CHAPTER VII.

THE PREPARING DEPARTMENT—SLIVER FORMATION.

Spread-boards.—The first step towards the production of a continuous thread from the disjointed fibres is the formation of a fibrous ribbon, technically known as a "sliver." This, in the case of long and valuable fibre, is done upon spread-boards, such as are shown in figs. 23, 24, 27, 28, and 29. The first two show the type used for flax, soft hemp, and jute long line. The latter three are descriptive of Good's combined hackler and spreader for Manila and New Zealand fibre.

The spread-board, figs. 23 and 24, consists of a table 2 to 4 feet broad, and, say, 6 feet long, over the surface of which four, six, or eight endless leathers A, are carried by means of rollers at either end. The leathers deliver the fibre through conductors to the feed rollers B B, and thence into the gill box C, which is rectangular in form and contains fallers upon which gills are fixed. The fallers are thin but deep bars extending parallel with the feed rollers, and resting at the ends upon top and bottom slides, the ends themselves being formed to work in the square threads of revolving screws, by means of which those upon the top slide are moved forward from the feed rollers and those upon the bottom slide in the opposite direction. The bottom screws are coarser, since they are only employed to conduct the fallers back again to the feed rollers, where they are raised by a tappet into the top screw and on to the top slide, where they conduct the fibre forward to the boss roller D, and are then knocked down by another tappet into the bottom screw and on to the bottom slide, there to repeat the motion. Spring or weighted guides are provided at each end of the slides to regulate the rise and fall of the bars front and back. The back end of the top slide is shaped to work in a groove in the faller end to assist in keeping them in correct position. The guard or guide at the front works in the same groove with the same object. In consequence of the wear and tear in the fallers and slides, entailed by the fall of the former, the spread-board is usually provided with levers actuated from the screw, which receive the faller as it leaves the top slide and deposit it upon the lower. In a spread-board the slides are usually inclined from back to front, to give the necessary height for a can at the front and a convenient height of table at the back. In the older machines the front end of the screws work in steel plates which are subject to wear, the working surfaces

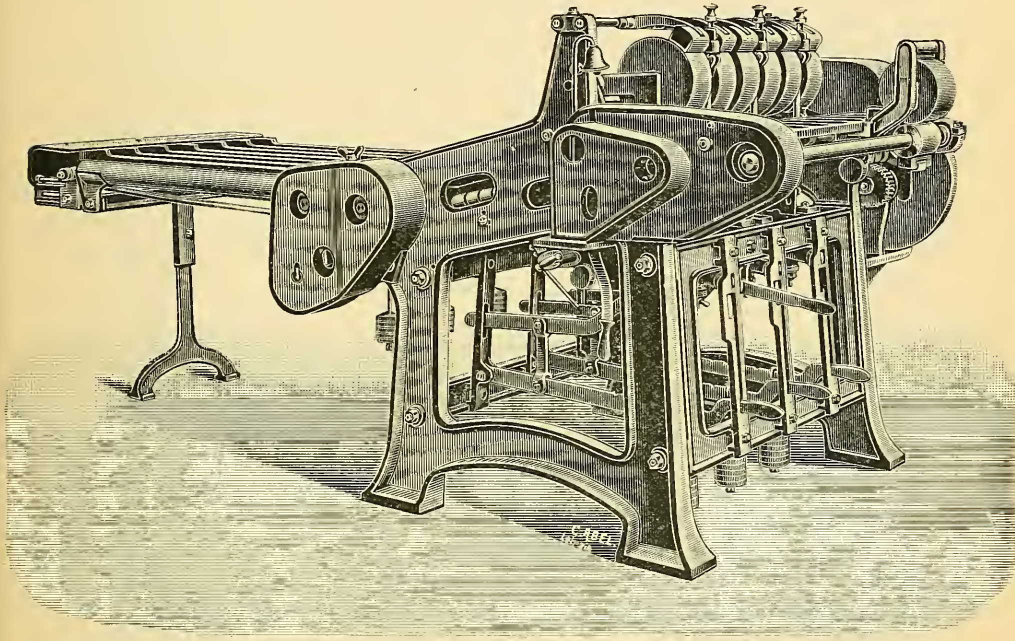

FIG. 23.—Spread-board for flax and hemp. (Made by Oscar Schimmel & Co., Chemnitz, Saxony.)

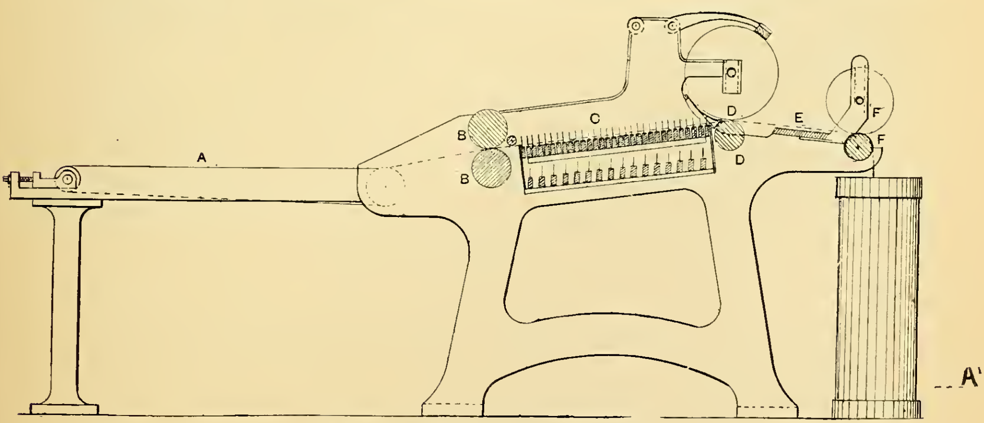

FIG. 24.—Long line spread-board.

being difficult to lubricate. The newer plan of partially surrounding the body of the screw with a cast iron block is much more satisfactory and durable. The fallers are of wrought iron with steel ends, the brass stocks of the gills being riveted on. The liability of the brass gill stock to become detached, and the weakening effect of the rivet through the faller, so often leading to jams and broken fallers, has led to various attempts to dispense with gill stocks by inserting longer pins directly in the faller bar itself. This method, no doubt, gives a firm gill, but it is difficult of construction and repair, since the faller bar is often more than 1 inch in depth, rendering the drilling of fine holes difficult in the extreme. Repairs can also be effected with the minimum loss of time when the gills are detachable, since they may be prepared beforehand and only require riveting on.

When the fallers rise close to the feed rollers B, the pins of the gills penetrate the fibre, which is conducted forward by them to the boss or drawing roller D. This roller has a surface speed ten to thirty times that of the feed or retaining rollers B. The fibre is consequently drawn through the gills, leading to a still further subdivision of the fibres. The gills govern the delivery of the fibre to the drawing rollers D, and prevent it from being "gulped" or drawn away irregularly, forming thick and thin places in the sliver. In order that the gills may do their work effectively they must "pin" the sliver properly—that is to say, the fibre must not ride over the top of the pins, but must be completely below the surface. When the fibre is rather stiff and hard or the gill rather fine, a small iron rod inserted between the delivery point of the feed rollers and the fallers, as shown in fig. 24, will be found to be a great aid towards good pinning. Usually it is merely necessary to keep the sliver tight in order that the gill may penetrate it. To keep the sliver tight the faller is given a small "lead" or greater surface speed than that of the feed roller. The "lead of the faller" is usually from 2 to 5 per cent.

To find the "Lead of Faller."—Suppose, for instance, that a wheel of 76 teeth, on the feed roller, gears into a stud pinion of 27 teeth, compounded with a stud wheel of 75 teeth, driving the back shaft by means of a pinion of 20 teeth. Upon the back shaft a bevel pinion, of 32 teeth, drives another of 20 teeth on the top screw. The pitch of the screw being $\frac{1}{2}$ inch, the faller moves forward $\frac{76 \times 75 \times 32 \times 1}{27 \times 20 \times 20 \times 2} = 8{\cdot}44$ inches for each revolution of the feed roller. The feed roller being $2\frac{3}{5}$ inches in diameter, it delivers to the fallers $2{\cdot}6 \times 3{\cdot}1416 = 8{\cdot}17$ inches in the same time. The faller, therefore, has a lead of $8{\cdot}44 - 8{\cdot}17 = {\cdot}27$ inch for each revolution of the feed roller, or a gain of $3\frac{1}{3}$ per cent.

To assist in obtaining the thorough pinning of the sliver, the position of the feed roller may be so arranged that its delivery surface is slightly below the top of the gill stock and the root of the pin. In front, however, the nip of the drawing rollers D must be above the top of the gill stock, lest the latter be cut by the fibre being drawn over it. The fibres being drawn through the gill and a conductor slightly narrower than the gill, they are rendered quite parallel and formed into a sliver of uniform width. Each of the four, six or eight slivers issuing from the rollers D, is passed through a separate slot in a doubling plate E, such as is shown in fig. 41 or at V in fig. 38, and all out again through another slot, the tension being maintained by means of a pair of delivery rollers F, having a slight lead, which, drawing the sliver through a conductor, deposit it in a can A′. If the doubling plate be properly slotted, *i.e.* with slots at an angle of 45° to the boss roller, and the correct tension maintained, each of the layers composing the compound sliver will ride evenly one on the top of the other, and a perfect sliver be produced. If the doubling plate be defective, or the tension of one or all of the slivers be unequal, a bad result will be obtained. It will generally be found that it is the second sliver from the delivery roller which runs slackest on the doubling plate, the reason being that it is this sliver which, when all are brought together, lies against the surface of the delivery roller and has its proper surface speed. The others lie further from the centre of the roller and consequently have a higher surface speed, the effective diameter of the delivery roller being, as far as the outside sliver is concerned, its own diameter *plus* twice the thickness of the combined sliver.

"*Bell Motion.*"—A bell mechanism, such as is shown in fig. 38, is generally used in connection with this class of spread-board. Its object is to measure off a certain length of sliver, say 400, 600, 800 or 1000 yards, into the can.

The "length of bell" is calculated as follows:—Suppose that the single threaded worm F on the end of the delivery roller drives a worm wheel A′ of 37 teeth, upon the pap of which is another worm C′, driving the bell wheel B′, which has 103 teeth. For one revolution of the bell wheel B′, the delivery roller makes $103 \times 37 = 3811$ revolutions. If its diameter be 3 inches and its circumference consequently $3 \times 3{\cdot}1416 = 9{\cdot}4248$ inches, $\frac{3811 \times 9{\cdot}4248}{36} = 1000$ yards will be delivered for each revolution of the bell wheel. If that wheel have but one ringing peg in it, the bell will ring for every 1000 yards. If the bell wheel have two pegs in it, as it sometimes has, only 500 yards will be delivered between the times of the ringing of the bell.

The screws, fallers, gills, slides, screw blocks, cams and guides are shown in detail in fig. 38. L L are the screws, M and D are faller bars, N is the knocking-down tappet of the top screw, O is the lifting tappet on the bottom screw, P is a faller guide, Q is one of the levers for depositing the faller on the bottom slide, and R are the screw blocks.

Back and Front Conductors.—The conductors behind the feed and delivery rollers are in two pieces and fixed at the required distance apart by means of screws. The boss roller conductors are either fixed or, preferably, loose. The fixed conductors are attached by set screws and steady pins to a bar running behind the roller. The loose conductor has often a projecting hook behind, which hangs on a rod corresponding to the conductor bar, or the conductor may merely lie against the bar. The front portion of the conductor is circled to half surround the boss roller, the toe projecting right into the nip of the rollers. The top face of the conductor is hollowed out to correspond with the curve of the largest pressing roller to be worked. The maximum and minimum size of pressing roller is limited by the height of the U's or supports which receive the ends of the axle upon which each pair of rollers is rigidly fixed. Brass or cast iron washers are provided to prevent the ends of the revolving axle from wearing the U's. The conductors and rollers are placed exactly opposite the rows of gills from which the sliver is to be drawn. The loose conductors have lugs between which the bosses of the pressing rollers work, the conductors being thus kept in their proper position. This is the point in which, in the author's opinion, the loose conductor is superior to the fast. With a fast conductor, if the pressing roller be not quite accurate in pitch or truth, the mouth of the conductor may not be quite covered during a part or the whole of a revolution. The fibre issuing from the uncovered portion is not drawn away regularly but comes away periodically in slubs or lumps which the subsequent processes cannot eliminate.

Sometimes a lump may cause the wooden roller to stick. When this occurs the sliver, which is being brought forward by the gill, is not drawn away but accumulates behind the conductor, often twisting a fast conductor and smashing the gills before it is noticed. The wood roller must be taken out, when the conductor can be slackened and the accumulation and obstruction removed. A loose conductor can be lifted out and replaced with greater ease, in addition to which the damage done when an accident of this kind occurs is much reduced, since the conductor, not being rigidly secured, gives way before the growth of the accumulation, thus saving the fallers and gills from being broken or crushed.

A considerable amount of pressure is required between the drawing rollers to draw the fibres at a fair speed from the gills. The pressure is applied by means of simple or compound levers placed underneath and fulcrumed in the framing of the machine. The levers draw the pressing rollers downwards by means of a rod known as the "spring-wire," with a hanger on the upper end, which encircles that portion of the arbour between the bosses of each respective pair of rollers. The pressure upon each pair of bosses may be from 250 lbs. to 1500 lbs., depending upon the breadth of the conductor. Given a sufficiently long reach, *i.e.* longer than the longest fibre, the pressure per inch in breadth of the conductor depends upon the loading of the gill, the closeness of the pins, the length of the fibre, and consequently the number of gills through which it has to be drawn. It is better to have a margin to draw upon when extra power is required, as it would be were the sliver twisted in the gill, since, if the drawing rollers are unable to draw the fibre from the gills, lumps are produced which the following equalising operations cannot completely eliminate.

The way to calculate the leverage or pressure exerted upon the rollers is as follows:—Supposing that a simple lever be employed, the weight used being 30 lbs., and placed at a distance of 40 inches from the fulcrum or working centre of the lever. The "spring-wire" is attached at a point 2 inches from the fulcrum. The pressure upon the bosses, as usually calculated, and neglecting the weight of the lever itself and the angle of the "spring-wire," is then $\frac{30 \times 40}{2} = 600$ lbs.

With two levers, one with a weight of 12 lbs. attached to a point 24 inches from its fulcrum, and compounded with another by means of a link pivoted at a point 3 inches from the fulcrum of the first and 24 inches from the fulcrum of the second, the "spring-wire" being attached at a point 2 inches from the fulcrum of the latter, the total pressure upon the roller, calculated as before, is now $\frac{12 \times 24 \times 24}{3 \times 2} = 1152$ lbs.

With the same two levers, combined with a swinging jib fulcrumed upon a shaft 9 inches behind the centre of the roller arbour, the spring-wire being attached at a point 12 inches from the same fulcrum, the pressure is now $\frac{12 \times 24 \times 24 \times 12}{3 \times 2 \times 9} = 1536$ lbs.

In practice, the weight of the levers themselves is usually neglected, but it should not be so, since their weight increases the actual pressure considerably. With two levers the effect would be the same as another weight equal to that of the levers, acting upon the upper lever at a point corresponding to the centre of gravity of the system, or the point from which the levers, if detached, might be suspended in equilibrium. The spring-wire is always inclined at an angle of, say, 30° to the vertical, since its point of attachment with the levers is not directly under the rollers, nor is the point of contact of the rollers exactly on the top, but a few degrees forward from the centre. The effect of this is to increase the pressure by an amount which may be obtained from the equation $b = \frac{a}{\cos \theta}$, where b = the actual pressure, a = the calculated pressure, and θ the angle at which the spring-wire is inclined to the vertical. The effect of these combined factors, *i.e.* the weight of the levers and the inclination of the spring-wire, may be ascertained by inserting a Salter's spring balance in the place of the spring-wire, tightening up until the levers are in suspension, and reading off the tension shown on the scale.

The feed and drawing rollers are of steel. The former is always plain. The latter is sometimes scored to increase its drawing capacity. The feed pressing rollers often press upon the roller underneath merely by their own weight, although the pressure is sometimes increased by means of levers and weights. The drawing pressing rollers, to which great pressure is applied as we have described, are of wood when flax is being dealt with. For jute a leather apron usually envelops the boss to increase its grip, while for the long and hard fibre of Manila, the front pressing rollers are better if made of pieces of leather, on edge, bolted between two steel flanges. For wooden rollers, alder, mahogany, satinwood and boxwood are most used. The two former woods are those usually employed when the boss is fairly wide, and the latter or harder woods for narrow-faced rollers. For coarse hemp, the ordinary boss roller with its pressing roller are sometimes replaced by Lawson's drawing head, as shown in fig. 25.

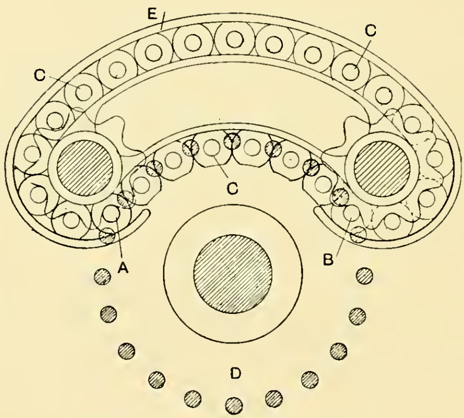

Fig. 25.—Lawson's drawing head.

Here an extended and interlocking holding surface A to B is formed by means of a series of loose-driven holding bars C, interlocking with the bars of a lantern wheel D, such loose bars being guided in their course by an endless race E. The material lies between the loose bars and those of the lantern wheel, where it is so tightly interlocked that the mechanism forms a very efficient drawing arrangement, and one which will wear for a long time if due care be exercised to prevent the bars being bent by lumps, etc.

The delivering roller is likewise of steel, with one or more enlarged bosses upon it. Upon these bosses, and supported by U's, lie the delivery pressing bosses, of metal, of large diameter and heavy. The surface speed of the delivery boss should be slightly superior to that of the drawing roller, in order that the slivers may be kept tight upon the doubling plate. If it have too great a lead the sliver will have a drawn and wavy appearance, while if the tension of the slivers be insufficient the resulting sliver is equally unsatisfactory.

Rubbers are used to prevent loose fibres from lapping round any of the revolving rollers between which they pass. They are either of the "dead"

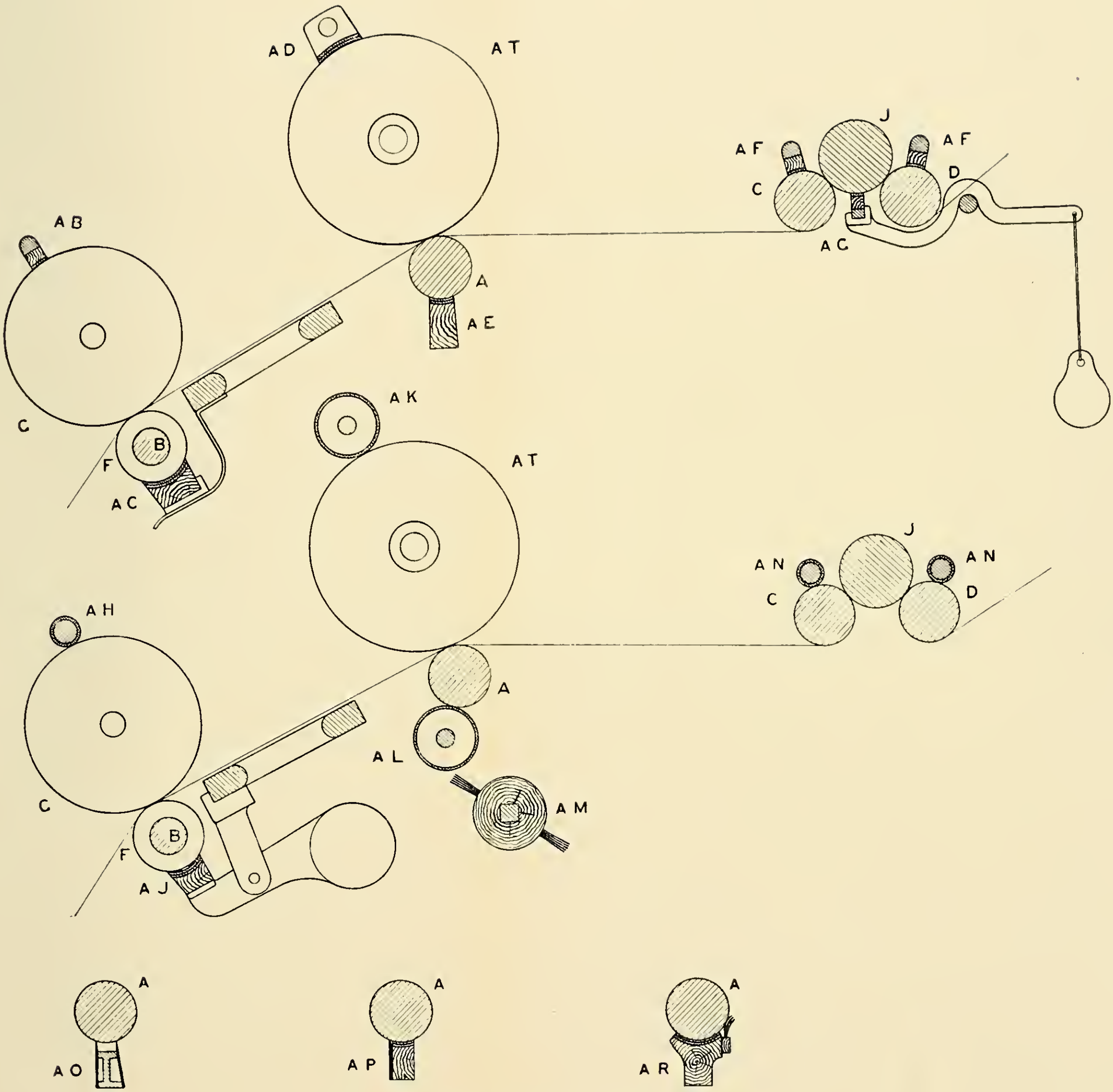

FIG. 26.—Rubbers for drawing frames.

or of the revolving type. Some examples of both, as applied to a drawing frame, are shown in fig. 26.

