CHAPTER IV.

STORING THE RAW MATERIAL, AND THE PRELIMINARY OPERATIONS OF BATCHING, SOFTENING, KNIFING, ROUGHING, BREAKING AND CUTTING.

Stocking and Sorting. — It is usual for spinning concerns to hold at least a few months' stock of raw fibre, bought, if possible, at a favourable moment, when the price is comparatively low. The holding of a stock of fibre is essential, if orders are to be accepted in advance without risk of losing money. The fibre is delivered in bales, mats, or "bobbins," according to its nature and origin. It should be placed in a dry, but cool, store, sheltered from the sun, as the beams of the latter often cause annoying changes of colour and evaporate the natural oil or spinning quality of the fibre. It is advisable to have good light available to examine and sort the fibre if desired, to roughly classify it into warp and weft, light and dark coloured, etc. Light-coloured Manila, for instance, is much more valuable than the common brown, and may sometimes be found in small quantities among the commoner colour. Specially light and specially dark flax yarns are sometimes in request for special purposes, rendering it profitable to sort out these colours even in small quantities. In flax spinning mills the most valuable fibre is sorted piece by piece by the hacklers, and to assist them it is advisable to "weigh off" the fibre bale by bale, and in farmer's lots when possible—that is to say, to keep together the flax which has been grown in the same field and watered in the same water. The less valuable fibre, in order to produce a cheap yarn, is often only roughly sorted and sent to the spread boards in "tipples." In this case, in order that the yarn produced may be regular in quality, the more thoroughly the raw material, which has been roughly selected, is mixed, the better. The larger the quantity that is mixed, so much the longer will the material run without abrupt changes in colour; and if a system of mixing on a large scale be adopted, much trouble will be avoided with striped yarn, and qualities will be much steadier. Fibre, to be used in this way, after being roughly sorted, may be sent to its mix and spread in an even layer over the whole extent of that mix, the thickness of the layer depending upon the extent of the mix and the quantity to be added. Other small parcels are added in layers until the mix contains the desired quantity of material, when the completed lot may be closed and worked off as required.

In taking fibre from the mix it should be taken out "of the face," or downwards, taking a proportional part of each layer, so that the quantity taken may contain parts of the original parcels proportionate to the original weights of the latter. In this way the lot may be worked off to the end without any change in the colours or quality of the yarn produced being experienced.

Book-keeping.—An invoice book should be kept, in which are entered the invoices as they arrive, with remarks on the quality of the fibre, the lots to which it is put, and the shortage or surplus in weight received. A "Lot Book" should also be kept, in which an exact account is kept of the quantity of fibre put to each lot, with notes as to its quality. In this way fibre of various qualities may be stocked in suitable quantities, and the same may easily be found and "weighed off" as required.

A "weigh-off" book should also be kept, in which a note is made of the quantity of each sort weighed off each day. When a lot runs out, the weight weighed off should of course total up to the weight of the lot as recorded in the lot book.

Soft Fibres.—Soft fibres, that is to say, flax and the true hemps, if to be spun into yarns finer than say 1000 yards per lb., must be hackled or split up into fine filaments, the most advantageous degree of hackling depending upon the quality of the fibre and the fineness of the yarn into which it is to be spun.

Hard Fibres.—Hard fibre, comprising Manila and New Zealand hemps, cannot be split up fine, and is spun into coarse yarns in its natural state. In some American ropeworks, where large quantities of Manila are run through daily, a machine called a "scutcher" is sometimes employed to open out the ends of the fibre before passing it on to the first breaker or combined spreader and hackler (figs. 27, 28, and 29).

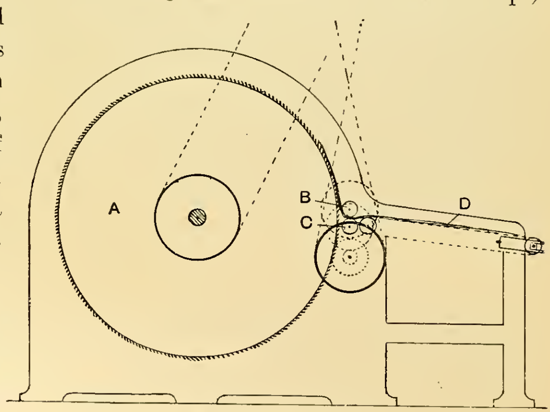


FIG. 4.—Knifing machine.

