, no matter what may be the diameter of the spool of yarn. The thread guides are traversed by a cam or eccentric. A very similar machine is the split drum winding frame, in which machine

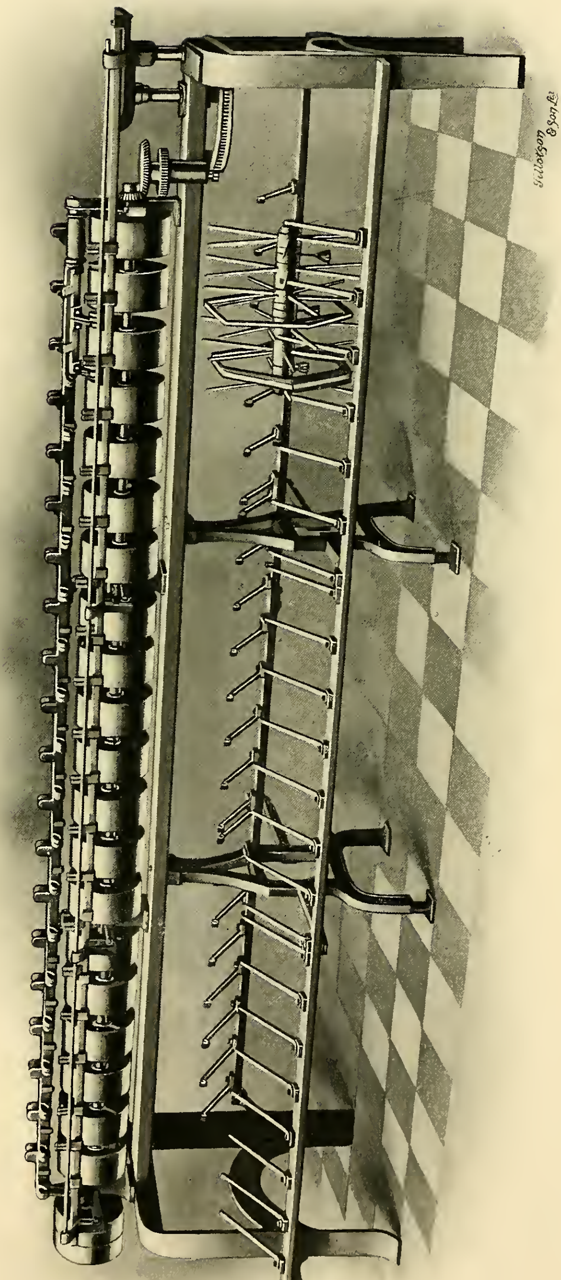

FIG. 81.—Improved single drum winding frame (latch and catch). (Made by Messrs Arundel & Co., Stockport, England.)

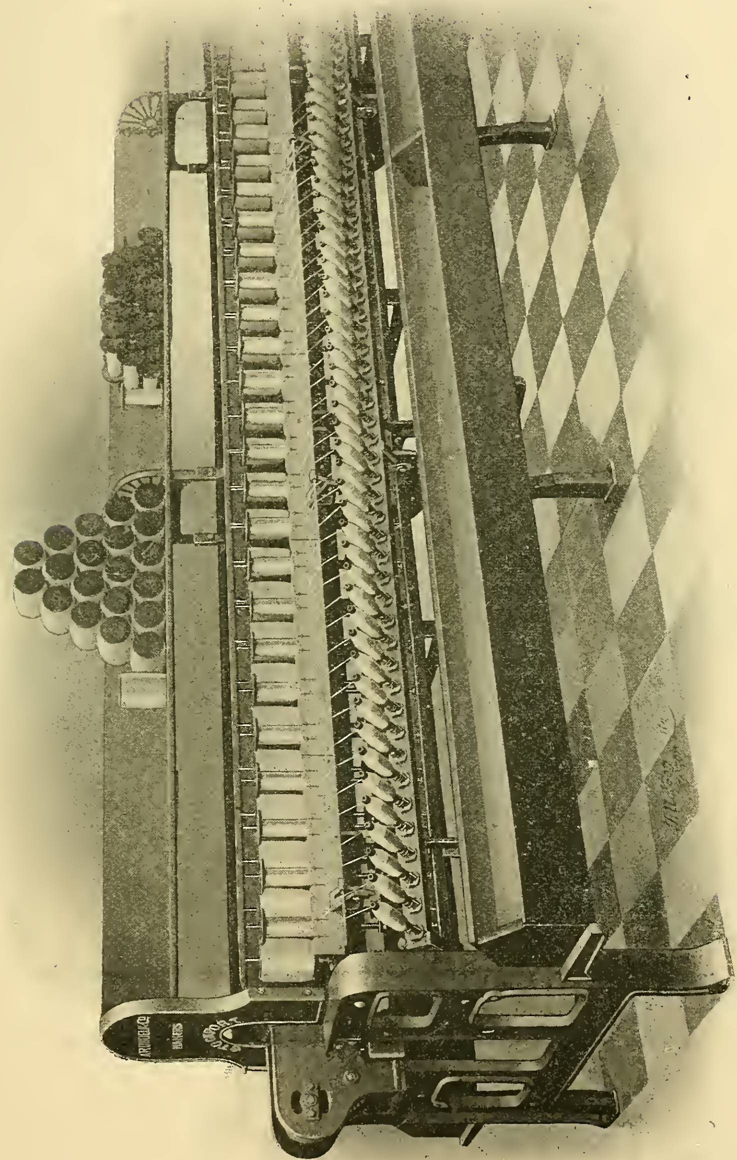

FIG. 80.—Upright spindle winding frame, with creeper motion for taking away empty bobbins. (Made by Messrs Arundel & Co., Stockport, England.)

a split extending across from one side of the face of the revolving drum to the other, acts as a thread guide.

During this re-winding process the yarn may be passed through a narrow slit called a clearer or slubber, and freed from all lumps, slubs, bad piecings, etc., which are cut out, and the ends united by a weaver's or other small knot. A convenient adjustable slubber is that patented and made by Messrs J. & T. Boyd, Ltd., Glasgow. When a number of yarns are to be twisted together some people prefer to first *double* them together upon

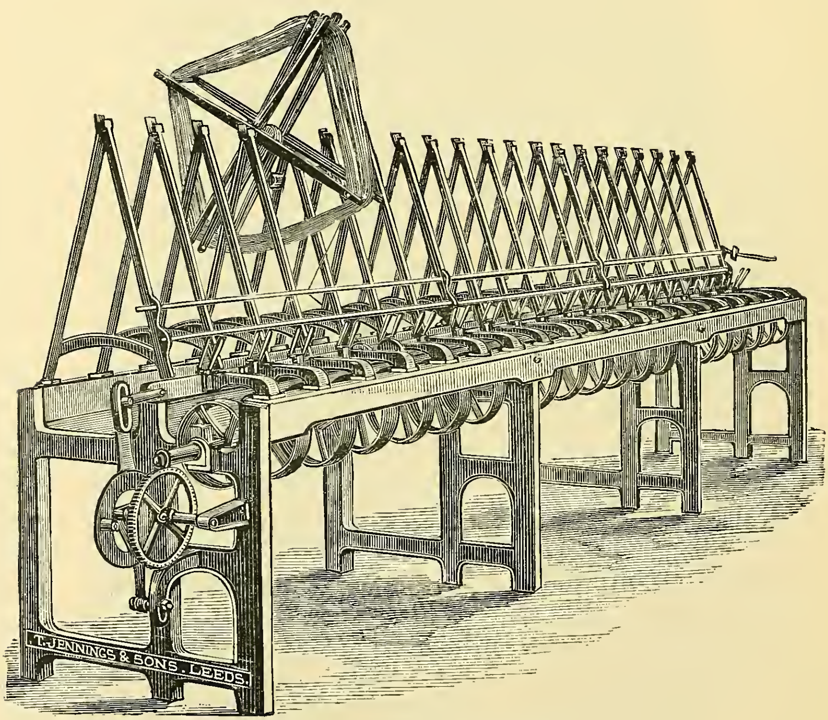

FIG. 82.—Winding or swifting frame.
(Made by Thomas Jennings & Sons, Leeds, England.)

a doubling winding frame provided with detector stop motions for each end, destined to prevent winding taking place on any individual bobbin after one of the yarns has run out or broken. These bobbins of doubled yarns, or the required number of bobbins of single yarn, are then put up in the creel of the twisting frame, brought round and through the delivery rollers, and twisted by the flyer or traveller.

Figs. 84, 85, and 86 show different forms of twisting frames for making threads and cords from single yarns.

The first shows most clearly the way in which, for wet twisting, the yarn is first guided into a trough of water, then under and round the

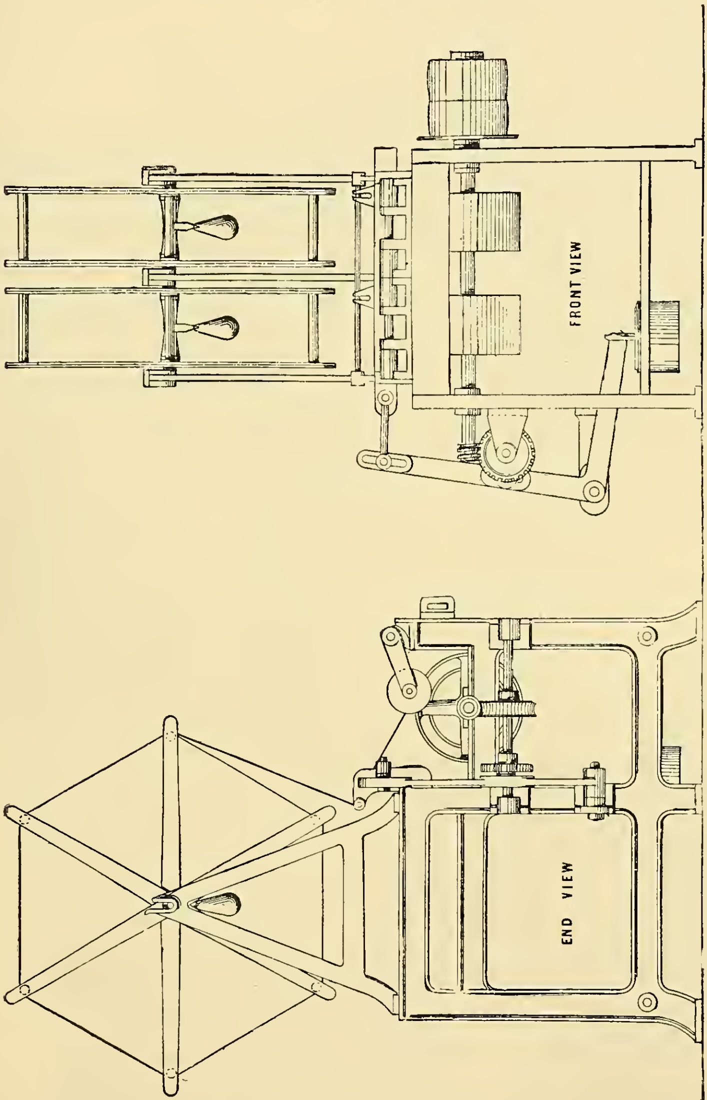

Fig. 83.—Winding or swifting frame. (Made by Mr William Bywater, Leeds, England.)

bottom delivery roller and through the nip of the top pressing roller, then back round a guide and over the top of the upper delivery roller (on which it lies in a groove), through the thread plate eye to the twisting action of the flyer and spindle. In the frame shown in fig. 86 each spindle is provided with a stop motion which, when one end of a set of threads being twisted together fails or breaks, instantly stops the individual spindle and roller, so that it is impossible for either to move further (leaving a perfectly twisted

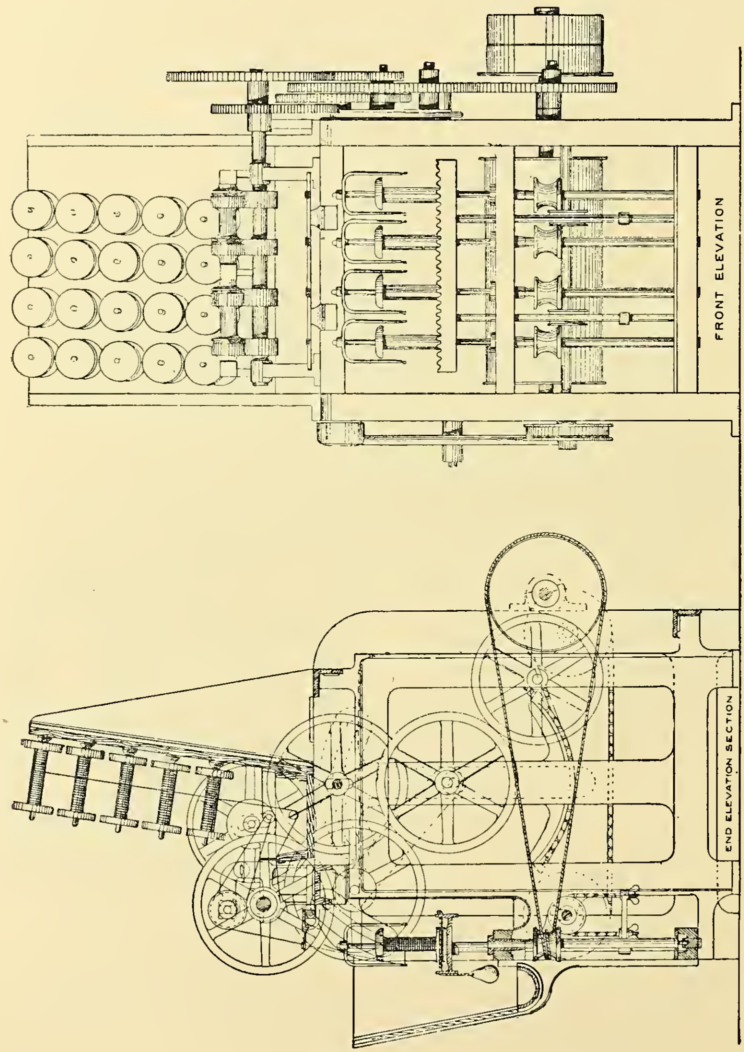

Fig. 84.—Twisting frame. (Made by Mr William Bywater, Leeds.)

thread between the feed roller and spindle and the broken end ready to be pieced in the single behind the delivery roller). A neat piecing in the single strand, and the proper amount of twist, where a piecing is made, are ensured, whilst bunch knots, singles, doubles and waste are avoided. No time is lost stooping down, stopping spindles, seeking the end

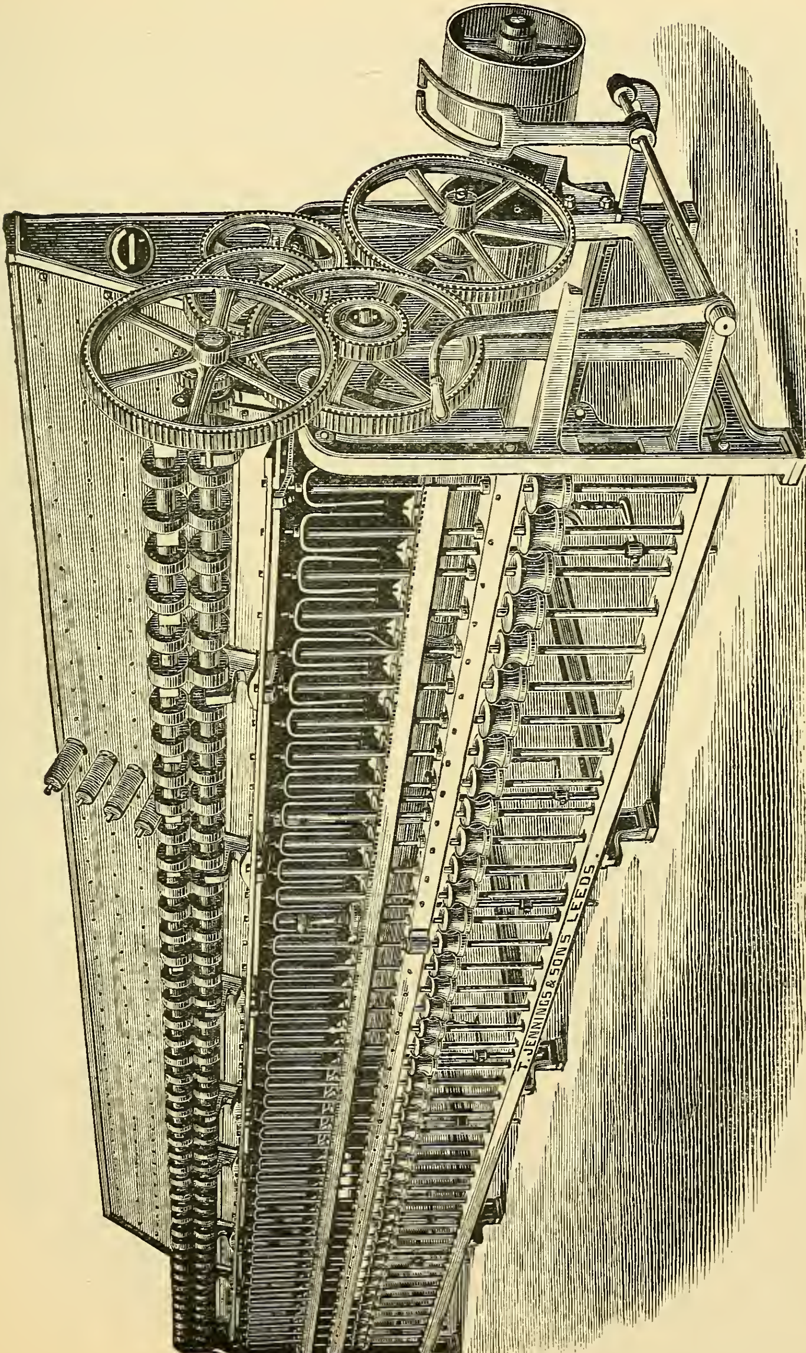

Fig. 85.—Twine twisting frame. (Made by Thomas Jennings & Sons, Leeds.)

upon the bobbin, and bringing it through the delivery rollers. Each bobbin may be doffed when filled, thereby saving the necessity of stopping the frame for doffing. Frames of the same make, but of a lighter class, fitted with high-speed flyer and ring spindles, are used for twisting sewing threads.

Flax for Threads.—Flax for thread must be very strong, and is generally chosen in the Irish, Flemish, Courtrai and Friesland markets. The coarser threads or yarns, such as shoe threads, which require great strength, are usually spun on the dry, demi-sec, or gill spinning principle, as already described. Fine yarns, for ordinary sewing threads, must be wet spun in the ordinary way. An ordinary fine roving frame may be converted into a gill spinning frame, capable of spinning up to 16's lea, by arranging the gearing for a long draft and high twist, and in order to obtain a decent turn off, by increasing the speed of the spindles, steadying them, if necessary, by cap plates. The finer qualities of Italian hemp may be, and are, frequently spun into yarns used by shoemakers and saddlers to make up into "waxed ends" for strong stitching. The strides made within recent years in shoe machinery, chiefly of American manufacture, and the consequent increase in the number of boot factories, has led thread makers to double and twist the old-fashioned single yarn or thread into a continuous "end" which is waxed, if required, either while being twisted or afterwards in the sewing machine. Such threads are known as "Blake," "McKay," or "Goodyear" threads, according to the make of sewing machine for which they are intended, and are composed of from 4 to 12 fold, 17's to 27's lea, twisted together by a number of turns equivalent, approximately, to the product of two and a half to three and the square root of the finished weight of the thread. Thus, a thread suitable for the Goodyear lock-stitch sole-sewing machine may have from four to ten yarns of 17½'s lea grey, or 20's lea bleached yarn, four to seven turns per inch twist, and capable of sustaining a weight of 26 to 60 lbs. A similar, but finer and harder, twisted thread is composed of from 4 to 10 fold 23 lea grey, or 27's lea bleached yarn, five to eight turns per inch twist, and capable of sustaining a weight of from 19 to 41 lbs. The construction of the sewing machine in which such threads are used, necessitates a very level and smooth thread. To obtain such, the individual yarns composing the thread must be held at a regular tension while being twisted together in the reverse direction to that in which they are spun. The finish and smoothness of the thread is further increased by passing it through a die or hole of the exact diameter of the thread, while being twisted and before winding on the bobbin. Such threads may be produced upon the ordinary twisting frames, such as are shown in figs. 84, 85 and 86, provided with creels to take in the required number of spools. The levelness of the thread is increased by adding to the frame the die plate referred to above, a register plate, a reed to spread the

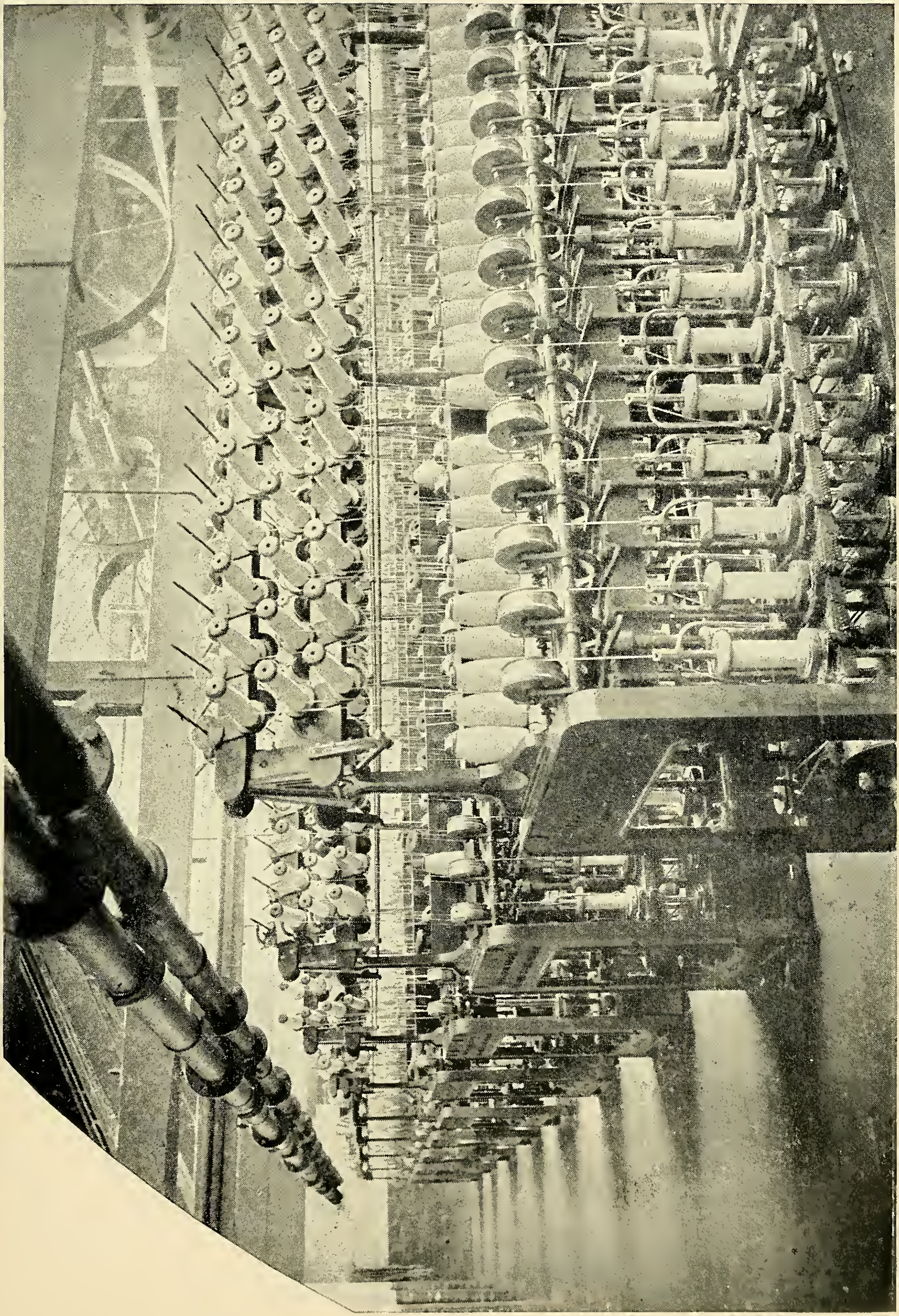

FIG. 86.—Boyd's patent stop-motion flyer twisters. (Made by Messrs J. & T. Boyd, Ltd., Glasgow.)

yarn, and lease rods to maintain an even tension and to enable a broken end to be replaced in its correct position. The bobbins may be dragged by metal drags, as shown in fig. 86, or controlled by differential gear, but the spindles should be positively driven by gearing in any case, in order that the correct twist may be maintained, notwithstanding the heavy drag required to draw the end through the die blocks. We believe that this class of thread is still further improved by being "cabled," or made on a machine constructed upon the Brownell principle, like those shown in figs. 87 and 88, but of lighter construction. The object is that a loose end may not untwist itself, which object is attained by giving each of the yarns composing the thread a "back-turn" or "forehard" while they are being twisted together—that is to say, giving the yarns an increased twist or merely maintaining their original twist, while the thread is being twisted in the opposite direction. The chief features of the Brownell machine are—a central spindle and bobbin for winding on and twisting the thread, around which are ranged the secondary spindles carrying the bobbins of single yarn. The latter are driven by belt or gearing, putting the desired amount of extra twist into the component yarns, which are drawn off their bobbins, through a forming block and compressor, twisted together in the reverse direction by the main flyer and wound upon the thread bobbin. It is advisable to have all the flyers positively driven by gearing, in order to avoid irregularities caused by slipping bands. For the same reason, the yarns must be drawn off their bobbins, and the thread twisted and wound at a constant speed, necessitating the use of haul pulleys which, with the gearing, form another example of epicyclic gear. The pair of haul pulleys have several grooves and work upon studs fixed in the face of the flyer frame or inside the head of the flyer, and are driven by a spur pinion on the end of the twist tube which passes through the turning centre of the flyer. This twist tube, through which the thread passes, is also given a positive motion, by means of gearing, in the same direction as that in which the flyer turns, hence the grooved haul pulleys are turned in one direction by their spur gearing engagement with the twist tube, while they are carried round the latter by their position on the head of the revolving flyer, which gives them a superior motion in the opposite direction. Their effective speed is, then, that due to the difference in driving power of the two motions, which difference, and consequently the turns per inch twist, may be changed by altering the speed of the twist tube. The thread from the compressor passes through the twist tube, round a small guide pulley, several times round the grooved haul pulleys, whence it passes to more small guide pulleys on the leg of the flyer, and thence to the bobbin, upon which it is wound in the ordinary way. To obtain a smooth and round thread, the tension of the component yarns must be as uniform as possible, and as it is prone to vary with the changing diameter of the bobbin from which it is being drawn, the bobbin should be lightly dragged in a manner in which the intensity may be diminished as the bobbin empties.