In this figure, A represents the boss or drawing roller, and A T its wooden pressing roller. B is the delivery shaft, with the boss F "sweated" upon it, and G is the calender or pressing roller which lies upon the boss F. A B, A D, and A F are different forms of pressing rubbers, dead, or pressing upon the rollers by reason of their own weight only. A C, A E, A O, A B, and A R are types of dead rubbers placed underneath rollers and pressed upwards by means of springs. A G and A J are similar rubbers pressed upwards by means of weighted levers, and A H, A K, A L, and A N are revolving rubbers driven by means of spur gearing *in the same direction* as, and consequently rubbing against, the bosses on which they press. The body of the rubber is of wood or metal, or both. The rubbing surface is covered with one or two layers of felt or thick flannel, which in the case of dead rubbers is glued on, and in the case of revolving rubbers, sewn on. Revolving rubbers obtain their motion from a spur pinion which is fixed upon the end of the roller against which they lie. When there is more than one revolving rubber boss upon the same rubber shaft, as is the case with the rubber A L, care must be taken that the flannel is all of the same thickness, or that the bosses are all of exactly the same diameter, otherwise some of the bosses will not enter into sufficiently close contact with the roller, and consequently will not act effectively in preventing laps. Dead rubber and the revolving ones A H, A K, and A N, which can be lifted out or raised, are cleaned periodically by hand. The rubbers A L, which are difficult to remove, are kept clean by means of the revolving brush A M, as shown in the figure. Care must be taken that rubbers acting upon pressing rollers are not too heavy, as when this is the case the proper revolution of those rollers may be impeded.

Draft Calculation.—As in most classes of spinning machinery in which the material is drawn out or elongated, the draft of the spread-board is produced by the greater surface speed of the drawing roller as compared with that of the feed roller. An example will suffice to show the method by which the theoretical draft may be calculated. A certain spread-board has a back or feed roller $2\frac{1}{4}$ inches in diameter. A wheel of 56 teeth is keyed upon the end of this roller and is called the feed roller wheel. This wheel drives a stud pinion of 20 teeth, compounded with a stud wheel of 130 teeth. The latter drives the back shaft through a pinion of 19 teeth, called the back shaft pinion. Upon the other end of the back shaft is fixed the draft "change" wheel, which we will say has 60 teeth. This draft change wheel drives the boss roller pinion of 38 teeth through a series of simple spur carriers or intermediates. The boss roller has the same diameter as the feed roller, namely, $2\frac{1}{4}$ inches. The circumference of these two rollers, bearing the same fixed ratio to their diameters, and taking the surface speed of the back roller as 1, we find that the surface speed of the boss or drawing roller is $\frac{1 \times 56 \times 130 \times 60}{20 \times 19 \times 38} = 30$, which is also the theoretical draft. The actual draft is rather less than this, being influenced by the thickness of the material between the rollers. The undrafted sliver held between the back rollers is, of course, thicker than the attenuated sliver held by the boss roller, hence the actual draft is shorter than the theoretical; to allow for this factor when calculating the draft, the diameter of the roller should, properly speaking, be considered to be augmented by half the thickness of the sliver passing over it. Had the diameters of back and drawing rollers not been the same, we should, in addition, have had to multiply by the diameter of the boss roller and divide by that of the back roller to obtain the draft.

Spreading.—The operation of spreading consists in spreading handfuls of fibre lengthwise upon the travelling leather A, or feed sheet of the spread-board, one piece overlapping the end of another in such a way that a continuous ribbon is formed, which, being delivered by the feed rollers B to the gills, is by them conveyed to the boss roller and drawn out or drafted and the fibres parallelised in their passage through the gills. Good spreading consists not only in the production of cans of sliver of very similar weight, but also of sliver regular in grist and weight from yard to yard.

For fine work the production of a uniform length of sliver from a given weight of fibre is usually left to the skill of the spreader, who, with constant practice, can hit off the weight very correctly. A method of obtaining, from the spread-board, cans of uniform length and weight, and which is often employed in medium and coarse mills, is known as the "clock system." Under this system the spreader can be compelled to put a given weight of material into a given length of sliver, the regularity with which she does so, however, depending upon her application and diligence.

The necessary mechanism consists of a Salter's spring balance with a dial graduated up to, say, 20 lbs., and a dish to hold a like weight of fibre, both being placed convenient to the hand of the spreader. Upon the delivery roller F (fig. 24) is a worm gearing with a changeable worm pinion upon a short shaft which lies underneath the sliver plate E. Upon the other end of this short shaft is a bevel pinion driving another upon a vertical spindle, which, by means of more bevel gearing, gives motion to the hand of a dial graduated in a similar manner to that upon the Salter's balance. If 20 lbs. of fibre are placed in the tray when the hand of the geared dial points to 20, both dials will be alike. The "board" being started, the aim of the spreader must be to keep them alike by spreading the fibre regularly, taking it from the scale and reducing the indicated weight as fast as the geared hand moves round backwards from 20 to 1. The 20 lbs. of fibre may thus be formed into any length of sliver, as the weight of yarn may require, by changing the pinion governing the speed of the geared dial hand, the delivery remaining constant.

The production of a sliver, uniform in weight and grist from yard to yard, depends entirely upon the method of spreading, as we will now explain. The degree of uniformity attained is inversely as the size of the pieces into which the fibre is divided for spreading, and directly as the amount by which these pieces overlap each other.

In spreading flax, for instance, the pieces from the sorter's bunch or from the machine room tipple, and weighing from 10 to 16 per lb., may be divided into four or more portions, which are spread in line overlapping each other to the extent that there is only from 1 to 6 inches distance from point to point of the pieces according to the length of the fibre and the size of those pieces. The shorter the fibre, the more closely together should the pieces be spread; and the closer together they are, the smaller must be the pieces to produce a sliver of given weight. Thin places, if not actual gaps, in the sliver will always be present if the draft of the board be too long or if the pieces be not sufficiently closely spread. Short fibre *requires* a short draft, while longer fibre will stand a longer one. Suppose we observe a board upon which 14-inch cut line is being spread. Being cut line, the fibres composing the pieces are more uniform in length than uncut fibre, and for this reason, and for the purpose of demonstration, we may consider the small pieces, into which the spreader divides the larger ones, as single fibres. As previously described, the spreader overlaps the pieces, leaving, say, 1 inch from point to point of each. The pieces composing this hand-formed sliver are presented to the drawing rollers in the same relative position as spread. Suppose the point of one piece is just caught in the nip of the drawing rollers—the draft being 18, or the surface speed of the drawing rollers approximately 18 times that of the fallers. While the succeeding piece is moving forward the 1 inch which it has to travel before being caught in the nip of the drawing rollers, the preceding piece has been drawn forward 18 times that distance, or 18 inches, thus forming a gap in the sliver. Had the fibre been longer or the draft shorter, the second piece would have been caught before the first had entirely disappeared, and consequently a continuous and more uniform sliver would have been produced. This shows, on an exaggerated scale, what really takes place in practice. Even in cut line the fibres are not really of the same length, consequently they are each caught in the nip at a different instant, and drawn forward to correspondingly advanced positions, thus forming an elongated and consequently attenuated sliver.

In spreading the pieces upon the leathers, the spreader should keep the top end of the piece, which goes first into the feed rollers, well pointed, so

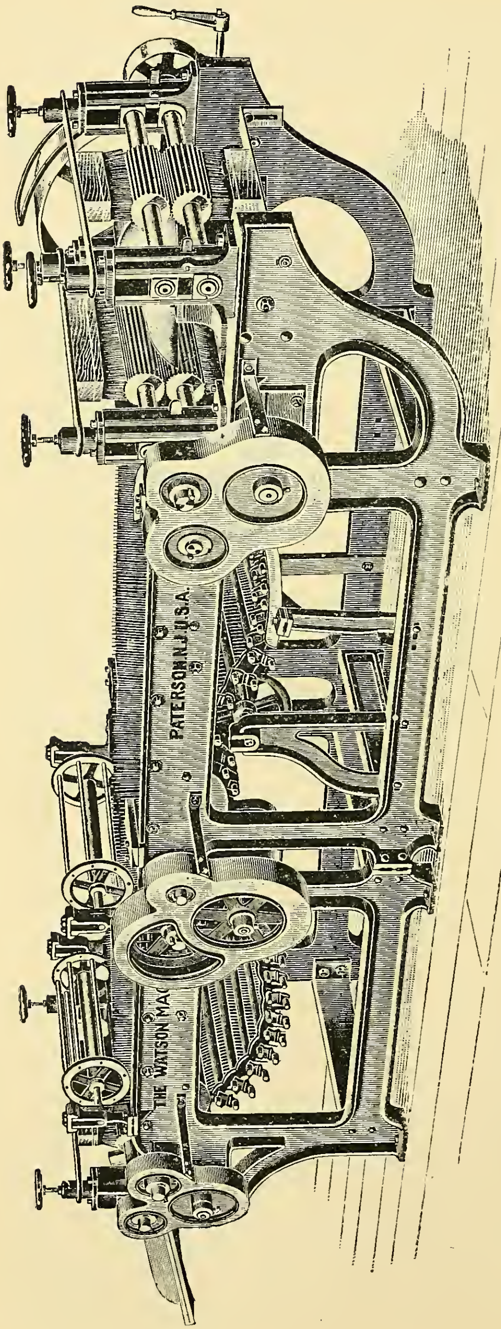

Fig. 27.—"Good's" combined hackler and spreader for Manila hemp.

that it may not catch upon and be turned over by the conductor as it enters, since, from what we have just said, it will be seen that turned ends may cause a gap in the sliver. The root end should be widened out and the piece flattened in order that the fibres may be drawn through the gill without being broken.

Throw-off Motion.—As it is essential to successful preparing, if working on the set system from the spread-board, that there should be exactly the same length of sliver in each can, it is advisable to insure that result, in spite of inattention on the part of the front minder, by the provision of a throw-off motion to cause the automatic stoppage of the spread-board when the bell rings. A very good one, by Lawson, acts in the following manner. When the frame is working, the throwing-off handle, which has a straight up-and-down motion, rests in a notch in a bar which is free to slide vertically in a guiding channel. When working, this bar is held at the top by a notched spring. A bell-crank lever, set free by the pin in the bell-wheel, pushes the spring off when the bell rings, and the sliding bar thus liberated falls, aided by a weight at its lower extremity, carrying with it the handle which actuates the belt fork. The force which the bell-crank lever referred to exerts upon its liberation is due to the recoil of a spiral spring attached to the lever at one end and to a fixed point at the other. When it is required to stop the board at any time, it is only necessary to spring the handle out of its notch in the sliding bar, and thus disconnect it from the rest of the motion.

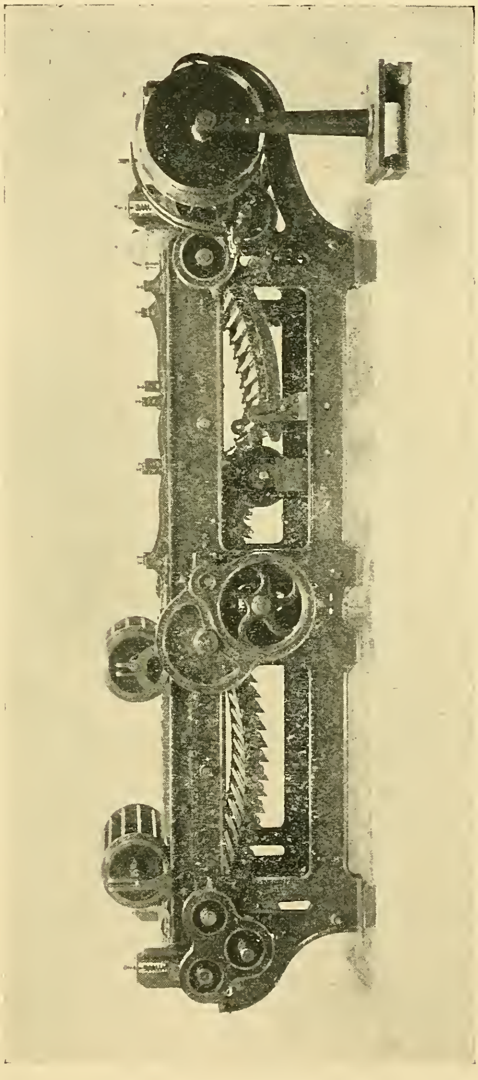

Fig. 28.—"Good's" combined hackler, and intermediate drawings, for Manila, sisal, etc. (Made by Messrs James Reynolds & Co., Belfast.)

Figs. 27 and 29 show the form of spread-board used to turn the raw fibres of Manila and New Zealand hemp into sliver.

Referring to figs. 28 and 29, it will be seen that the machine has two chain sheets, B and C, of gill bars, the former of which is carried round at a speed slightly greater than the surface speed of the feed rollers D, which are fluted and pressed together by means of springs. The sheet C, however, has 5 to 11 times the surface speed of the sheet B, so that while the fibre is held by the rollers D and the teeth of the sheet B, it is combed or hackled, and the fibres rendered straighter and more parallel by the teeth of the sheet C. The fibre is then caught by the heavily weighted rollers E, which have a greater surface speed than the quick sheet, so that the material is consequently drawn through the teeth of the quick sheet and still further parallelised, being at the same time condensed into a sliver which is deposited in a large can, or coiled by hand into a large heap upon the floor. Hard fibre, such as that of Manila and New Zealand hemp, becomes much softer and more pliable, and works better through the gills if it is slightly lubricated. Colour being of no consequence when working hard *brown* fibre, it is usual to use a cheap mineral oil of fair body which may be applied to the material with a rose-headed can before spreading, or by the use of the apparatus shown in fig. 29, which is much superior to hand application, in that it is perfectly regular and may be varied in

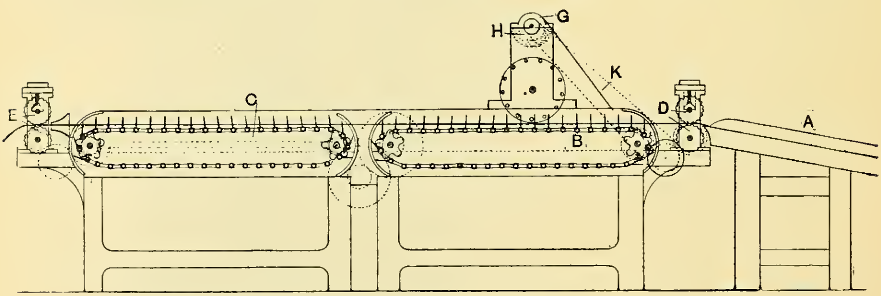

FIG. 29.—"Good's" combined hackler and spreader for Manila fibre.

quantity as desired. G is a plain oil roller, say 24 inches wide, or rather wider than the row of gills, which is often 23 inches in breadth. The roller is partly submerged in a trough of oil H, which should be kept filled up to as near as possible the same level. Upon the end of the oil roller is a rope pulley, driven from another pulley compounded with the intermediate wheel between the feed roller and the slow sheet back roller. The oil roller, being thus turned, carries round with it a thin film of oil which is scraped off by an edge pressed against the surface of the roller, and runs down an inclined and channelled sheet K, dropping upon the fibre in the teeth of the slow sheet as shown. The feed of oil is thus regularly distributed, and stops and starts with the machine. We should mention that the oil is much more effective as a softening agent if it be heated. If it be not hot it will not sink into the fibre in the same way, and will very likely ooze out of the goods when finished. The quantity of oil used may be varied by changing the pulley on the oil roller.

The gill bars have "dogs" on their ends, which, running on guides on the sides of the framing, hold the teeth perpendicular, or give them a slight backward rake as required. The dogs consist of elbow cranks, from one arm of which a stud projects outwards. On the outer face of the arm is a transverse groove which works upon a rib forming part of the guide. The "dogs" are alternately upon opposite ends of the bars. In this way, by increasing the thickness of the guides above or below, the foremost bars of the slow sheet may be turned so as to give their teeth a backward rake, while in the same way the rear bars and teeth of the quick sheet are given a forward rake, so that, the fibre not being able to slip over their points, they comb the material more effectually. As the bars of the quick sheet approach the drawing rollers, their teeth should be inclined backwards for the same reason. The machine should have a stop motion to cause the stoppage of the frame should the material lap round the sheet, as it sometimes does. An arrangement of this sort has a lever underneath the sheet, which lever, when depressed by such an accumulation, releases the belt fork and shifts the belt on to the slack pulley. The following are the chief particulars of a combined hackler and spreader suitable for forming sliver to be prepared for binder twine or rope yarn:—Pitch of gill bars, 4½ inches; width of gill (one row), 23 inches; teeth in the row, 28; length of the tooth out of the bar, 5 inches; suitable drafts, 10 to 20; speed of the slow sheet in feet per minute, 16 to 32; speed of the quick sheet in feet per minute, 175; rate of delivery in feet per minute, 200.

In this machine the chain sheets are often used to communicate motion from the boss roller to the feed rollers, and the gearing is arranged in the following way:—The boss roller has a wheel of 38 teeth keyed upon it, which drives a wheel of 50 teeth on the front carrying roller of the quick sheet as shown. The back roller of the quick sheet is then driven at the same speed by a side shaft through two pairs of mitre bevels of 26 teeth each. Upon the quick sheet back roller is a wheel of 20 teeth driving a stud wheel of 80 teeth as shown. Compounded with this wheel is a stud pinion of 30 teeth, driving the wheel of 80 teeth on the front roller of the slow sheet. There are chain sprockets of 5 teeth on this roller, and similar sprocket wheels on the back sheet roller, so that this latter moves at the same speed. The back sheet roller has a wheel of 40 teeth upon it, and drives, through an intermediate, another wheel of 40 teeth on the feed roller. The boss or drawing roller and the feed rollers are of the same size, namely, 6 inches in diameter, so that, starting with the feed rollers, the relative speed of the feed and delivery, or the draft, is equal to

$$\frac{40 \times 5 \times 80 \times 80 \times 26 \times 26 \times 50 \times 6}{40 \times 5 \times 30 \times 20 \times 26 \times 26 \times 28 \times 6} = 19.$$

Large handfuls of fibre are thrown endwise upon the feed table A, spread flat as far as possible and caused to overlap each other, forming one continuous sliver, which is drawn into the machine by the feed roller. The fibre is forced into the pins of the sheet by means of the bars of the lantern roller or wheel shown, which revolves with it.

The type of spreader usually used, by ramie spinners, to form a ribbon from the pieces which come from the flat dressing frame (fig. 21) comprises a spreading table, feed rollers, screw fallers and gills, such as we have described. The drawing rollers are fluted, and the fleece of fibre issuing from them, instead of being condensed into a narrow sliver, is formed by the lap cylinder and its enveloping apron into a roll or lap, which is used to feed the following machine.

Breaker or Devil Card.—The formation of sliver from the short and tangled fibres or tow, which has been formed in the scutching and hackling processes, requires machinery of quite a different nature, the process being known as carding. Combining a splitting and cleaning action with sliver formation, this process affords a cheaper method of forming a ribbon than that already described, and for this reason is often employed for long fibre of low quality such as the common marks of Riga and Pernau flax and for jute. Long fibre thus treated is said to be "broken up" or made into tow.

Figs. 30 and 31 show the form of machine best adapted to that purpose. It is called a "breaker" or "devil" card. The fibre is spread upon the inclined feed sheet A (fig. 31), passes between the shell B and the feed roller C, and is broken over the edge of the shell and carried away by the cylinder D. Two pairs of workers and strippers, E and F, open the material still further before it reaches the doffer G, which is stripped by the rollers H, which catch the long "braird" standing up upon the doffer, draw it off, and either deposit it upon the floor or pass it down over a broad tin conductor, which gradually contracts into a bell mouth at the calender rollers, which compress the sliver thus formed and deposit it in a can.