Knifing.—Some classes of Indian hemp, intended for spinning without being hackled, may have their flat or flaggy ends treated in the "knifing" machine (fig. 4). It will be seen that it consists of a toothed cylinder A, running at a speed of about 200 revolutions per minute. In the rear of the cylinder, and horizontal with its centre, are a pair of fluted rollers B and C, driven independently from the toothed cylinder by a separate belt, as shown. By a suitable arrangement of three pulleys—one of them being a loose one—and a long handle for shifting the belt from one to the other, the feed rollers may be stopped or driven at will in either direction. In this way the operative is enabled to spread a "strick" of fibre upon the

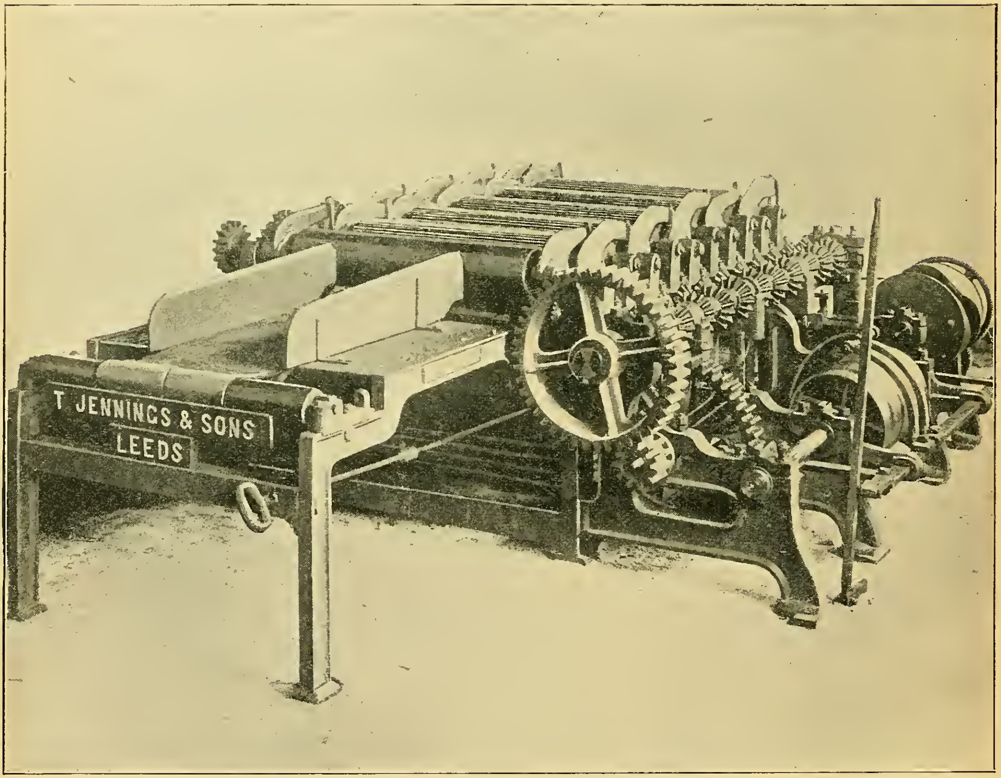


FIG. 5.—Horizontal hemp softener.

endless feed sheet D, introduce the bad end between the feed rollers as far as required, retain it there until the toothed cylinder has acted upon it sufficiently long, and then withdraw it again without danger to herself. The flat ends and fibre cut away are thrown down below the cylinder, and may be prepared for spinning inferior yarns in a way to be described later on.

Batching Jute.—Jute has the property of being softened and improved in its spinning qualities by the application of a mixture of oil, soap, and water. The process known as "batching" consists in spreading the fibre in layers, the oil being applied to each layer with a watering-can. The pile should be allowed to remain from twenty-four to forty-eight hours, in order that the lubricative may be absorbed by the fibre. The quantity of oil and water to be applied varies from 25 to 30 per cent. of the weight