The yarns, if desired, may be passed through water or melted wax when on their passage to the laying block. Wet twisting enables one to avoid snarled thread, while hardening the twist considerably. Thread which has been twisted very hard while dry, and is consequently inclined to snarl, remains quite straight if damped in the hank and dried under tension.

Cable Thread.—Ordinary flax and hemp sewing threads may be divided into two classes. The one known as cabled thread is usually stronger and with a harder surface, which withstands friction better than the other, which consists of several yarns twisted together into a strand in the ordinary way. Cabled thread has the same construction as a well-made rope—that is to say, a number of yarns are twisted into strands, and several strands—usually three—again twisted together into the finished thread. The principle of construction, and one which gives a thread which will retain its twist, is that the strands are formed by twisting in the opposite direction to that in which the yarns were spun, the direction being again reversed when the strands come to be combined together, a "back-turn" or "forehard" being usually provided to keep the twist imparted in one operation from being partially lost in the succeeding. Ingenious machines have been invented to complete the stranding and cabling operations in the same machine at one and the same time. Such machines have, around a central spindle, a number of groups of secondary spindles corresponding with the number of strands in the thread. Each secondary group contains as many spindles as there are yarns in the strand, and each spindle revolving on its axis and in groups of two or more around another, form a combination which may be compared to a solar system with a sun and groups of satellites, which, while themselves turning round, are again revolving round a sun of their own.

A 6-cord cable-laid flax thread, much used, in canary colour, for sewing boot and shoe uppers, may be formed in this way by taking, say, a good 50's Courtrai warp yarn, twisted to the left at the rate of seventeen to twenty turns per inch, and twisting two threads together to the right in a strand having twelve to fifteen turns per inch twist. Three of these strands are then twisted together to the left, forming a thread equal in weight to 8½'s lea, which may be twisted as highly as twelve turns per inch.

Ordinary linen threads for machine sewing are twisted upon a wet twisting frame, the yarns being preferably first doubled together and wound upon the same bobbin upon a good stop motion doubling winding frame.

The danger of "single" is thus obviated, as a good stop motion will stop the winding on of the yarn before a broken end has disappeared upon the bobbin. For instance, a good 60's 3-cord flax thread may be composed of three yarns of No. 60's full warp twist, spun to the right and then twisted together to the left, forming a thread about equal in weight to 20 leas per lb. As a general rule threads are finished with the spindles running in a clockwise direction, looking at them from above. For this reason, if, as in the ordinary thread, there are two twisting operations, the yarn should be spun to the right, contra-clockwise or reverse twist. If there be three operations, as for cabled thread, spin to the left in the ordinary way.

Theory of Yarn and Thread Construction.—A single yarn is a narrow ribbon, of parallel fibres, which has been twisted to the right or left, forming a spiral which is more or less cylindrical in proportion to the number of turns of twist in a given length. If the theory of this operation be studied, and if a piece of yarn be carefully examined under the microscope, it will be seen that it is the outside edges of the ribbon which have been turned around a central or neutral axis, and that the fibres which compose the thread are straighter in the ratio of their distance from the outside. For this reason, with the same material, the greater the diameter of the yarn the weaker it is in proportion ; and *vice versâ*, the finer the yarn is, the material being the same, the harder and proportionately stronger it is. It is the fibres on the outside of the yarn which bear the strain, because they are stretched in being twisted around the fibres which form the interior of the yarn, these latter being perhaps slightly compressed by the contraction in length of the yarn as it is being twisted. These facts may be taken advantage of when we wish to produce a thread as durable and strong as possible—sewing thread, for instance—because the thread will be stronger and more regular and durable, in proportion to the number of fine single yarns which are employed and twisted together.

Fancy Yarns.—In twisting yarns together for ordinary threads, twines, cords, and ropes, those yarns should be as level and regular as possible and all of the same grist or thickness, as if a coarse and a fine thread be twisted together the product will always have a wavy appearance, because the fine end will twist spirally round the coarser.

This fact is taken advantage of in producing the fancy yarn known as *fil ondulé.* Other fancy yarns are produced by doubling two or more threads together in special ways. For instance, what is known as "looped yarn" may be formed by delivering one of the ends more quickly than the rest, the excess length forming loops upon the main thread.

"Bead yarn" is produced by twisting together a right and left-handed twist yarn. The twist is taken out of the one, while it is increased in the other, the length of the former being increased while the latter is contracted in length, giving the product a wavy appearance.

"Nopped yarn" is produced in a somewhat similar manner to that in which "looped yarn" is produced. The excess length of the nopping thread is, however, let away more suddenly and quickly at regular intervals by means of an arrangement of levers and swinging guides actuated by a cam causing the formation of hard, round nops or beads.

A great variety of effects may be obtained by employing yarns of various colours and combining them in different ways. Slubbed yarn is produced by delivering at regular intervals into yarns while twisting, short lengths of cotton slubbing, which is dyed the desired colour. Slubs may also be obtained of yarn only by stopping delivery of the main or ground thread at regular intervals and lapping around it, with a quick traverse motion of the required length, the slubbing thread which is constantly being delivered at a higher speed.

Range of Twines.—The usual range of twines which may be twisted upon the frames shown in figs. 84, 85, and 86, are, commencing with the finest, 2-fold 16-lea, 2-fold 12-lea, 3-fold 12-lea, 2-fold 8-lea, 3-fold 10-lea, 2-fold 6-lea, 3-fold 8-lea, 2-fold 5-lea, 2-fold 4-lea, 3-fold 6-lea, 3-fold 5-lea, 2-fold $3\frac{1}{2}$-lea, 3-fold 4-lea, 3-fold 3-lea, 2-fold 2-lea, 3-fold 2-lea, 3-fold $1\frac{1}{2}$-lea, 3-fold 1-lea, up to 6-fold 1-lea.

Suitable twists will be for—

2-fold 16 -lea,		440	turns per foot.
2-fold 12 -lea,		382	,, ,,
3-fold 12 -lea,	and 2-fold 8-lea,	312	,, ,,
3-fold 10 -lea,		283	,, ,,
2-fold 6 -lea,		270	,, ,,
3-fold 8 -lea,		254	,, ,,
2-fold 5 -lea,		246	,, ,,
2-fold 4 -lea,	3-fold 6-lea,	220	,, ,,
2-fold $3\frac{1}{2}$-lea,		206	,, ,,
3-fold 5 -lea,		201	,, ,,
3-fold 4 -lea,		180	,, ,,
3-fold 3 -lea,	2-fold 2-lea,	156	,, ,,
3-fold 2 -lea,		127	,, ,,
3-fold $1\frac{1}{2}$-lea,		110	,, ,,
3-fold 1 -lea,		90	,, ,,
6-fold 1 -lea,		64	,, ,,

Twine Laying or Cabling.—Fig. 87 shows a twine laying or cabling machine suitable for cords up to $\frac{1}{4}$ inch diameter. Either two or three stranded cords may be made. It is used for making fishing twines and whipcords. The yarns are given "forehard" by the spindles seen at the top of the frame, and then the ends passing downwards, pass through the forming top and are twisted together by the main spindle and flyer. Three ordinary makes of whipcords are 6-fold 10-lea, 6-fold 8-lea, and 6-fold 6-lea, which are composed of three strands of 2-fold yarn forehardened and twisted together in the opposite direction with 277 turns per foot twist for the 6-fold 10-lea, 248 turns per foot twist for the 6-fold 8-lea, and 215 turns per foot twist for the 6-fold 6-lea.

Figs. 88 and 89 show other forms of cabling machines. The latter is a form which is often used for twisting trawl twine, which is made from three threads of white Manila spun on the machine shown in fig. 49,

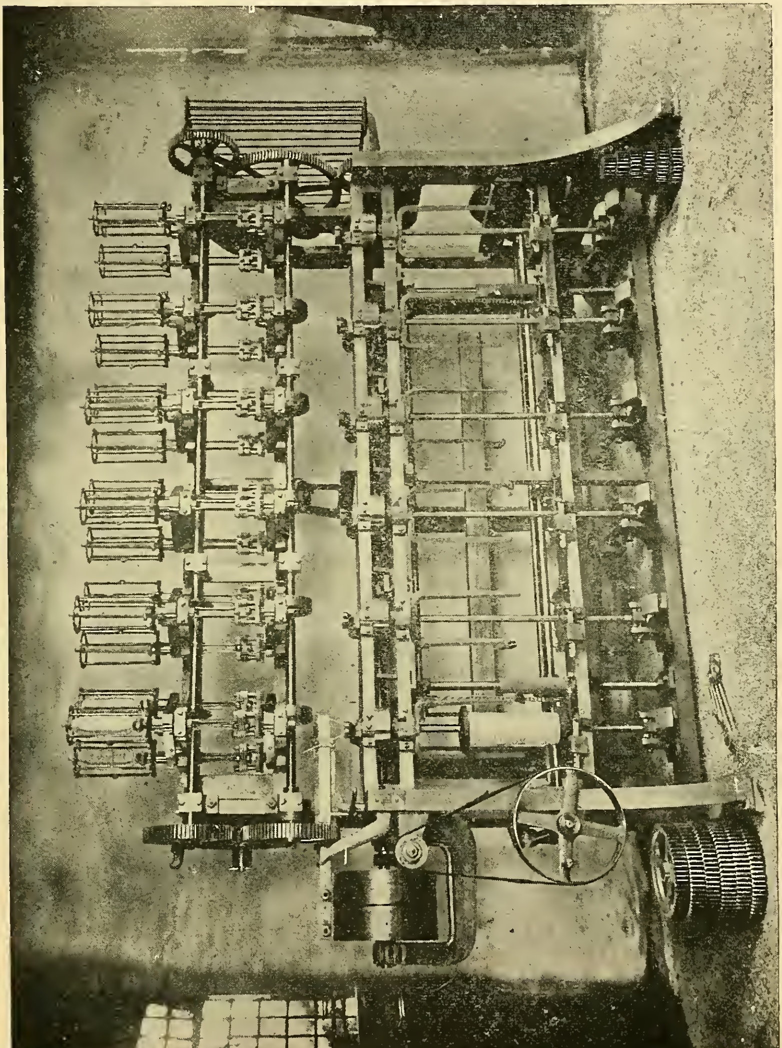

Fig. 87.—Cabling machine for cards. (Made by Mr William Bywater, Leeds.)

and each weighing 320 yards per lb. These when twisted together form a common make of trawl twine weighing 100 yards per lb., and which may be twisted with about 125 turns per foot.

A very good form of trawl twine laying machine is that made by Messrs

Samuel Lawson & Sons, Leeds. It is of very similar construction to that shown in fig. 89. In Lawson's machine, as in the American machine shown, motion is given from the line shaft to a horizontal parallel with it,

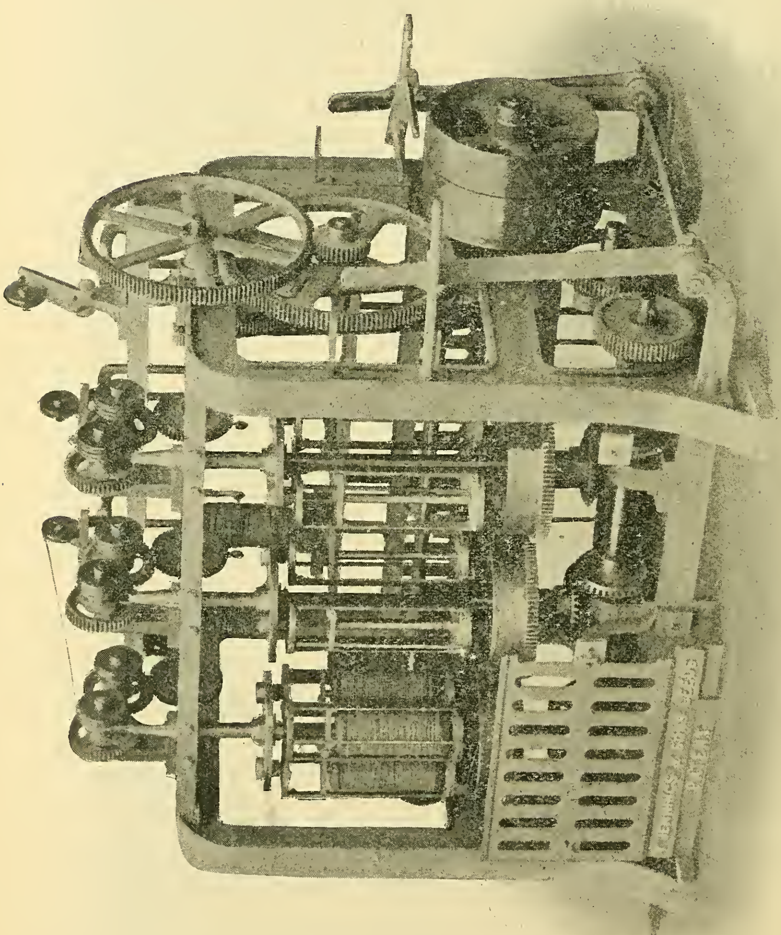

Fig. 88.—Cabling or laying machine. (Made by T. Jennings & Sons, Leeds.)

which is shown to the extreme right in fig. 89. Upon this latter shaft large bevel wheels gear with bevel pinions upon the extremities of the lower shafts. Upon these shafts are a series of pulleys. The first to the right is a drag pulley driving the sleeve of the bobbin carrier. Next comes the flyer pulley driving the flyer at a constant speed, and then an expansive

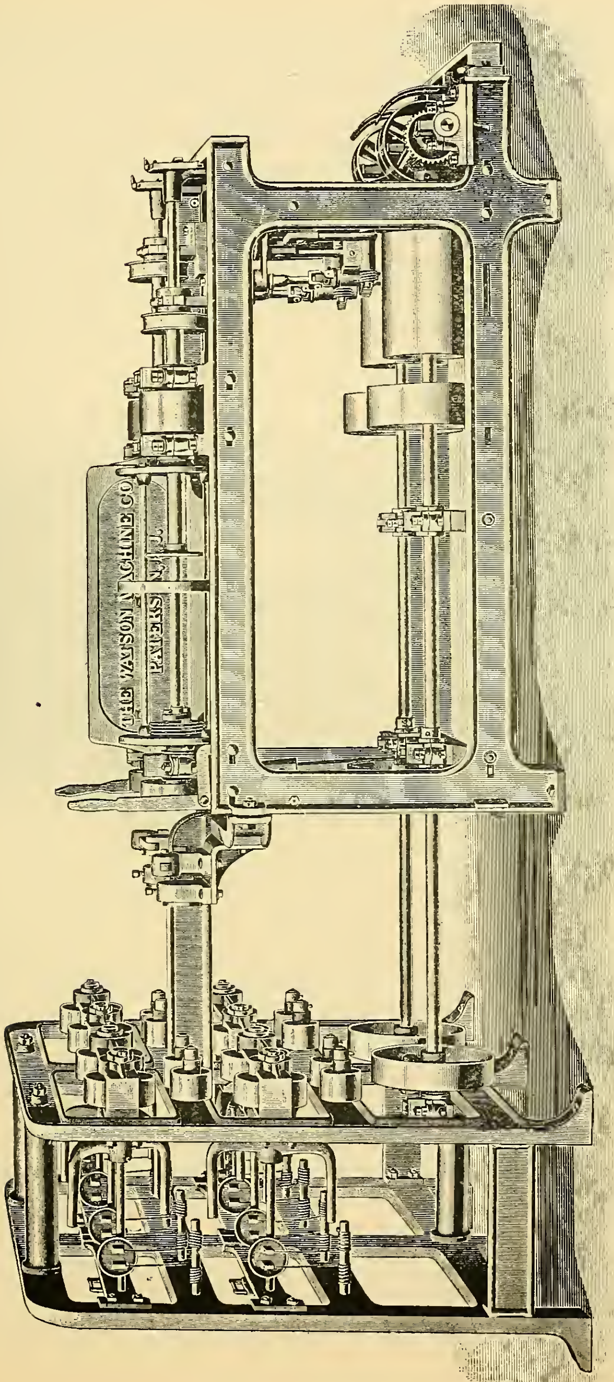

Fig. 89.—A 2-spindle machine to lay 2-, 3- or 4-ply cord. (Made by the Watson Machine Co., Paterson, New Jersey.)

twist pulley for a flat belt which drives the twist tube pulley at the requisite speed to put in the twist required. The last pulley to the left drives the "back twist" or forehardening flyers, of which there are three or four per main spindle.

In Lawson's machine the bobbins of yarn are connected with carriers through which tension is applied by means of friction drags. In the American machine, fig. 89, it will be seen that tension is obtained by means of spring pressers which bear against the surface of the yarn upon the bobbin.

In the former machine a stop motion is provided for each of the ends passing through the forming top. It consists of a wire with a heavy tailpiece for each end. The three or four wires are centred upon a stud, and

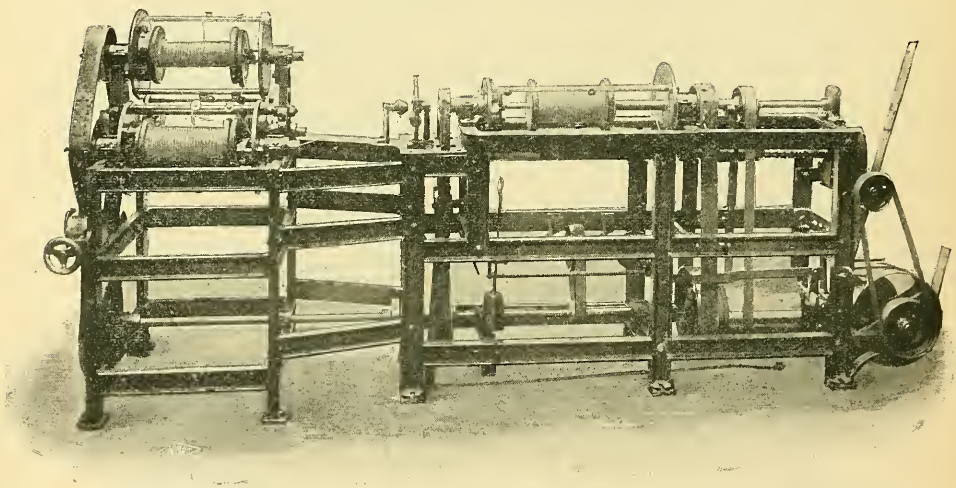

Fig. 90.—Horizontal laying machine for box and sash cords, clothes lines, etc. (2 to 4 fold). (Made by Messrs James Reynolds & Co., Belfast.)

the heavy tailpieces are kept supported by the pressure of the end upon the wire arm of the lever. When an end breaks, the tailpiece falls upon the long arm of a lever, the short arm of which is connected with a catch which is pressed home by the pull of a spring upon an arm keyed to the starting side shaft. The catch is thus raised and the spring puts the belt on to the slack pulley. The main bobbin traverse, as in the automatic spinner, figs. 47 and 48, is driven by a worm upon the bottom shaft, driving into a worm wheel upon the bottom of an inclined shaft, upon the upper end of which is a bevel pinion which drives into a bevel wheel upon a right and left-hand screw which works the traversing block.

Figs. 90 and 91 show horizontal machines for laying or cabling 2-, 3-, 4-, 5-, 6-, 7-, or 8-fold box and sash cord, clothes lines, etc.

In twisting frames in which a delivery roller is used, the twist is changed by increasing or diminishing the speed of that roller, and consequently augmenting or reducing the delivery. The speed of the spindles remaining constant, the degree of twist is inversely proportionate to the rate of delivery. The principle is exactly the same as in the wet and dry spinning frame described and explained in Chapters XII. and XIII. In machines which have no delivery rollers, such as figs. 89, 90, and 91, and in which the yarn is drawn through by haul pulleys as in the automatic spinner (p. 126), the twist is changed by means of the twist pulley, which drives the twist tube and through it affects the speed of the haul pulleys.

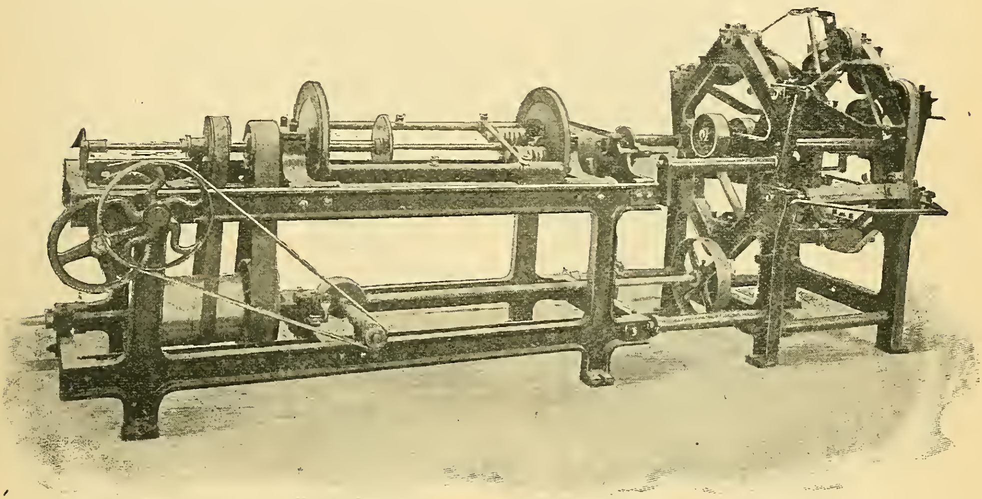

FIG. 91.—Horizontal laying machine for cords, etc. (5 to 8-fold).

The calculation for the twist may be made in exactly the same way as shown on page 127.

Sizing and Polishing Threads and Twine.—After threads and twines from soft fibre have been twisted, they are generally sized and polished. This is done by winding them from bobbin to bobbin through a special machine in which the thread or twine passes through troughs of starch and then between squeezing rollers, over circular brushes and heated cylinders, and into contact with rapidly revolving polishing rollers. Figs. 92, 93, and 94 give a good idea of what these machines are. The first is a twine washing and carding machine with two washing troughs and six carding rollers. The second is a twine polishing machine for fine twines up to 4-fold 8-lea, and the third a large polishing machine for coarser twines with one washing and three size troughs, three carding, five rubbing and four polishing rollers, and lastly, two drying cylinders. In fig. 92 it will be seen that the twine is first drawn from the twisting frame bobbins through a water trough and then over three carding rollers covered with strong wire cards. These carding rollers remove much shove and inequalities from rough twines, and at the same time improve its

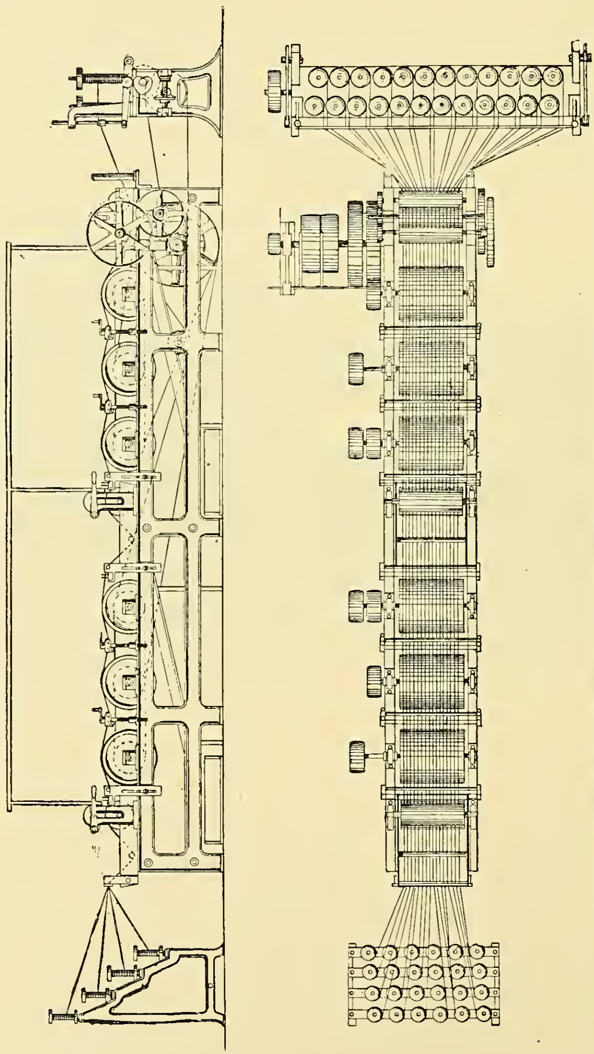

Fig. 92.—Twine twisting and carding machine. (Made by Mr Wm. Bywater, Leeds.)

colour. It will be seen that the twine then passes through a second water trough, and is still further cleaned by a second series of three carding rollers before being again wound upon bobbins in the winding-up frame. In the polishing machine, fig. 93, the twine first passes through a washing trough and pair of squeezing rollers, then over a rubbing roller and into a size trough, then through squeezing rollers to the tin drying cylinder, around which it passes before coming in contact with the three polishing

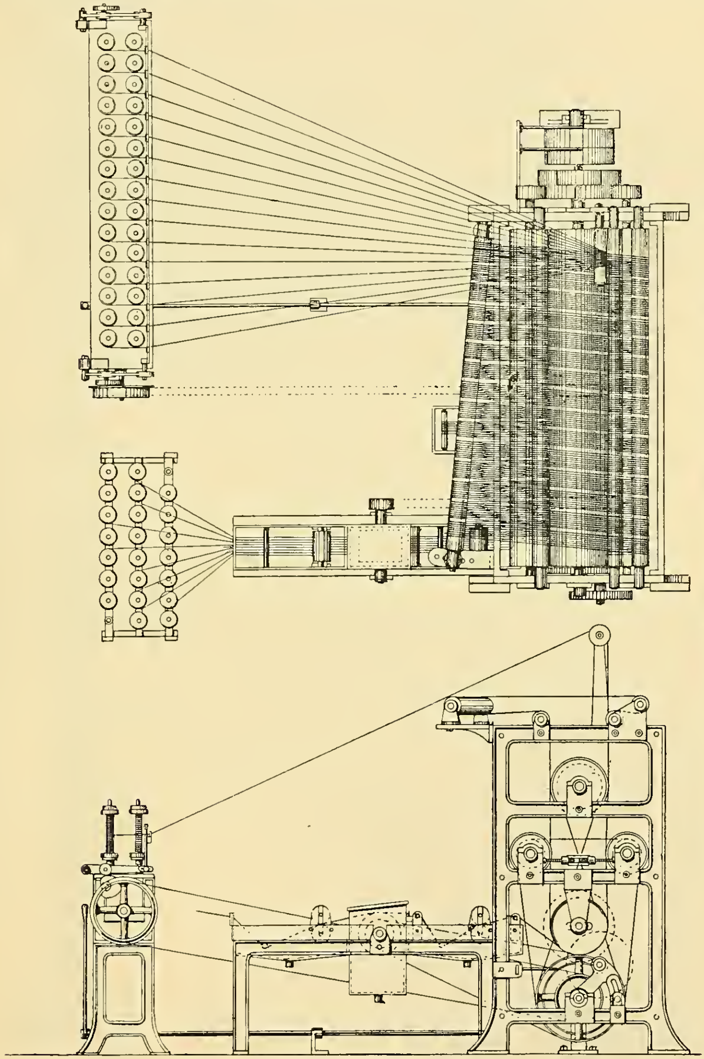

FIG. 93.—Twine polishing machine. (Made by Mr Wm. Bywater, Leeds.)

rollers, whence it is guided to the winding-up spools. In the larger machine, fig. 96, the twines first pass through the washing trough and squeezing rollers and over three carding rollers, to the size trough and size squeezing rollers, and over one pair of rubbing rollers. Thence they pass through the second size trough and squeezing rollers to three more rubbing rollers, after which the twines pass repeatedly around the two drying cylinders, between which they are brought in contact with the four rapidly revolving polishing rollers.