In fig. 31 the feed sheet A is of canvas or of leather, the shell B is of cast iron, and its edge approaches parallel to, and close to, the face of the cylinder D, which is usually about 4 feet in diameter, and 4 feet in width or in face, and turns at a speed of about 180 revolutions per minute in the direction of the arrow. It is clothed with "lags" or staves of beechwood, X, set with needle-pointed steel pins at a distance of about 9 per square inch. The feed roller C, the strippers and workers E and F, and the doffer G, are clothed in a similar manner or with steel-covered leather fillet set with steel or iron wire teeth put in in the form of a staple. Their pins are much longer than those of the cylinder, since it is their function to hold the fibre, for which reason also, those of the workers especially, are given what is known as a knee bend. The angle or inclination of the pins on the cylinder and rollers is of great importance in increasing or diminishing the efficiency of the card, both as regards the quality of the work done and the quantity of waste made. The angles most usually employed are—cylinder 75° with the surface, feed roller 60°, strippers 30°, workers 40°, and doffer 35°. Pins set in leather usually traverse their foundation

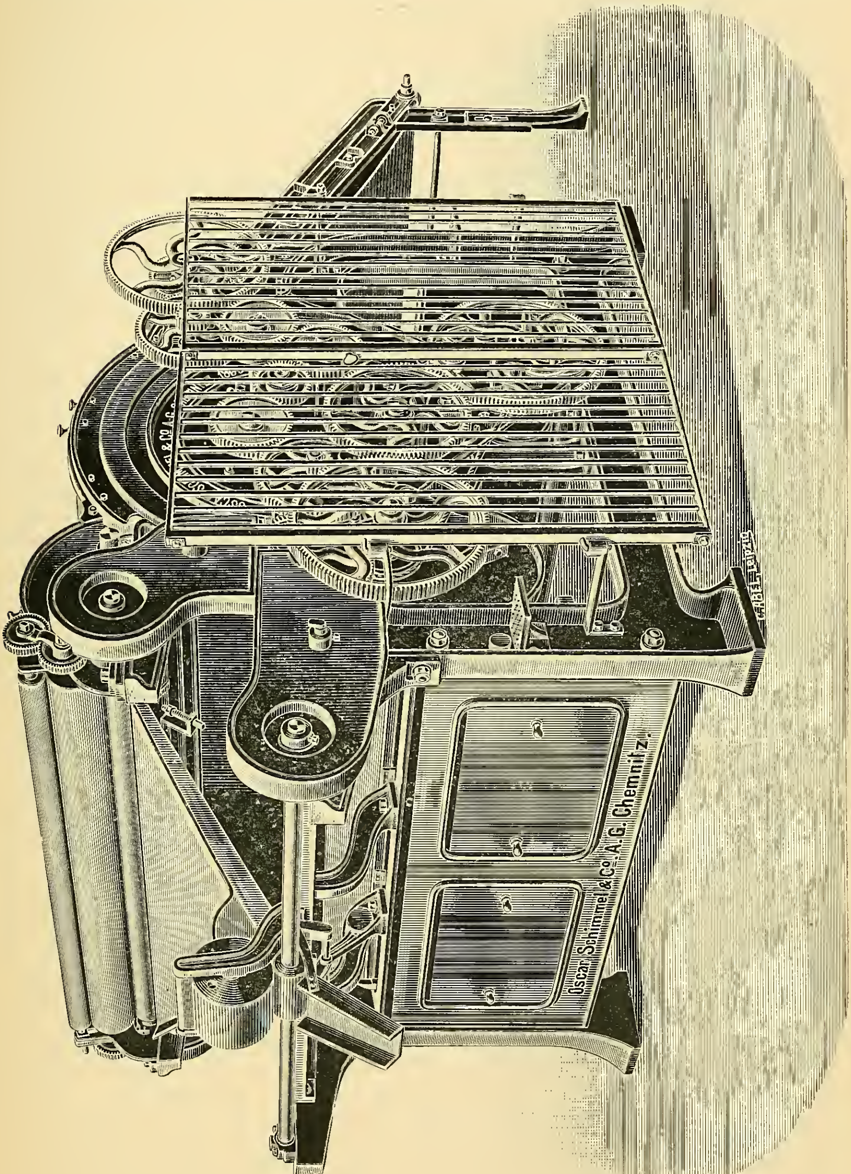

FIG. 30.—Breaker card for jute.

at right angles, and are then "knee bent" to the required angle. Pins set in wood cannot be "knee bent," but must be sent through the lag in a sloping direction. Each pair of rollers is set close to each other and to the cylinder, the stripper being in advance of the worker, relatively to the direction of motion of the cylinder. The pins of the cylinder are inclined towards the direction of motion in order to hold the material. The pins of the worker oppose those of the cylinder, and consequently comb, clean and render parallel the fibres which are held by the cylinder pins. In doing so, the worker retains much tangled fibre, lumps, etc., which it carries round until it is cleared by the stripper, which has a surface speed 50 to 100 times that of the worker. The angle of the stripper pins is in the direction of their rotation, so that they retain the material until they are themselves stripped by the cylinder revolving at seven or eight times their surface speed. The doffer acts in a similar manner to a worker, and is cleared by the pair of plain or scored rollers as described.

The following is a very usual setting for a breaker card :—Feed roller to shell, 8 B.W.G. ; feed roller to cylinder, 15 B.W.G. ; shell to cylinder, $\frac{3}{8}$ inch ; No. 1 worker to cylinder, 12 B.W.G.; No. 2 worker to cylinder, 14 B.W.G. ; strippers to cylinder, 14 B.W.G. ; workers to strippers, 16 B.W.G. ; doffer to cylinder, 16 B.W.G. ; "drawing off" rollers to doffer, 8 B.W.G.

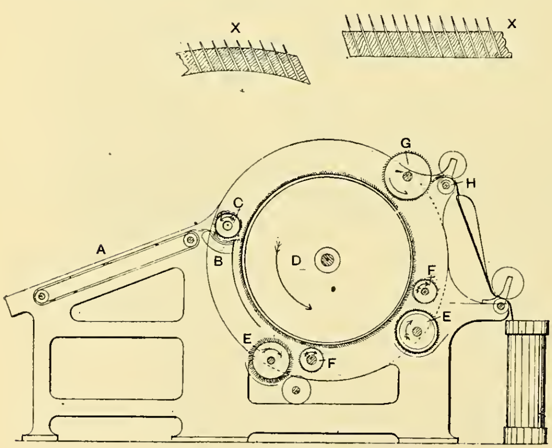

Fig. 31.—Breaker card.

Instead of the "shell feed" just described, where the feed roller C holds the fibre while the pins of the cylinder hackle and break it away as it hangs over the edge of the shell B, another form of breaker card has a pair of fluted feed rollers from which the fibre is taken by a revolving roller about 18 inches in diameter, clothed with coarse steel-covered leather fillet. This roller is usually driven by a wheel in which a safety pin is inserted so that it may run out of gear if a large lump, such as would injure the cylinder, is passed in by the feed rollers. By means of a handle the operator should also be able to reverse or stop the feed rollers at will. The large taking-in roller is stripped by the cylinder, which, striking downwards, carries the material past two or three pairs of workers and strippers as before. Nearly all breaker cards have plain tin rollers, known as dummy rollers, set in the spaces between the pairs of rollers on the under side of the card. The function of these dummies is to prevent any long fibre from falling to waste, while permitting the shove, etc., to escape. They revolve at about the same speed as the workers.

Carding.—Card pins for working long vegetable fibres are round or needle-pointed, being ground prior to insertion in the beech or oak staves or leather fillet. The staves or "lags" are generally $\frac{3}{8}$ inch to $\frac{3}{4}$ inch thick according to the work and 24 inches long, which means two or three rows respectively for cards of 4 feet and 6 feet face. The "lags" should be hollowed in the inside and rounded on the face to the circle of the cylinder or roller upon which they are to be placed. Leather fillet is usually 2 inches broad and $\frac{3}{16}$ inch or $\frac{1}{4}$ inch thick. The ends of the pieces of which it is composed are planed off, as regards thickness, to a point, so that they may be cemented together without increase of thickness at the joint. One end of the fillet having been first bevelled off to a point in breadth from a distance equal to the circumference of the roller for which it is intended, it is attached by screws to the end of the roller, and then the length of the fillet tightly and closely lapped spirally round the roller until the other end is reached, when it is again screwed to the roller, and the end cut off level with the edge of the roller. It is advisable to put in additional screws at intervals across the face of the roller, lest, by some accident, one portion of the fillet should become detached or broken while the card is working, and the whole length be wrapped round the cylinder or some of the other rollers, doing damage which it will require days to repair.

The "clock system," as described for the spread-board, page 70, is often used in connection with the breaker card, in order to obtain sliver of uniform weight for a given length.

Ramie tow or noil is usually carded and put into the form of sliver over an ordinary roller card, as used for cotton.

CHAPTER VIII.

TOW CARDING AND MIXING.

Fine Carding.—In the last chapter we treated of carding merely as a means of breaking up and forming into a sliver certain coarse long fibres which do not possess sufficient quality to render them worthy of the more expensive hackling and spreading treatment. Fine carding is a continuation of the same operation with the object of further cleaning and parallelising the fibres, which are again delivered in the form of sliver.

Finisher Card.—Figs. 32, 33 and 34 show the type of finisher card as used for flax, hemp and jute. Fibre coming from the breaker card, if in the form of sliver, is fed in by placing the requisite number of cans at the rear of the feed sheet, which draws the sliver from the can and delivers it to the feed rollers. If it be in a loose condition, it is, like flax, hemp and jute tows produced in the hackling process, spread upon the feed sheet C, fig. 32, by hand, or by means of the automatic feeder shown in the figure.

In order to obtain the delivery of a sliver of uniform weight per unit of length, the tow must be regularly spread upon the feed sheet. With the automatic feeder shown in fig. 32, laps of a given weight are automatically weighed in the balance 1, 2, and then deposited at regular intervals upon the travelling feed sheet C. The tow to be worked is placed in the hopper 3, and carried away by a spiked apron 4, which is driven by a friction clutch 5, and a belt from the feeder shaft 6, which receives motion from the card itself by the belt 7. The swinging knife 8 levels the tow upon the spiked apron and prevents too much from passing, while a similar knife, 9, strips it off and throws it into the bucket 2 of the weighing apparatus. By shifting the weight W on the arm of the beam, which is balanced on a knife edge 10, any weight of a lap may be formed; for when the bucket falls, owing to the weight of the tow in it, the tumbler 11, which has been holding the weighted dog or catch 13, out of contact with the notched disc of the friction clutch, is moved and the catch holds the spiked apron at rest, stopping the delivery of tow. When the proper moment for depositing the lap has arrived, or when a pin in the wheel 14 comes in contact with the tail end of a lever 15, fulcrumed in 16, the long sword arm 17 of the lever 15 is depressed, and coming in contact with a pin opens the two swinging sides of the bucket 2, permitting its contents to fall upon the travelling lattice 18. A travelling board, 19, actuated by a crank on the same wheel, 14, follows up each lap and unites it with the previous one, while a beater, 20, cements the union and levels the tow upon the sheet. The rising of the empty bucket places the tumbler, 11, in a position to again hold the catch, which is now withdrawn by another lever actuated by a pin in the wheel 14, and a new cycle of operations commences. This feeder was introduced about twelve years ago from the woollen trade, and has never been a great success as regards quality of work, owing to the length of the fibre and the high speed of the feed sheet or the comparatively short draft of tow cards as compared with woollen cards. In spite of the action of the board 19 and the beater 20, the fibre

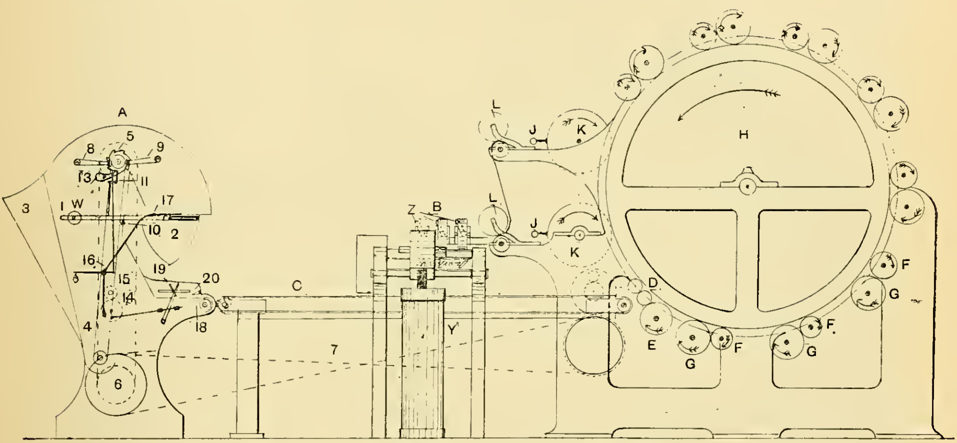

FIG. 32.—Finisher card with hopper feed.

is unevenly laid upon the feed sheet, the result being a regular succession of thick and thin places, the latter marking the junction of the laps. An improvement is effected by throwing down the laps diagonally, but hand feeding, if properly carried out, is really the best.

The care which is exercised in this respect on the Continent has a great deal to do with the superiority of many French, German, and Belgian tow yarns.

The best way to make really good work with the hand is to mark off the feed sheet into well-defined sections, which have usually an area of about 36 × 22 inches, or 792 square inches. The correct quantity of tow to spread upon these given areas may be found by experiment, or calculated, if the approximate quantity of card waste is known. Suppose that we wish to produce card sliver weighing $1\frac{1}{2}$ lbs. per 100 yards, and that the card waste of this class of material has been found to be equal to

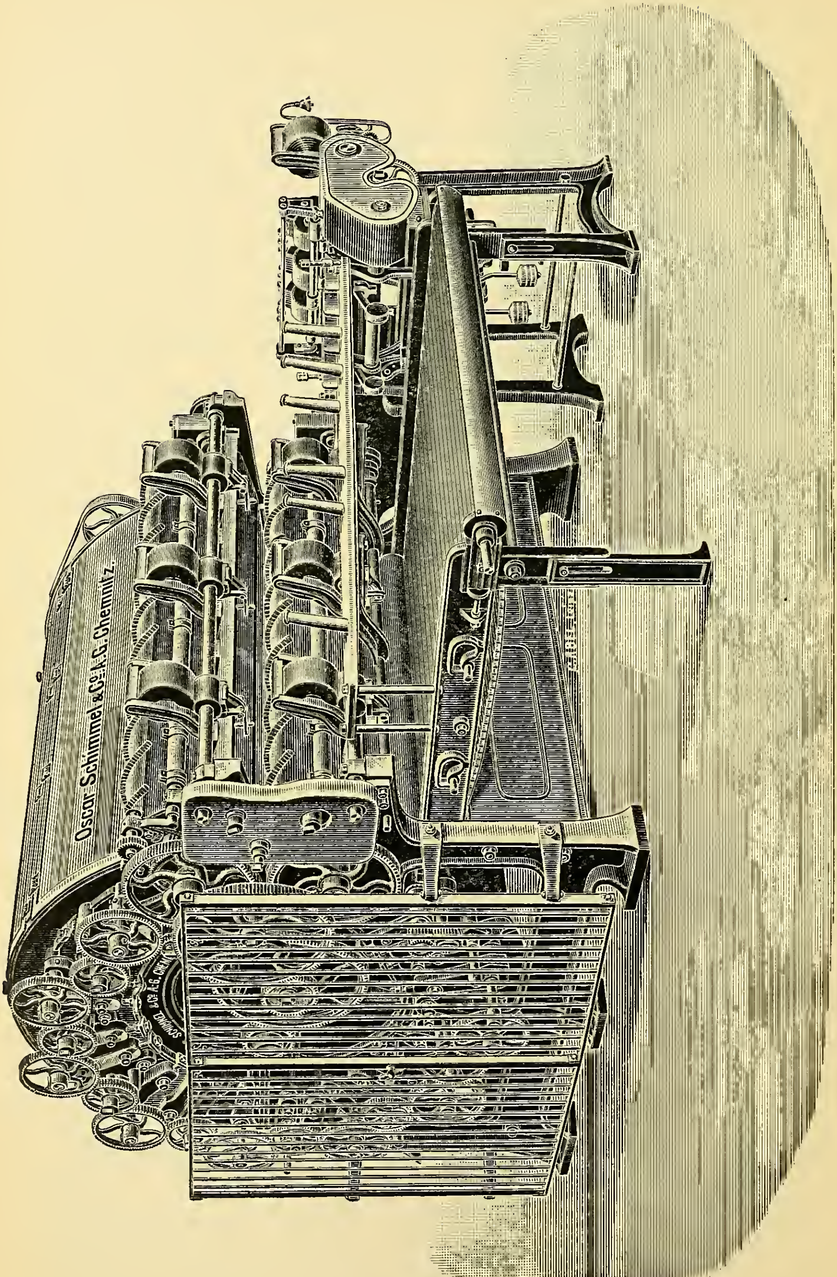

Fig. 33.—Tow card.

25 per cent. of raw material to the card. The draft of the card, or the relative surface speed of the drawing-off and feed rollers, we will suppose to be 20. If there be no drawing head, this is all we require. If there

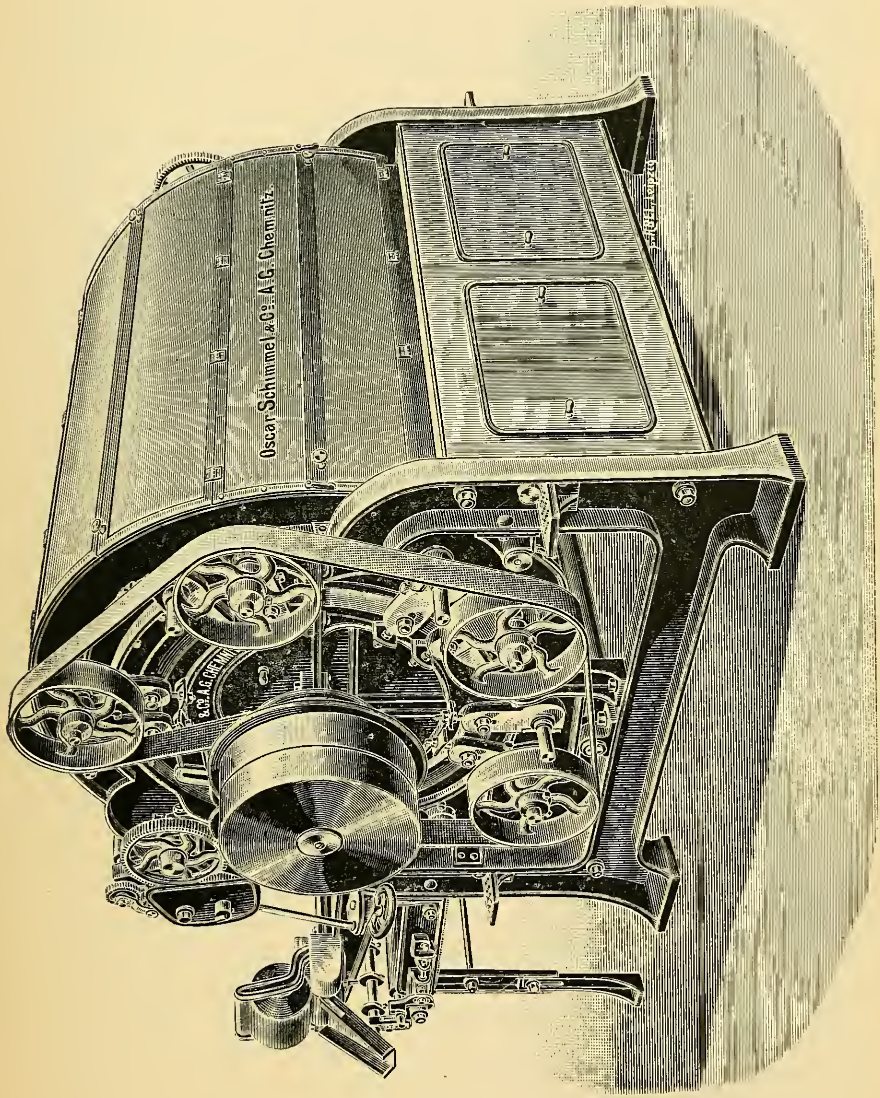

FIG. 34.—Finisher card for jute.

is a drawing head, say, with a draft of 2, the effective draft of the card and drawing head combined is the product of their drafts, or $20 \times 2 = 40$. In this case the weight of tow to be spread over each area of 792 square inches, there being three such areas in the width of the card, is $\frac{(1\frac{1}{2}+33\frac{1}{3}\text{ per cent.})\times 40}{3\times 100}=\frac{2\times 40}{3\times 100}=\frac{4}{15}$ lb. = 69 drs. nearly. It will be seen that $33\frac{1}{3}$ per cent. on the weight of the sliver is the equivalent of 25 per cent. on the raw material. If the card be the same, but without a drawing head, the weight which must be put into the scale to weigh the laps of tow will only require to be $\frac{69}{2}=34\frac{1}{2}$ drs.