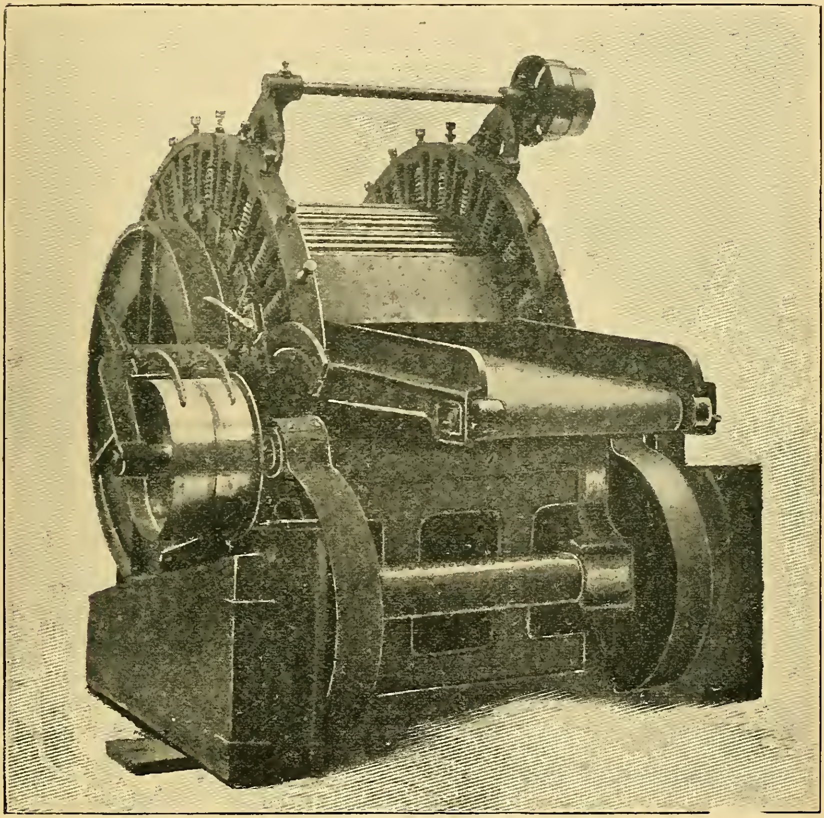


FIG. 6.—Circular hemp softening machine, with reciprocating motion.
(Made by James Reynolds & Co., Belfast.)

of fibre treated. Jute will absorb more oil in summer than in winter. Almost 1 gallon per bale, or from 5½ to 7 gallons per ton, is the quantity usually applied. The following oil mixtures are used :—

No. 1. Mineral oil, 2 gallons ; whale oil, 2½ gallons ; seal oil, 2½ gallons ; water, 40 gallons.

No. 2. 1 part seal oil, 5 parts sperm oil, 1 part soap, 40 parts water.

No. 3. 1½ parts mineral oil, 2 parts sperm oil, 2 parts seal oil, ¼ part soap in 30 parts water.

Hemp Softening.—The spinning quality of the finer hemps is much improved by rolling under pressure. "Stricks" of hemp are sometimes formed into an endless band by splicing the root and top ends together, and run as long as necessary between the rollers of a machine similar to the yarn softener and polisher, fig. 99. Another old-fashioned softener which is still used, and which many spinners consider to give superior results to modern machines, is almost identical in principle with an ordinary mortar mill.

Two forms of modern softeners are shown in figs. 5 and 6, the one being a horizontal and the other a circular machine. For the same number of rollers the former, of course, occupies more floor space than the latter. Fig. 7 gives some idea as to the arrangement of the circular machine. It will be seen that the fluted rollers A B and C D are pressed together by strong springs, and have a reciprocating rolling motion given to them by gearing combined with cranks and ratchet wheels. The throw of the cranks is so arranged that the forward movement of the rolling rollers is greater than the retrograde, and the hemp being spread upon the table E, after being well rolled, is delivered upon the apron F.

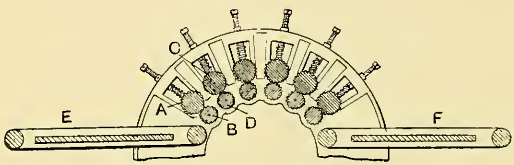


FIG. 7.—Hemp softener.

Cutting.—Hemp is nearly always too long to be prepared and spun over comparatively fine machinery without being first cut into lengths of about 24 inches. A cutter, as represented in fig. 8, is generally employed for this purpose. A is a circular knife or cutter, about 21 inches in diameter, and driven from a counter-shaft by a belt as shown, at a speed of about 900 revolutions per minute. B B B B are four pairs of holding rollers, each two pairs being acted upon and pressed together by the weight W, acting through compound levers and links as shown, and exerting a pressure of more than one ton, distributed between two pairs of holding rollers. The cutter blade A consists of three steel rings, each about $\frac{1}{4}$ inch thick, placed side by side and keyed upon a shaft supported by the gables of the machine, and carrying the driving pulley keyed upon one end. From the other end of this shaft a retarded train of gearing drives the bottom holding rollers, which are of cast iron, 14 inches in diameter and 2 inches in face, with vertical or circumferential grooves or flutes of 1-inch pitch. The bottom roller has two flutes and the top roller only one, with two grooves. Each pair of bottom rollers is keyed upon a shaft at any required distance from the cutter blade, the ends of the shaft being supported and turning in blocks or brasses set in the standards. The top or pressing rollers are free to move up and down in slides in the gables, and are driven by friction. The nip of the holding rollers should be horizontal with the centre of the cutter and in the same vertical plane as the periphery of the blade. The rollers are set one on each side of the cutter with a space of about $\frac{3}{4}$ inch between. Upon the rim of each of the rings composing the cutter blade are projecting teeth of diamond-shaped construction, placed at distances of about 3 inches apart. It is most important that these teeth should be of the proper shape and bluntness to cut through the fibre without shearing the ends quite square, which would seriously affect the combining and spinning properties of the fibre. The holding rollers make two to three revolutions per minute.