Fig. 95 gives a general view of a large twine polishing machine of

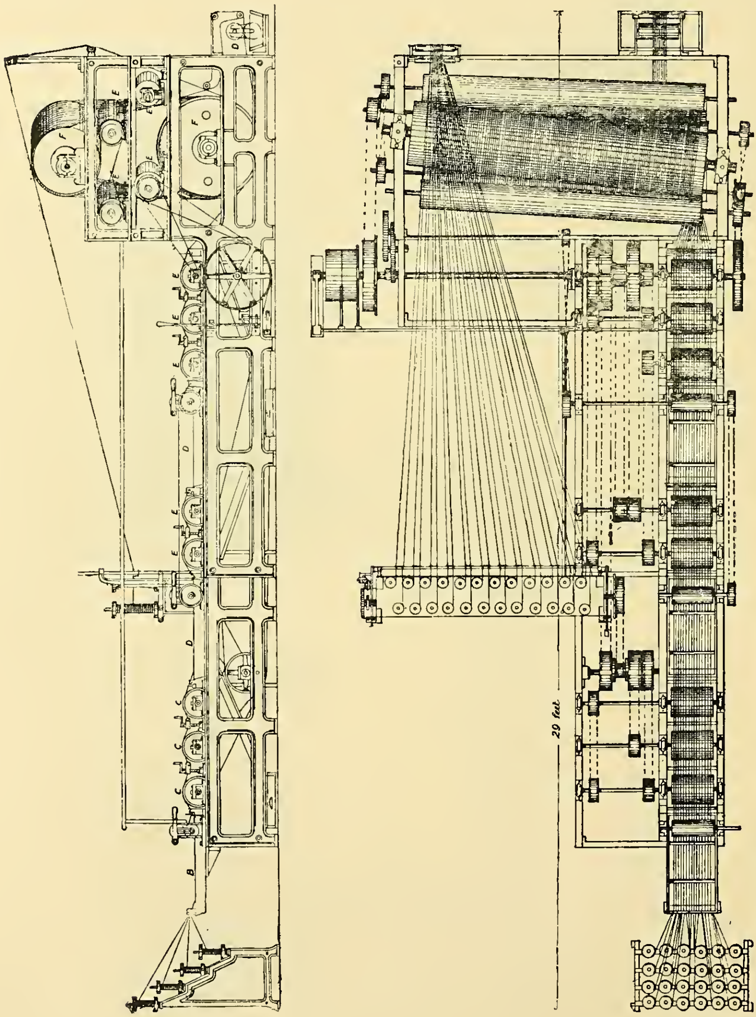

Fig. 94.—Twine polishing machine. (Made by Mr Wm. Bywater, Leeds.)

somewhat similar construction. Threads are sometimes sized in the hank, which, after being put through a pair of indiarubber squeezing rollers, is put on to the polishing rollers of the machine shown in fig. 96. The hank revolves there until sufficient lustre has been put upon the thread.

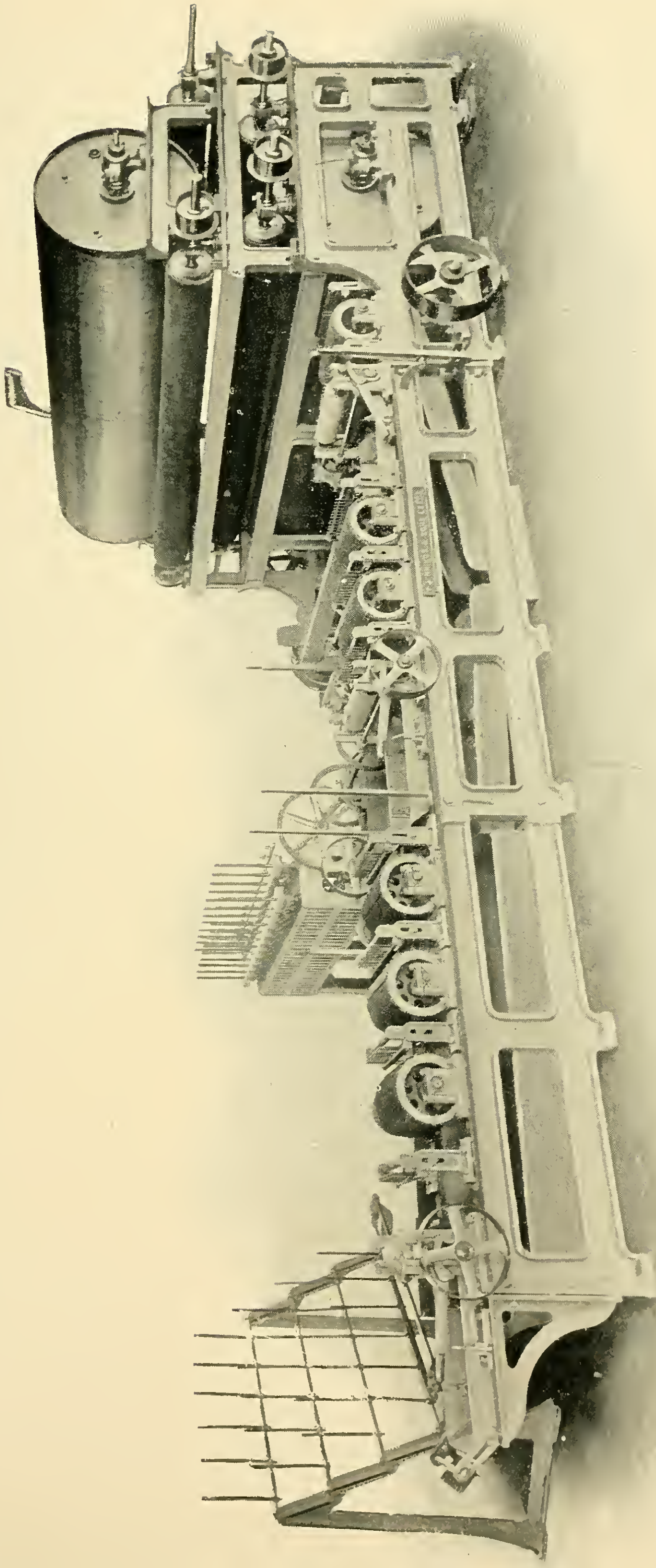

Fig. 95.—Improved large twine polishing machine. (Made by Messrs Thomas Jennings & Sons, Leeds.)

Fig. 97 is another form of cord bobbin-to-bobbin polishing machine used for polishing picture and window-blind cord.

Starch or Dressing.—Potato flour is much used in the preparation of starch or dressing for twines, while for threads such materials as oil, white wax, gum tragacanth, gum arabic, Castile soap, borax, salts of sorrel, alum, salt, gelatine, Iceland or Irish moss, zinc chloride, etc., are sometimes mixed in small quantities with the size or starch, if a patent glaze be not employed. Yarns for coloured threads should be hank dyed. For light shades the yarns must be first bleached or, at least, boiled in soda lye.

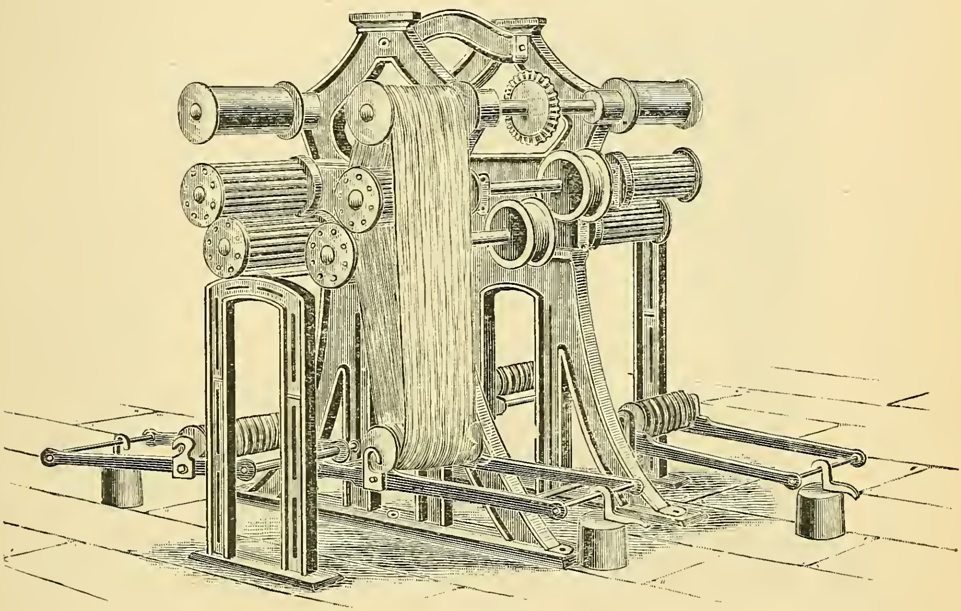

FIG. 96.—Double-sided hank polishing machine.
(Made by Messrs Walter M'Gee & Son, Ltd., Paisley.)

Softening Threads.—For some purposes linen threads require to be softened after twisting and reeling. This is done by placing the hanks upon the hooks of the hank twisting machine shown in fig. 98, which first twists the hanks tight in one direction and then automatically reverses the motion and twists them in the opposite direction, repeating the operation until the required degree of softness is attained. The bottom hook rail, of course, lifts as the hank shortens or contracts by twist, and in this way actuates, at a certain point, the reversing gear, consisting of the usual arrangement of two loose and one fast pulley with an open and crossed belt. The top hooks are turned by bevel gear, as shown.

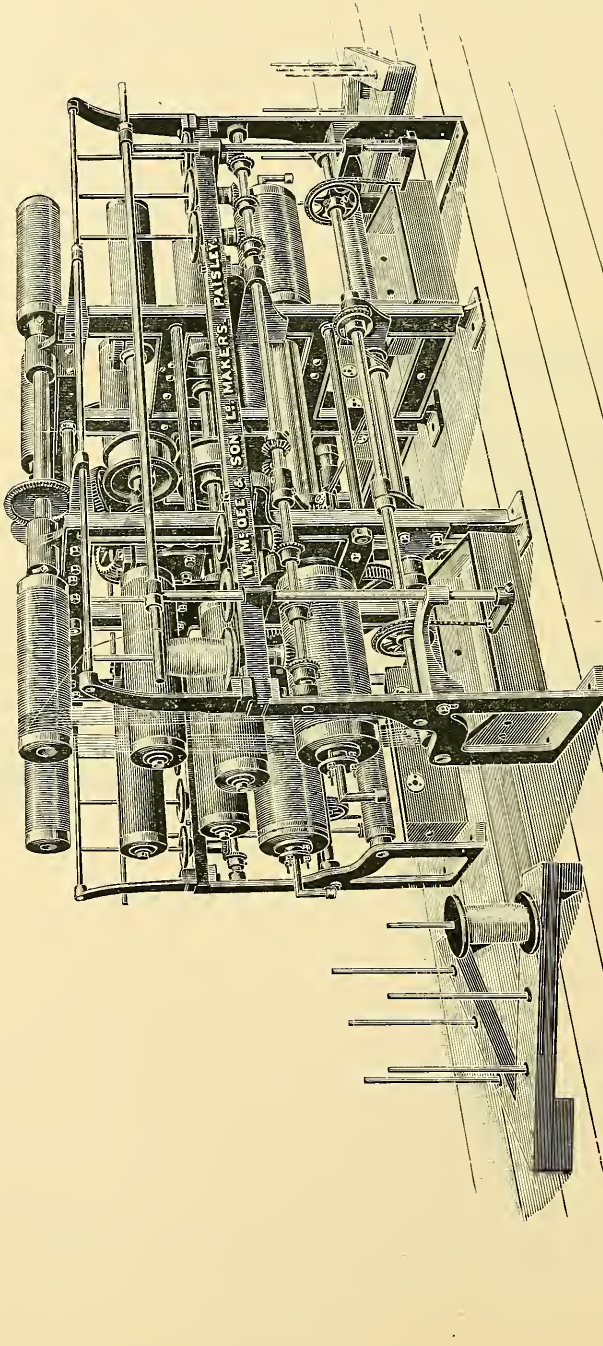

Fig. 97.—Bobbin-to-bobbin cord polishing machine. (Made by Messrs Walter M'Gee & Sons, Ltd., Paisley.)

Thread Glazing.—Threads are sometimes glazed in the hank by rolling under pressure in a machine similar to that shown in fig. 99. In this machine the middle roller, which is usually of compressed paper, swivels outwards, permitting the hank to be evenly spread around it and the tension roller. The middle roller is then swivelled back into its place and the work proceeds. An automatic crossing motion is applied so that every

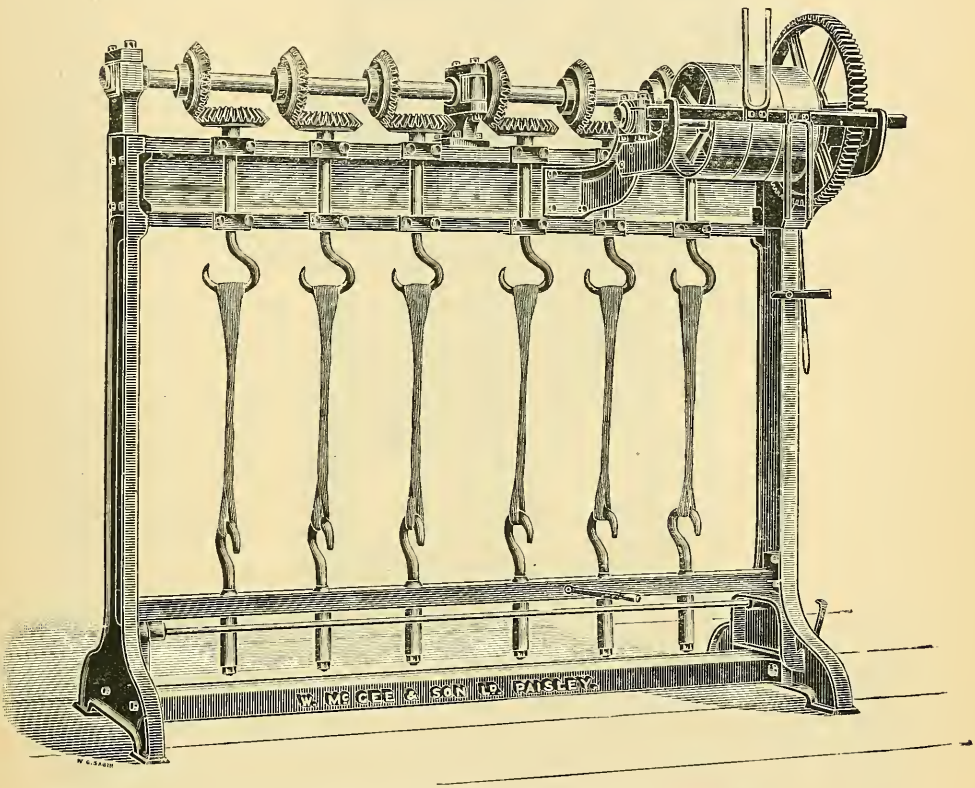

Fig. 98.—Hank twisting machine for linen or cotton threads.

thread of the hank is equally polished, and in order that every hank may be worked alike, there is also a knocking-off motion by means of which the time occupied in rolling each hank is automatically arranged, thus ensuring regularity of finish.

Balling Yarns, Threads and Twines.—Nearly all shoe yarns, as well as shop twines, are put upon the market in balls varying in weight from 1 oz. to 16 ozs. These balls are made upon a balling machine, which works upon the same principle as that used for reaper yarn and described on page 222. Figs. 100, 101, 102, 103, and 104, show different forms of balling machines suitable for shoe threads and shop twines. Fig. 100 makes balls up to $2\frac{1}{4}$ inches diameter, the shaping of the ball being done by hand. Upon the machine, fig. 101, larger balls up to 6 inches diameter

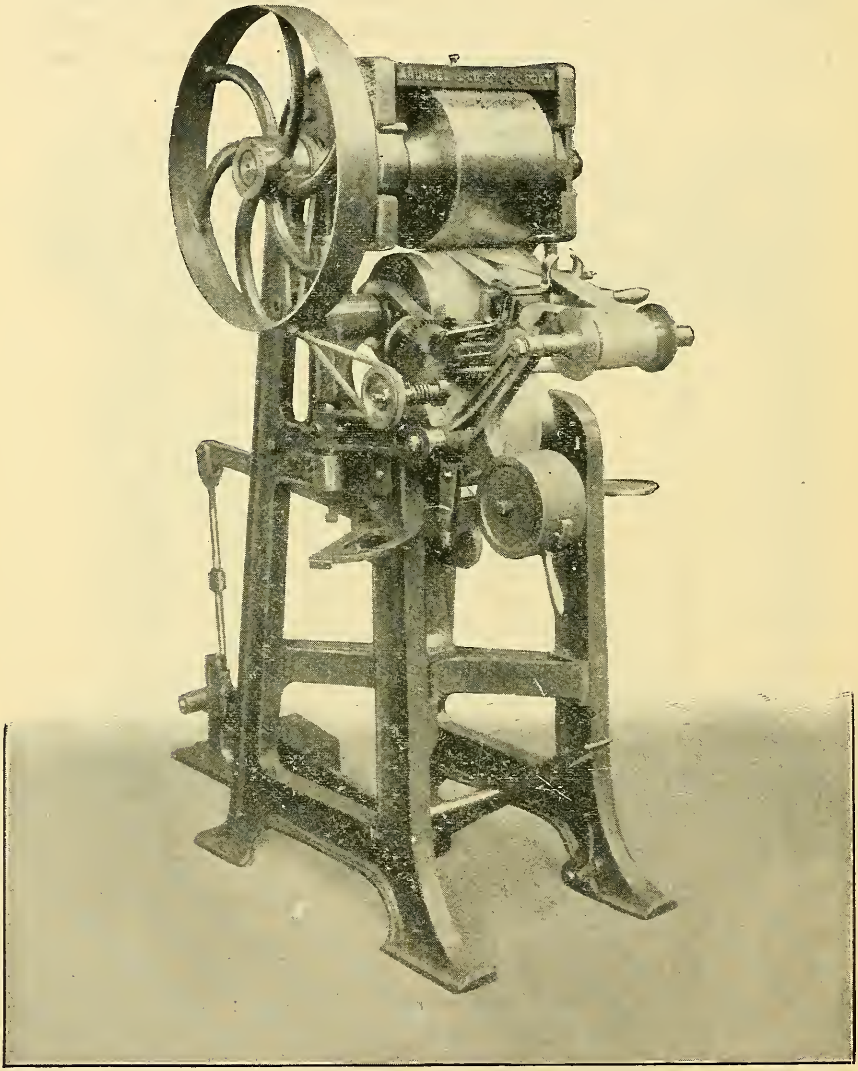

FIG. 99.—Improved yarn preparing machine. (Made by Messrs Arundel & Co., Stockport.)

may be made. The machine, fig. 102, is made in four sizes: No 1 for making small balls of yarn; No. 2 for balls of shoe thread; No. 3 for making $\frac{1}{4}$, $\frac{1}{2}$, and 1 lb. balls of shop twine, and No. 4 for making heavier twines into

2 lb. balls or less. These machines make two balls at once. The ball pegs are driven by a friction plate and change wheels.

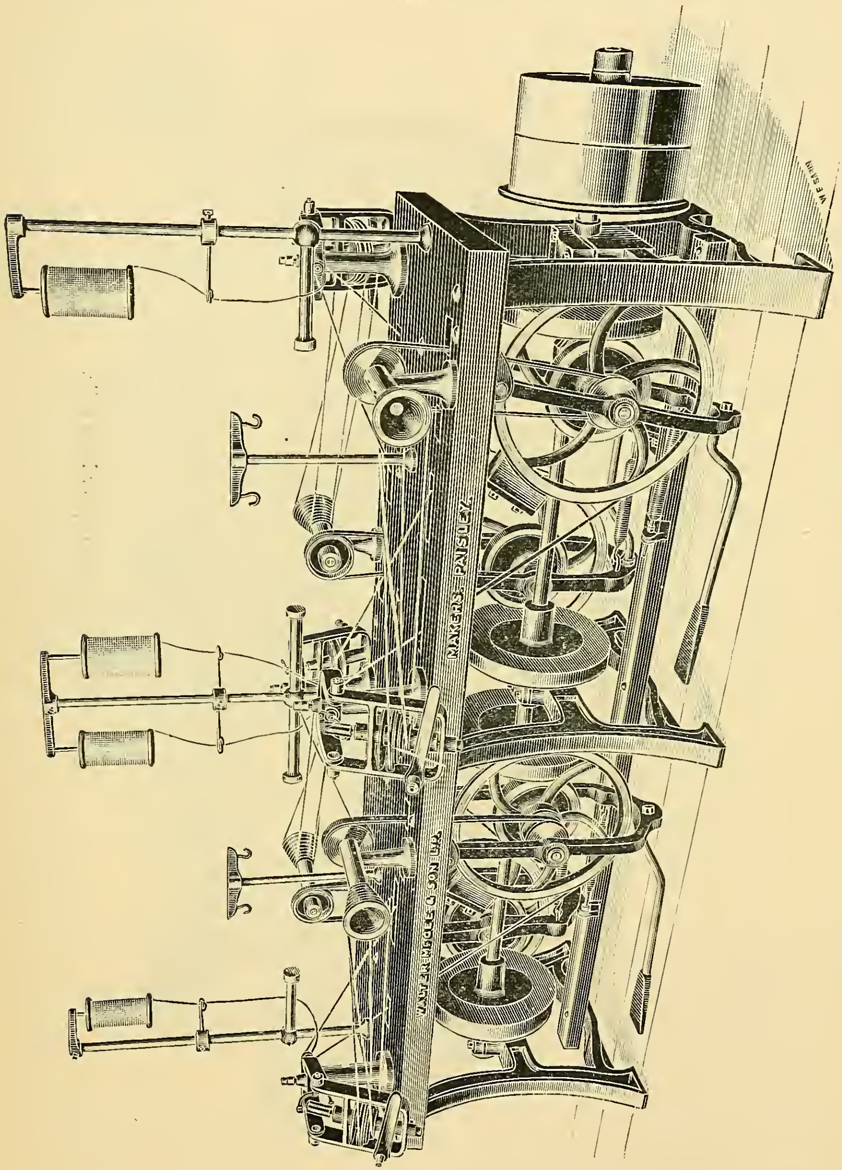

Fig. 100.—Hand balling machine. (Made by Messrs Walter M'Gee & Son, Paisley.)