Balling or Lap Machine.—In some mills a ball or lap-forming machine is used to form a number of slivers from the breaker card into a lap which is used to feed the fine or finishing card. Such a machine consists merely of a framing carrying a pair of calender rollers, a back sliver plate, and a surface drum upon which the lap is wound upon a rod or tube. Cans from the breaker card to the number of six to twelve are placed at the back, and the slivers evenly distributed over the required breadth. They thus form an even sheet, say 22 inches in width, which is compressed and wound into a lap. These laps are then placed in a stand at the end of the fine card feed sheet and gradually unrolled and fed into the feed rollers.

Full Circle Downstriker Roller Card.—The ordinary finisher card, as used for flax and fine hemp-tows, and shown in figs. 32 and 33, is a full circle downstriker roller card. The cylinder H is usually either 4, 5 or 6 feet in diameter, and the face or breadth 6 feet. The feed sheet C is horizontal, and approaches the cylinder considerably below the level of its centre. The axle of the cylinder is supported on either side, in pedestals attached to the side framing, which also carries one, two, or three doffers K, and the adjustable brackets supporting the feed rollers D, the workers F, and the strippers G. In this card there are two feed rollers D set fairly close together and turning in such a way as to draw in the material between them and present it to the cylinder. The teeth of both rollers are set in brass shells about 3 inches in diameter, and are inclined in a direction opposite to that in which the rollers turn; so that the cylinder, striking downwards, at a distance equal to 12 to 18 B.W.G. from the top feed roller, clears it. The bottom feed roller, whose teeth oppose those of the cylinder, is set at a greater distance from it, say 7 to 13 B.W.G., so that the raw material, which is being subjected to the action of the cylinder for the first time, may not be too severely dealt with, but merely prepared for the first worker, which is set considerably closer to the cylinder. The bottom feed roller acts, in addition, in the same manner as a worker, and must be cleared by a stripper E, which in this case is placed on its rear side, instead of on the front side as with the workers, a clear proof that a stripper will act equally well on either side of a worker. The surface speed of the feed rollers, their diameter being reckoned as the diameter of the barrel plus the length of the pin on one side only, should be rather greater than that of the feed sheet, so that all tendency to choke may be avoided.

The number of pairs of workers and strippers surrounding the cylinder varies according to the diameter of the latter and the fineness of the card. There may be from four to ten. A card is usually described as having, say, $8\frac{1}{2}$ pairs of rollers, the half pair denoting the feed stripper E. The doffers K are cleared by vibrating knives or combs J, instead of by drawing-off rollers, as in the "devil" card, figs. 30 and 31. On a card which is 6 feet broad the web of tow from each doffer is usually divided into three parts, each of which is drawn through a trumpet-mouthed conductor by the condensing rollers L and passed down and doubled with the corresponding sliver from the doffer below. The combined slivers from the bottom doffer are passed round "horns" Z, inserted in a smooth sliver plate, upon which the three slivers are conducted to the side of the card and either at once doubled together and delivered into a can Y by calender rollers, or first passed over what is known as a "rotary" or "drawing-head," upon which they are given a short draft through gills, then doubled together upon a sliver plate and deposited in a can by delivery rollers.

The diameter of the workers of the finisher card is from 4 to 7 inches and the strippers 5 to 8 inches, according to their number and the fineness of the card. This diameter must bear some relation to the length of the fibre to be worked, as long fibres require large rollers, so that the material cannot completely encircle the roller and thus oppose easy stripping and produce laps. The doffers are from 18 to 24 inches in diameter. The cylinder is driven at a speed of from 160 to 210 revolutions per minute, while the workers make four to twelve and the strippers 260 to 400 revolutions respectively in the same time. The card receives its motion by a belt which drives the main cylinder from a drum on the line shaft. The strippers and doffing knives are driven by one long belt from a pulley on the axle of the main cylinder. The workers, feeds and doffers are driven by gearing from a pinion upon the other end of the main cylinder axle. As regards the direction of inclination of the pins, those on the workers and doffers oppose those on the cylinder, while as regards direction of rotation they recede before it. It will thus be seen that quick workers give less work, so that by providing change pinions the card may be adapted to obtain the best results from various classes of tow. A large cylinder pinion causes both feed workers and doffers to run quicker, while the speed of the cylinder remains the same; so that in addition to a reduction in cleaning capacity caused by the quick workers, the material is actually run quicker through the card, receiving in its transit less work from the cylinder in consequence. The strippers throw off impurities in proportion to their speed, for which reason they are often run rather fast when working nappy tow.

For reasons such as these as stated above, to work hard and clean tow, the workers and strippers should be run slow, while a large cylinder pinion should be employed. To take out naps, run the workers and strippers fast and use a medium cylinder pinion with close setting all round the card. To make clean sliver from dirty tow regardless of waste, the strippers must be fast or the workers slow. Less cleaning and less waste is effected by passing the tow quickly through the card by putting on a large cylinder pinion. If the tow is full of a sticky shove, in order to clean it, the workers must be slow. If the shove be loose, fast workers will do. For soft and dirty tows, fast workers and strippers with a medium cylinder pinion is what is required. For hard, dirty tow, run the workers slow, the strippers at a moderate speed, and use a large cylinder pinion. For soft, clean tows, run the workers fast and the strippers slow, and use a medium cylinder pinion.

As regards the setting of the card, the distance apart of the surfaces of the rollers in relation to each other and to the cylinder is a most important point in tow carding. First, as regards the feed rollers, which receive between them the uncarded fibre and deliver it to the card, the distance between them must be such as to contain the comparative thick and heavy sheet of raw material without straining the rollers. They must, however, be sufficiently close to exert a controlling action over the delivery of the tow to the cylinder, and not permit it to be carried away in lumps. The distance from point to point of their pins, which are about ½ inch out of the brass, ranges from 8 to 10 B.W.G. according to the weight of the feed. As the top feed roller is cleared of any tow which may tend to lap round it, by the revolving cylinder, it must be set sufficiently close to the latter to be brought under its influence, say a distance equal to from 12 to 18 B.W.G.

As in the hackling machine, where we use a very coarse hackle at first, the bottom feed roller, which acts as a worker with regard to the cylinder, must not be set too close to the latter, or the fibre will be too severely handled and broken up. The usual distance equals 7 to 13 B.W.G.

For a reason just mentioned, the rollers all round the card should be more distant from the cylinder the nearer they are to the feed roller and to the entry of the raw material, while their distance from the cylinder should diminish as the fibre becomes combed and level, as it does as it approaches the doffers. The first worker may be set to the cylinder with a 10 to 15 B.W.G., while the last worker is distant only 13 to 19 B.W.G., both according to the fineness of the card. In a similar way the strippers may be set to their workers and to the cylinder at a distance equal to 12 to 22 B.W.G.

The doffers, being in their order the furthest removed from the feeds, are set quite close, say 13 to 22 B.W.G. When there is more than one doffer, the second is set to the cylinder one number finer than the top; while if there be three doffers, the bottom one is set one number closer than is the middle one. The calender or collecting rollers for the bottom doffer, or for the middle and bottom doffer, if there be three, are given a slight lead in surface speed over the rollers above them, in order to keep the slivers tight. For the same reason the feed rollers of the drawing head, if there be one, should also have a slightly greater surface speed than the collecting rollers of the bottom doffer.

The weight of the sliver in grains per yard for a 6 × 5 tow card should be nearly as follows:—10's to 12's lea = 182 grs., 14's to 16's lea = 154 grs., 18's to 22's lea = 119 grs., 25's to 30's lea = 102 grs., 35's to 60's lea = 84 grs.; and the weight put through each card per day of ten hours—10's to 12's lea, 500 lbs.; 14's to 16's lea, 440 lbs.; 18's to 22's lea, 380 lbs.; 25's to 30's lea, 330 lbs.; 35's to 60's lea, 260 lbs.

When three doffers are employed, the tow must be fed rather heavily or quickly to the card, in order that the nine slivers from the three doffers may have sufficient consistency to carry.

In order that the cylinder may carry a heavy load of fibre without dropping a large portion of it, the pins must be long and of considerable rake. Since the teeth of the cylinder and workers do not intersect each other, and are not even point to point, it is only those fibres which project above the surface which receive any work. When the cylinder is heavily loaded, most of the material is below the surface and hence receives no work. Considerations of this sort have led of late years to a tendency towards lighter loading of the card, a shorter cylinder pin, and consequent reduction of the number of doffers to two and even to one.

One-doffer Card.—A card recently in vogue has but one doffer, which, however, is considerably over the ordinary size, in order that a large number of gathering points may be exposed on the line of near approach of cylinder and doffer.

Light carding means light card sliver, which has led to the rejection, in some cases, of the rotary head.

This machine reduces the weight of the sliver by drafting, but does not increase its levelness, since no doublings are or can be introduced. Its one advantage is the increased parallelism it gives to the fibres, which, in turn, adds to the strength of the sliver. An old three-doffer card may easily be adapted for lighter carding by removing the top doffer and inserting in its place an additional pair of workers and strippers.

Card-doffing Knives.—Card-doffing knives are of two sorts, known as quick and slow speed. The latter is an old type still at work in some mills, the two or three knives being linked together and driven, or given a reciprocating up-and-down motion, by means of cranks on a shaft driven by the stripper belt.

In the new quick-speed knife, motion is given to each separately, by means of eccentrics driven at a high speed and revolving in oil-baths.

Whichever form be used, the working centre of each comb should be in the same plane as the centre of the doffer, and the length of the oscillation should be the same on either side of this line. The comb should be set as close as possible to the doffer without touching it. Circular revolving brushes are placed in contact with the doffers at a point above the combs or doffing knives. These brushes keep the doffer clean by gathering up any stray fibres which may have escaped the action of the knives. Bands of brass around the doffers will be found useful in producing a good division of the fleece among the three or more drawing-off or calender rollers.

Covering in of Cards.—The covering in of flax, hemp and jute cards is now rendered necessary by law, so that it is almost impossible for accidents to occur, except through the greatest carelessness. When they do occur, they are generally of a serious character, as the card is a most dangerous machine. The covers are generally of sheet iron surrounding the upper portion and sides down to the ground. In some mills, means are provided to draw away the dust generated inside the cover by means of suction pipes and a fan.

Card Fires.—As fires are of no unusual occurrence, especially with some sorts of tow, such an arrangement may assist the spread of the fire from one card to another. When a fire occurs, the chief aim of those in charge should be to keep it confined to the card in which it is burning, and to protect that card from injury. Water should be thrown upon the floor under and around the card, but on no account upon it, as the best way of preserving the clothing of the rollers and cylinder from injury is to keep them running. Whiting may be thrown upon fiercely burning portions or into corners, with good effect and without injury to the card.

The Gearing and Driving of the Card.—We will now deal with the gearing of the card, from which the speed of the various rollers may be obtained. The speed of the line shaft is the first consideration. This should be run at about the same speed as that at which it is desired to run the main cylinder of the card, since the card being a very heavy machine to drive, and especially so to start from a state of rest, it will be found advisable to have both driving drum and driven pulley about the same size, and about 26 inches in diameter, in order to get a good bearing surface for the belt on both drum and pulley. Suppose the line shaft to run at 200 revolutions per minute and to have upon it a 26-inch drum driving a pulley of the same diameter upon the end of the axle of the main card cylinder. The cylinder will thus also make 200 revolutions per minute. First take a case where the workers, doffers and feed rollers are driven from the cylinder by means of a cylinder pinion fixed upon the opposite end of the cylinder axle to that on which the driving pulley is keyed. With a medium cylinder pinion of, say, 30 teeth and the worker wheels having 72 teeth, the latter may be driven through a train of intermediates, comprising two double reducing wheels of, say, 130 and 35, 136 and 50 teeth respectively, at a speed of $\frac{200 \times 30 \times 35 \times 50}{130 \times 136 \times 72}$ = nearly $8\frac{1}{2}$ revolutions per minute. By changing one of these stud pinions, the speed of the workers may be changed at will. The so-called draft of the card being, as in all other machines, the relative surface speeds of feed and delivery, we will proceed to find the length delivered by the delivery rollers while the feed roller is making one revolution, and then divide by the circumference of the feed roller and thus obtain the draft of the card. The gearing between the feed and delivery rollers comprises the feed roller wheel of, say, 80 teeth, doffer pinion 36 teeth, doffer wheel 136 teeth, and delivery roller pinions of 26 teeth. The diameter of the delivery roller being 4 inches, $\frac{80 \times 136 \times 4 \times 3{\cdot}1416}{36 \times 26} = 146$ inches are delivered for each revolution of the feeds, which, if $3\frac{1}{4}$ inches in diameter or 10·2 inches in circumference, means a draft of $\frac{146}{10{\cdot}2} = 14{\cdot}3$. Where the draft gearing is all on the same side of the card it is generally driven by one of the delivery rollers which receives its motion from the drawing head, which is driven by a belt, as we will presently explain. The gearing arranged in this way may be as follows:—Diameter of the feed rollers $2\frac{3}{4}$ inches, feed roller wheel 130 teeth, stud pinion 46 teeth, stud wheel 92 teeth, delivery roller pinion 27 teeth, and the diameter of the delivery roller $4\frac{1}{4}$ inches, giving a draft of $\frac{130 \times 92 \times 4\frac{1}{4}}{46 \times 27 \times 2\frac{3}{4}} = 14{\cdot}8$.

The speed of the strippers on the same card may be found from that of the cylinder by multiplying the latter by the diameter of the fancy pulley and dividing by the diameter of the stripper pulley. Thus with a fancy pulley 20 inches in diameter and stripper pulleys 14 inches in diameter, the speed of the latter will be $\frac{200 \times 20}{14}$ = nearly 286 revolutions.

It is the surface speed of the rollers, however, which is the point to be considered. If the cylinder be 5 feet in diameter to the point of its pins, its surface speed will be $200 \times 5 \times 3{\cdot}1416 = 3141{\cdot}6$ feet per minute, while that of the workers and strippers, their diameters being 7 and 8 inches respectively, will be $\frac{8{\cdot}25 \times 7 \times 3{\cdot}1416}{12} = 15{\cdot}1$ feet, and $\frac{286 \times 8 \times 3{\cdot}1416}{12} = 599$ feet.

Their relative surface speeds, that of the cylinder being taken as 100, are then—cylinder 100, strippers 19, and workers ·5 nearly. These speeds will give good results with Baltic tows containing a considerable quantity of loose shove. Modifications may be made to suit any special work, such as clean soft tow, hard dirty tow, or fine nappy tow, etc., if the functions of the rollers as set forth be borne in mind.

Fineness of the Card Clothing.—The fineness of the clothing of the rollers of the card is generally in proportion to that of the cylinder, while the latter depends upon the work for which the card is intended, varying from 4 to 9 pins per square inch, in a coarse breaker card, to 64 pins per square inch in some of the latest fine cards.

On the Continent the fineness of the card is generally expressed as above, in pins per square inch; while elsewhere one finds the pins per inch in the row spoken of, the latter being quite as explicit as the former, it being understood that the pins per inch count the same both ways as regards the cylinder staves, so that, for instance, 6 per inch in the row equals $6 \times 6 = 36$ per square inch. The following tables show the usual grades of tow card clothing both in wood and leather.

Card Staves or Lags.

Staves for—														
Cylinder 24 in. × 3 in.	Pins per inch	2	$2\frac{1}{2}$	3	$3\frac{1}{2}$	4	$4\frac{1}{2}$	5	$5\frac{1}{2}$	6	$6\frac{1}{2}$	7	$7\frac{1}{2}$	8
Strippers 24 in. × $2\frac{1}{2}$ in.	Pins per square inch.	4	6	9	12	16	20	25	30	36	42	49	56	64
Doffers 24 in. × $2\frac{1}{2}$ in.	No. of wire B.W.G.	12	14	16	16	17	17	18	18	19	19	19	20	20
	Length of pin out of wood for cylinder clothing	$\frac{3}{8}$	$\frac{3}{8}$	$\frac{5}{16}$	$\frac{5}{16}$	$\frac{5}{16}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{3}{16}$	$\frac{3}{16}$	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{1}{8}$

Leather Card Filleting.

Pins per inch	2×2	2×3	2×4	2×5	3×5	3×6	3×7	3×8	4×8	4×10	5×10	5×12	5×14	6×14	6×17	6×20
Pins per square inch	4	6	8	10	15	18	21	24	32	40	50	60	70	84	102	120
Length of pin out of leather	$\frac{1}{2}$ in.	$\frac{1}{2}$ in.	$\frac{1}{2}$ in.	$\frac{1}{2}$ in.	$\frac{7}{16}$ in.	$\frac{3}{8}$ in.	$\frac{3}{8}$ in.	$\frac{3}{8}$ in.	$\frac{5}{16}$ in.	$\frac{1}{4}$ in.	$\frac{1}{4}$ in.	$\frac{1}{4}$ in.	$\frac{3}{16}$ in.	$\frac{3}{16}$ in.	$\frac{3}{16}$ in.	$\frac{3}{16}$ in.
No. of wire B.W.G.	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25

It will be noticed that in filleting for workers, strippers and doffers, the wire used is generally coarser than it is for the same number of pins per inch in wood, because the pins, besides being longer, are weaker, in that they are of iron and not of steel.

The Rotary Head.—The "Rotary" is a small drawing head, placed at the side of the card, which receives the three slivers, as delivered from the calender or collecting rollers, and drafts them out. It has a pair of back or retaining rollers, as shown in fig. 35, a set of gill bars, a brass roller with wooden pressing rollers, a doubling plate, and a pair of delivery or calender rollers. The gill bars have three rows of gills corresponding with the three slivers from the bottom doffer, which are led along the sliver plate and passed into the back rollers of the rotary. The rollers of the latter are thus at right angles to the cylinder of the card. The delivery into the can may be in either direction, but it is convenient to have it at the front side of the rotary, so that it may be easily watched by the carder who is feeding at the front of the card.

Owing to the high speed at which the machine runs, screw gills are never employed in drawing heads of this description.

The name "rotary head" itself is derived from an old way of driving the gill bars, which is still in considerable use.

In this arrangement there is, between the drawing and retaining rollers, a barrel with deep brass flanges or ends in which a number of slots are cut in an almost radial direction. Into these slots the ends of the gill bars pass freely, projecting on the other side into a cam-shaped groove, which, while the barrel revolves, determines and directs their movements as they are carried round. The shape of the groove is so arranged that the gills rise fairly perpendicularly and close to the feed rollers, and approach fairly close to the nip of the drawing rollers. Several inventors have tried, with success, to imitate more perfectly the direct penetration and fall of the screw gill without diminishing the velocity of the bars.

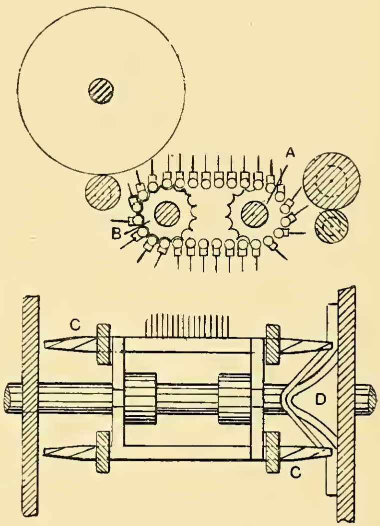

FIG. 35.—Push-bar drawing head.

One of the best and simplest of these motions is known as the "push-bar," since, after being raised in the teeth of a pinion, one bar pushes the others along a horizontal slide, until it enters the teeth of a similar pinion, which supports it until the bottom slide is reached. The opposite ends of alternate bars have crank-shaped lugs or pieces attached to them, which, while the round of the bar is in the teeth of the pinion, are guided in an outside groove, which controls and renders perpendicular the ascent and descent of the gills.

Short "nips," or near approach of the gill to the rollers, back and front, is an important point in gill drawing. If the gills rise too far from the back rollers, and at a considerable inclination to the vertical, they do not penetrate or "pin" the sliver properly; while, if they drop before approaching close to the drawing roller, the drafting of the sliver is uncontrolled and the material is "gulped" or drawn away irregularly, causing thick and thin places in the sliver produced.

Gamble's Push-bar Drawing Head.—In the arrangement shown in fig. 35, which is known as Gamble's patent, and made by Messrs Combe, Barbour & Combe, Ltd., Belfast, in order that the gill bars and gills may be controlled during their ascent and descent into the required angle, the ends of the bars C are made flat or oval, and are more or less twisted as shown. Special guides D act progressively along the twisted surface, and coming in contact with different portions of it, turn the bar into the required position, and keep it there while the rise or fall takes place.

Drawing Head.—The calculation for the draft of the drawing head is similar to that of the spread-board, page 69, so that a single example is all that anyone will require. Take the actual case of a rotary which has a back roller wheel of 44 teeth, a stud pinion of 16 teeth compounded with a stud wheel of 28 teeth, which gears with the back shaft pinion of 22 teeth. On the other end of the back shaft is a draft change wheel which, we will say, has 25 teeth, and drives a boss roller wheel of 40 teeth through carriers.

The diameter of the back roller being $1\frac{3}{4}$ inches and that of the boss roller 2 inches, the calculated draft is then $\frac{44 \times 28 \times 25 \times 2}{16 \times 22 \times 40 \times 1{\cdot}75} = 2{\cdot}5$. Drawing heads are driven in a variety of ways. The older way of driving through a cross shaft from the geared side of the card, employing a clutch to throw the rotary alone out of gear, is not so convenient as the newer way of driving the rotary, through a fast-and-loose pulley and a belt, from a pulley on the cylinder shaft, as the feed roller and doffer gearing may also be connected with this drive, so that if it be found necessary to stop the rotary for a moment the feed rollers and doffer are brought to rest at the same time, stopping delivery to and from the card and allowing all to start off again without trouble. When the card has been stopped in this way, it is advisable to run off a few yards of sliver after starting, as the tow which has remained in the card may have been rather weakened by the continued revolution of the cylinder.

Gearing.—The gearing usually occupies one side of the card and the pulleys and belts the other. The most usual way of giving motion to the workers, feeds and doffers is by means of the changeable cylinder pinion placed on the free end of the cylinder axle, but occasionally all the gearing of the card is independent of the cylinder and receives motion from the drawing head, which is itself driven by a belt from the cylinder axle. Sometimes only the feed and doffer gearing is independent, while the workers are driven by a cylinder pinion. In connection with the feed roller wheel it is advisable to have some sort of a safety device, so that if any foreign substance is introduced by accident with the tow between the feed rollers, they may be automatically stopped and thus save the cylinder and rollers from damage.

Safety Devices.—A very good arrangement is to have the intermediate wheel, which gears with the feed roller wheel, working upon a stud set in the short arm of a bell crank lever, the long arm of which is weighted so as to keep the wheels in gear under ordinary circumstances, but which will allow the teeth to slip over each other when the free motion of the feed rollers is obstructed.

Mixing.—Except when yarns of specially light or dark colours are required, various sorts and colours of tow are usually mixed together to obtain a lot of the desired average shade and value. It is a very convenient arrangement to have the tow store situated under the hackling department, so that the tows produced may be thrown down various traps according to their quality, the roughing tow in one place, the machine tow in another, and the sorter's tow in a third.

There should be plenty of floor space in the tow store to sort the material, as well as numerous roomy bins in which to make and store the mixes. The best method of mixing is to lay the various sorts of material in layers one on top of the other, over an area proportionate to the size of the "mix" or blend. When a quantity of material is being taken from the mix to the card it should be pulled "out of the face," so that the quantities of the various sorts in that part may be in the same ratio as they are in the bulk. When all the material has first to be passed over the breaker card, the various sorts may be carded separately and then mixed together in the correct proportions by putting up the required number of cans of each at the back of the finisher card or at the back of the balling or lap-forming machine, if one be employed.

When only one card is used and there is a marked difference in any tow from the others with which it is to be spun, it is often best to card it separately in a manner suiting its requirements and then to mix it in at the back of the doubling frame, which we will treat of in our next chapter. For instance, if we are mixing a clean but soft Kama tow with Baltic machine tow, containing more or less shove, it will be found that less waste will be made if the Kama is worked upon a separate card, arranged in such a way that the workers are run rather fast and the strippers slow, in order to save the fibre, which requires very little cleaning, but merely to be straightened and put into sliver. The remainder of the material must receive more work, to accomplish which the workers must be run slow and the strippers rather fast. The following examples of tow mixes will give some idea as to what is required for coarse and fine numbers.

A 40's rope yarn may be composed of $\frac{1}{2}$ aloe fibre, $\frac{1}{4}$ jute and $\frac{1}{4}$ YC hemp tow.

A 1 lea yarn for twine may be made from pure Italian Strappatura tow.

8's lea dry spun weft may be produced from Irish rescutched tow.

14's lea wet spun warp may be composed of $\frac{1}{4}$ rescutched tow, $\frac{1}{4}$ Irish hand-scutched roughing tow, $\frac{1}{2}$ Irish 1 and 2 machine tow.

16's lea dew-retted tow : $\frac{1}{4}$ Kama II, $\frac{1}{2}$ Bejetsky roughing tow, $\frac{1}{4}$ 1 and 2 Bejetsky machine tow.

20's wet spun tow warp : $\frac{1}{4}$ Irish, $\frac{1}{4}$ Flemish, $\frac{1}{4}$ Dutch, $\frac{1}{4}$ Pernau No. 2 machine tows.

40's lea tow weft ; $\frac{1}{4}$ Irish, $\frac{1}{4}$ Flemish ; $\frac{1}{4}$ Dutch, No. 3 machine tow with $\frac{1}{4}$ No. 4 Pernau machine tow.

40's lea tow warp : $\frac{1}{3}$ Brittany No. 3 machine tow, $\frac{1}{3}$ Irish sorting tow, $\frac{1}{3}$ Brittany sorting tow.

50's lea tow weft : $\frac{1}{3}$ Flemish sorting tow, $\frac{1}{3}$ Irish sorting tow, $\frac{1}{3}$ Dutch No. 4 machine tow.

55's lea tow warp : all Courtrai long line sorting tow.

60's lea tow weft : $\frac{1}{3}$ Irish, $\frac{1}{3}$ Flemish, $\frac{1}{3}$ Dutch sorting tow.

65's lea tow warp : all Courtrai cut line sorting tow.

70's lea tow weft : all No. 4 Courtrai cut line machine tow.

Important experiments are now going on both at home and on the Continent in the use of the Hopper Feeder, of the constant feeding type, to the formation of a lap for card feeding. We believe that a good tack is being followed, and that presently we may see the suppression of the present method of card feeding as described at the beginning of the chapter.

CHAPTER IX.

PREPARING, DRAWING AND DOUBLING, AND TOW COMBING.

Drawing and Doubling.—We are now in possession of a number of continuous ribbons or slivers which have been prepared, in the case of long line, upon the spreader, and in the case of tow, upon the card, and composed of fibres lying parallel to and overlapping one another.

It now remains to elongate them so as to reduce them to the size of the yarn required. This is done upon a series of drawing frames which also afford an opportunity of doubling a number of slivers together in order to produce another, more regular in weight per unit of length. It is not astonishing that doubling has this effect, as it would be unreasonable to suppose that the thick places in one sliver should correspond with thick places in the others. It is more than likely that they should frequently coincide with corresponding *thin* places and combine to make a more regular sliver.

Preparing.—Preparing machinery is combined and worked in "Systems." In the case of line, each system comprises one or two spread-boards, three or four drawing frames, and one roving frame.

In the case of tow-preparing machinery, a system comprises one or two cards, two, three or four drawing frames and a roving frame. The insertion and use of the combing machine in the tow system is optional.

With four to eight leathers on the spread-board, and a draft of 16 to 30, four to eight rows of gills per delivery on the drawing frames, with drafts of 10 to 16 and a draft of from 10 to 16 on the roving frame, the combined doubling obtained may range from 1500 to 80,000, and the combined drafts from 65,000 to 6,900,000.

For tow with two to six rows of gills per delivery on the drawing frames, and drafts of from six to nine on the drawing and roving frames, the total doubling may range from 24 to 144, and the total drafts from 377 to 4840.

The Spiral Drawing Frame.—Figs. 36, 37, 42 and 43 give general views of several types of drawing frames. Figs. 38, 39, 40, 41, 44 and 45, show similar frames more in detail. Fig. 36 is a back view of a spiral drawing frame for flax, etc., as made by a German firm. Fig. 37 is a front view of a similar frame of English make suitable for flax or hemp tow.

Fig. 38 is a sectional view of a spiral drawing frame for long hemp.

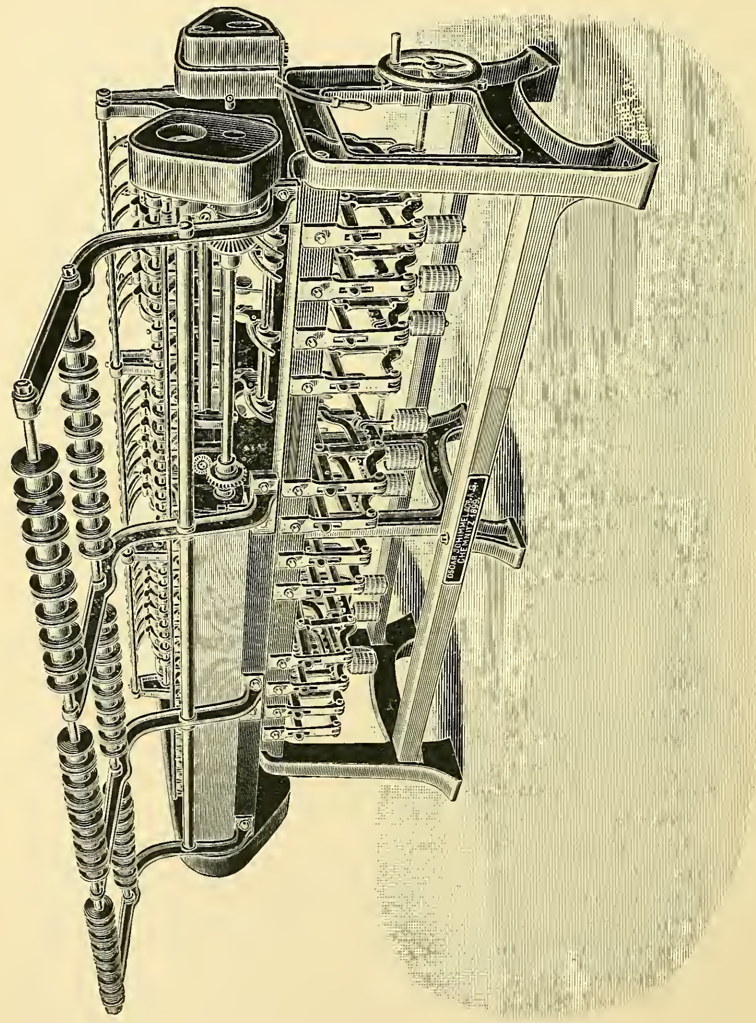

Fig. 36.—Spiral drawing frame (back view).

Fig. 39 shows the arrangement of the back shafts, rollers, screws and gearing for a spiral drawing frame, such as fig. 37.

Fig. 40 shows a traverse motion for the front roller, such as is supplied to modern spiral drawing and roving frames.

Fig. 41 shows a sliver or doubling plate for a drawing frame with three deliveries per head, and four rows per delivery. Messrs Mackie's patent conductors are clearly to be seen upon the under side.

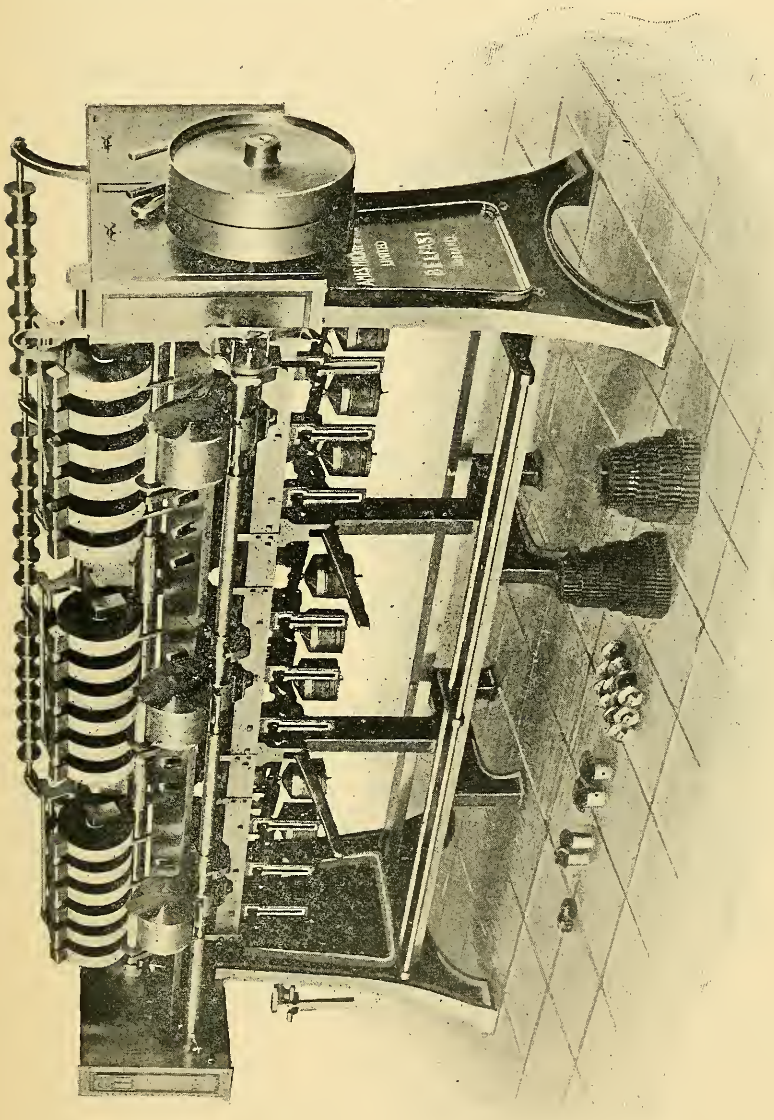

Fig. 37.—Spiral drawing frame for flax or hemp tow (front view).

Fig. 42 gives a general view of a chain-bar drawing frame with apron head as used for Manila to follow the combined hackler and spreader, figs. 27 and 29.

Figs. 43 and 44 show chain-bar drawing frames for jute, and fig. 45 a section through the bars of Fraser's ring drawing frame, also for jute.

Each drawing frame is made up of from one head, as in fig. 42, to

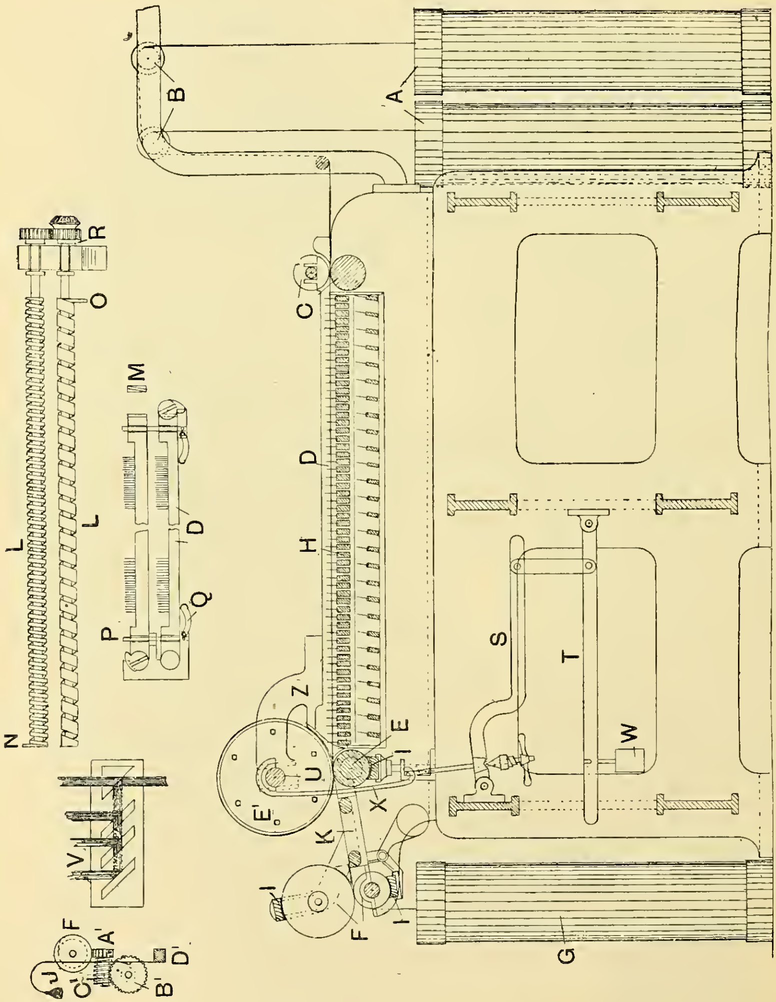

FIG. 38.—Spiral drawing frame for long hemp.

three or more heads, as in figs. 36 and 37. Each head has a separate set of faller or gill bars. Upon each faller or bar are from one row, as in fig. 42, to eight or more rows, as in fig. 36, of gills, constructed as described for the spread-board in Chapter VII. In fig. 36 a back cover is removed disclosing the back shaft E with its bevels W working into the screw bevels M, as seen more clearly in fig. 39. Fig. 36 also shows clearly the sliver guide pulleys over which the slivers pass from the cans to the back or feed roller D, fig. 39.

In fig. 37 the boss or drawing roller A, delivery bosses F with their pressings G and the fast-and-loose belt pulleys L and K, fig. 39, are clearly to be seen, as is also the sliver doubling plate and wooden pressings for

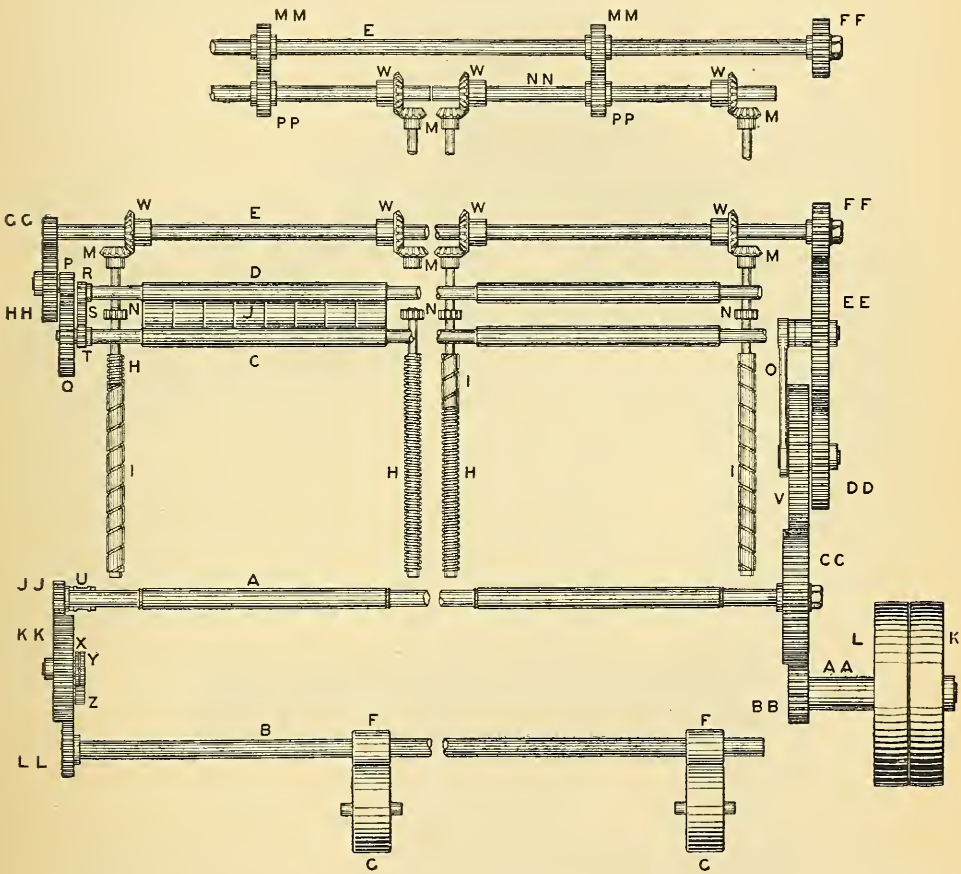

FIG. 39.—Diagram of gearing rollers and shafts for drawing frames, with single or double back shafts.

the drawing roller with dead rubbers lying upon them. There is a bell motion to be seen in connection with the delivery roller and revolving rubbers on the delivery pressings or calender rollers. The throwing-off handles and the levers and weights for applying pressure upon the wooden pressing rollers are to be seen underneath.