The machines shown in figs. 103 and 104 are for still heavier twines, and will make balls up to 8 lbs. in weight. It will be seen that the principal organs of the balling machine are the flyer and the ball peg upon which the ball is formed, and which lies at a variable angle between the

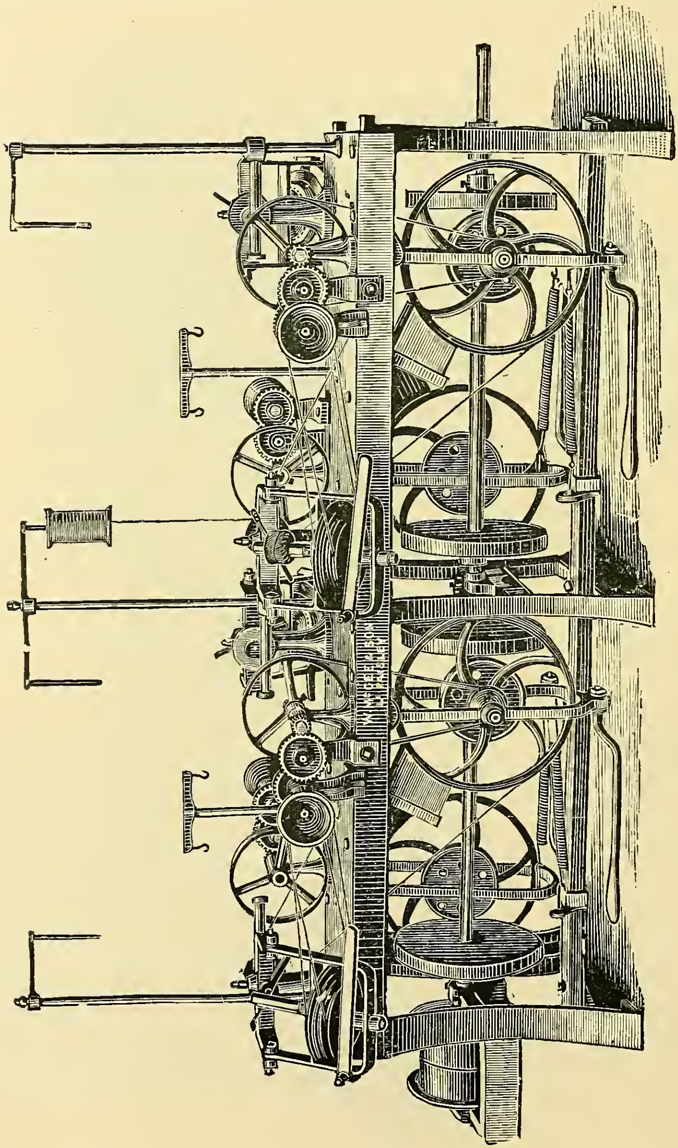

Fig. 101.—Balling machine for large balls.

legs of the flyer. The closeness together of the laps of thread or twine forming the ball depends upon the speed of the ball peg, which should be turned slowly upon its own axis. The ball is shaped by changing the inclination of the ball peg either automatically or by hand, while the changes of speed are effected by shifting the position of a bowl upon a friction plate or cone, or by shifting a band upon the grooved cone pulleys.

Skeining Threads.—Carpet and tailors' threads are generally skeined upon a power reel, such as described on p. 207, "cross reeling" being preferable, as the end is more easily found. The swifts used are generally

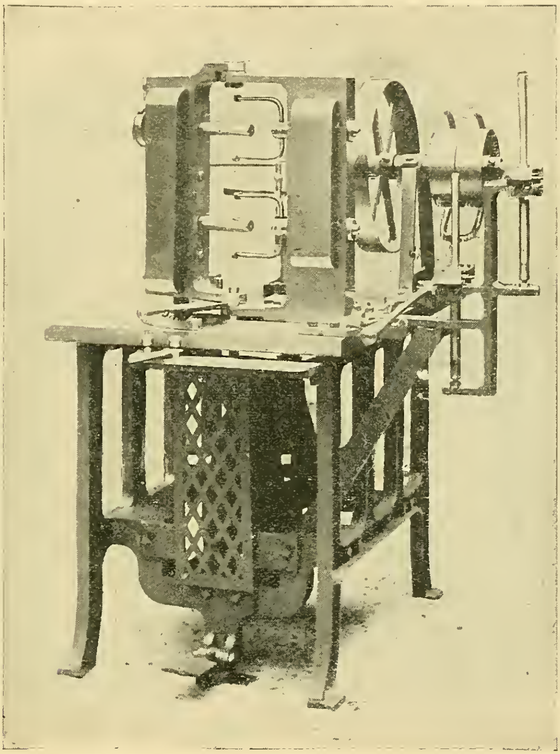

FIG. 102.—Balling machine (four sizes).
(Made by Mr Wm. Bywater.)

45, 50, 60, 72 or 90 inches in circumference, and the skeins 1 oz. or 2 oz. in weight. Bookbinders' and Jacquard threads are also usually skeined, the former in skeins $\frac{1}{2}$ oz. to 2 ozs. in weight, and the latter in skeins of 2 ozs. to 8 ozs. "Gilling" twine for fishing nets is generally balled. Shoe threads, carpet and tailors' threads, are also sometimes wound upon paper tubes on a split drum cheese winder or upon a roll winder, such as Leeson's Universal, or a machine like that shown in fig. 105.

Leeson's Universal Winder.—This machine is made in four sizes, and will make rolls from $2\frac{1}{4}$ to 12 inches long. In the smaller machines the thread guide traverse is worked by a cam, but in the others it is worked by a screw. Each head is automatic in stopping at any given size of roll, or when the end breaks or runs off. It will be noticed that when the roll reaches a certain diameter the rate of thread traverse bears such a relation to the circumferential speed of the roll that the laps of thread lie closely and regularly. At that moment the rolls have a nice appearance, which renders them suitable for retailing.

"*Randing*" *Twines.*—Twines are sometimes made up into "rands" (see

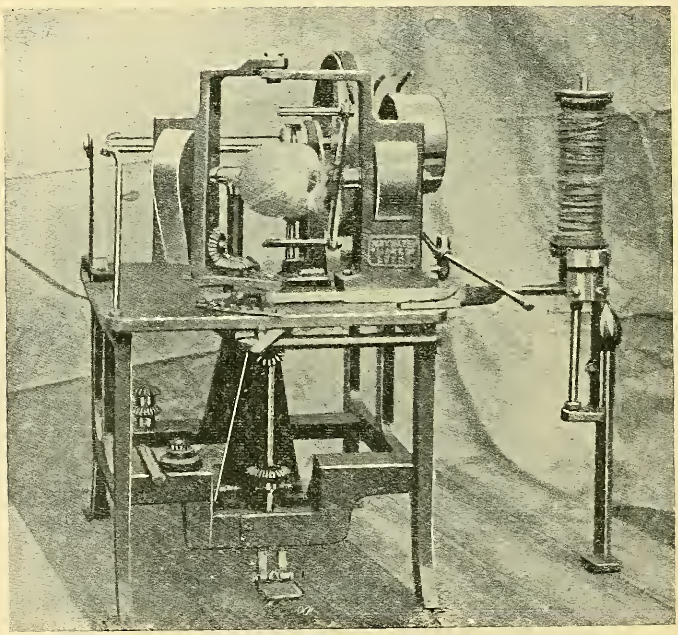

FIG. 103.—Balling machine (for large sizes). (Made by Mr Wm. Bywater.)

fig. 106) 10 inches to 4 feet in length upon the randing machine shown. The twine is first lapped round and between the hooks fixed at the required distance, the end being then wound on the "rand" by a leading screw, the speed of which is changeable to suit various thicknesses of twine.

Spooling of Sewing Threads.—Ordinary linen sewing threads are generally put upon the market on spools or reels one or two ounces in weight and containing a given length of thread. The inclined sides of the well-known reel or spool necessitate a winding machine of delicate and intricate construction. In the newest machines of this sort the empty reels are placed in a sort of magazine, from which they are fed, one by one, to the winding mandril or spindle. As many as ten spools may be wound at one time, and as they run up to 5000 revolutions per minute, a daily production of 30 gross of 200 yard spools may be obtained. The spools are pushed on and off the winding spindles by means of a sliding piece and lever. The thread guide is attached to a rocking shaft, and kept pressed against the thread upon the spool by means of a suspended weight or a spring. The presser guide is traversed in opposite directions by means of right and left-handed screws, with which sectional nuts, attached to arms fitting loosely on the presser guide, are alternately brought in contact upon

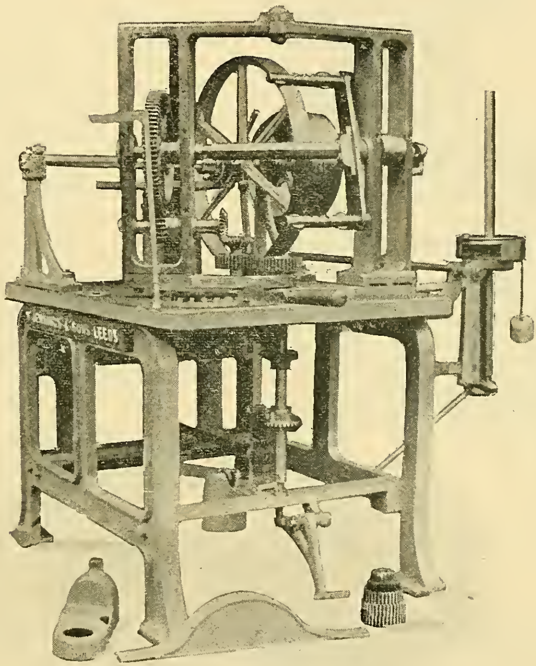

FIG. 104.—Balling machine (for large balls).

the guide reaching the end of its traverse. These arms and nuts cause the presser guide to move in either direction, according to which of them is engaged with the screw above it. The distance which the presser guide is moved to the right or left, or the engagement or disengagement of the sectional nuts with their screws, is regulated by the contact of feelers attached to the thread guide, with the conical sides of the spool, or by a cylindrical traverse changer. This changer, if used, should have half as many long projections as there are layers of thread upon the spool to be wound, the length of these projections progressively increasing as the space between the conical ends of the spool increases. The sectional nuts are raised into contact with the screws by means of springs. The arm of each nut has upon it a lip which engages the space between the projections on the changer. The nut is thus kept in contact with its screw until the inside of the lip is traversed beyond the end of the projection, when the nut falls out of contact with the screw. At the same moment, the other nut and arm are automatically raised, and the presser guide is traversed in a similar manner in the opposite direction. The raising of the nut at each end of the traverse turns the changer one division. The speed of the thread traverse is regulated, by the position of a belt upon a pair of cones, to suit the diameter of the thread being wound. When the spool is completely wound, a nick is automatically cut in its edge, and the end inserted and cut off, the full spool pushed off into a receptacle and replaced by an empty one from the magazine, the same being even automatically stamped or labelled in its passage through the machine.

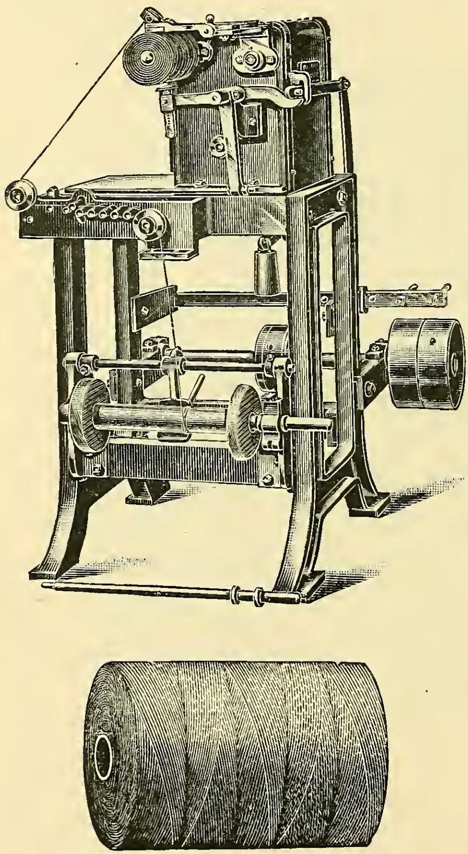

Fig. 105.—Roll winding machine. (Made by Mr Wm. Bywater.)

Figs. 107, 108, 109, 110 and 111 show different systems of thread spooling machines. Fig. 107 is a hand machine, in which the girl has to fill the reels by her hand with a guide which is traversed by a right and left-handed screw. The machine, fig. 108, is made in four sizes for spooling from 50 up to 10,000 yards. The attendants have only to fix the ends, take off the spools when full, and put on empty ones. The leading feature of the machine shown in fig. 109 is that there are two rows of spindles upon which the spools are filled. These spindles are fixed in a frame which revolves on bearings, so that, whilst the spools on one row of spindles are being filled with thread, the attendant can be taking off the full spools and putting empty ones on the other row of spindles. Consequently, little loss of time takes place between the "sets," and the machine does a greater quantity of work, although not running at a high speed.

Fig. 110 is a self-acting spooling machine on Weild's principle. In this

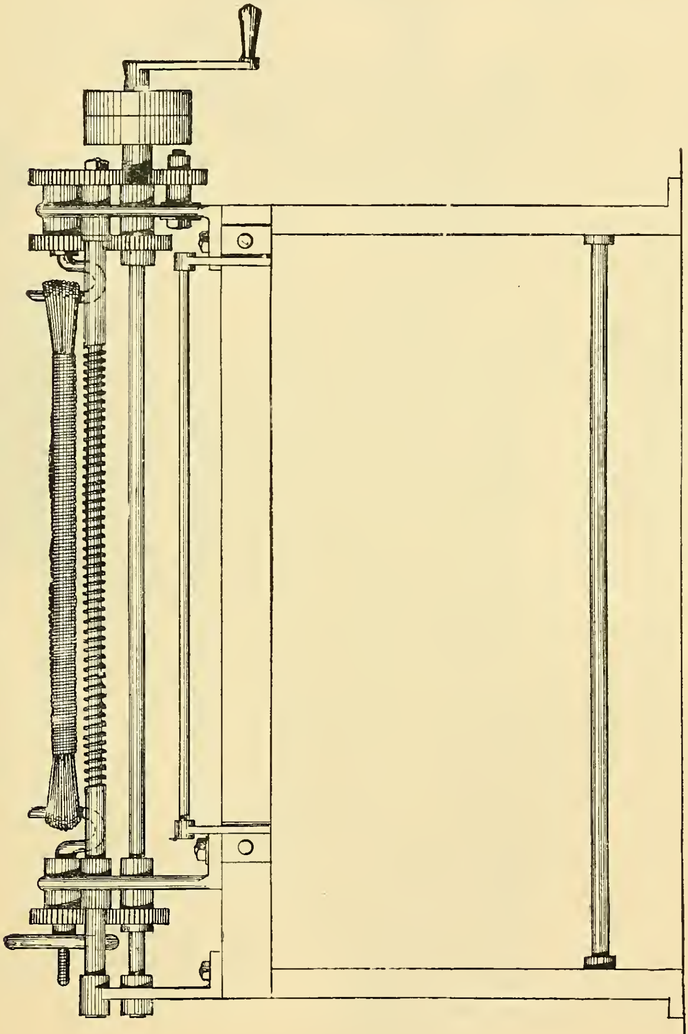

Fig. 106.—Randing machine. (Made by Mr Wm. Bywater Leeds.)

machine the pressure of the thread guide on the surface of the spool is regulated by a cam, and the greater pressure comes only upon the last two layers. This machine is also convenient, in that half-filled spools are easily completed. The spools run on short centres, which cause them to run

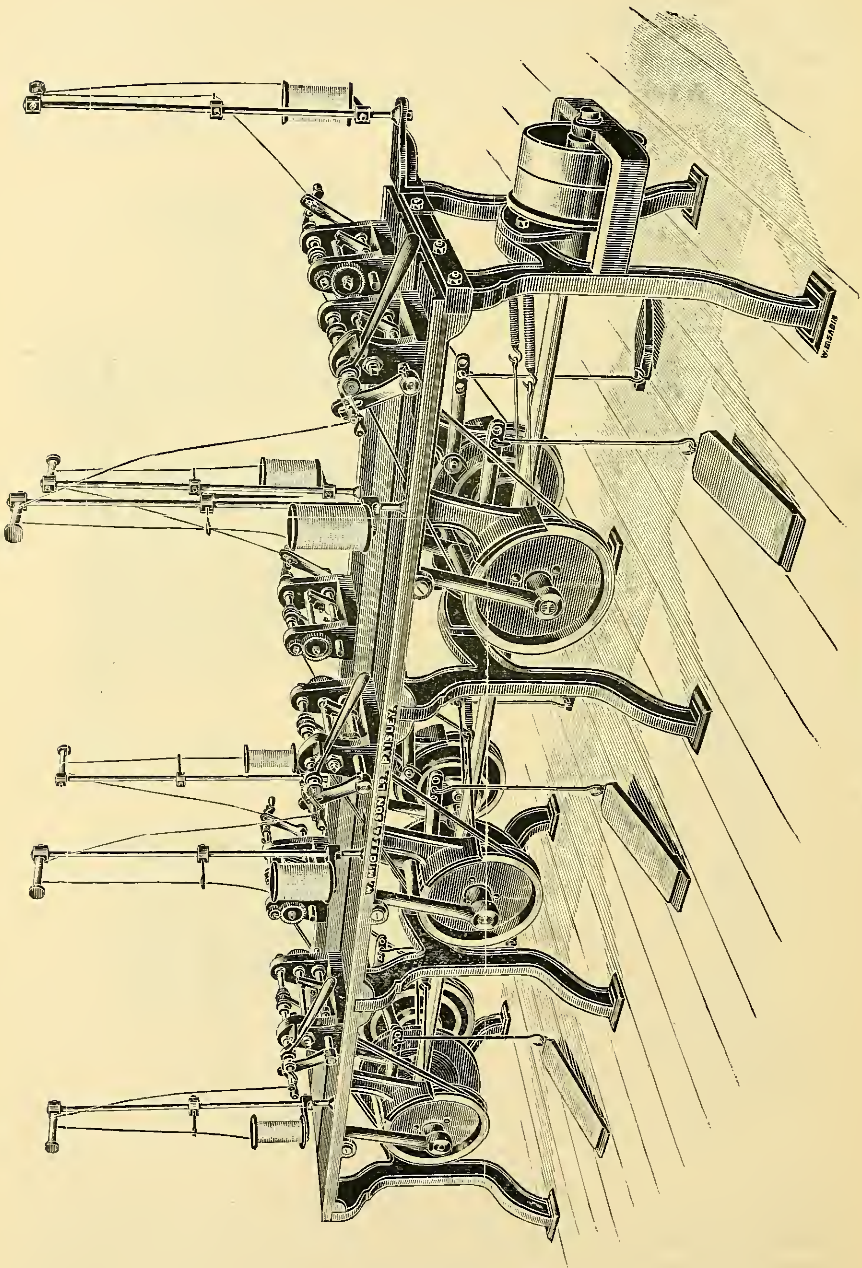

FIG. 107.—Hand spooling machine.

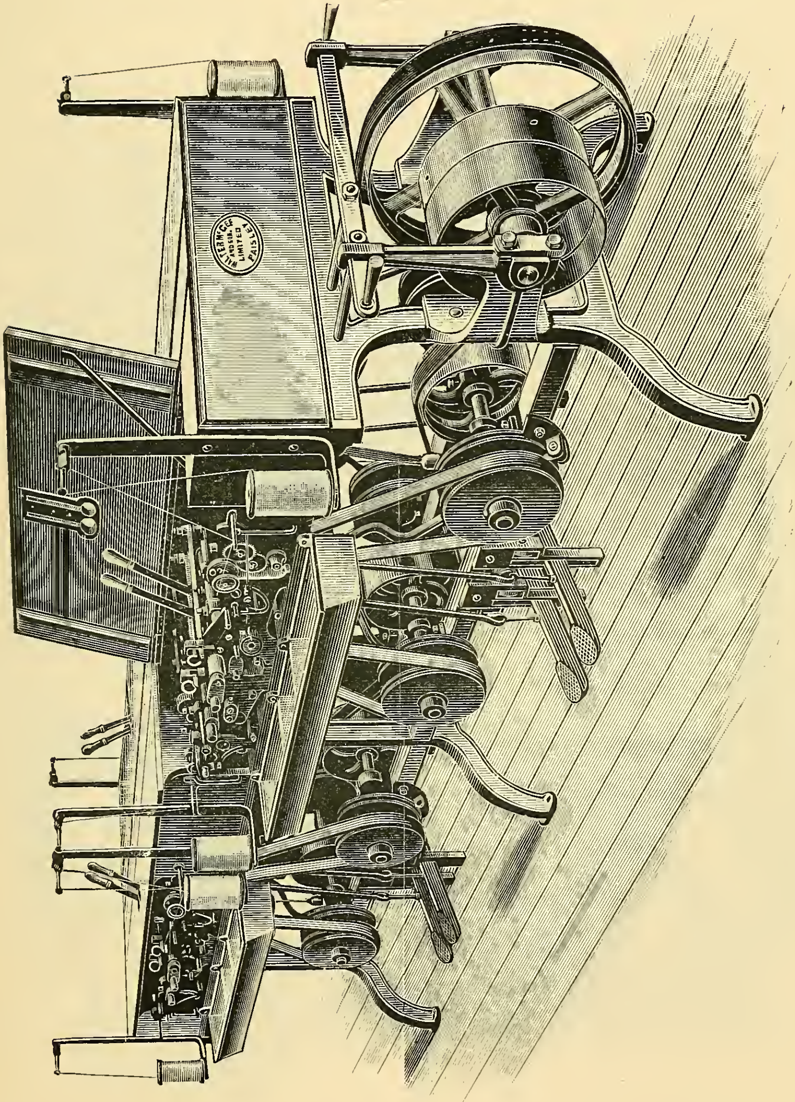

Fig. 108.—Improved semi-self-acting spooling machine (Conant system).

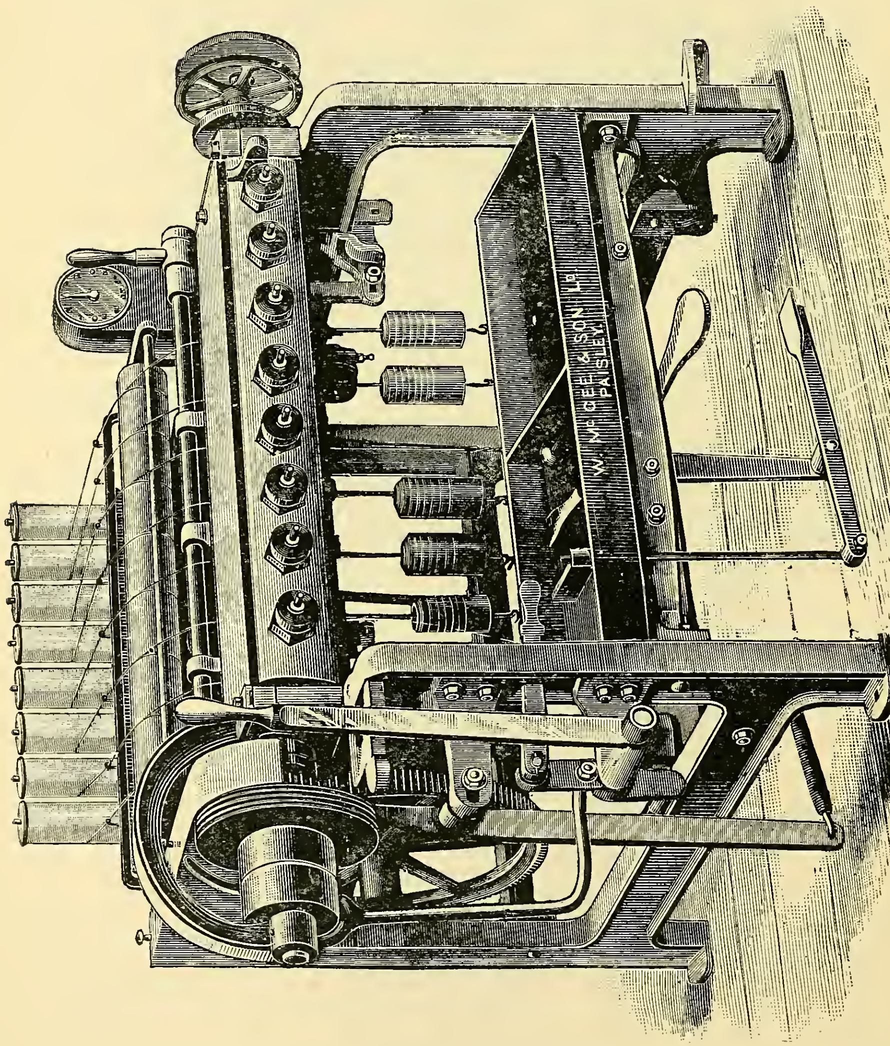

Fig. 109.—Improved 8-, 10-, or 12-spindle semi-self-acting spooling machine, for filling a number of spools at one operation (Smith's principle).

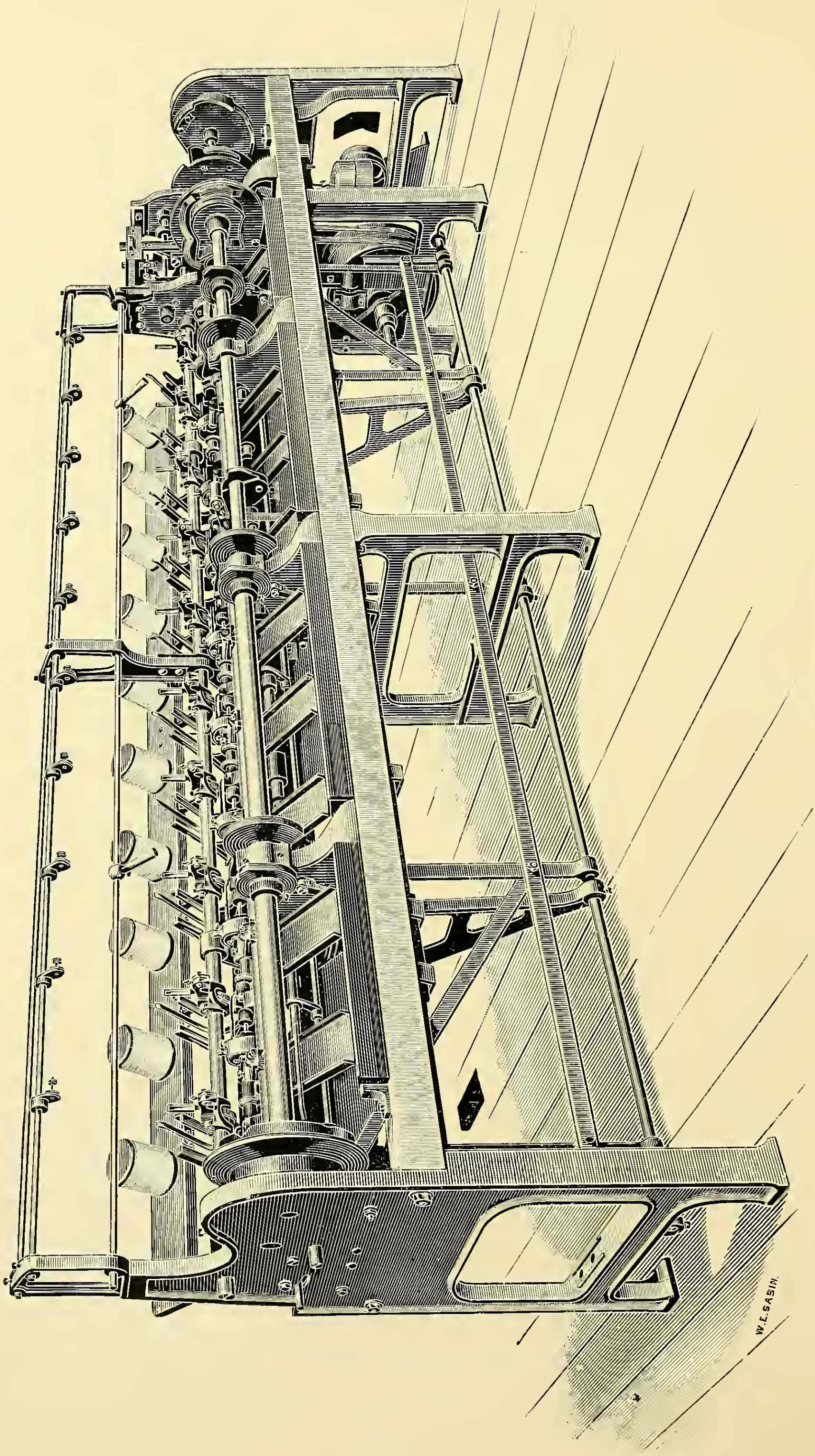

FIG. 111.—New automatic thread spooling machine (Booth's patent).

truer and make better work. It will be noticed that there is a friction break on the top shaft for stopping the machine instantaneously when the belt is thrown off. The machine can wind spools from 1 inch long and 1 inch diameter to $2\frac{1}{4}$ inches long by $1\frac{3}{4}$ inches diameter. In the machine shown in fig. 111 the spindles are driven at both ends, enabling the spools to be run at a very high rate of speed.

Hand-measuring Reel and Re-winding Head.—A useful tool for the thread department is the hand-measuring reel and re-winding head shown in

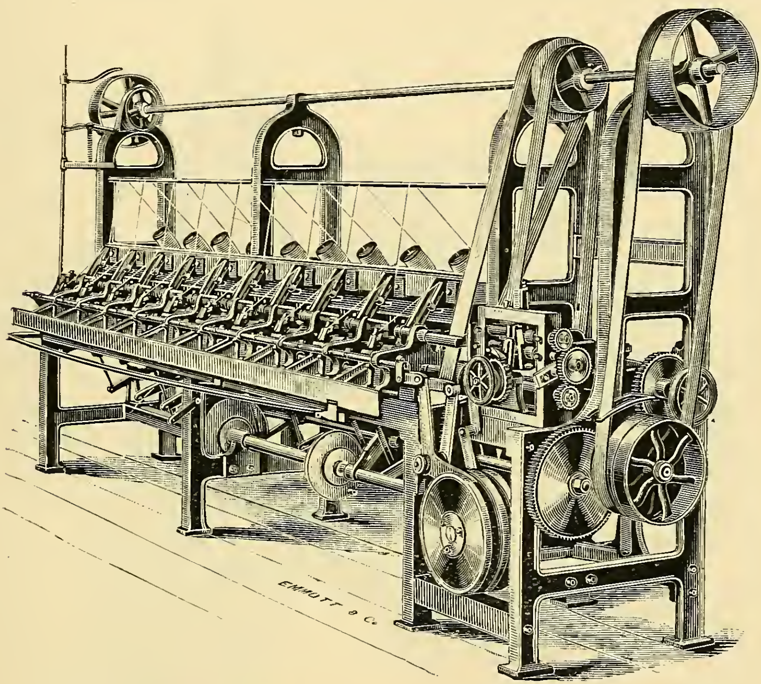

FIG. 110.—Improved self-acting spooling machine (Weild's principle).

fig. 112. The reel, which may be 36 inches in circumference, is convenient for verifying the length on small spools. There is a traverse motion for spreading the thread on the face of the reel, and a measuring motion to measure up to 1000 yards. The re-winding head shown to the left of the figure is for the purpose of re-winding on to large bobbins for re-spooling the thread which has been measured upon the reel.

Prices of Flax and Hemp Cords, Lines and Threads.—In order that the reader may have some idea as to the relative prices of flax and hemp cords, lines and threads and the yarns for producing them, we here give a comparative price list.

Flax gill spun shoe thread,	3 to 6 leas per lb.,	9d. to 12½d.	per lb.
Flax gill-spun saddler's thread,	12 to 18 ,,	2s. to 2s. 2d.	,,
Shoemaker's hemp line yarn,	8 to 12 ,,	12d. to 13d.	,,
Dry and demi-sec hemp line yarn,	1 to 12 ,,	8d. to 12d.	,,
Dry and demi-sec hemp tow yarn,	1 to 12 ,,	5d. to 9d.	,,
Wet spun hemp line yarn,	3 to 25 ,,	7d. to 1s. 6d.	,,
Wet spun hemp tow yarn,	3 to 18 ,,	6d. to 11d.	,,
2-fold 6-lea to 2-fold 16-lea flax threads,		10d. to 17½d.	,,
2-fold 6-lea to 6-fold 16-lea demi-sec spun shoe threads,		14d. to 2s.	,,
2- or 3-ply hemp seaming twine,		8d.	,,
2- or 3-ply hemp shop twines,		6d. to 8d.	,,

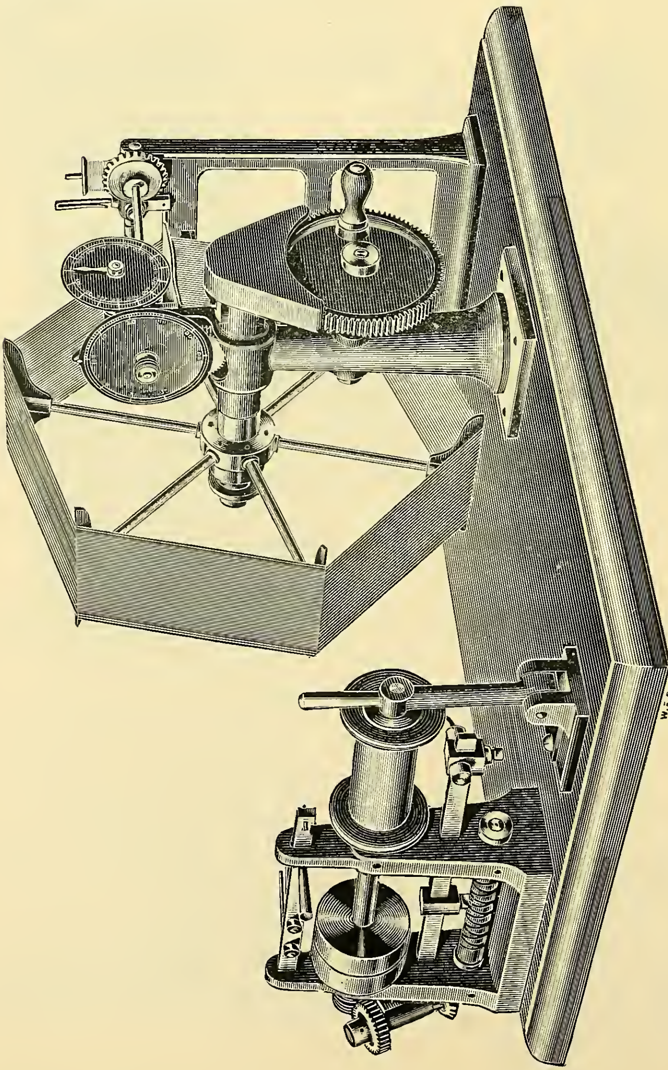

FIG. 112.—Hand-measuring reel and re-winding head.

CHAPTER XVII.

ROPE MAKING.

Construction of Ropes.—Hemp is practically the only one of the long vegetable fibres used by rope makers. The soft hemps are best for the standing rigging of ships, or for running rigging where a heavy purchase is required, while Manila is preferred for light running rigging.

Ropes are made by twisting several yarns together into strands, each strand containing an equal number of yarns, then laying them up in a spiral form so that each separate yarn bears an equal strain. The strength of the rope is the combined strengths of each of the separate yarns, and unless these yarns be very carefully twisted together, so as to bring an equal strain upon each part, the rope is imperfect. The strands must then be smoothly, evenly and closely laid. Ropes may be divided into three classes, namely, hawser-laid, shroud-laid, and cable-laid.

A hawser-laid rope is composed of three strands of yarn, twisted to the right or with the sun.

A shroud-laid rope has four strands, and is twisted in the same direction as the foregoing.

A cable-laid rope is composed of three hawser-laid ropes twisted together to the left or against the sun. It thus actually contains nine yarn strands.

The remarks which were made on p. 235 about thread construction hold good also as regards ropes, for the best and strongest cordage is built up of a large number of single yarns composed of long fibres placed parallel to one another, with the end of one fibre overlapping the end of its neighbour, the whole being secured together by friction produced among them by twisting. As the strength of the fibres, however, is diminished when they are twisted out of the direction of the tensile strain which they are to sustain, no more twist should be given than is necessary to impart sufficient friction to prevent them from slipping and parting endwise.

In order to produce a cord or rope which will not stretch much, and in which the strain is equally borne by the large number of single yarns of which it is composed, the latter may be stretched and held without twisting whilst a few well twisted strands are wrapped around this central core, producing a rope which will not stretch much and which will resist a good deal of friction.

Cablets are small cable-laid ropes measuring from 1 to 10 inches in circumference; larger sizes are termed cables. Shroud and hawser-laid ropes seldom exceed 10 inches in circumference.

Shroud-laid ropes require a core placed in the centre of the strands which are laid around it. As its object is merely to keep the strands in position, it is generally made of inferior yarn.

Flat hemp ropes are made of four or six ropes, each composed of three strands and laid alternately to the right and to the left; these are stretched side by side and sewn through in a zigzag direction.

Bolt rope, which is sewn around the edges of sails of ships, should be well made of fine yarns spun from the best Riga or Rhone hemp well tarred in the best Stockholm tar. There should not be too much tension when closing the strands, as it causes the rope to be hard to sew on. A hard stranded and flexible rope will last longer than a hard closed rope, which will generally break before it bends, and wears badly.

Lessom is the primary strand from which hawsers are made.

Strength of Ropes.—The strength of ropes made from the best Riga hemp is about 1700 lbs. per square inch of section.

The strength of ropes made from Manila hemp varies from 1100 to 1700 lbs. per square inch of section, according to the quality of the fibre.

Tarred ropes are about one-fourth less in strength than white cordage.

The larger the cordage the less its strength per unit of section.

The working or maximum proof strength of cordage may be calculated by multiplying the square of its circumference in inches by 200 to 300 lbs.

Rope Manufacture and Machinery.—Ropes are made in one of two ways—either in a long rope walk by means of machines which work in pairs, and which are technically known as the "foreboard" or "foreturn machine" and the "traveller," or in an ordinary building upon "house machines," which comprise stranding and closing machines. The length of a rope walk should not be less than 150 fathoms or 900 feet, so as to produce ropes of a minimum length of 120 fathoms.

The yarns used by the rope-walk spinner have either been spun by hand or have been bought from the machine spinner in the form of warps or hauls. If a tarred rope is to be manufactured, the hauls of yarn are first passed through the tarring machine, fig. 113, and then, after lying for a few hours, wound upon large bobbins in a yarn winding machine, such as is shown in fig. 114. In the tarring machine the tar is contained in a wooden tar tank 12 feet long, 18 inches wide, and 32 inches deep, which may advantageously be lined with copper. The tar is heated by solid drawn copper steam coils. The machine has a powerful double-geared hauling-out apparatus, as well as a nipping and immersion apparatus.

Tarred rope is extensively manufactured, as it is less subject to injury

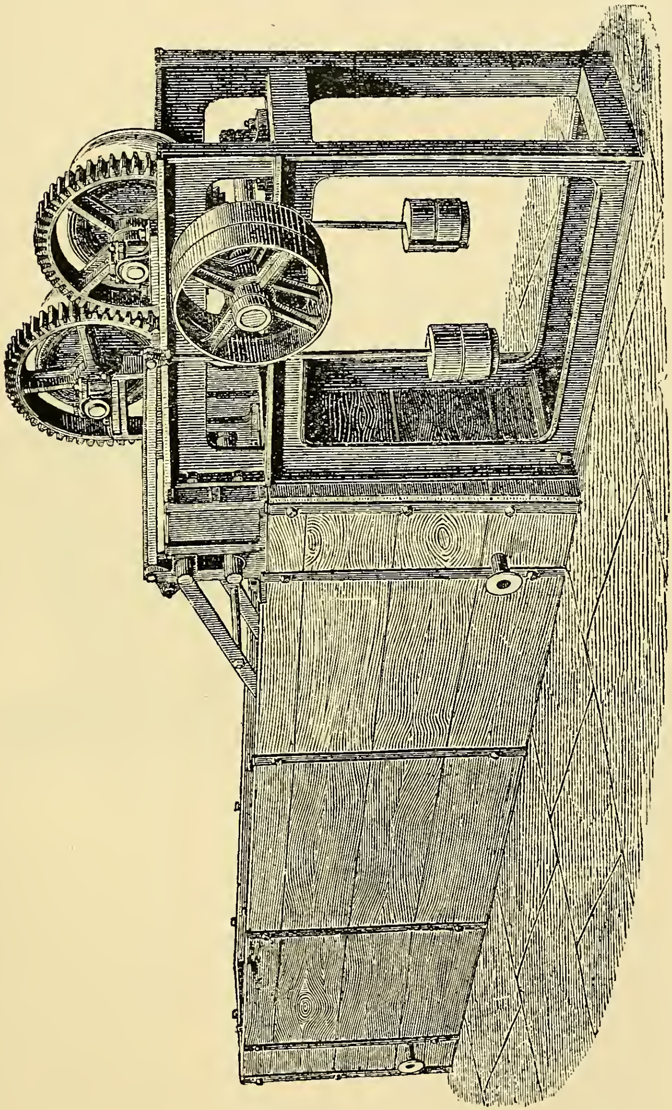

Fig. 113.—Yarn tarring machine. (Made by Thomas Barraclough, London.)

by the weather than white cordage. Rope yarns take up from 20 to 30 per cent. of their weight in tar. Russian hemps take the tar particularly well. At one time it was thought that coal tar burned the strands and was not suitable for ropes, but it is now recognised that this is not so, and it is consequently much used, as is also Archangel and Stockholm tar, or a mixture of both. The tar should be heated to 220° F. in order to evaporate the moisture. The speed of the yarn through the tar should not exceed 15 feet per minute.

The forming of a strand is the first operation in the production of a rope. In the rope walk this is done by means of the forming machine or traveller shown in fig. 115. This machine runs on rails from one end of the walk to the other, being made to travel by means of a ground rope, which, made fast at the ends of the walk, is coiled round a drum, so that by the revolu-

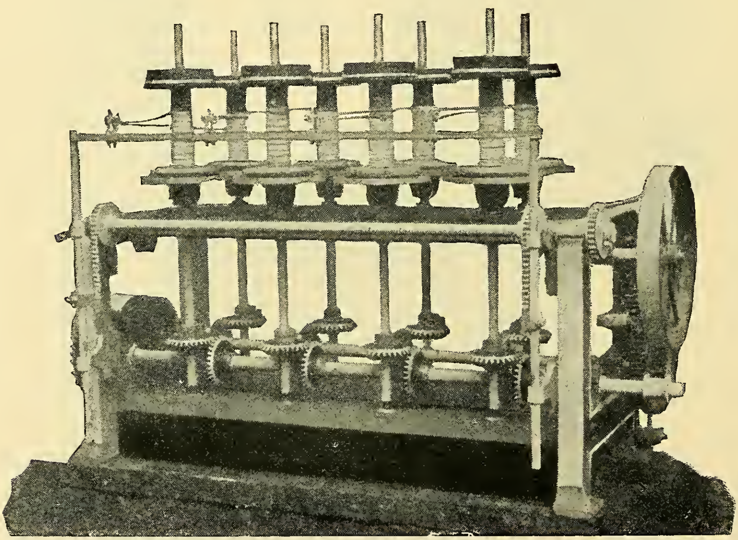

Fig. 114.—8-spindle yarn winding machine.
(Made by Thomas Barraclough, London.)

tion of the drum the machine is made to travel along the walk. The ground rope drum is caused to revolve by means of an endless rope called a fly rope, which takes a turn round a whelp wheel and, passing round pulleys at the top and bottom of the walk, acts as a driving rope, being driven by an engine. The revolution of the ground rope drum is communicated by means of gearing to the twisting hooks, or "nibs" upon which the yarns to be twisted into strands are hooked. Each hook takes the number of yarns required to form the strand, the yarns, after leaving their bobbins, passing first through separate holes in a register plate, shown in fig. 116, and then converging into one common point through a carefully bored and bell-mouthed cast iron tube set in a steam chest (also shown in fig. 116) which heats the tube. The hole in this tube is taper, and varies in diameter for each size of strand. The hole in the tube necessary to form a strand for a rope 3 inches in circumference, for instance, being $\frac{1}{2}$ inch diameter at the

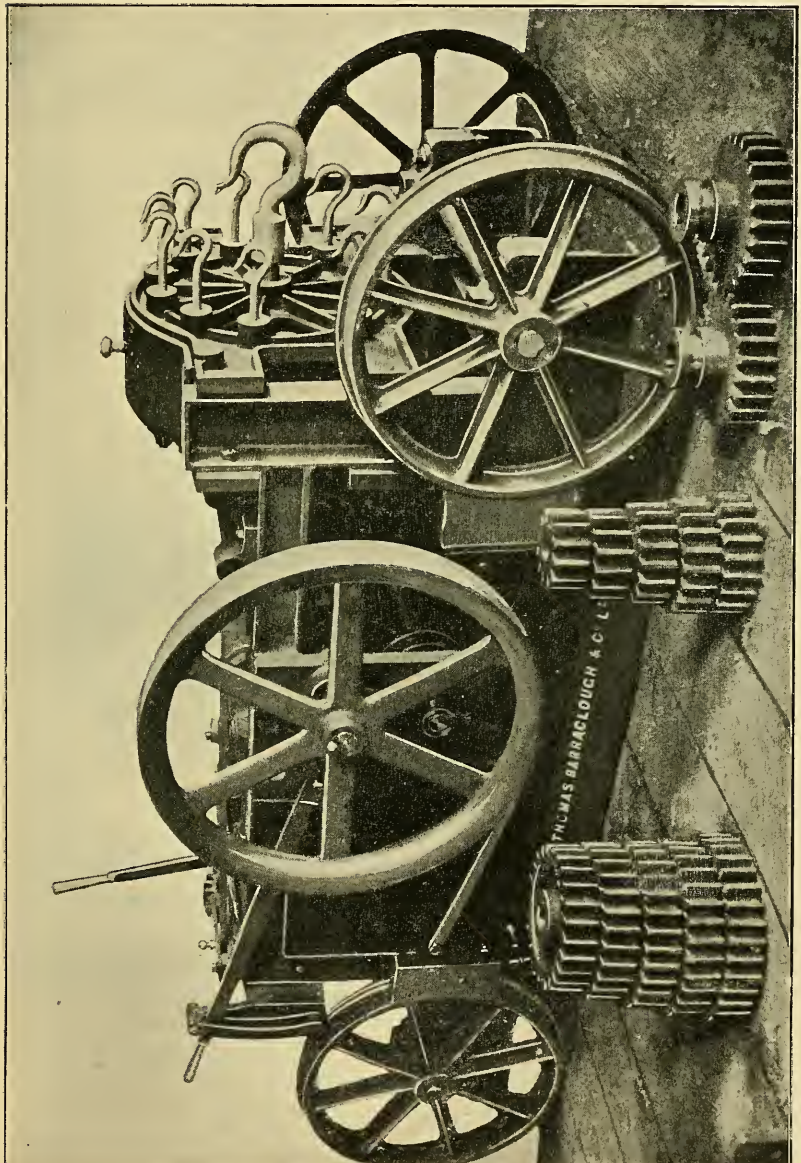

Fig. 115.—Traveller. (Made by Thomas Barraclough, London.)

smaller end and $\frac{9}{16}$ inch diameter at the larger end, and for the strands of a rope 2 inches in girth $\frac{5}{16}$ inch at the smaller end and $\frac{7}{16}$ inch at the larger end, the convergent yarns from the concentric circles of drilled holes in the register plate enter the tube at the large trumpet-mouthed end and are forced through, fitting tightly into the tube; they are thus squeezed tightly together before being attached to the forming machine, fig. 117.

The correct twist is given to the strands by introducing a suitable change pinion into the gearing connecting the ground rope drum with the twisting hooks. The desired relative speed of hooks and backward motion of the traveller is thus easily obtained.

Register or Stranding Machine.—The "house machine" upon which strands may likewise be formed is called a register or stranding machine. Occupying comparatively little space, it twists the yarns into a strand, and

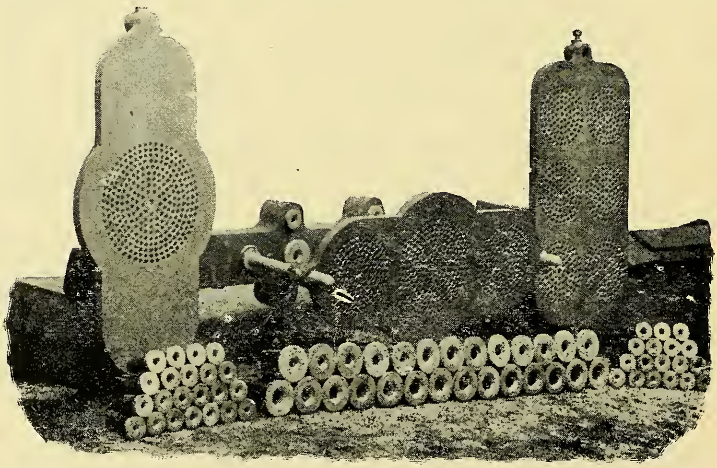

Fig. 116.—Steam chest, register plates and tubes.
(Made by Thomas Barraclough, London.)

winds the latter upon a drum as fast as formed. The yarns are drawn from bobbins placed in a "bank" as before, and after traversing the holes of a register plate pass through one hollow bearing of the revolving framework of the machine which carries the drawing pulleys, the winding drum, the guiding frame and its grooved barrel. Upon the outside bearing of the revolving frame is a clutch by means of which the frame is connected with, and put in motion by, a revolving shaft. After passing through the hollow bearing of the revolving frame, the yarns of the strand take half a turn around each of two drawing pulleys, and are thus drawn forward and twisted into the strand which, passing on, is delivered and automatically wound upon a drum in a regular manner by means of a guiding frame, which is made to move from end to end of the drum by means of a stud on the frame working in a spiral groove cut in a grooved and revolving barrel. The drawing pulleys, grooved barrel, and winding drum are all driven at the proper speed

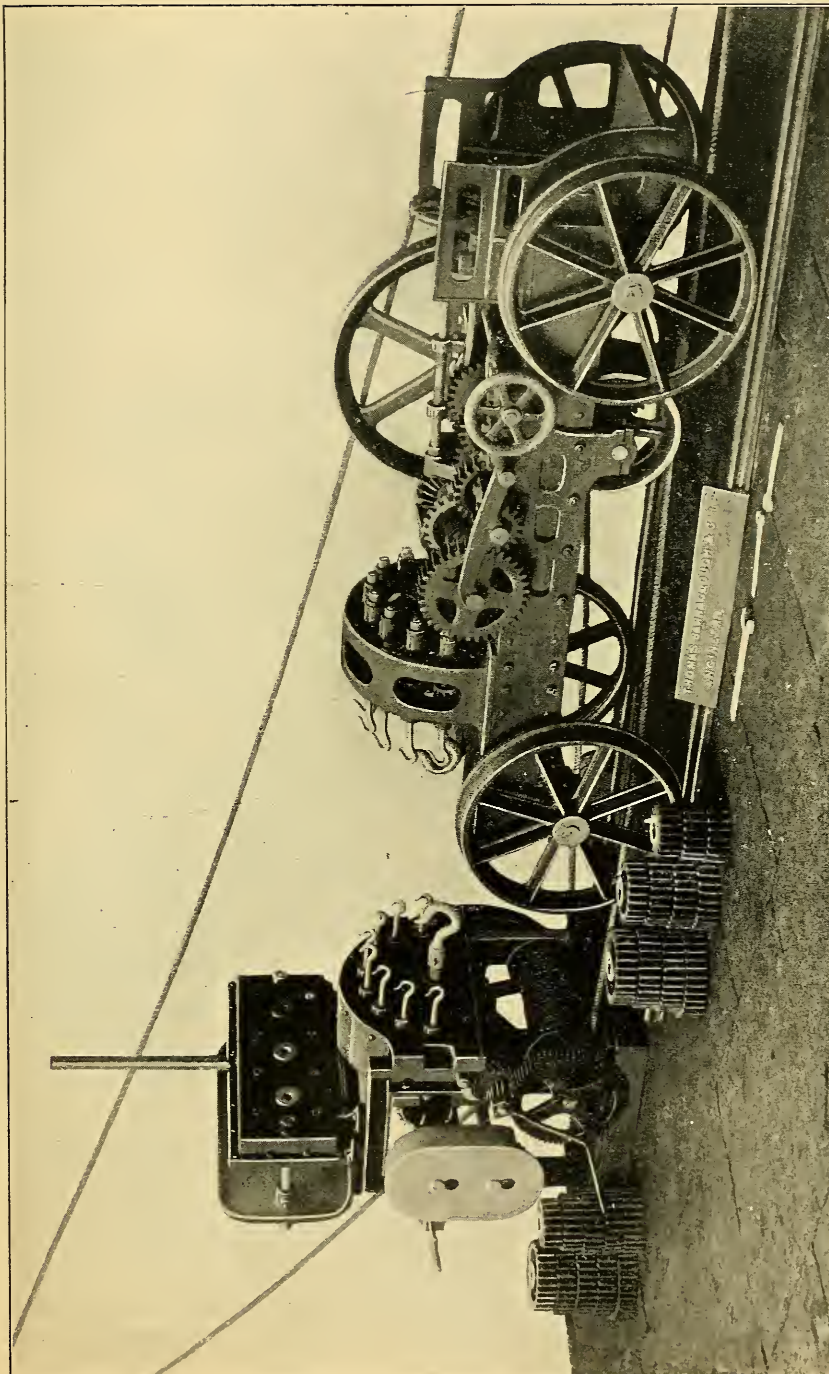

Fig. 117.—Foreturn machine and traveller.

by gearing which is put in motion by means of a spur-wheel gearing into a stationary pinion fixed to the plummer-block in which the hollow bearing revolves. A friction clutch is inserted in the train of gearing which connects the drawing pulleys and winding drum, so that the tension and speed of the strand remain constant, notwithstanding the gradually increasing diameter of the winding drum. Figs. 118 and 119 show horizontal stranding or registering machines of somewhat similar construction to the older machine just described. Change tubes are provided of exactly the same diameter internally as the outside diameter of the strand to be formed. The machine, fig. 118, is provided with an indicator to show the length of the strand made, also with a means of heating the change tubes by either gas or steam.