In fig. 38, A A are the cans from a spread-board, or from another drawing frame or preparing machine, such as fig. 42, B the sliver guide pulleys, C the feed rollers, D the gill bars or fallers, E the drawing rollers, F the delivery rollers, and G the can which will be taken to the next drawing frame. The gill bars on the upper slide H have approximately the same surface speed as the feed rollers C. The rollers E have a surface speed 8 to 16 times as great, giving drafts of from 8 to 16 respectively. The delivery rollers F have a slight lead on the drawing rollers in order to keep the sliver tight on the doubling plate K. The faller bars are moved

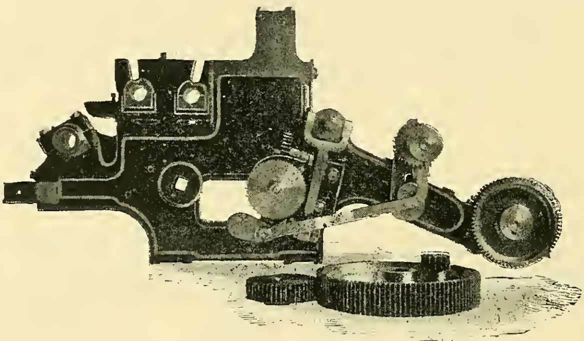

Fig. 40.—Traverse motion for drawing frame front roller.
(As made by Messrs James Mackie & Sons, Ltd., Belfast.)

by the screws shown in detail at L. The ends are cut as shown at M, to fit into the screw threads, while the gills remain vertical when on the top slide. The upper screw, of comparatively fine pitch, moves the fallers forward upon the top slide, until they fall or are knocked down into the threads of the lower screw by the tappet N. The bottom screw is of coarse

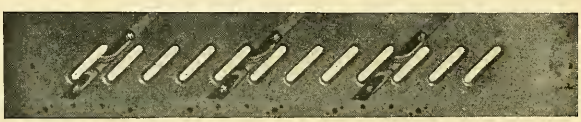

Fig. 41.—Patent conductor on under side of sliver plate.
(As supplied by Messrs James Mackie & Sons, Ltd., Belfast.)

pitch, so that fewer fallers are required. It turns at the same speed as the top screw, and the tappet O raises one faller every revolution into the threads of the upper screw and on to the top slide. There are pieces, P, back and front, at the ends of the slides, to guide the fallers in their up-and-down movement. The front guides fit into grooves in the faller ends as shown. In order that heavy fallers may not wear the bottom slide in consequence of their constant dropping, faller lowerers Q are provided, which being moved up and down at the right moment by an eccentric R on the rear end of the bottom screw, catch the faller and lower it gently on to the bottom slide. The lower drawing roller E is of steel and scored to give it more gripping power. The pressing roller E′ may be of wood, but it is much better if made of pieces of leather, on edge, bolted between two steel flanges. The pressure is applied by means of compound levers

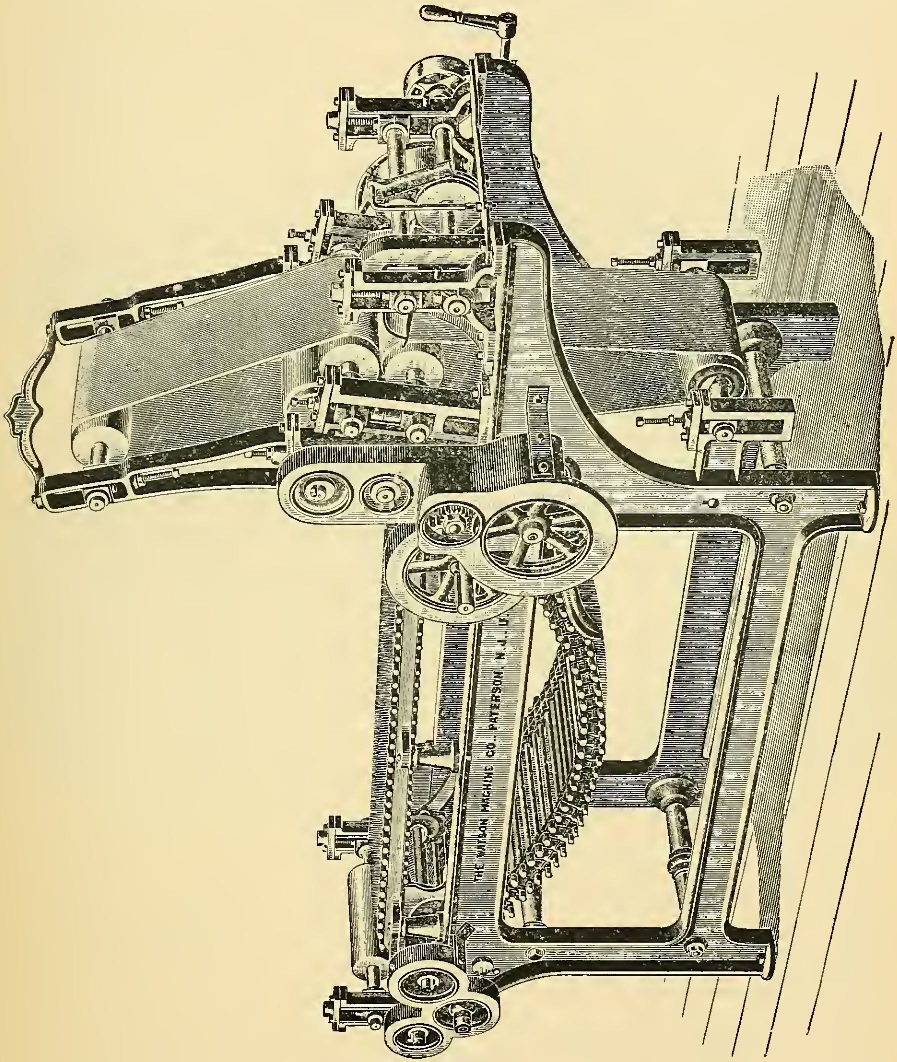

Fig. 42.—Apron head chain-bar drawing frame for Manila.

S and T, the weight W, and the hanger X. The pull of the levers should be as nearly as possible in a straight line passing through the centre of the two rollers. The centre line of the groove in the bracket Z should also correspond, so that as little power as possible may be lost in friction against the groove.

The bell mechanism was explained on page 65 in connection with the spread-board. As a general rule, it is only used upon the first drawing or bell frame when not applied to the spread-board or card as the case may be, although a fine system, for instance, may advantageously have bells applied to all the drawing frames in order to insure equal lengths in the cans and render possible the passing together and the pulling to waste of all the unavoidable piecings and the production of a more perfectly level yarn.

In fig. 39, A is the front roller, B the delivery shaft, C the front back roller, D the back back roller, E the back shaft, F the delivery boss, G the delivery pressing roller, H the right and left-hand top screws, I the right

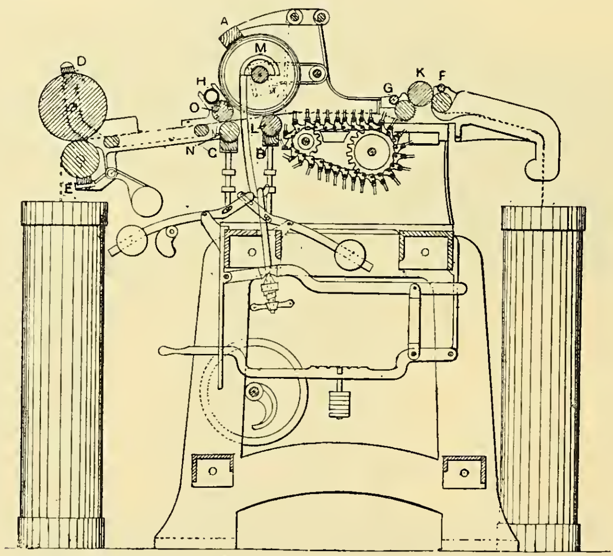

Fig. 43.—Chain-bar drawing frame for jute.

and left-hand bottom screws, J the "jockey" rollers, K the slack pulley, and L the fast driving pulley. U is the traverse motion bush, seen also in fig. 40. X is a dead wheel, Y the eccentric wheel, and Z a pinion, all for the traverse motion of the drawing roller. A A is the driving pulley socket, N N are double back shafts for each head, and M M and P P are the back shaft wheels.

The advantage of double back shafts for each head is, that when a faller jams and a safety pin breaks, only that head upon which the accident occurs is stopped, instead of having the whole frame stopped, as is the inevitable result when a single back shaft is used.

Proceeding to the gearing:—The general speed of the frame is altered by changing the pinion B B, which is called the speed change pinion and drives the front roller wheel C C.

The delivery roller is commanded by the front roller delivery pinion J J driving the delivery roller wheel L L through the delivery intermediate K K.

The draft gearing is as follows:—The front roller wheel C C drives the draft gearing stud wheel V, upon the pap of which is keyed the draft gearing stud pinion D D. This latter pinion drives the draft change pinion F F, and the back shaft E, through the draft gearing intermediate

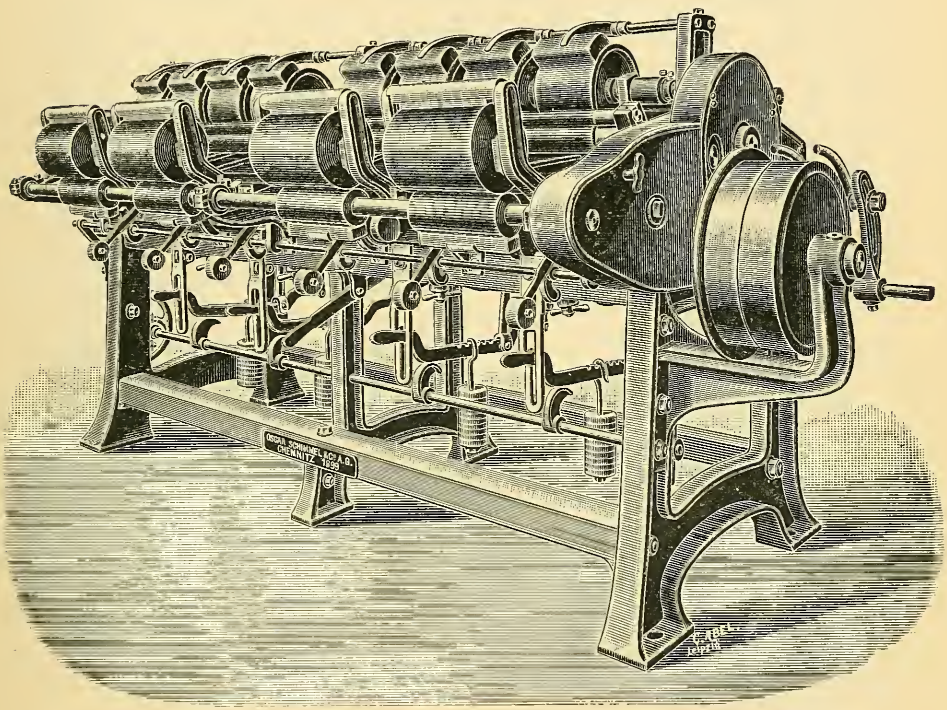

Fig. 44.—Chain-bar drawing frame for jute.

E E. Upon the other end of the back shaft, the back shaft pinion G G is keyed and drives the back roller stud wheel H H. Upon the same socket is the back roller gear stud pinion P, which in turn drives the front back roller through the back roller wheel Q. The back back roller is driven from the front back roller by the pinion T driving the pinion R through the intermediate S. W are the back shaft bevels driving the bevels M keyed upon the bottom screws. The top screws are driven from the bottom screws by means of similar spur pinions N.

The calculations for the lead of fallers and the draft of the drawing frame are similar to those given in Chapter VII.

Preparing machinery is usually fitted with some method of securing the gills and fallers against damage when a faller sticks or a "crush" occurs. This usually takes the form of a safety pin through which motion is imparted to the back shaft which drives the screws and fallers. A pinion upon the back shaft, which is the draft change pinion F F, when a single back shaft is used, and either of the back shaft wheels M M or P P, when the double back shaft is employed, is loose upon a socket upon the shaft itself and faces close up to a face plate on the socket. About $1\frac{1}{2}$ or 2 inches from the centre of the face plate and pinion, a small hole is bored to receive a short piece of brass wire, which, when inserted and the wheel and face plate kept in close contact by means of a nut or loose collar on the shaft, affords a medium for driving the back shaft and screws. When the back shaft becomes too stiff to turn through a "squeeze," etc., the brass pin is sheared through, and the frame or head put out of gear. A spring clutch wheel is sometimes employed instead of the safety pins, with a like result.

Boss Roller Traverse Motion.—A traverse motion, such as is shown in fig. 40, should be applied to all drawing and roving frames. Its object is to give the drawing rollers a very slow reciprocating longitudinal motion in order to equalise the wear, and prevent cutting of the journal or bearing or welting of that part of the wood roller immediately in contact with the sliver, and thus considerably increase the life of the wood roller.

The patent adjustable conductor on the under side of the sliver plate, as shown in fig. 41, tends to equalise the tension on the slivers and ensure perfect selvages, and thus render the drafting through the gills of the following frame more perfect.

The "Apron Head."—Fig. 42, which represents a type of machine much used in America to follow and reduce the sliver from the combined hackler and spreader, fig. 29, affords an example of the apron head, which is also used for jute.

It will be seen that in the apron head the drawing rollers are surrounded by endless aprons of leather kept tight by adjustable tension rollers. The leather affords a good gripping surface, while the long circumference of the leather aprons enables them to be used for a considerable time without renewal.

Setting the Fallers and Screws.—In screw gill drawing and roving frames consisting of more than one head, the screws should be so set in relation to each other that in no head do the fallers rise or fall at the same moment, thus equalising the load on the back shaft. In practice the ordinary screws and fallers cannot be run at a speed of more than 200 per minute, owing to the fallers jamming and sticking front or back, through wear of the slides, etc. Attempts have been made with some success to raise the speed of the fallers by using double-threaded screws, which raise or let

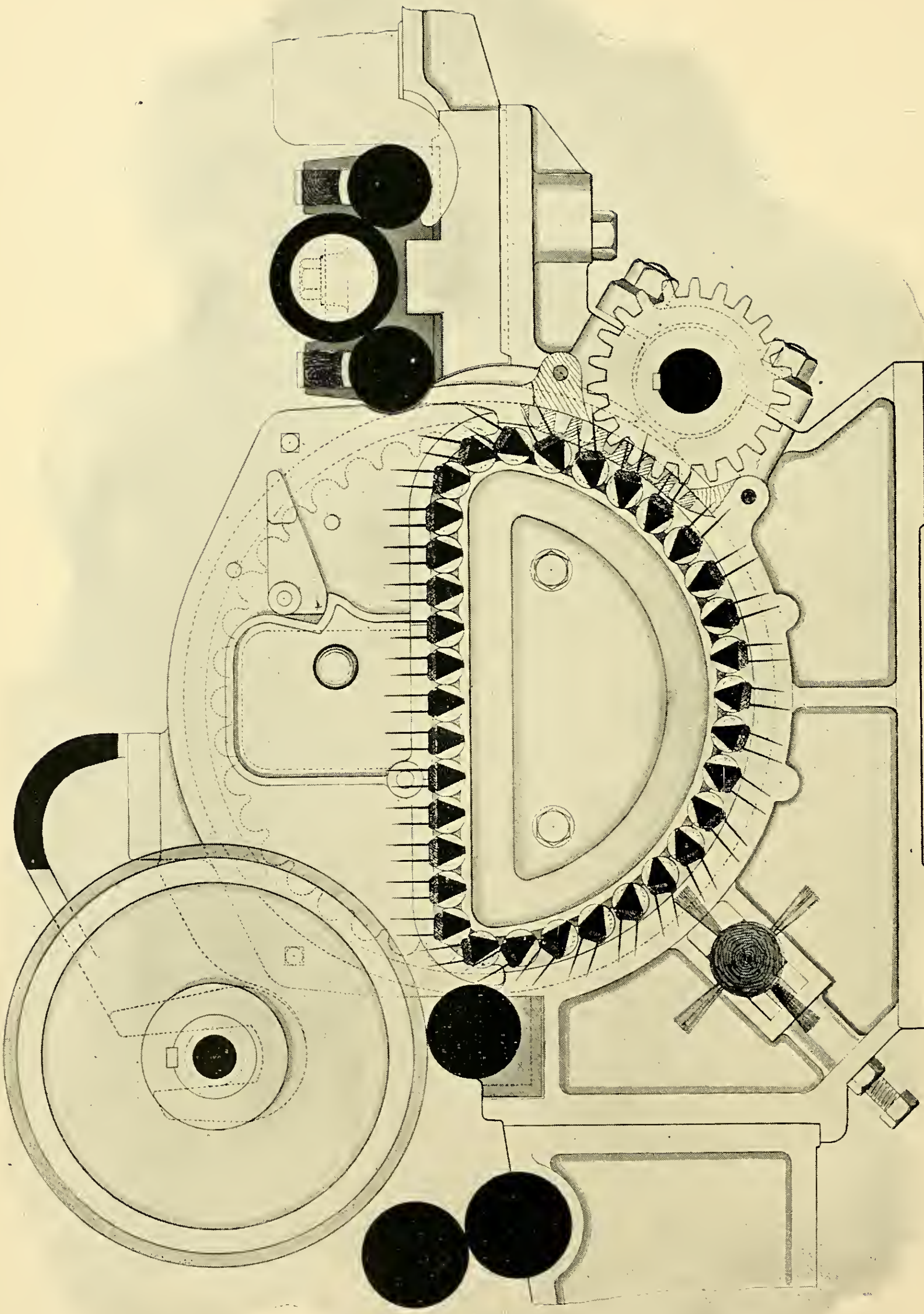

FIG. 45.—Section through bars of Fraser's patent "ring" drawing frame for jute.

fall two fallers each revolution; this can be successfully accomplished when combined with guards pivoted back and front, and locked together by a rod underneath, the tappets being set so that the rise and fall is alternate, and the guards adjusted so that, when the front is open, the back is closed, and *vice versâ*. However, when, as in jute machinery, it is desired to run quickly and obtain a high turn-off on short drafts, the chain gill or push-bar drawing head is to be preferred to the screw gill as being simpler and less liable to accidents, although it is not so perfect as regards short nips and direct penetration and withdrawal of the pins from the sliver.

Chain Gill-bar Drawing Frame.—Fig. 42 shows the form of chain bars used in Manila machinery, in which the bars are guided and kept rigidly in position by means of blocks, on their ends, the arms of which engage with either side of the top slide.

The "Ring" Push-bar Drawing Frame.—Figs. 43 and 44 illustrate a form of chain gill-bar drawing frame much used for jute, while fig. 45 gives a sectional view of the new "ring" push-bar drawing frame for the same fibre as manufactured by Messrs Douglas Fraser & Sons of Arbroath.

Gamble's Push-bar Drawing Head.—Gamble's push-bar arrangement, as shown in fig. 35 and made by Messrs Combe, Barbour & Combe, Ltd., Belfast, is also much used for jute drawing. Instead of being carried, in the circular part of their course, in the teeth of spur carriers as in Gamble's patent, the bar in the "ring" drawing frame rests in the teeth of the annular wheel or ring shown. When they have risen to near the centre line of the ring at the retaining rollers, they are deflected by means of an upper race into a horizontal path. On reaching the drawing roller they slide smoothly over the comparatively sharp corner of the race, and are caught again into gear by the teeth of the rings. A slotted cam controls the canting of the bars by means of their cranked ends, and is so designed as to cause the pins to enter and leave the sliver in a vertical position, the result being good pinning and a short "nip" at the drawing roller. The driving shaft is outside the path of the gill bars, and is geared by pinions into shrouded teeth in the outer circumference of the rings, as shown. The bars are of triangular section at the gills, and can be readily lifted out after lifting a latch and opening a hinged door in the cover.

Retaining and Jockey Roller.—In figs. 39, 43 and 45 the form of double feed or retaining roller D C and G F, with intermediate jockey rollers J and K, generally used for flax, hemp, jute and tow drawing and roving frame, can be seen. The sliver is passed from the can through a conductor under the roller F or D, round the jockey roller K or J, and down and under the front feed roller G or C, where it is pinned by the gills. At A G in fig. 26 is shown the application of a dead rubber to the under side of the jockey roller. Some spinners do not care for this rubber, as the tension of the spring which holds the rubber diminishes the effective pressure or weight of the jockey roller. Another arrangement in which some spinners believe is the application of a hollow shell, under the back feed roller F or D, which collects dust and shove and keeps the sliver out of contact with the roller. The position of an extra pair of drawing rollers generally used for jute drawings is shown at N O, fig. 43, and also in fig. 45.

Preparing Systems.—The following are particulars of preparing systems in everyday use. Firstly, for preparing Manila or New Zealand hemp for automatic gill spinning into binder twine, or reaper yarn, or rope yarn, or white Manila for trawl twine.

	Spreader and Hackler.	1st Finishers.	2nd Finishers.	Bell Frame.	Sett Frame.	3rd Drawing.
	Chain Gills.			Screw Gills.		
Rows of gills for delivery,	1	1	1	4	6	6
Deliveries per frame,	1	1	1	4	6	6
Width of gill,	23 in.	22½ in.	19½ in.	7½ in.	4¾ in.	4 in.
Pitch of gill bars or screws,	4½ in.	3¾ in.	3¾ in.	1½ in.	1¼ in.	1 in.
Pins in the row of gill,	28	36	39	13	14	15
Length of the pin out of the bar,	5 in.	4 in.	3½ in.	2¾ in.	2½ in.	2¼ in.
Suitable drafts,	10–20	10–20	10–20	10	10	10
Speed of the quick sheet in feet per minute,	175	175	175	...	...	...
Rate of delivery in feet per minute,	200	200	200	...	...	...
Speed of the slow sheet in feet per minute,	16–32	16–32	16–32	...	...	...