The strand made by the registering machine is sometimes re-wound upon

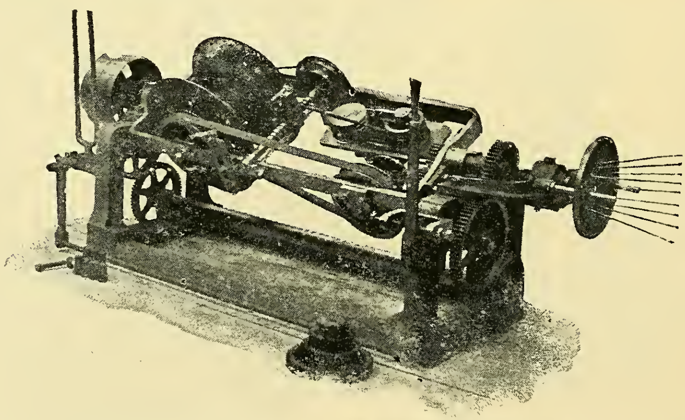

FIG. 118.—Horizontal stranding machine. (Made by Thomas Barraclough, London.)

another bobbin for the closing machine, in order that it may be laid into the rope in the same way, end for end, as that in which it was formed.

Horizontal Laying or Closing Machines.—Figs. 120, 121 and 122 show three forms of horizontal laying or closing machines for laying the strands from the stranding or register machines into ropes. Fig. 123 shows a vertical machine for the same purpose. It will be seen that these machines perform two operations, viz., they put additional twist into each strand, and then close the three or four strands into a rope, which is drawn through the machine by means of draw drums, and automatically wound upon a reel or bobbin. In fig. 120, for instance, three spools of strand from the forming machine figure are placed in the three revolving spool frames shown. The ends of strand pass first through the hollow bearings of the spool frames, and then together through a compressor to the draw drums,

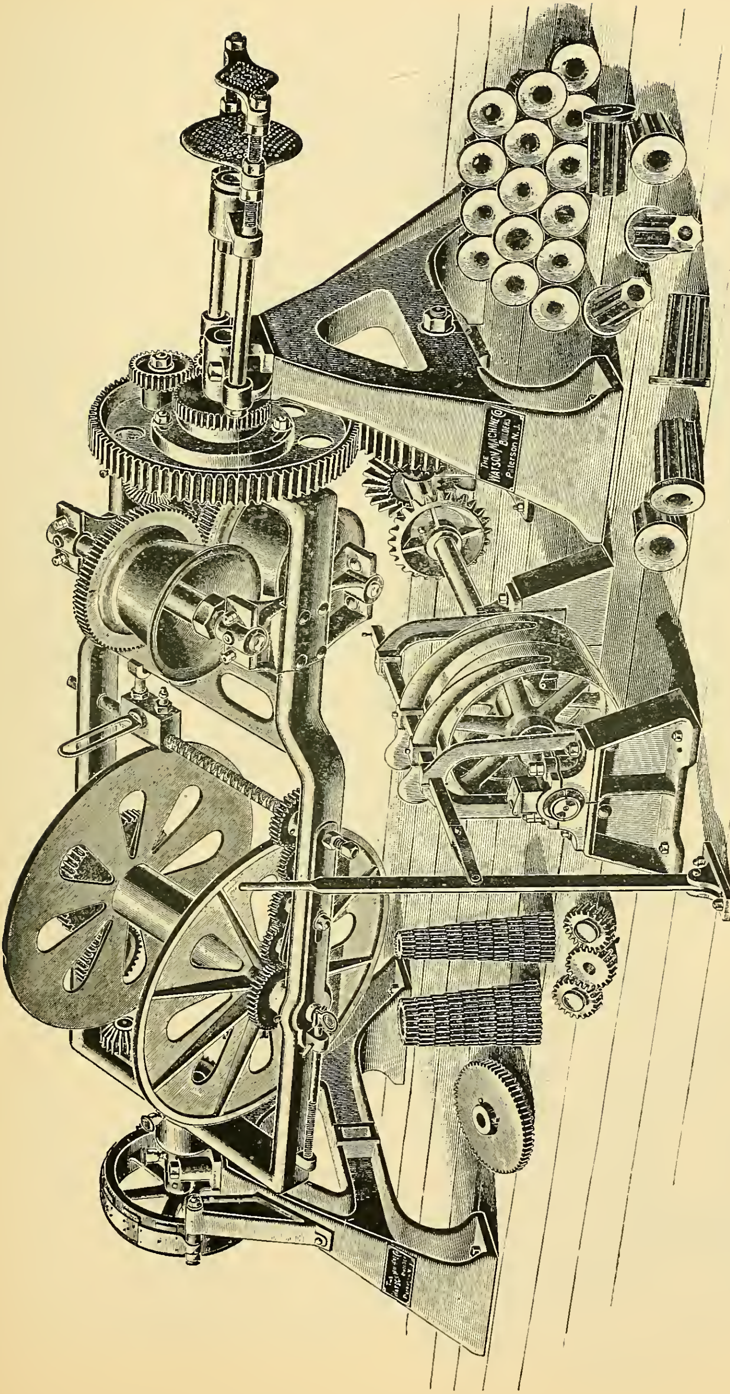

Fig. 119.—Horizontal strand forming machine to make strands from $\frac{3}{4}$ inch diameter to 2 inches diameter.

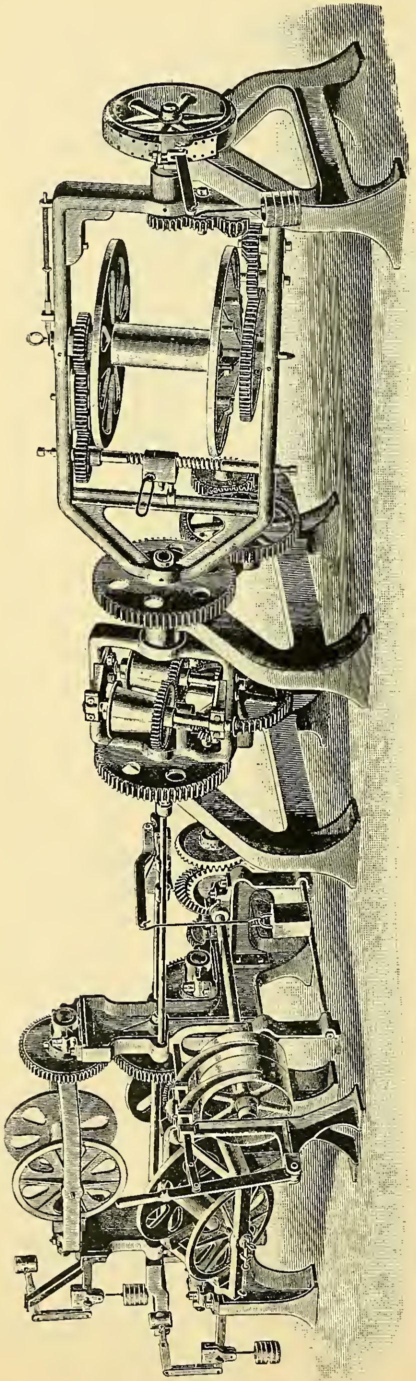

Fig. 120.—Horizontal strand closing or laying machine, to lay either 3 or 4 strands into rope from $\frac{1}{2}$ inch to 1 inch diameter. (Made by The Watson Machine Co., Paterson, N.J.)

which, revolving with the rope drum frame, twist the strands together into a rope, which is delivered through the hollow bearing and automatically wound upon the drum shown. A uniform tension upon the strands is insured by friction breaks applied upon the edges of the strand spools.

Since, in these machines, the strands are closed into a rope by being twisted together in the reverse direction to that in which the strands themselves were originally twisted, the spool frames are turned in such a direction and at the requisite speed, not only to maintain the original twist of the strand, but also to give it a slight additional twist or forehard in order to ensure the yarns in each strand being thoroughly closed upon one another. The machines, figs. 122, 123, are furnished with a geared draw-off apparatus in the bobbin flyers to ensure perfect equality in the lengths of the strands. Stranding and closing machines are generally worked in sets, each set consisting of two stranding machines and one closing machine. Horizontal closing machines are preferable for the smaller sizes of ropes. Vertical machines are more advantageous for the larger

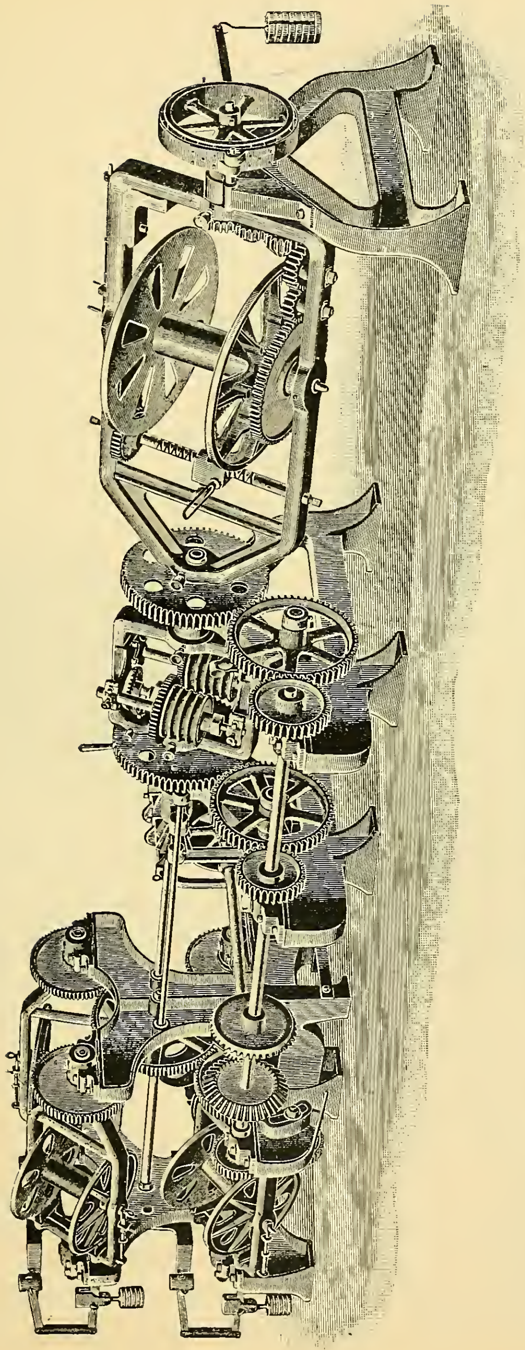

Fig. 121.—3- or 4-strand layer or closing machine to lay rope from 1 inch diameter to 2 inches diameter.
(Made by The Watson Machine Co., Paterson, N.J.)

sized ropes, principally on account of the greater facility afforded for putting the large strand bobbins in them.

The method employed in closing strands into a rope in a hand rope-walk is as follows:—The strands to be twisted together are each attached to one of the hooks of the "foreturn machine," figs. 117 and 124, which is placed at one end of the walk. The other extremities of the strands

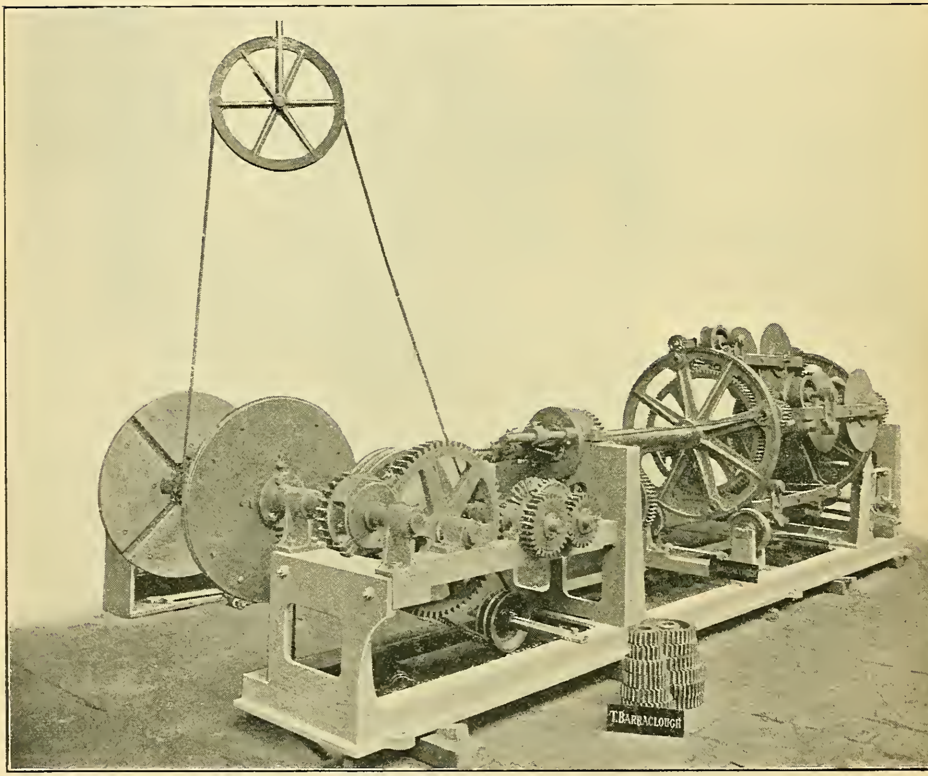

FIG. 122.—Horizontal 3- and 4-strand closing machine.
(Made by Thomas Barraclough, London.)

are attached, all together, to one of the hooks of the traveller, fig. 115, which is situated at the other end of the walk. The machines are shown together in fig. 117. The hooks turn in such a direction that while the traveller twists the strands together in the opposite direction to that in which they were formed, the hooks of the foreturn machine, turning in the opposite direction, prevent any loss of twist in the strands.

The strands for the rope are stretched tight along the walk from the hooks of the foreturn or laying machine at one end to the forelock

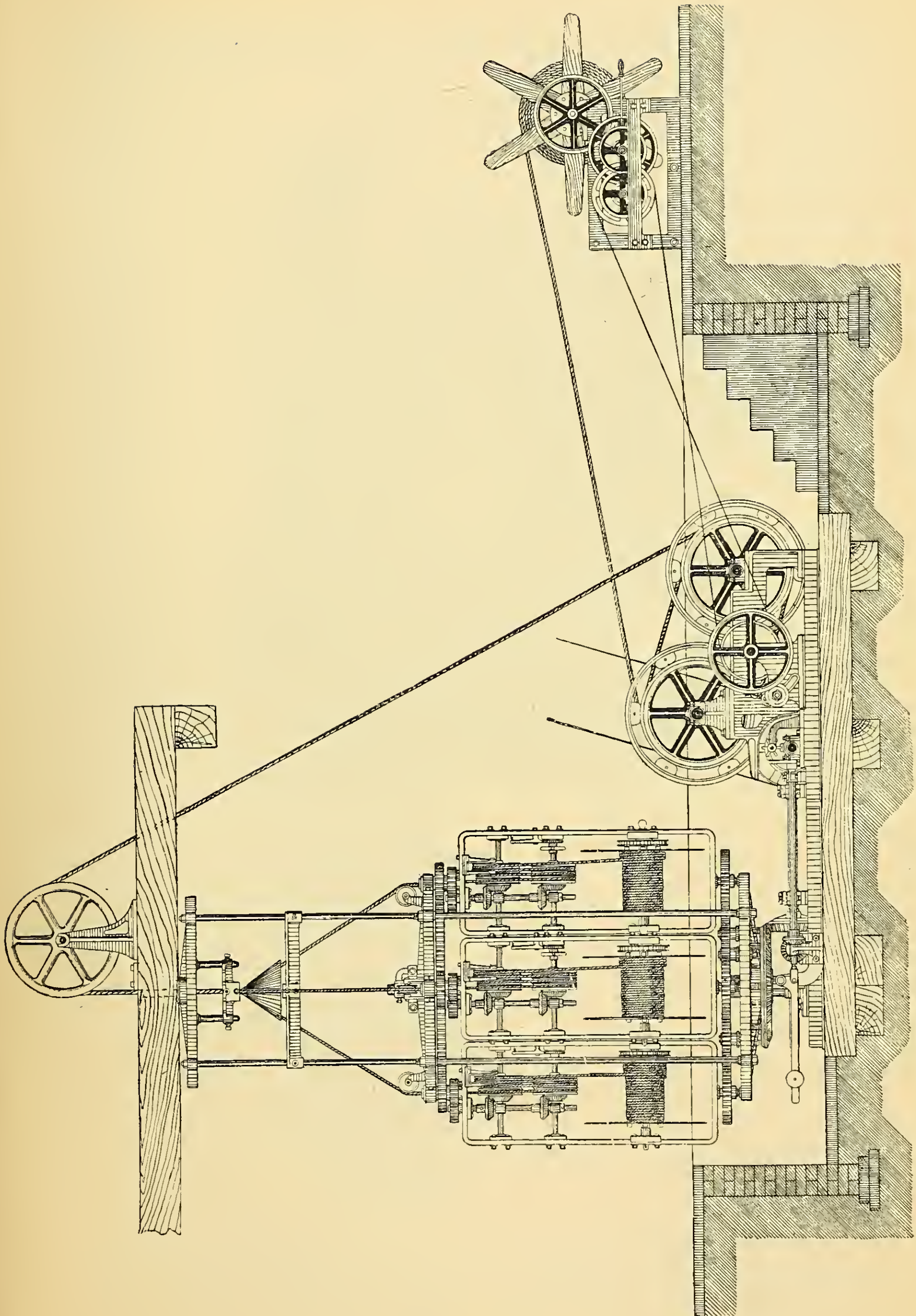

Fig. 123.—Vertical closing machine for 3- and 4-strand ropes. (Made by Thos. Barraclough, London.)

or hook of the lower lying machine or traveller, and are supported off the ground and kept separate by means of posts, placed at distances of every

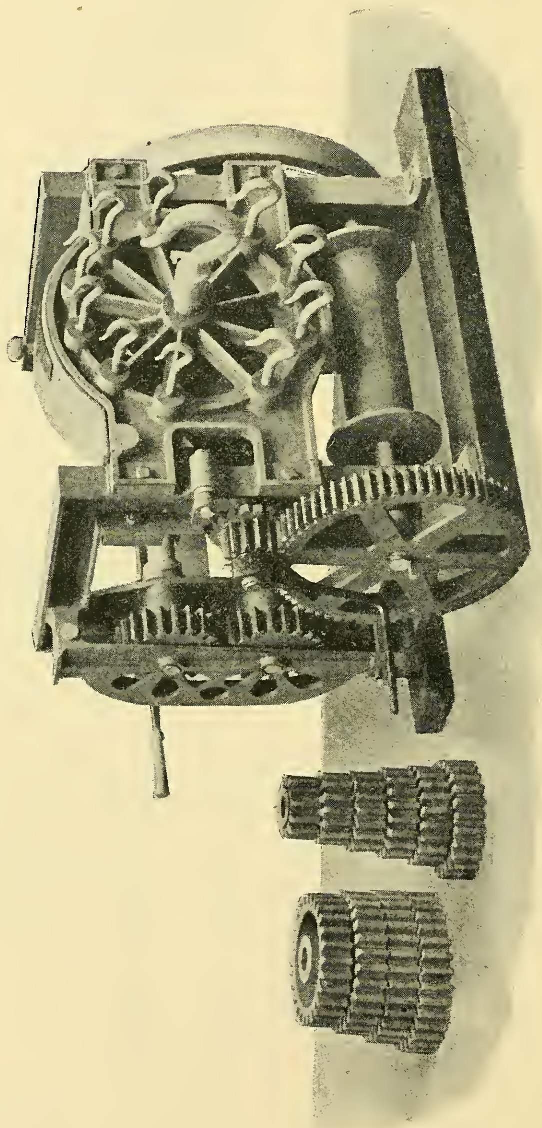

Fig. 124.—Foreturn machine. (Made by Thomas Barraclough, London.)

ten yards, with pegs to carry the strands. A taper piece of wood, fig. 125, called the laying top, is inserted between the strands close to the traveller towards which the smaller end points. The laying top has in it three longitudinal grooves, A, B and C, each of which carries one of the strands. A "topstick," or handle D, passes through the top and affords a means of holding the top. Except for the smaller ropes, a top car is used for supporting the top. The foreturn machine being put in motion by means of a belt, and the traveller by means of the fly rope, the strands are laid close together, the top being forced backwards by the twist. The motion of the laying top must be very regular and slow, as it is governed by means of a piece of rope attached to the handle and coiled round the rope already twisted, thus acting as a drag. As the contraction by twist in closing the strands amounts to about 33 per cent. of the length of those strands, the traveller is drawn up the walk, its motion being retarded and the rope held tight by means of a break, or by weights placed on the framing of the machine. The degree of twist required to close strands into a firm rope is inversely proportional to the diameter of the rope. Calculated on the basis of sixteen turns per foot, which gives a well-made rope of 1 inch diameter—

A rope	$\frac{3}{8}$-inch	in diameter	may have	42	turns per foot.
,,	$\frac{1}{2}$	,,	,,	32	,,
,,	$\frac{5}{8}$	,,	,,	25	,,
,,	$\frac{3}{4}$	,,	,,	21	,,
,,	$\frac{7}{8}$	,,	,,	18	,,
,,	$1\frac{1}{8}$	,,	,,	14	,,
,,	$1\frac{1}{4}$	,,	,,	13	,,
,,	$1\frac{3}{8}$	,,	,,	12	,,
,,	$1\frac{1}{2}$	,,	,,	11	,,
,,	$1\frac{3}{4}$	,,	,,	9	,,
,,	2	,,	,,	8	,,
,,	$2\frac{1}{4}$	,,	,,	7	,,
,,	$2\frac{1}{2}$	,,	,,	$6\frac{1}{2}$	,,
,,	3	,,	,,	$5\frac{1}{2}$	,,

Compound Rope Machines.—Most modern machine ropeworks are now supplied with compound rope machines such as are shown in figs. 126, 127, 128, and 129.

In fig. 126 it will be seen that the bobbins full of yarn are placed upon spindles in the wrought iron flyers. These flyers revolve each on its own axis in order to form the strands, and the flyers also revolve round a common centre (sun and planet motion), in order to lay up the rope, which is drawn through the machine by means of draw sheaves, and wound on to the

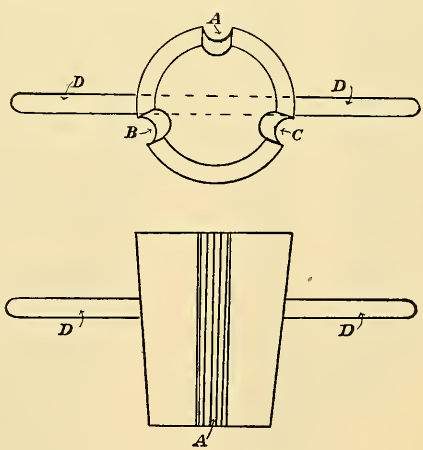

FIG. 125.—Laying top.

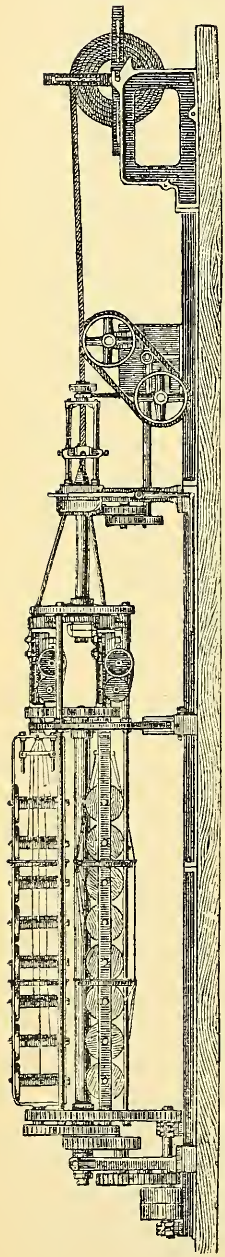

Fig. 126.—Horizontal compound hemp rope laying machine. (Made by Thomas Barraclough, London.)

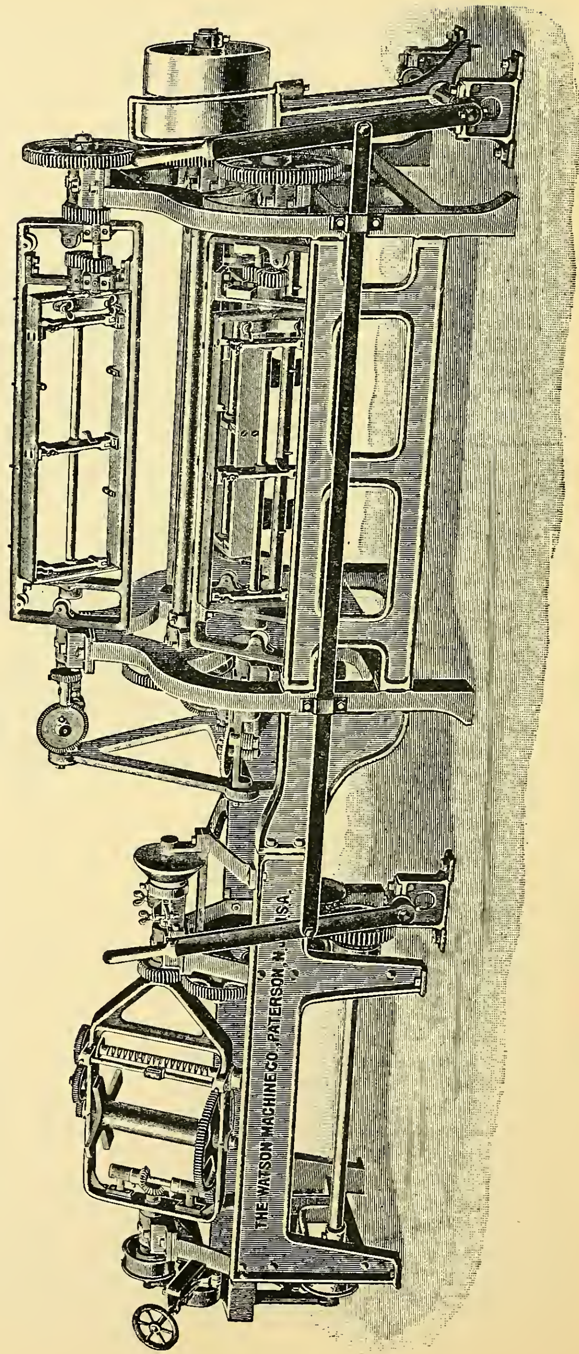

Fig. 127.—Six-thread horizontal rope machine for forming and laying rope from $\frac{3}{16}$ inch to $1\frac{1}{4}$ inch in diameter.

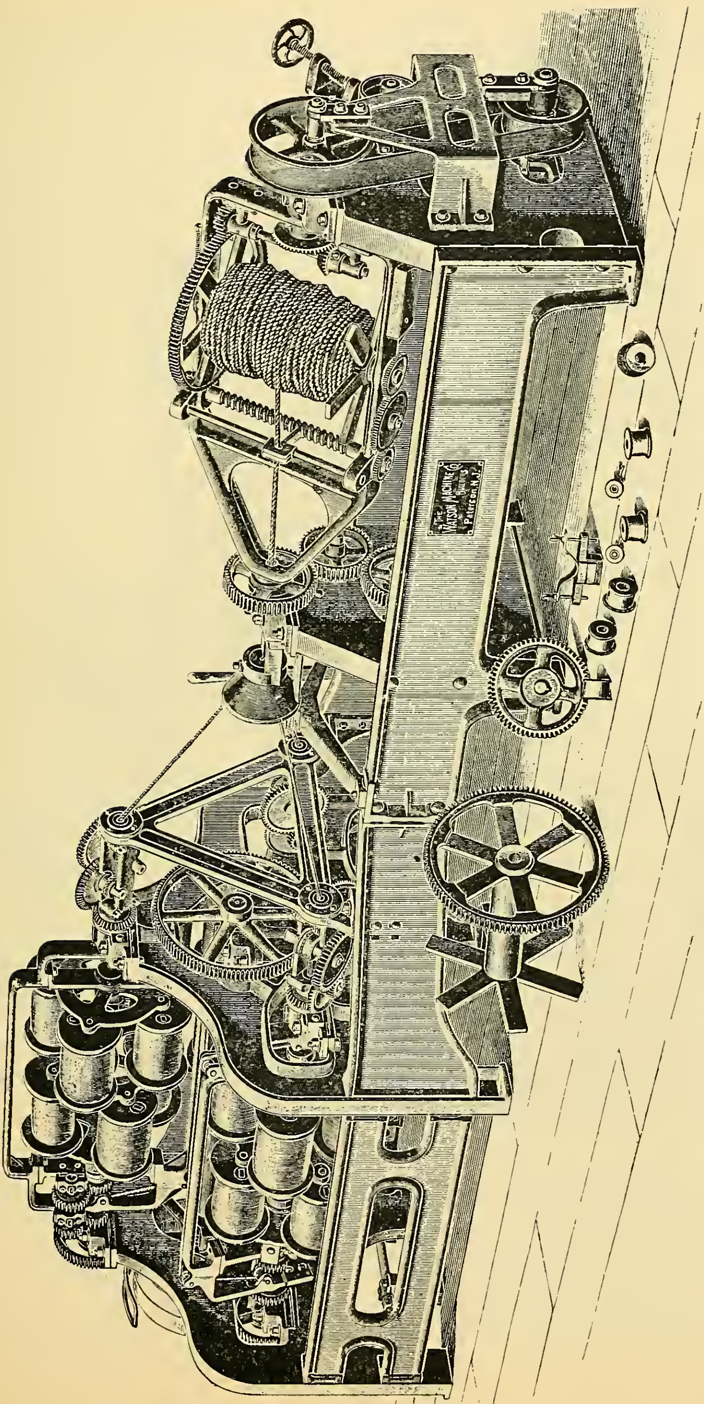

Fig. 128.—Twenty-four-thread compound rope machine to form and lay ropes in one operation.

rope reel as shown. The machine, fig. 127, is rather differently arranged. Two bobbins of yarn are placed upon the central spindle of each of the

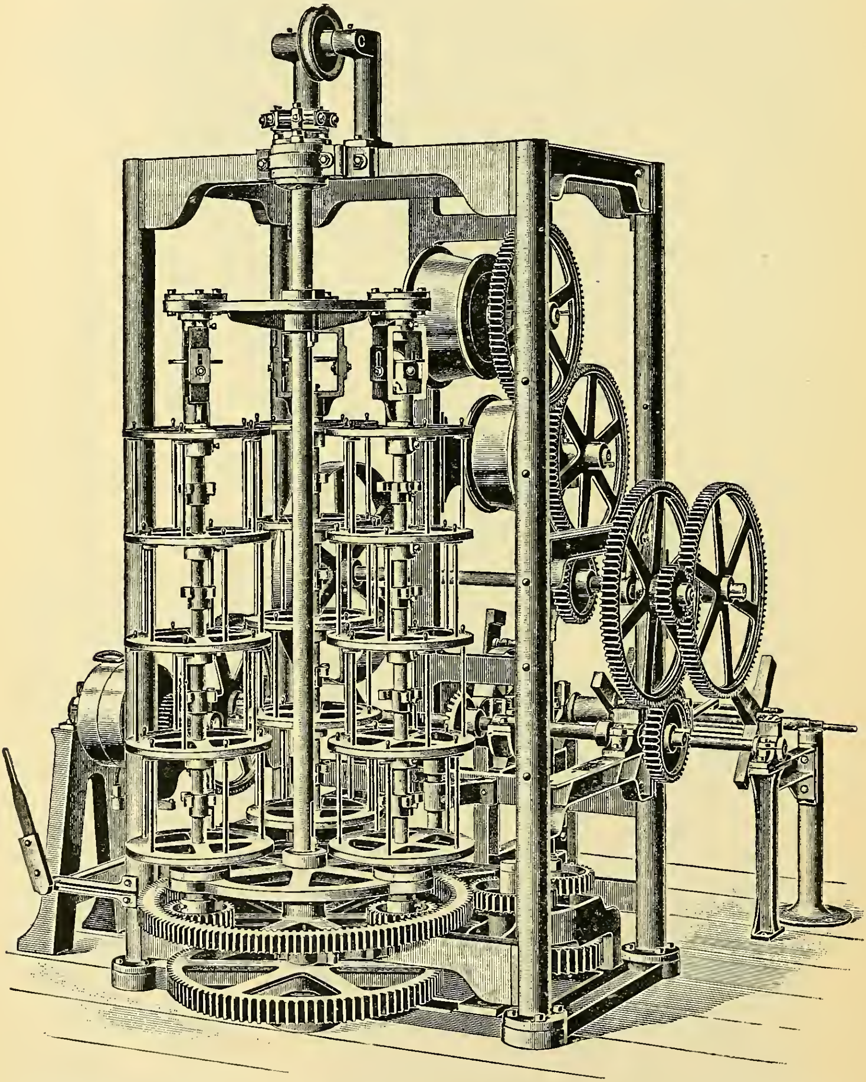

FIG. 129.—Sixty-thread vertical compound rope machine to form and lay rope from $\frac{3}{4}$ inch diameter to 1 inch diameter. (Made by The Watson Machine Co., Paterson, N.J., U.S.A.)

three flyers, which revolve in a fixed framework and merely serve to form the strands which, passing round the guide pulleys shown, are drawn forward by haul pulleys, thus ensuring that each strand is of equal length and twist. The three strands meet in the centre of the machine where the top or cone is placed, and are laid together by the revolving take-up flyer, seen to the left of the figure, which contains the bobbin or reel for the finished rope. The rope is wound on automatically, and the bobbin is easily removed from the flyer. In the machine, fig. 128, each flyer contains eight bobbins of yarn, the ends being formed into strands which are drawn forward and laid into a rope, as in the previous machine. Fig. 129 is a vertical machine capable of forming three series of twenty threads each into strands, and laying the same into a rope, which it winds automatically upon the rope reel.

Change wheels should be provided for machines of these descriptions, by means of which the amount of twist imparted to each strand may be varied, so as to harden or soften it, also in order that the ropes may be laid with a hard or soft lay, thus enabling the machine to produce any description of rope which may be required.

Compound machines are very convenient, in that they take up very little space, require little driving power, and are very economical in the matter of wages, since one man is sufficient to attend to each machine.

Rules for Rope Makers.—The following rules and axioms may be found useful by rope makers :—

Since the basis of rope yarn numbering, as explained on page 133, is the number of threads per strand required to produce a three-strand hawser-laid rope which has a circumference of 3 inches, and since the section of the rope and the number of threads required is proportional to the square of the circumference of the rope—

To find the number of threads per strand for a three-strand rope of any diameter. Rule :—Square the circumference of the rope, multiply by the number of the yarn which it is proposed to use, and divide the product thus obtained by 9 or 3^2.

To find the number of threads per strand for a four-strand shroud-laid rope of given diameter :—Divide the product of the square of the rope's circumference and the number of the yarn by $13\frac{1}{2}$.

To find the number of threads per strand for a three-strand cable, which, as we explained, consists of three hawser-laid ropes laid together and therefore contains nine primary strands :—Divide the product of the square of the circumference of the cable in inches and the number or size of the yarn by 36.

In a similar way the number of threads per strand for a four-strand cable is found by the following rule :—Divide the product of the circumference of the cable and the number of the yarn to be employed by 48.

As regards the lengths of the single yarns to be used in forming the strands, these, in consequence of the contraction by twist, require to be considerably longer than the length of rope to be produced. The following rules will be found useful in determining their approximate lengths.

The length of yarn to make a three-strand hawser-laid rope is found as follows. Rule :—Multiply the length of the rope by 3 and divide by 2. To find the length of yarn to make a four-strand hawser-laid rope of given length, multiply the length of the rope by 11 and divide by 7.

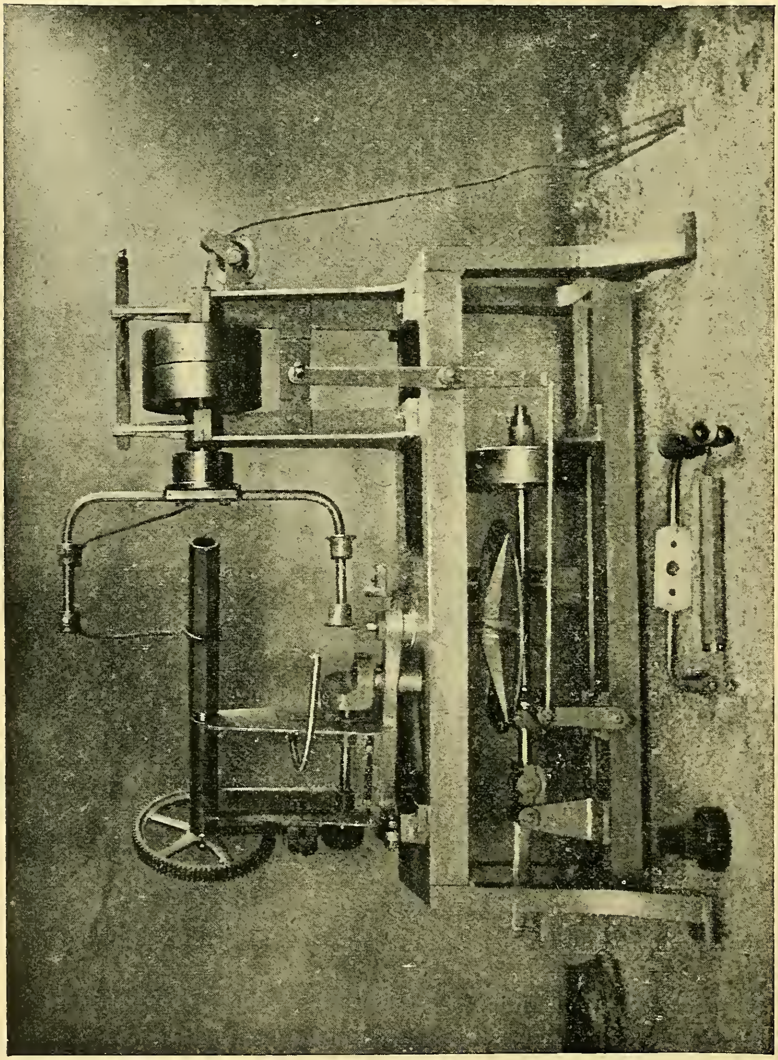

Fig. 130.—Coarse balling machine. (Made by Mr Wm. Bywater, Leeds.)

To find the length of yarns required to make a three-strand cable of given length, multiply the length of the cable by 5 and divide by 3.

To find the length of yarns to make a four-strand cable of given length, multiply the length of the cable by 7 and divide by 4.

The length of yarn required to make the core or heart for a four-strand hawser-laid rope is equal to the length of the rope multiplied by 5 and divided by 4.

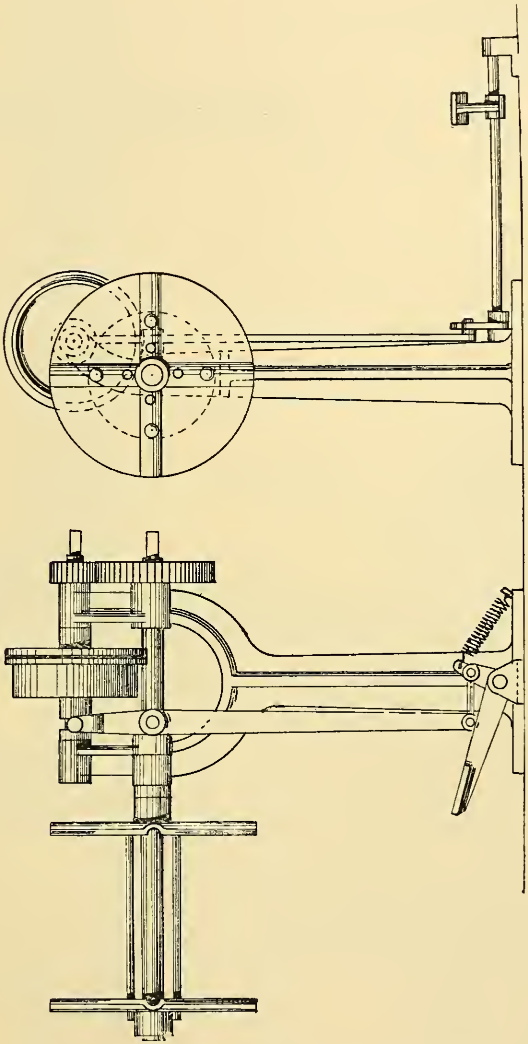

Fig. 131.—Coiling machine. (Made by Mr Wm. Bywater, Leeds.)

The length of yarn to make the heart for a four-strand *cable* is found by multiplying the length of the cable by 6 and dividing by 5.

The length of yarn to make bolt rope is equal to the length of the rope multiplied by 7 and divided by 5.

The circumference of a strand required to make a three-strand hawser-laid rope is half that of the rope itself. For a four-strand hawser-laid rope it is equal to the circumference of the rope multiplied by 6 and divided by 15.

For a three-strand *cable* the size of the "lessom," or primary strand, is equal to the size of the cable divided by 4. The size of the lessom for a four-strand *cable* is found by multiplying the size of the cable by 2 and dividing by 9.

The length of *rope* required as a strand for a three-strand *cable* is equal to the length of the cable multiplied by 10 and divided by 9. For a four-strand cable it is equal to the length of the cable multiplied by 5 and divided by 4.

The diameter or bore of the tube employed in forming the strands for a three-strand hawser is found by dividing the size or circumference of the rope by 6. For a four-strand shroud-laid rope it is found in a similar manner by dividing the size or circumference of the rope by the number 7.

The following table gives the number of yarns per strand and the weight per fathom of various sizes of rope made from 25-thread yarn :—

Circumference of Rope in Inches.	Yarns per Strand 25-thread Yarn.	Weight per Fathom.	
		lbs.	ozs.
¾	2 yarns per strand,	...	2
1	3 ,, ,,	...	3½
1¼	5 ,, ,,	...	5½
1½	7 ,, ,,	...	7½
1¾	9 ,, ,,	...	10½
2	11 ,, ,,	...	14
2¼	14 ,, ,,	1	1½
2½	17 ,, ,,	1	5½
2¾	21 ,, ,,	1	10
3	25 ,, ,,	1	15⅜
3½	34 ,, ,,	2	10
4	44 ,, ,,	3	7
4½	56 ,, ,,	4	5¾
5	69 ,, ,,	5	6
5½	84 ,, ,,	6	8
6	100 ,, ,,	7	12
6½	117 ,, ,,	9	1½
7	136 ,, ,,	10	8¾
7½	156 ,, ,,	12	1¾
8	177 ,, ,,	13	12½

To find the inside diameter of the tube required in forming the *strands* for a three-strand *cable*, divide the circumference of the cable by 12. For a four-strand *cable* divide the circumference of the cable by 14. When a rope stretches, its circumference decreases inversely as the square root of relative increase in length. For instance, if 100 yards of rope having a circumference of 6 inches be stretched until it is 400 yards long, its cir-

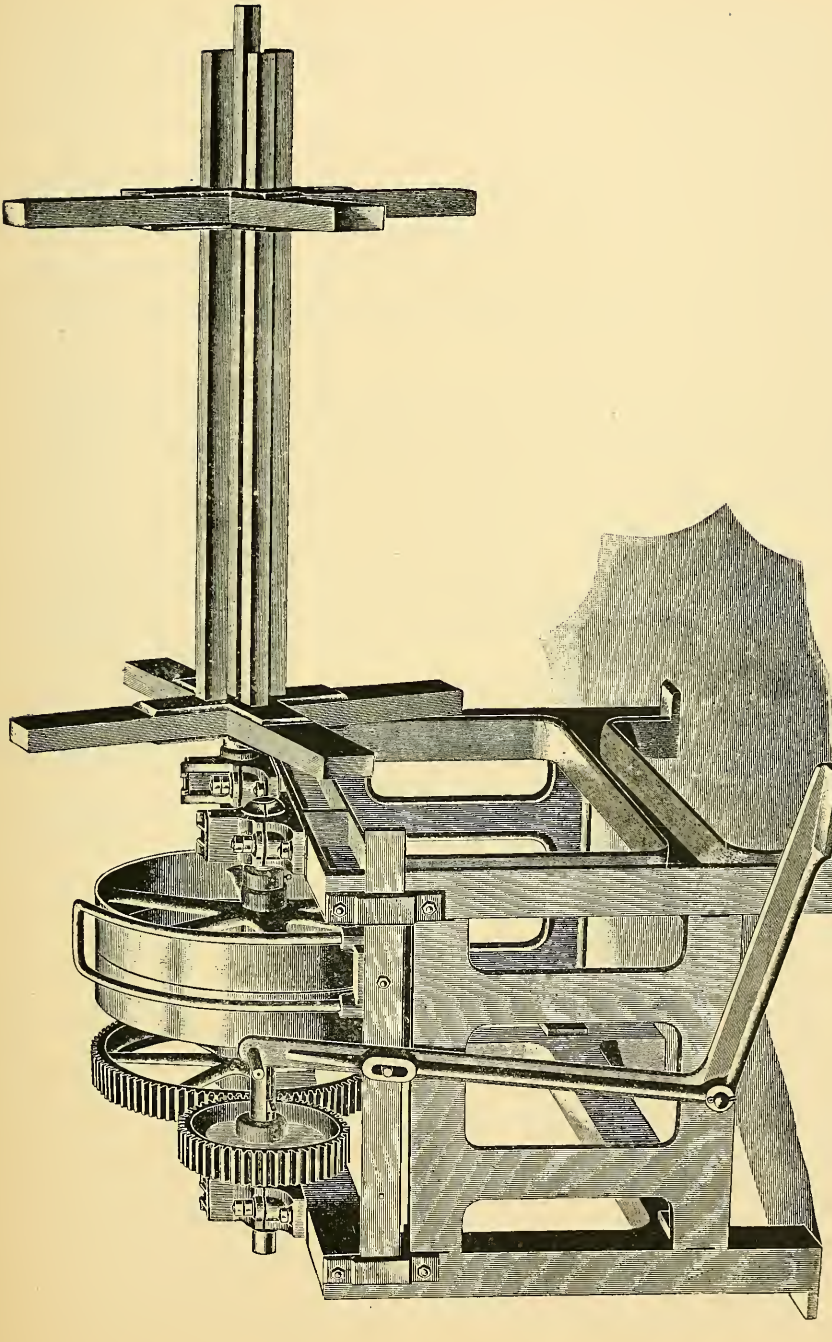

FIG. 132.—Geared rope reel. (Made by The Watson Machine Co., Paterson, U.S.A.)

cumference will then be $\frac{6}{\sqrt{4}} = 3$ inches; or inversely, if 100 yards of 6-inch rope be stretched until its circumference is only 3 inches, its length is then $\frac{100 \times 6^2}{3^2} = 400$ yards.

Weight of Ropes.—With regard to the weight of ropes, the approximate weight in cwts. of 130 fathoms or 320 yards of three-strand cable may be found by squaring the size of the cable and dividing by 3. The approximate weight of one yard in lbs. may be found by multiplying the square of the circumference of the cable by 15, and dividing the product thus obtained by 128. The weight of shroud hawsers are to one another as the squares of their circumferences.

The weight of one fathom or two yards of 3-inch rope is approximately 31 ozs. The weight of the same length of any other sized rope may be found by squaring the circumference of the rope, multiplying by 31, and dividing the product by 9. The weight of one fathom of 6-inch rope is thus $\frac{6^2 \times 31}{9} = 124$ ozs. or 7 lbs. 12 ozs.

Balling Small Rope.—Small ropes up to $\frac{3}{4}$-inch diameter when finished may be wound into balls up to 84 lbs. weight directly from the rope-walk or from the bobbin of a compound rope machine, fig. 128, upon a coarse balling machine, fig. 130.

Coiling Ropes.—Heavier ropes are generally coiled. The machine, fig. 131, which is power-driven by means of a friction pulley worked by a foot lever, makes coils up to 20 inches in diameter and 16 inches wide. The geared rope reel, fig. 132, is adapted to reel ropes from 1 inch to 2 inches in diameter. The ropes are now ready to be stored or sent out in fulfilment of orders.

CHAPTER XVIII.

THE MECHANICAL DEPARTMENT: REPAIRS—FLUTING—HACKLE-SETTING —WOOD TURNING—OILS AND OILING.

The Mechanic Shop.—No mill should be without a well-equipped mechanic shop for the execution of the repairs necessary to keep the whole plant in a high state of efficiency. If the mill be sufficiently large to warrant the expense, a capable engineer should be employed, charged with the general oversight of the machinery of the whole mill—buildings, engines, boilers, shafting, dynamos, electric wiring, etc., included.

The shop itself should be under the immediate control of a foreman mechanic, who should arrange the work of the men, and see it properly carried out. In a wet spinning mill of say 20,000 fine spindles or 10,000 coarse spindles, a good mechanic, aided by a three or four years' apprentice, should be kept constantly employed in the spinning room, keeping the frames well lined up, renewing the brasses and thread plate eyes, as well as seeing that the rove guides maintain their maximum traverse—a most important point as regards the wear and tear of both the bottom brass roller and its wooden or guttapercha pressings. In a similar manner, two men will find sufficient occupation in maintaining the preparing machinery in good working condition. If the frames be at all coarse, or quickly driven, the wear and tear on the faller and slide ends is considerable, as it also is on the tappets which lift the fallers from the bottom slide. If these parts are not kept in good order, the work, both for the preparing master, hackle-setters, and mechanics, is augmented by the sticking and breaking of fallers, crushing of gills, etc. In a mill where automatic spinners are employed in spinning rope yarns, binder twine, etc., one mechanic per hundred spindles should be left in constant attendance upon these machines, setting the throats and regulating mechanism for different grists of yarn, and keeping all in good working order. Hopper feeders and combing machines likewise require a great deal of attention to get the best possible results.