Next, for preparing jute long line to be spun into yarn from 1200 to 1800 yards per lb.

Particulars.	Spreader.	Drawing.			Roving.
		1st.	2nd.	3rd.	
Heads per frame,	1	2	3	3	6
Rows of gills per head,	4	4	6	6	8
Length of reach,	40 in.	36 in.	32 in.	28 in.	24 in.
Breadth of gill,	7 ,,	5 ,,	4 ,,	3 ,,	2 ,,
Breadth of conductor,	6 ,,	4 ,,	3 ,,	2 ,,	¾ ,,
Length of pin in gill,	2½ ,,	2 ,,	1¾ ,,	1½ ,,	1¼ ,,
Pins per inch (two rows),	3	4	5	6	7
Pitch of screw,	1 in.	⅞ in.	¾ in.	⅝ in.	½ in.
Deliveries per head,	1	1	1	2	8

For spinning flax, hemp, and jute long line into yarn from 1500 to 2700 yards per lb.

Particulars.	Spreader.	Drawings.			Roving.
		1st.	2nd.	3rd.	
Heads per frame,	1	2	3	3	6
Rows of gills per head,	4	4	6	8	10
Length of reach,	40 in.	36 in.	32 in.	28 in.	24 in.
Breadth of gill,	$6\frac{1}{2}$,,	$4\frac{1}{2}$,,	$3\frac{1}{2}$,,	$2\frac{3}{4}$,,	2 ,,
Breadth of conductor,	$5\frac{1}{2}$,,	$3\frac{1}{2}$,,	$2\frac{1}{2}$,,	$1\frac{3}{4}$,,	$\frac{3}{4}$,,
Length of pins in the gill,	$2\frac{1}{2}$,,	2 ,,	$1\frac{3}{4}$,,	$1\frac{1}{2}$,,	$1\frac{1}{4}$,,
Pins per inch (two rows),	4	5	6	7	8
Pitch of screw,	$\frac{7}{8}$ in.	$\frac{3}{4}$ in.	$\frac{5}{8}$ in.	$\frac{1}{2}$ in.	$\frac{1}{2}$ in.
Deliveries per head,	1	1	1	2	10

For spinning flax, hemp, and jute long line into yarn from 2400 to 3600 yards per lb.

Particulars.	Spreader.	Drawings.			Roving.
		1st.	2nd.	3rd.	
Heads per frame,	1	2	3	3	6
Rows of gills per head,	4	4	6	8	10
Length of reach,	38 in.	35 in.	32 in.	28 in.	24 in.
Breadth of gill,	5 ,,	4 ,,	3 ,,	$2\frac{1}{2}$,,	2 ,,
Breadth of conductor,	4 ,,	3 ,,	2 ,,	$1\frac{3}{4}$,,	$\frac{3}{4}$,,
Length of pin in gill,	$2\frac{1}{2}$,,	2 ,,	$1\frac{3}{4}$,,	$1\frac{1}{2}$,,	$1\frac{1}{4}$,,
Pins per inch (two rows),	4	5	6	7	8
Pitch of screw,	$\frac{7}{8}$ in.	$\frac{3}{4}$ in.	$\frac{5}{8}$ in.	$\frac{1}{2}$ in.	$\frac{1}{2}$ in.
Deliveries per head,	1	1	1	2	10

For spinning flax and hemp tows into yarn from 3400 to 4800 yards per lb., forming the sliver upon a 5 × 6 feet card 16 pins per square inch on the cylinder, with $6\frac{1}{2}$ pairs of rollers.

Particulars.	Drawings.				Roving Frame.
	Bell Frame.	Sett Frame.	3rd.	4th.	
Heads per frame,	2	2	3	4	7
Rows of gills per head,	6	6	6	8	10
Deliveries per head,	1	1	1	2	10
Doublings,	6	6	6	4	1
Length of reach,	12 in.	11 in.	10 in.	9 in.	8 in.
Pitch of screw,	$\frac{5}{8}$,,	$\frac{9}{16}$,,	$\frac{1}{2}$,,	$\frac{7}{16}$,,	$\frac{3}{8}$,,
Breadth of conductor,	$2\frac{1}{4}$,,	$2\frac{1}{16}$,,	$1\frac{7}{8}$,,	$1\frac{3}{4}$,,	$\frac{1}{2}$,,
Breadth of gill,	3 ,,	3 ,,	$2\frac{3}{4}$,,	$2\frac{1}{2}$,,	2 ,,
Length of pin out of the stock,	$\frac{3}{4}$,,	$\frac{3}{4}$,,	$\frac{3}{4}$,,	$\frac{3}{4}$,,	$\frac{3}{4}$,,
Pins per inch (two rows),	8	10	12	14	16

For spinning flax, hemp, and jute long line yarn from 3000 to 4800 yards per lb.

Particulars.	Spreader.	Drawings.			Roving.
		1st.	2nd.	3rd.	
Heads per frame, ...	1	2	2	3	7
Rows of gills per head, . . .	4	4	6	8	10
Length of reach, ...	38 in.	35 in.	32 in.	28 in.	24 in.
Breadth of gill, ...	$4\frac{1}{2}$,,	$3\frac{1}{2}$,,	$2\frac{1}{2}$,,	$2\frac{1}{8}$,,	$1\frac{3}{4}$,,
Breadth of conductor, . . .	$3\frac{1}{2}$,,	$2\frac{1}{2}$,,	2 ,,	$1\frac{1}{2}$,,	$\frac{1}{2}$,,
Length of pins in gill, . . .	$2\frac{1}{8}$,,	$1\frac{3}{4}$,,	$1\frac{1}{2}$,,	$1\frac{1}{4}$,,	$1\frac{1}{8}$,,
Pins per inch (two rows), . .	6	7	8	9	10
Pitch of screw, ...	$\frac{3}{4}$ in.	$\frac{11}{16}$ in.	$\frac{5}{8}$ in.	$\frac{9}{16}$ in.	$\frac{1}{2}$ in.
Deliveries per head, . . .	1	1	1	2	10

For spinning flax and hemp long line into yarn from 4200 to 5400 yards per lb.

Particulars.	Spreader.	Drawings.			Roving Frame.
		1st.	2nd.	3rd.	
Heads per frame, ...	1	2	2	3	7
Rows of gills per head, . . .	4	4	6	8	10
Length of reach in inches, . .	38	35	32	28	24
Breadth of gill in inches, . .	$4\frac{1}{4}$	$3\frac{1}{4}$	$2\frac{1}{4}$	2	$1\frac{3}{4}$
Breadth of conductor in inches, .	$3\frac{1}{4}$	$2\frac{1}{4}$	$1\frac{7}{8}$	$1\frac{1}{2}$	$\frac{1}{2}$
Length of pin in gill in inches, .	2	$1\frac{5}{8}$	$1\frac{3}{8}$	$1\frac{1}{4}$	$1\frac{1}{8}$
Pins per inch (two rows), .	7	8	9	10	12
Pitch of screw, ...	$\frac{3}{4}$ in.	$\frac{11}{16}$ in.	$\frac{5}{8}$ in.	$\frac{9}{16}$ in.	$\frac{1}{2}$
Deliveries per head, . . .	1	1	1	2	10

For spinning flax and hemp long line into yarn from 5400 to 6600 yards per lb.

Particulars.	Spreader.	Drawings.			Roving Frame.
		1st.	2nd.	3rd.	
Heads per frame, ...	1	2	2	3	7
Rows of gills per head, . . .	4	6	6	8	10
Length of reach in inches, . .	38	35	32	28	24
Breadth of gill in inches, . .	4	3	$2\frac{1}{4}$	2	$1\frac{3}{4}$
Breadth of conductor in inches, .	3	$2\frac{1}{4}$	$1\frac{7}{8}$	$1\frac{1}{2}$	$\frac{1}{2}$
Length of pins in gill in inches, .	2	$1\frac{5}{8}$	$1\frac{3}{8}$	$1\frac{1}{4}$	$1\frac{1}{8}$
Pins per inch (two rows), . . .	8	9	10	12	14
Pitch of screw, ...	$\frac{3}{4}$ in.	$\frac{11}{16}$ in.	$\frac{5}{8}$ in.	$\frac{9}{16}$ in.	$\frac{1}{2}$ in.
Deliveries per inch, ...	1	1	1	2	10

For spinning flax long line into yarn from 6000 to 9000 yards per lb.

Particulars.	Spreader.	Drawings.			Roving Frame.
		1st.	2nd.	3rd.	
Heads per frame,	1	2	2	3	7
Rows of gills per head,	6	6	6	8	10
Deliveries per head,	1	1	1	2	10
Length of reach in inches,	36	30	28	26	24
Breadth of gill in inches,	4	3	$2\frac{1}{2}$	2	$1\frac{1}{2}$
Breadth of conductor in inches,	3	$2\frac{1}{2}$	$1\frac{3}{4}$	$1\frac{1}{4}$	$\frac{1}{2}$
Length of pin in inches,	$1\frac{3}{4}$	$1\frac{3}{8}$	$1\frac{1}{4}$	$1\frac{1}{8}$	1
Pins per inch,	9	10	11	13	15
Pitch of screw,	$\frac{11}{16}$ in.	$\frac{5}{8}$ in.	$\frac{1}{2}$ in.	$\frac{7}{16}$ in.	$\frac{3}{8}$ in.

A system for spinning flax tow into yarn from 4800 to 7500 yards per lb., forming the sliver upon a 5 × 6 feet card $4\frac{1}{2}$ pins per inch.

Particulars.	Drawings.				Roving Frame.
	Bell Frame.	Sett Frame.	3rd.	4th.	
Heads per frame,	2	2	3	4	7
Rows of gills per head,	6	6	6	8	10
Deliveries per head,	1	1	1	2	10
Length of reach in inches,	14	13	12	11	10
Pitch of screw,	$\frac{1}{2}$ in.	$\frac{1}{2}$ in.	$\frac{7}{16}$ in.	$\frac{7}{16}$ in.	$\frac{3}{8}$ in.
Breadth of conductor in inches,	$2\frac{1}{2}$	$2\frac{1}{4}$	2	$1\frac{3}{4}$	$\frac{1}{2}$
Breadth of gill in inches,	3	$2\frac{3}{4}$	$2\frac{1}{2}$	$2\frac{1}{4}$	$1\frac{1}{2}$
Length of pin in inches,	1	1	$\frac{7}{8}$	$\frac{7}{8}$	$\frac{3}{4}$
Pins per inch in gill,	10	12	14	16	18

A system for spinning flax long line into yarn from 9000 to 15,000 yards per lb.

Particulars.	Spreader.	Drawings.				Roving.
		1st.	2nd.	3rd.	4th.	
Heads per frame,	1	2	3	4	5	7
Rows of gills per head,	6	6	8	8	12	10
Deliveries per head,	1	1	1	1	2	10
Length of reach in inches,	30	26	22	18	15	14
Pitch of screw,	$\frac{1}{2}$ in.	$\frac{1}{2}$ in.	$\frac{1}{2}$ in.	$\frac{3}{8}$ in.	$\frac{3}{8}$ in.	$\frac{3}{8}$ in.
Breadth of conductor in inches,	$2\frac{1}{2}$	2	$1\frac{1}{2}$	1	$\frac{3}{4}$	$\frac{1}{2}$
Breadth of gill in inches,	$3\frac{1}{4}$	$2\frac{3}{4}$	$2\frac{1}{4}$	$1\frac{3}{4}$	$1\frac{1}{2}$	$1\frac{1}{4}$
Length of pin in inches,	$1\frac{7}{8}$	$1\frac{3}{4}$	$1\frac{1}{2}$	$1\frac{1}{4}$	1	$\frac{3}{4}$
Pins per inch in gill,	10	12	15	18	21	24

A system for spinning flax long line into yarn from 15,000 to 24,000 yards per lb.

Particulars.	Spreader.	Drawings.				Roving Frame.
		1st.	2nd.	3rd.	4th.	
Heads per frame,	1	3	3	4	5	7
Rows of gills per head,	6	8	8	8	12	10
Deliveries per head,	1	1	1	1	2	10
Length of reach in inches,	30	26	22	18	14	12
Pitch of screw,	$\frac{1}{2}$ in.	$\frac{1}{2}$ in.	$\frac{7}{16}$ in.	$\frac{3}{8}$ in.	$\frac{3}{8}$ in.	$\frac{3}{8}$ in.
Breadth of conductor in inches,	$2\frac{1}{2}$	2	$1\frac{1}{2}$	1	$\frac{3}{4}$	$\frac{3}{8}$ in.
Breadth of gill in inches,	$3\frac{1}{4}$	$2\frac{3}{4}$	$2\frac{1}{4}$	$1\frac{3}{4}$	$1\frac{1}{2}$	$1\frac{1}{4}$
Length of pin in gill in inches,	$1\frac{7}{8}$	$1\frac{5}{8}$	$1\frac{3}{8}$	$1\frac{1}{8}$	$\frac{7}{8}$	$\frac{5}{8}$
Pins per inch in gill,	10	14	18	22	26	30

A system for spinning flax tow into yarn from 7500 to 12,000 yards per lb., forming the sliver upon a 5 × 6 feet card, 25 pins per square inch on the cylinder.

Particulars.	Drawings.				Roving Frame.
	Bell Frame.	Sett Frame.	3rd.	4th.	
Heads per frame,	2	2	2	3	7
Rows of gills per head,	6	6	8	8	10
Deliveries per head,	1	2	2	4	10
Length of reach in inches,	12	11	10	9	8
Pitch of screw,	$\frac{1}{2}$ in.	$\frac{1}{2}$ in.	$\frac{7}{16}$ in.	$\frac{7}{16}$ in.	$\frac{3}{8}$ in.
Breadth of conductor in inches,	$2\frac{1}{4}$	2	$1\frac{3}{4}$	$1\frac{1}{4}$	$\frac{1}{2}$
Breadth of gill in inches,	$2\frac{3}{4}$	$2\frac{3}{4}$	$2\frac{1}{4}$	2	$1\frac{1}{4}$
Length of pin in inches,.	1	1	$\frac{7}{8}$	$\frac{7}{8}$	$\frac{3}{4}$
Pins per inch in row of gill,	12	15	18	21	24

A system for spinning flax tow into yarn from 12,000 to 24,000 yards per lb., forming the sliver on a 5 × 6 feet card, 36 pins per square inch on the cylinder, and combing it for the finer numbers.

Particulars.	Drawings.				Roving Frame.
	Bell Frame.	Sett Frame.	3rd.	4th.	
Heads per frame,	2	2	3	3	7
Rows of gills per head,	6	6	8	8	10
Deliveries per head,	1	1	2	2	10
Length of reach in inches,	11	$10\frac{1}{2}$	10	$9\frac{1}{2}$	9
Breadth of gill in inches,	$2\frac{1}{2}$	2	$1\frac{1}{2}$	$1\frac{1}{4}$	1
Breadth of conductor in inches,	$1\frac{3}{4}$	$1\frac{1}{4}$	$\frac{7}{8}$	$\frac{3}{4}$	$\frac{3}{8}$
Length of pin in gill in inches,	$1\frac{1}{8}$	$1\frac{1}{8}$	1	1	$\frac{3}{4}$
Pins per inch in row of gill,	12	14	16	18	21
Pitch of screw,	$\frac{1}{2}$ in.	$\frac{1}{2}$ in.	$\frac{7}{16}$ in.	$\frac{3}{8}$ in.	$\frac{5}{16}$ in.

A system for spinning flax long line into yarn from 24,000 to 36,000 yards per lb.

Particulars.	Spreader.	Drawings.				Roving Frame.
		1st.	2nd.	3rd.	4th.	
Heads per frame,	1	2	2	3	3	8
Rows of gills per head,	6	8	8	8	8	10
Deliveries per head,	1	1	2	2	2	10
Length of reach in inches,	28	26	24	22	20	18
Pitch of screw,	$\frac{3}{8}$ in.	$\frac{3}{8}$ in.	$\frac{5}{16}$ in.	$\frac{5}{16}$ in.	$\frac{1}{4}$ in.	$\frac{1}{5}$ in.
Breadth of conductor in inches,	$1\frac{1}{4}$	$1\frac{1}{8}$	$\frac{7}{8}$	$\frac{3}{4}$	$\frac{9}{16}$	$\frac{1}{2}$
Breadth of gill in inches,	$2\frac{1}{4}$	$2\frac{1}{8}$	$1\frac{1}{2}$	$1\frac{1}{4}$	1	$\frac{3}{4}$
Length of pin in inches over all,	$1\frac{1}{8}$	1	$\frac{7}{8}$	$\frac{3}{4}$	$\frac{5}{8}$	$\frac{9}{16}$
Pins per inch in row of gill,	20	24	28	32	35	38

A system for spinning flax line into yarn from 36,000 to 75,000 yards per lb.

Particulars.	Spreader.	Drawings.				Roving Frame.
		1st.	2nd.	3rd.	4th.	
Heads per frame,	1	3	3	3	4	8
Rows of gills per head,	4	8	8	8	8	12
Deliveries per head,	1	1	2	2	2	12
Length of reach in inches,	18	17	16	15	14	13
Pitch of screw,	$\frac{3}{8}$ in.	$\frac{3}{8}$ in.	$\frac{5}{16}$ in.	$\frac{5}{16}$ in.	$\frac{1}{4}$ in.	$\frac{3}{16}$ in.
Breadth of conductor in inches,	$\frac{7}{8}$	$\frac{3}{4}$	$\frac{5}{8}$	$\frac{3}{8}$	$\frac{1}{4}$	$\frac{1}{12}$
Breadth of gill in inches,	$1\frac{1}{2}$	$1\frac{1}{4}$	1	$\frac{7}{8}$	$\frac{3}{4}$	$\frac{1}{2}$
Pins per inch in row of gill,	36	40	45	50	55	60
Length of pin in inches over all,	$1\frac{1}{16}$	$\frac{15}{16}$	$\frac{13}{16}$	$\frac{11}{16}$	$\frac{9}{16}$	$\frac{1}{2}$

Doublings.—The number of doublings given upon a drawing frame depends upon the number of rows of gills and deliveries per head and whether one or two slivers are put up per row of gills. The number of rows of gills per head must be proportional to the breadth of the gill and to the pitch of the screw, for a number of broad rows of gills per head means long fallers, which are not so stiff and rigid as shorter ones of the same thickness. If there be but one sliver per row of gills, the number of doublings equals the number of rows per head divided by the number of deliveries per head. If there be two slivers per row of gills, the number of doublings is of course increased twofold.

Short Drafts and Single Slivers.—When making warps and superior yarns, spinners often work with shorter drafts and only one sliver per row of gills, thus giving the material plenty of room in the gill, and insuring good pinning and freedom from overloading and overriding in the gill. It is also essential to perfect work to have a properly formed sliver delivered into the feed rollers and gill of the succeeding frame in a perfectly flat and straight condition—in fact, just as it leaves the delivery roller of the preceding frame. When there are a number of cans to be put up at the back of a frame, sliver guides are required. These are flanged pulleys of polished cast iron, supported and grouped upon rods, so that there is one pulley directly above each of the cans which stand behind the frame in rows to admit of easy access to the attendant to replace empty cans and piece up ends which are broken or running out. The shape of these guide pulleys is a matter of importance, since if not properly constructed they do not deliver the sliver straight into the gills. They have sometimes been made rounded on the face with the object of keeping the sliver in the centre, in the same way that a driving belt will run in the centre of a round-faced pulley. This effect is not obtained in the case of slivers, however, as their tension is not sufficiently great; in fact, a round-faced sliver pulley tends rather to throw the sliver to one side or the other, which is just what must be avoided. For weak tow slivers it is advisable to give the sliver guide pulleys the same surface speed as the feed rollers, by means of a belt, and thus lift the sliver from the can without strain.

The proper proportioning of the gills to suit the work to be done on the frames is of great importance. If the gills be too narrow they will be overloaded, part of the sliver, in all probability, not being pinned at all, but riding over the top of the pins and being consequently gulped and improperly drawn. The gill should be about one inch wider than the front conductor, and the back conductor be set so that it is about a quarter inch narrower than the gill, or the same width as the front conductor of the previous frame, so that the sliver may be flat and well spread in the gill, which it should nearly fill as regards width. The best results as regards perfect drawing will be obtained when the sliver is rather light in the gill.