The engineer should have at his command one or two skilled mechanics capable of working the machine tools, planing and shaping machines, wheel-cutting machine, boss roller fluting machine, etc., as well as of doing any repairs necessary to the engine or mill gearing. If toothed gearing be used in the main power transmissions, they will frequently have to renew the wooden teeth in the mortice wheels, a job which, to be properly done, requires a certain amount of skill and knowledge of toothed gearing. An iron turner will also find constant employment in turning up castings of wheels and pulleys, guide pulley spindles, wet spinning frame reach screws, as well as the innumerable small brass fittings, screws, etc., always required. To his lot also falls the skimming of the preparing room front rollers, as well as of the journals of both preparing and spinning frame rollers when required, which should be never if they are of sufficient dimensions and well seated in suitable bearings. The boring out of such articles as brass bearings, spindle steps and collars, etc., also falls to the work of the lathe and iron turner, so that he will be kept well employed. The wood turner is another indispensable member of the staff. If the mill uses, cuts and turns up its own wooden spinning room pressings, he must have at least one assistant, or advanced apprentice. His chief work lies in the mounting and turning up of the wooden rollers for the preparing frames, a work rendered lighter and less costly if a large stock of really good and well-seasoned wood be kept for that purpose. One or two carpenters may be kept constantly employed upon the repairs necessary to keep the buildings and plant in order, re-cover the preparing room rubbers with flannel, etc.

A staff of five or six hackle-setters under a capable foreman will also be required to keep the gills, hackles and card clothing in order. If uninjured by crushes or other accidents, gill pins, as well as hackle and card pins, are cut by the fibre in the course of time, and must be replaced. The cards should be thoroughly examined when being cleaned, and all bent pins set and put in place, spoiled staves replaced or repaired, and the card clothing otherwise kept in perfect order. New gills and hackles must likewise be made and prepared to replace those which become past repair. To make these new gills and hackles, a drilling machine is required, provided with change gearing, ratchets, etc., so that any required number of pins per inch can be spaced off with the greatest nicety.

The Fluting Shop.—The fluting shop for the wet spinning frame pressing rollers is an important branch of the mechanical department, often placed for convenience in close proximity to the spinning room itself. If all or many wooden rollers are used, a considerable number of machines and fluters are required to keep pace with—as compared with indiarubber or guttapercha—the more frequent flutings required to make good work. A twenty or thirty-thousand spindle wet spinning mill will require six to eight single-headed fluting machines with about four attendants.

It is quite worth while to pay a fluting master to look after this important department, as a good spin depends so much upon the quality of the rollers and the wholeness of their flutes. Although the first cost is high, the quality of the yarn is improved by using as much Persian boxwood as possible, as it is very hard and durable and takes a good smooth flute. The fluting master will be kept well employed in properly arranging the work, setting the machines, and maintaining the cutters in good working order. The latter should be sharpened twice a day and turned up once a week.

Boxwood, which is the most suitable wood for fine-spinning bosses, is of such a hard and brittle nature that its working properties are materially improved, its natural oil brought to the surface, and the wood mellowed by a steep of some weeks in water. The exact time required depends upon the quality of the wood and the temperature of the water. An active fermentation should have set in and subsided again, leaving the rollers slimy and oily, before they should be put in use.

The tool for fluting guttapercha and indiarubber bosses is stationary, while that for wood is circular and makes 600 to 800 revolutions per minute. The former cuts cleaner if a drop of water is kept constantly upon it. The diameter of the roller depends upon the pitch and number of flutes upon its periphery. Thus the diameter on the pitch line of a roller of ninety flutes, fluted to 30 per inch, is $\frac{90}{30} = 3$ inches. Its external diameter, or that by which it is gauged, is rather more than this, or the diameter of the pitch circle plus the depth of one flute.

The roller is held horizontally upon centres, moved backwards and forwards under the cutter by a crank, being shifted round at each stroke a distance equivalent to one flute by an index wheel and pawl, the latter actuated by an incline, as the carriage moves backwards and forwards. The cutter is moved upwards and downwards to suit the various diameters of rollers, by means of a screw and hand wheel. Various arrangements are used to fix the exact height of the cutter necessary to give the diameter of roller required by the index used. In one of them, an adjustable screw in the head is tightened down upon one of the steps of a graduated cam turning upon a centre directly underneath. This cam is shaped and stepped to give the diameter of rollers required for any number of flutes when the adjustable screw has been set to give one or any of them. A common way is to set the head by trial for one roller, to mark the position of the hand wheel, and to flute off a number of rollers of similar size by bringing the hand wheel round to the same point each time when lowering the cutter. An improvement upon the latter method is to so arrange the pitch of the screw which raises and lowers the head and cutter, that a half or quarter turn of the hand wheel diminishes the diameter of the roller by an amount corresponding with a given number of flutes. Thus, if in fluting a roller to 30 flutes per inch in diameter, we wish to diminish its diameter each time by an amount corresponding to three flutes, we must lower the head

$\frac{3}{30 \times 2} = \frac{1}{20}$ inch, which may be done by using a screw of ten threads per inch and giving the hand wheel one half turn for each size of roller, or a screw of five threads per inch and a quarter turn, or other similar combination. The edge of the hand wheel should be divided off by a suitable number of nicks, into which presses an adjustable spring. The spring, besides preventing the shifting of the screw by vibration, may be set for one roller, and all the others in the range may be fluted correctly by changing the index wheel and screwing round the hand wheel one or more nicks.

The question of fluting brings us back to the mechanic shop to see the machine used for fluting the long spinning frame rollers. In principle it is much the same as the machine already described. Its movements are, of course, much slower, since the rollers to be fluted are of brass and not of wood or guttapercha. Its fluting tools are stationary, while a very long carriage is moved backward and forward by means of an endless worm turned by bevel gearing, fast and loose pulleys, and quick and slow-speed belts.

The carriage may be arranged to carry two or more lines of rollers, while the head carries a like number of cutters.

During the cutting stroke the slow-speed belt is upon the fast pulley and the quick-speed belt upon the central loose pulley. As the carriage nears the end of its run, it shifts a lever which changes the belt—the slow-speed on to the loose pulley and the quick-speed on to the fast pulley, in order that as little time as possible may be lost in the return or non-effective stroke. The rollers are turned round a distance corresponding with one flute, before each cutting stroke, in a similar manner as in the small fluting machine. The fast and slow-speed belts should be crossed and open, or *vice versâ*, to run the carriage backward and forward.

Scoring Rollers.—Analogous with fluting is the scoring of the calender rollers of a card, the drawing-off rollers of a breaker card, the front roller of a hemp drawing or roving frame, the bosses on a dry spinning frame drawing roller, or the ending rollers of an Erskine ender.

The latter are usually scored in a helical fashion, the roller being turned round to the required extent during the cutting stroke by means of a triangular slide.

Maintenance of Machinery.—Wet spinning frame boss or drawing rollers, if they receive proper treatment, should only require refluting once every six or seven years. If the rove traverse be too short, the bosses scored by the spinner's picker, or the flutes worn down by hard indiarubber pressing, etc., they must be refluted more frequently, decreasing the value of the frame each time. The parts which require the greatest amount of attention and repairs are the boss roller bearings and the spindle steps and collars. The great pressure which the former have to carry, and the high surface speed, as compared with the top roller, of the journals which work in them, cause them to wear down quickly, increasing the projection or the distance back of the face of the drawing roller from the line of the spindle, and, consequently, the bearing upon the thread plate eye and the strain upon the yarn. Once every year at least, then, should the boss roller bearings be lined up and replaced by new brasses as soon as they get too thin. As long as sufficient body of metal remains, it is sufficient to "pack" them outwards by putting pieces of tin or sheet iron underneath or behind them in their seats. The mechanics who have charge of this work should be provided with a template, or short piece of roller, with one or two bosses of the proper size upon it. With the aid of this template they set the two end bearings at either side at the proper distance back from the spindle line, and then stretching a fine whipcord line tightly across from one end to the other in the centre of the brasses, and another cord on their bottom lips, they insert the remaining brasses and "pack" them out to this line. The greatest care should be taken that these brasses are tightly driven into their seats, for if they be not, they will retreat when the pressure goes on, and be worthless as a firm and stable bearing. The top roller brasses require to be replaced much less frequently, but should be re-lined up at the same time as those of the bottom roller. A change in the angle made by a line passing over the faces of the top and bottom rollers makes a great difference in the distribution of the pressure upon the rollers and the portion of the pressure applied, which is lost or rendered ineffective as an upward or downward thrust upon the stand that carries the saddle.

When the rove is suddenly broken off short in the reach, too large an angle frequently causes it to lap upon the top roller instead of continuing to fall downwards, as it should do until again caught by the drawing rollers.

Excessive wear in the spindle bearings, of both dry and wet frames, is as detrimental to a good spin as is a boss roller which is too far back or out of line. It causes the spindle to bounce and vibrate to such an extent as to render it impossible to spin a fine or weak yarn. If either the spindle neck or collar is too much worn, the latter must be replaced by a new one bored out an exact fit for the existing spindle neck, or the spindle must be changed for one having a neck of large diameter. Which of these courses will be found cheapest and most expedient depends upon the state of wear of the other parts of the spindle, notably the blade and top. If these parts be much worn, it is advisable to renew the spindle and save the collars; if the spindle is good, preserve it and renew the collars. End play in the spindle, producing bouncing, and caused by wear in the spindle step or bottom of neck collar, may be cured by inserting a thin zinc washer between the step rail and the rim of the brass step. The collar upon the spindle between its butt and neck is thus brought into contact with the brass neck collar, effectually preventing bouncing of the spindle. The brass neck collars are secured in the neck rail by means of screws, which must be kept tight. The neck rail is apt to become bowed and out of line through being frequently struck by the hanging and swinging drag weights.

This constant striking causes an extension in the side struck, so that the rail is bowed outwards and must be straightened by blows upon the other side.

To maintain a good spin and perfectly formed bobbins, the builders and builder motion must be kept in good repair. Owing to the weight of the drags upon the front of the builder plates the holes in the latter, into which fit the conical ends of the poker rods, are apt to wear, allowing the builders to tilt forward, perhaps to such an extent that they touch and wear the spindle blade, or in any case form an imperfect bearing for the bobbins. The builder plates also wear around the spindle holes, where the bases of the bobbins rest upon them, and should be replaned periodically, especially if a change in the form or dimensions of the bobbin base be contemplated.

The thread plate eyes, too, cut more or less quickly, according to the nature of the yarn which has been spun through them.

A warp yarn, spun, as it should be, under a heavy drag and high tension, will naturally cut the eye more quickly than will a weft yarn spun under a low tension.

The thread plate eyes are short lengths of brass rod, set and riveted in the cast iron thread plate, immediately over the top of the spindle. The eyehole is bored through the centre of the brass and communicates with the outside of the plate by a slot, through which the end is passed. When this eyelet, as we have said, becomes cut, the eye must be knocked out and a fresh one put in. It is convenient to cast the brass eyes in round bars and to cut them off with a saw in lengths slightly greater than the thickness of the thread plate. The brass trough lip and the brass rove guides in the trough and creel will also wear and cut in time, in consequence of the passage of the rove over them, and must be shifted and replaced periodically. When new collars and steps are made for a frame they should be left tight, in order that they may be rimed out an exact fit after insertion in the bars.

Turning again to preparing machinery, the chief wear and tear is found in those parts which run at the highest speeds and do the most work. In the drawing frames it is the slides, screws and cams which require most attention; while in the roving frame we have in addition to keep the parts of the differential winding motion, the studs of the twist gearing, and the spindle bearings in good order. As regards the faller slides, it is the back and front end of the top and the front end of the bottom slide which wear the most. The top slide wears short in consequence of the passage of the faller up and down at the back and front respectively. The bottom slide is grooved at the front where the faller touches it as it falls from the top slide. When the top slide becomes too short, there is an excess of play room for the faller in rising and falling, for which reason it frequently turns and jams. This slide can often be sufficiently lengthened by heating the ends and striking the under sides in such a way that a hollow is formed and the length of the slide considerably increased, its thickness being maintained. The cam upon the bottom screw, which lifts the faller on to the top slide, is the one which wears most. Like the other cams, it should be of the best tempered steel and specially case-hardened. To facilitate their being changed, these cams have usually a tailpiece which, passing through a slot in the end of the screw, enables them to be keyed to the latter. They must be carefully shaped to pass between the threads of their corresponding screws. It occasionally happens that a piece of the square screw thread is broken out. When this occurs it is best to dovetail and braze in another piece of steel, shaping it so as to render the thread true and continuous.

The "turning up" or sliding of the drawing frame and roving frame front rollers is a work for the iron turner, a work rendered necessary by the wear occasioned by the friction of the outside edges of the wooden pressing rollers upon it. As we believe that the reason for this occurrence is not generally understood, we will explain it. The boss or front roller revolves with a given angular velocity or surface speed. The outside surface speed of the sliver which passes over it is greater in consequence of the radius of the roller being increased by the thickness of the sliver. The surface speed of the sliver is imparted to the wooden pressing roller which rides upon it, consequently the wooden roller has a higher surface speed than the metal boss roller, a result which is intensified with regard to the edges of the wooden roller when the latter becomes indented over that part of its face which covers the sliver. This grooving of the boss roller is prevented, or at any rate diminished, by the traversing motion shown in fig. 40, which is now generally applied to all frames except the spread-board. When this motion is applied the journals are made extra long, and the roller given a very slow longitudinal reciprocating motion by means of a combination of lever, eccentric, worm, and worm wheel and ratchet and pawl, actuated, in the case of the drawing frame, by a crank and connecting rod, and often, in the case of the roving frame, by the up-and-down motion of the builder. Needless to say, this motion is equally advantageous for increasing the life of the journals upon which the roller turns. The brasses or bearings of the front roller wear down in time and must be packed up or replaced, else the top surface of the roller will become too low, and the fibres in being drafted, touch and cut the brass gill stocks.

"White metal" bearings give very good results in preparing machinery, although their use for wet spinning is not to be advocated. Brasses may be repaired with white metal by placing them between end pieces prepared to receive, at the proper height, a template journal or core which, being placed in position, enables the molten metal to be poured in and a serviceable bearing formed.

The back retaining or feed rollers are apt to wear outwards in consequence of the weight and thrust of the "jockey" roller upon them. When this occurs with that roller which is towards the front of the frame, it is apt to make it come in contact with the gills as the faller rises, if the nip be very short. If there be but one delivery per head on a drawing frame, or when, under certain circumstances, the bosses upon the delivery roller are not symmetrically placed with regard to the bearings of that roller, the latter wears down to that side upon which is the boss, in consequence of the weight of the calender roller upon it. There should be no wear upon the supports or U's of the pressing rollers if brass or cast iron washers are always used upon the ends of the roller axles. They may be occasionally broken, however, by laps which, when "licking up" is prevalent, are apt to gather upon the end of the roller axle. If the support of one of the calender rollers is broken it should be replaced by another, or patched in such a way that its exact length is preserved, for, if the supports on either side be of unequal length, the calender roller will ride askew upon its boss and a drawn, unsightly and imperfect sliver be produced.

The remarks made in connection with the spinning frame spindles apply equally to those of the roving frame and twisting frame, although the same nicety of adjustment is not absolutely essential. An unbalanced flyer, or one with an arm broken, should never be allowed to continue in use, as the throw occasioned wears out the collar and at once causes the spindle to wobble.

The pins in the roving frame flyer heads will have to be renewed from time to time, as may also those in the bobbin carriers. The studs carrying intermediates, or double wheels, in frames of every description, must be kept thoroughly oiled, else constant repairs will be rendered necessary.

Lubrication.—Good lubrication in a mill is of paramount importance in saving of coal and cost of repairs. It has as its object the reduction of friction between two parts of a machine which must necessarily rub one over the other. These parts are sometimes flat surfaces, as in the case of the cross head of a horizontal steam engine, slipping along in its guides or slides, but more often they are a journal or cylindrical body and a hollowed-out bearing.

All metals are of more or less granular or crystalline structure, and when viewed under the microscope appear porous. Even when smooth to the naked eye, they are not really smooth, but only comparatively so, so that when moved one over the other their surfaces interlock more or less, causing friction or resistance to motion.

Friction is reduced and perhaps sometimes almost eliminated by lubrication, or, in other words, by the insertion of a thin film of oil, etc., between the rubbing surfaces. The quality of the oil required depends chiefly upon the pressure which exists between the surfaces to be lubricated.

If a heavy journal be oiled with a light mineral oil, for instance, the lubricant will be squeezed out by the pressure exerted upon it, and will not be allowed to remain and form the oil layer required to keep the surfaces apart.

For such a journal—the crank-shaft bearing, for instance—an oil of considerable body or consistency is required. For a light bearing, on the other hand—such, for instance, as the neck and collar of a fine spinning spindle—a light oil, but one of really good lubricating power, such as Arctic sperm, is required. If a heavy oil were used for this purpose, although keeping the surfaces apart, it would retard the speed of a light and quick-running spindle and make the frame heavy to drive.

The cheapest form of lubricant is oil of mineral origin, sometimes called Oleonapthe I., II., etc. This oil, produced chiefly in the distillation of the illuminating oils, is lacking in body, but is of high specific gravity. Alone, these oils are rather poor lubricants, but are useful when mixed with vegetable and animal oils of low gravity. A mixture composed of three parts of best mineral or Oleonapthe II., and one part sperm or lard oil, for instance, forms a good and cheap ordinary spindle and light machinery oil. For fine work, however, it is best to employ the best sperm oil only. Pure mineral oil is not a good lubricant for wet spinning, as water will not combine with it. It is not retained between the spindle neck and collar, but is washed out or runs down the spindle butt.

Water will combine with a vegetable oil, forming a greasy emulsion. For this reason, rape or colza oil is much used in the spinning room in a pure state, to grease the spindle blades; or, mixed with mineral oil, to lubricate the spindle.

It is difficult to make a proper mixture of vegetable and mineral oil without raising the temperature of both, as they will not combine when cold. It is dangerous to use any oil that has a low flash-point—that is to say, one which gives off an inflammable vapour at a comparatively low temperature, say 150° F. Such an oil, if used on a heated journal, may cause a fire, especially if a light be brought near it and into contact with the inflammable vapour given off.

Although a heated journal should be unknown in a well-regulated mill, if such should occur, it should be cooled down by a copious supply of soapy water. Indeed with some badly-designed or overloaded engines it has been found necessary to supply the crank-shaft bearings or those of the first motion shaft with a tank and supply pipe for soapy water, or with a supply of cold water which may have to be kept running all day. A cooling mixture which has been recommended for hot journals is formed by boiling together 4 lbs. of palm oil, 4 lbs. of tallow, 2 lbs. of salt, 2 lbs. of sulphur, 2 lbs. of blacklead, $\frac{1}{2}$ lb. saltpetre, and $\frac{1}{2}$ lb. of antimony, to which, after straining, should be added $\frac{1}{4}$ lb. of hartshorn and $\frac{1}{4}$ lb. of soap linament. Blacklead is often a useful substitute for a liquid lubricant where the presence of black oil is a disadvantage.

Mixed with tallow for guide pulley greases it is again useful, and in the form of the Belleville packing is one of the best materials the author has met with for the stuffing-box of the Corliss valve spindle.

Blacklead does not lubricate as does an oil, but rather fills up the pores in the rubbing surfaces, and forms a fine skin which facilitates the motion of the parts the one over the other.

The various greases supplied for lubricating purposes are economical, if properly applied, from the fact that they only run when required, or when the bearing, becoming hot, melts them. For this reason, tallow or mica grease may be advantageously used as a reserve in the oil-boxes of cards, or in the covers of preparing frame front roller bearings. In the former case the hard grease should rise above the oil holes which are left uncovered by grease, in order that a little oil may be given before the morning start. If the journal tends to heat during the course of the day, the grease melts, and supplies the oil required. In a similar manner, the grease contained in the boss roller journal covers remains solid until oil is required, when it furnishes the requisite supply.

Grease is almost universally employed in lubricating fans. If a Stauffer or similar lubricator be used on the end of a pipe communicating with the oil hole in the bearing, the fan, even when set in a window or outside wall, may be effectively lubricated from the interior of the building without the trouble and risk of getting to the outside. Grease lubricators should be on the "tell-tale" principle, that is to say, with a piston and spring for pushing on the grease, and a projecting knob, which shows how much grease remains in the lubricator. The greases most in use are the Stauffer, King-fisher, Mica, and the various petroleum products.

One of the most important oils, both as regards quantity and quality, required in an establishment, is that for lubricating the inside surface of the steam cylinders. For this purpose an oil is required which remains undecomposed under the combined action of heat and pressure. The best cylinder oils are of mineral origin, are often of a dark colour, and, what is essential in this class of lubricant, have a very high flash and igniting point, 500° F. and 550° F. respectively.

All oils, especially those of a dark colour, should be well filtered previous to use, in order to remove sand or other foreign substances which would cut up and spoil the bearing. An oil should be able to stand cold as well as heat without solidifying, for upon a cold frosty morning the load upon the engine is often considerably increased, for the reason that the oil in many of the bearings has become more viscid, if not actually congealed.

Oil Testing.—It is important that the manager or engineer of a mill should, from time to time, test the oils with which he is being supplied, to ascertain if they are quite suitable for the work, that they are unadulterated, and that the quality is being kept up. There is so much trickery carried on in the oil trade, that it is advisable to deal only with houses of standing, who have a reputation to keep up. The tests usually applied have as their object to ascertain the specific gravity, the body or fluidity, the flash-point, and the presence of acids in the oil.

Specific gravity is the weight of a given volume of oil compared with that of the same volume of water. The weight of a cubic foot of water is 1000 ozs., so that the weight in ounces of a cubic foot of oil actually represents its specific gravity in degrees. In practice, it is more usual and convenient to employ an instrument called a hydrometer in ascertaining the specific gravity of liquids. This instrument consists of a long glass stem, hermetically sealed, and terminating in a bulb loaded with quicksilver, etc. When plunged in a liquid, it stands and floats upright, its centre of gravity being very low down. The stem is graduated. The point to which the surface of the liquid, when the latter is water, reaches, may be marked 1000, and the other divisions marked off by trial in liquids of known specific gravity.

Specific gravities should be taken at the standard temperature of 60° F., or 15° C., for 5° F. makes a difference of 2° in the gravity of the oil. The following list shows the specific gravity of the more usual mill oils :—Water = 1 ; rape seed oil or colza = ·914 ; olive oil = ·914 ; raw linseed oil = ·929 ; castor oil = ·966 ; Arctic sperm = ·881 ; tallow = ·913 ; neatsfoot oil = ·914 ; lard oil = ·917 ; sperm or whale oil = ·925 ; mineral = ·886 ; Oleonapthe I. = ·920 ; Oleonapthe II. = ·900. An oil of high specific gravity does not of necessity possess much body. The body or fluidity of the oil is most easily tested by means of a pipette or graduated glass tube, provided with a small hole at one end and open at the other.

Comparative tests may then be made by drawing up a given quantity of oil into the tube, and watching the time it takes to empty itself drop by drop. Distilled water may again be used as a standard.

The flash-point of an oil may be determined by heating a small quantity in an open vessel in a spot protected from draughts, which would dispel the vapours given off. From time to time a lighted match should be passed over the mouth of the vessel. When the vapour catches fire, the temperature of the oil or the flash-point is noted. To test for the acids which are sometimes present in oils which have been chemically refined or which have been developed by fermentation in vegetable or animal oils, a very good way is to put a sample in a glass bottle with a clean copper wire running air-tight through the cork. Place the bottle in a sunny window for a few weeks, and watch for the appearance of verdigris on the copper. If such appears, there are traces of acid in the oil which will act injuriously on the bearings of any machine to which it is applied.

Self-oiling Pedestals and Bearings.—Shafting turns in pedestals, supported in wall boxes, or upon beams, brackets or hangers. The old-fashioned pedestal has ordinary solid brass bearings, generally grooved to retain the oil, which is supplied by an oil bottle and needle lubricator fixed in the cap. Of late years oil bottles have been replaced in many instances by tell-tale lubricators for Kingfisher, mica or other grease. Several forms of self-oiling pedestals are in extensive use. One form has an oil reservoir underneath the brass, into which dip one or more endless chains, or wire or metal rings, which lie upon the upper surface of the shaft, and are there caused to revolve and carry up the oil with them. The oil as it runs from the end of the bearing is caught in an oil dish at each end and returned to the oil reservoir to be used over again. These pedestals work well if the dirty oil be drawn off periodically from the bottom of the reservoir; if this be not attended to, the chains will stick and become useless.

For heavy first or second motion shaft bearings, Mohler's patent self-lubricating bearing is the best the author has seen. The shaft has a cast iron collar fast upon it in the centre of the bearing, which collar works in corresponding grooves in top and bottom brasses. The bottom groove communicates with an oil reservoir under the bearing, so that the revolving collar carries up a good deal of oil with it. The upper part of the groove in the top brass is open, and has in it a scraper which scrapes off the oil carried up by the collar and spreads it over the surface of the journal.

Lubricators.—Lubricators for use upon the steam engine are usually of the adjustable needle type, by means of which any given number of drops per minute may be allowed to fall upon the bearing. There are also ingeniously devised lubricators by means of which measured quantities of oil are pumped into the cylinder against steam pressure, and the crank-shaft bearings, crank pins, etc., kept constantly lubricated with oil which circulates round and round, and is filtered and used over and over again. The waste oil which accumulates in the zinc trays placed underneath the cranks, etc., should be carefully filtered and used for unimportant bearings.

Indicator Trials.—Trials may be made as to the relative values of the different oils for the engine and shafting, spinning room, etc., by the use of the steam engine indicator noticed in Chapter XX.