Weight of the Slivers on the Doubling Plate.—A good axiom will be found to be that the separate slivers upon the sliver plate should weigh 32 yards per ounce per inch in breadth. If the following method of proportioning the gills be carried out, the results will be found to correspond with the best modern practice. First determine the heaviest rove combined with the longest drafts it is proposed to work over the system. The yards per ounce of the rove, divided by the draft of the roving frame, will give the yards per ounce of sliver in the roving frame gill. This result, multiplied by the rows of gills per delivery on the 4th drawing and divided by the draft of the 4th drawing, gives the yards per ounce of sliver in each gill of the 4th drawing. If, as is usual, there are two slivers per row of gills on the 1st, 2nd, 3rd, and 4th drawings, the yards per ounce of sliver in the 3rd drawing gill will be twice the yards per ounce in the 4th drawing gill, multiplied by the rows per delivery on the 3rd drawing, and divided by the draft of the 3rd drawing. Then, again, the yards per ounce of sliver in the 2nd drawing gill will be twice the yards per ounce in the 3rd drawing gill, multiplied by the rows per delivery on the 2nd drawing and divided by the draft of the 2nd drawing. The yards per ounce of sliver in the 1st drawing gill will be twice the yards per ounce on the 2nd drawing gill, multiplied by the rows per delivery on the 1st drawing frame and divided by the draft of the 1st drawing. In a similar manner the yards per ounce of sliver in the gill of the spread-board is twice the yards per ounce of sliver in the 1st drawing gill, multiplied by the rows of gills per delivery on the spreader and divided by the draft of the spreader. If there be but three drawings per system, leave out the 1st drawing in the above and consider the 2nd, 3rd, and 4th as 1st, 2nd, and 3rd. Thus, if in making rove 100 yards per ounce we have the following drafts: Roving frame 12, 4th drawing frame 17, 3rd drawing frame 16, 2nd drawing frame 15, 1st drawing frame 18, and the spread-board 30, with 6 rows per delivery on the 4th drawing, 4 on the 3rd, 4 on the 2nd, 8 on the 1st, and 8 on the spreader, with two slivers per row on the 1st, 2nd, 3rd, and 4th drawings; the yards per ounce of sliver in the gills is: Roving 8·3, 4th drawing 2·9, 3rd drawing 1·45, 2nd drawing ·75, 1st drawing ·6, and spreader ·3.

Capacity, etc., of Gills.—From the following table suitable gills can be selected for each weight of sliver:—

Yards per oz. of sliver in gill,	·3	·4	6	·7
Capacity of gill in inches, .	$4\frac{1}{2} \times 1\frac{1}{4}$	$4 \times 1\frac{1}{4}$	4×1	$3\frac{1}{2} \times 1$
Yards per oz. of sliver in gill,	·8	1	1·2	1·5
Capacity of gill in inches, .	$3\frac{1}{4} \times 1$	3×1	$2\frac{3}{4} \times 1$	$2\frac{1}{2} \times 1$
Yards per oz. of sliver in gill,	1·7	2	2·5	2·7
Capacity of gill in inches, .	$2\frac{1}{4} \times 1$	2×1	$1\frac{3}{4} \times 1$	$1\frac{3}{4} \times \frac{7}{8}$
Yards per oz. of sliver in gill,	4	5	6·5	8
Capacity of gill in inches, .	$1\frac{1}{2} \times 1$	$1\frac{1}{2} \times \frac{3}{4}$	$1\frac{3}{8} \times \frac{3}{4}$	$1\frac{1}{4} \times \frac{3}{4}$
Yards per oz. of sliver in gill,	10	15	20	over 20
Capacity of gill in inches, .	$1\frac{1}{8} \times \frac{3}{4}$	$1 \times \frac{3}{4}$	$\frac{3}{4} \times \frac{9}{16}$	$\frac{1}{2} \times \frac{1}{2}$

Thus, for the roving frame, a gill $1\frac{1}{4}$ inches broad with a $\frac{3}{4}$-inch pin; for the 4th drawing frame, a gill $1\frac{3}{4}$ inches broad with a pin $\frac{7}{8}$ inch long; for the 3rd drawing frame, a gill $2\frac{1}{2}$ inches broad with a pin 1 inch long; for the 2nd drawing frame, a gill $3\frac{1}{2}$ inches broad with a 1-inch pin; for the 1st drawing frame, a 4-inch gill with a 1-inch pin; and for the spreader, a $4\frac{1}{2}$-inch gill with $1\frac{1}{4}$-inch pin, will be found to give satisfactory results. The length of pin mentioned here is the over all length. The thickness of the gill stock is usually from $\frac{1}{8}$ inch in the finer gills to $\frac{1}{4}$ inch in the coarser, leaving the effective length of the pin short of the over all length by this amount.

The pins per inch in the gill depend upon the fineness of the material to be prepared. Coarse material intended for heavy yarn is only smashed up and broken when worked through too fine a gill, but for fine material of good quality and intended for fine yarns, the more gilling which it receives the better, as the fibres are capable of further subdivision, and the yarn will be level and regular in thickness, in proportion to the number of individual fibres which it contains, and to the number of doublings which the sliver has undergone. The number of wire, or size of pin, to be used in order to obtain a sufficiently strong gill, must be directly as the pins per inch, and inversely as the length of the pin, for a closely set gill of fine pins may be as firm and strong as a coarser gill of stronger wire. A long pinned gill is not so firm as one with shorter pins, hence, if the pins be very long, they should be of heavy wire.

The following table of gills corresponds with modern practice :—

Breadth of gill in inches, .	more than 4	4	$3\frac{3}{4}$	$3\frac{1}{2}$
Pins per inch, . . .	6 to 9	7 to 10	8 to 13	8 to 14
Number of wire B.W.G., .	13 to 16	14 to 17	14 to 18	14 to 19
Breadth of gill in inches, .	$3\frac{1}{4}$	3	$2\frac{3}{4}$	$2\frac{1}{2}$
Pins per inch, . . .	9 to 15	9 to 16	10 to 18	12 to 23
Number of wire B.W.G., .	15 to 20	15 to 21	15 to 22	16 to 23
Breadth of gill in inches, .	$2\frac{1}{4}$	2	$1\frac{3}{4}$	$1\frac{1}{2}$
Pins per inch, . . .	14 to 24	14 to 27	14 to 28	16 to 30
Number of wire B.W.G., .	18 to 24	18 to 24	18 to 25	21 to 25
Breadth of gill in inches, .	$1\frac{1}{4}$	1	$\frac{3}{4}$	$\frac{1}{2}$
Pins per inch, . . .	18 to 35	20 to 42	36 to 42	44 to 60
Number of wire B.W.G., .	22 to 26	24 to 27	27 to 28	28 to 30

Systems for preparing coarse tow, say 10's to 16's lea, should start with gills say 8 per inch on the rotary of card, and finish with gills say 16 per inch on the roving frame. For medium tows, start with pins 8 per inch in the rotary gill, and finish with 18 per inch in the roving gill. In preparing fine tows, start with 10 per inch in the rotary gill, and finish with 20 or more per inch in the roving gill. In preparing for 40's to 60's line, 12 per inch in the spreader gill and 24 per inch in the roving gill will give good results, as will 15 per inch in the spreader gill and 36 per inch in the roving gill when making 60's to 90's line. Systems for preparing 90's to 150's line would do well to start with gills 20 per inch on the spreader and finish with 40 per inch on the roving frame.

Twenty-five per inch in the spread-board gill and 50 per inch in the roving frame gill will be suitable for 150's to 200's lea line, as will 30 and 60 per inch for 200's to 400's lea line.

The length of reach, or the distance from the centre of the front back roller to the centre of the drawing roller, should be at least equal to the length of the longest fibres to be drawn.

The finer the screw the shorter the nip and the more level the sliver obtained, as, when the faller does not approach close enough to the drawing roller, the material is apt to be gulped, or drawn away quickly, when the bar falls, and thus produce thicks and thins in the sliver. The pitch of screw can scarcely be made less than $\frac{3}{16}$ inch to give a strong enough screw thread and a sufficiently thick faller bar to carry the gill stock. The following table of pitch of screws, proportional to the breadth of gill, will be found to work well in practice.

Breadth of gill in inches,	$4\frac{1}{2}$	4	$3\frac{3}{4}$	$3\frac{1}{2}$	$3\frac{1}{2} \times 3$
Pitch of screw, . .	$\frac{3}{4}$ in.	$\frac{11}{16}$ in.	$\frac{5}{8}$ in.	$\frac{9}{16}$ in.	$\frac{1}{2}$ in.
Rows per head, . .	6	6	6	6	6
Breadth of gill in inches,	$2\frac{3}{4}$	$2\frac{1}{2}$ to $1\frac{1}{4}$	1	$\frac{7}{8}$	$\frac{1}{2}$
Pitch of screw, . .	$\frac{7}{16}$ in.	$\frac{3}{8}$ in.	$\frac{5}{16}$ in.	$\frac{1}{5}$ in.	$\frac{3}{16}$ in.
Rows per head, . .	6	8	10	10	12

Tow Combing.—Tow slivers are combed when it is desired to remove the naps and short fibres which remain after carding, and to produce a yarn which resembles and is almost equal to line. It is usually practised upon fine nappy tows, such as that from the top end of fine Courtrai, for instance, or upon long, but rough, tow of good quality, such as Irish scutching tow, and the Flemish Codillas. Since the percentage of noils produced is considerable, and their value very small compared with that of the combed sliver, combing only pays when the difference in value of noil and tow is comparatively small, that is to say, when tow is cheap. Combs for flax tow are constructed on the Heilmann principle. The best in use to-day is probably Slumberger's, a comb of German construction. The best comb is that which produces noil of minimum quantity and shortest staple. It is similar in principle to the cotton comb, but much stronger, heavier, and better adapted for long and inelastic fibre. Instead of being made into a lap, the slivers, usually to the number of twelve, are drawn from cans which are placed behind the machine—passed over brass conductors to a feeding and retaining arrangement, consisting of intersecting gills, then through and between the cushion plate and nipper, to the comb circle which, together with the top comb, extracts the noil. The combed fibre is drawn off and formed into a sliver by the detaching roller and drawing off segment working in combination. The roller is surrounded by a leather apron which serves to carry the fibre quickly forward, leaving it sufficiently slack to be drawn away, notwithstanding the intermittent motion of the machine, by a condensing and delivery roller revolving constantly. This roller delivers the compressed sliver into a can. The action of the machine, more minutely described, is as follows :—We will suppose that a set of twelve cans of sliver which has been doubled and drawn at least once, has been placed behind the machine and the ends brought over the brass conductors, through the retaining arrangement of intersecting gills, and into the feed rollers. These rollers deliver the slivers between the nipper knife and cushion plate, which hold it firmly while a number of rows of combs fixed upon one segment of a revolving cylinder comb out the end. When the segment of the cylinder occupied by the combs is past, the nipper knife, which is actuated by levers and a cam, is raised from the cushion plate, the single row top comb comes down and penetrates the protruding fibres, and the detaching rollers are brought down into the path of the fluted segment of the comb cylinder. The fibres which are being slowly and intermittently let down through the feed rollers, will have been subjected to several strokes of the comb cylinder before they project sufficiently far to be caught between the drawing off roller and the fluted segment. When they are caught, their tail ends are drawn through the top comb, which prevents any shorter and not fully-combed fibres being drawn through after them, and they themselves pass up between the rollers, and form the foundation of the sliver. When the fluted segment follows the comb round the next time, there are some fresh fibres ready to be added to those already drawn through, which, for the purpose of being spliced, so to speak, with them, are brought back half the distance they were previously advanced. This is effected by a cam which turns the detaching rollers one-third of a revolution backwards and two-thirds of a revolution forwards. This cycle of operations being repeated, a continuous sliver is formed of long fibres, which have been combed repeatedly through their entire length by the revolving comb segment. The latter is cleared of short fibre by a circular brush which deposits the noil upon a toothed doffer, from which it is removed by a vibrating knife. After combing, drafting and doubling are continued as before.

The "Heavy Spreading" System.—A new method of working has lately been introduced into line preparing. It is termed the heavy spreading system, and, if properly carried out, gives as good, if not a better yarn, and effects a saving in the cost of preparing.

A coarse spread-board with wide conductors and gills, and often more than one delivery, replaces two or more finer ones. The pieces of flax, etc., are spread whole, if possible, thus avoiding the handling and tossing of the fibre which often occurs when the piece is subdivided. The heavy slivers obtained are reduced to the old weight by drafting and doubling upon an additional drawing head. It is the author's opinion that the chief benefit of the system lies in the additional doublings which are obtained without additional cost. The extra gilling obtained has a beneficial effect upon fibre of good quality, and will in some cases permit of the production of good yarn from less hackled flax, which comes in cheap in consequence of the high yield obtained from the machines. Many mills have put in coarse boards for heavy spreading and reduced the number of their spreaders by one-half or more. The old spread-boards have in most cases been turned into drawing heads by removing the spreading table and substituting sliver guides and pulleys, as in an ordinary drawing frame.

Speeding a System.—The correct speeding of a system is an important point in preparing for spinning. The roving frame should be run as many hours as possible per week, consistent with keeping the working parts perfectly clean and in good order. To show the correct method of speeding a system, take as an example one in which the roving frame fallers are running at a speed of 75 inches per minute. The draft being 16, $75 \times 16 = 1200$ inches are delivered per minute by the boss roller, which, if $1\frac{1}{2}$ inches in diameter or 4·7 inches in circumference, makes $\frac{1200}{4 \cdot 7} = 255$ revolutions per minute. The necessary speed of the boss rollers of the drawing frames and spreader may be found from the speed of the roving frame boss roller as follows:—

To find the speed at which the boss roller of the 3rd or 4th drawing should run, divide the continued product of the speed of the roving frame boss roller, its diameter and the number of spindles, by the product of the draft of the roving frame, number of deliveries on that drawing frame, and the diameter of its boss roller. Thus, suppose that in addition to the speed of the boss roller of the roving frame being 255 and its diameter $1\frac{1}{2}$ inches, the number of spindles is 60, its draft 16 and the number of deliveries on the 4th drawing 4, with a boss roller 2 inches in diameter, the speed of the latter should be $\frac{255 \times 1 \cdot 5 \times 60}{16 \times 4 \times 2} = 179$ revolutions per minute. Some spinners prefer to run the finishing drawing frame about 10 per cent. slower than the speed found in this way, because the roving frame is frequently stopped for doffing. If this speed be maintained, however, the drawing frames may be stopped every week for a length of time sufficient for their proper cleaning. The speeds of the other drawings and spread-board may be found in a similar manner from the speed of the following frame, the number of slivers at the back of that frame being substituted for the number of spindles. It will be found right in practice to add 10 to 15 per cent. to the speed of the 1st drawing or set frame thus obtained, since this frame is frequently stopped when sets run out.

To Change the Weight of the Rove.—When the "clock" system is employed, the weight of rove is altered by changing the clock pinion so as to spread the given weight of fibre over a greater or less length of feed sheet, as before explained. If the sett system be the one which is used, the actual weight of a sett required to produce rove of a given weight may be approximately ascertained by calculation in the following manner:—Suppose that we require the rove to weigh 150 yards per ounce, and that the drafts of the system are: Roving frame 16, 3rd drawing 15, 2nd drawing 16 and 1st drawing 17, while the doublings are 8, 12 and 12 respectively for the 3rd, 2nd and 1st drawings, and the "bell," or length of sliver in each set can, 800 yards.

The rule is to multiply the yards in the "bell" by the drafts and the number of cans in the sett and to divide by the product of the yards per lb. of rove and the doublings. Thus in the example before us, the weight of the sett equals $\frac{800 \times 16 \times 15 \times 16 \times 17 \times 12}{(100 \times 16) \times 8 \times 12 \times 12} = 340$ lbs., and the average weight of each of the twelve cans in the sett $\frac{340}{12} = 28$ lbs. 5 ozs.

The factors which modify this theoretical result are, loss in weight during the process, owing to dust and shove falling out, shortening of the drafts by "bulking," and contraction of the rove by twist. An explanation of the words "shortening of the drafts by bulking" is required. Owing to the passage of comparatively heavy slivers between the back rollers, their effective diameter and consequent feeding capacity is increased by an amount proportional to half the thickness of the sliver. Instead of the bare diameter of the roller, then, it is this diameter which determines the actual draft.

Slivers are frequently shortened or increased in thickness by being pressed tightly in short laps into the cans. The effects of this can be easily seen in heavy setts, when, if this be not allowed for, the rove will come out heavier than desired. Variations in the weight of the same rove may frequently be traced to the same cause, since, when sliver for the roving frame is scarce the cans are hurried forward half full, and when there is plenty of sliver they are filled to their utmost capacity. Especially with dirty material the loss in weight frequently counterbalances the gain by "bulking" and contraction by twist.

Licking up.—A frequent source of trouble in the preparing room, and of light and imperfect rove, is what is known as "licking up." "Licking up" is the adhesion of light slivers to the wooden pressing or drawing rollers, which is most noticed when the air is dry, as it often is in cold frosty weather or when easterly winds are prevalent, as they usually are in the month of March.

The cause may, in the author's opinion, be looked for in the electricity generated by the friction of the fibres as they are rapidly drawn through the gills. All are familiar with the electrical effects produced by the combing of long hair or the frictional electricity generated in amber when rubbed, also with the conductive properties of water and damp air. When the atmosphere is moist, "licking up" does not take place, since the frictional electricity referred to is absorbed.

In practice, the remedy, if not the cause, of this phenomenon is known. It consists merely in artificially supplying the lacking moisture by blowing off steam through the room, in the use of one of the humidifying arrangements which will be described in Chapter XIX., and in moistening the faces of the wooden pressing rollers with water or with a specially prepared wash. This wash must also be frequently used to keep the faces of the wooden rollers free from the gummy matter which is deposited upon them by the passing fibre. A wash made up after the following recipe will act as a solvent upon all such matter, and, being highly volatile, dries up quickly :—Two parts of petroleum, one part of raw linseed oil, and one part of turpentine. Some prefer to substitute spirits of wine for the linseed oil and some to use linseed oil pure, believing that it nourishes the wood.

Use of Table of Constant Numbers.—It is a very good plan for the preparing master, in addition to having a book containing full particulars of all his frames with their drafts, etc., to make out a table of constant numbers for each system and frame. The constant number referred to is obtained by supposing rove of unit length per unit of weight, or one yard per ounce ; one, divided by the draft of the roving frame, then represents the yards per ounce of sliver delivered from the finishing drawing frame ; this, multiplied by the doublings and divided by the draft of that frame, represents the yards per ounce of sliver delivered from the 3rd drawing frame.

In a similar manner constants for the weights of sliver delivered from the 2nd and 1st drawing frames and spread-board may be obtained.

These constants, kept preferably in decimals, when multiplied by the yards per ounce of the rove being made, give the weight the slivers should be as delivered from each frame. If an intelligent overlooker suspects that any mistake has been made by his hands, he can weigh the slivers and see to what degree their weight has been affected, and remedy the mistake as far as possible. Take as an example a system with drafts and doubling as follows :—Roving frame draft 12 ; 4th drawing frame draft 12 with 8 doublings ; 3rd drawing frame draft 12 with 8 doublings ; 2nd drawing frame draft 16 with 12 doublings ; 1st drawing or set frame draft 16 with 12 doublings. The constant for the 4th drawing frame is then $\frac{1}{12} = {\cdot}083$; 3rd drawing $\frac{{\cdot}083 \times 8}{12} = {\cdot}05$; 2nd drawing $\frac{{\cdot}05 \times 8}{12} = {\cdot}037$; 1st drawing $\frac{{\cdot}037 \times 12}{16} = {\cdot}028$, and spreader $\frac{{\cdot}028 \times 12}{16} = {\cdot}021$. The actual yards per ounce of sliver at each frame, that on the roving frame being, say, 100, is then roving frame 100, 4th drawing 8·3, 3rd drawing 5·5, 2nd drawing 3·7, 1st drawing 2·8, and spreader 2·1.

To avoid Mixes.—In order to avoid mistakes and the mixing of cans in the preparing room, it is a very good plan to distinguish by different colours the cans of the various systems and to distinguish by distinct markings, such as one, two, three, or four bands of colour, the 1st, 2nd, 3rd and 4th drawing frame cans.

Workers' Charges.—In a medium or fine room, Irish hands are quite capable of the charges and earn the wages as under: Spreaders can spread from 3 to 8 leathers according to the draft and speed of the board and the degree of care required. Their wages run from 8s. to 9s. 6d. per week. Spread-board front minders can attend to six 8-leather or ten 4-leather boards and earn 7s. 6d. per week. Back minders look after nine to sixteen heads, and earn 7s. to 7s. 6d. per week. The drawers or front minders can attend to six to eight heads of fronts and a similar number of backs, or, in the case of those behind the roving frame, 1½ frames of roving backs or nine or ten heads. Their wages are from 8s. to 9s. 6d. per week.

Most Continental spinners prefer to put one drawer in complete charge of one or two drawing frames, both back and front, and to have the roving frames minded in the same way. The arrangement has some advantages.

Ramie Preparing Machinery.—The preparing machinery most in vogue for ramie is on the screw gill principle, and is worked as we have described.

The type of drawing head or gill box as used for worsted or silk waste is preferred, its chief feature being the double or intersecting gill.