The machine being started and having attained full speed, the cutter

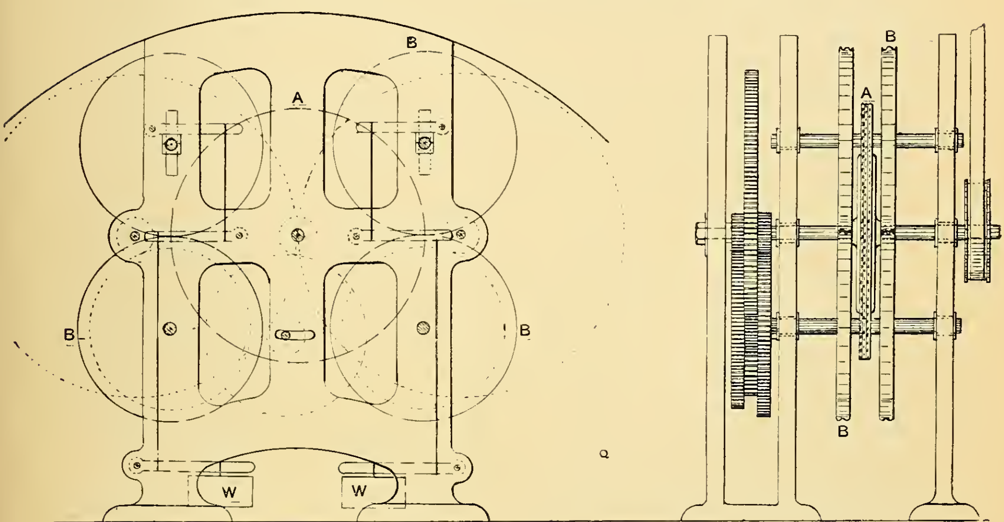


Fig. 8.—Flax cutter.

boy takes a large handful of fibre, and standing in front of the machine, holds the fibre firmly with both hands, and allows it to pass in between the holding rollers with the part to be cut opposite to the cutting blade. He holds the piece firmly and bears down upon the bottom rollers, his hands passing outside them, until the cutting is complete, when he withdraws the cut pieces. A boy can thus cut about 4 cwts. of hemp per day.

Flax, although seldom too long to work without cutting, is sometimes cut upon this same machine with a different object. It is almost impossible to procure flax long line capable of being spun into the finest and best quality yarns. The reason is that the ends of the fibre are more or less imperfect. The root end, which ripens first, is often coarse, dry, and flat-fibred. The top end, which bore any branches the plant had, is fine and "nappy," both root and top being inferior to the middle portion.

It is to obtain this middle portion that the use of the cutter is resorted to.

Stacking.—To prepare flax for the cutter, the heads are opened and the fibre pieced out into large handfuls, which are lightly drawn over the rougher's hackle, in order to comb out and replace any straggling fibres which might otherwise go into the tow. This process is technically known as "stacking." It is then cut as we have described, the resulting "middles" being usually 14, 16, or 18 inches in length. The root ends often go as tow, but the top ends and sometimes the roots are separated into smaller pieces for the hackling machine, as, of course, are also the middles.

Piecing Out.—The "piecing out" of flax, hemp, or jute is the division of the heads into small handfuls or pieces, six or eight to the pound, which is a convenient size to enable the fibre to be properly hackled either by hand or machine.

Flax Roughing.—The roughing process consists in roughly straightening and parallelising the fibres, squaring the root end or otherwise replacing in position any fibres which may have been allowed through careless handling to slip from their proper positions. Its object is to save these straggling fibres from escaping into the tow, which loss would inevitably occur were they not properly held by the hand of the hand-dresser or the holder of the hackling machine. A result of the operation is the separation of the very coarsest tow or broken fibres which have been produced in the scutching process. Its separation at this stage is an advantage, since the machine tow is thus rendered purer and more valuable. It is only within recent years that "roughing" has been practised at all in Continental mills which spin much cheap Russian flax. The cost of the process is not always repaid when dealing with flax of low quality, the value of whose tow is almost equal to that of the flax itself. Roughing does not pay unless the product of the gain in yield in pounds and the value of the dressed line per pound exceeds the value of the extra tow which would have resulted through non-roughing.

Irish flax is usually so badly handled by farmers and scutchers that it practically *must* be roughed, while Courtrai, and in fact almost every description of Flemish and Dutch flax as well as fibre which has been cut, does not really require to be roughed but may merely be pieced out.

The rougher's tools consist of a coarse hackle or comb and a "touch pin," for squaring the end.

The rougher's hackle consists of a wooden "stock," usually of beech, $16\frac{1}{4}$ inches long by 5 inches broad and $1\frac{5}{8}$ inch thick. An area of $9\frac{1}{4}$ inches by 4 inches in the centre of this stock is studded with steel pins 6 inches to $7\frac{1}{4}$ inches long and of 5 or 6 B.W.G. There are generally eleven pins per row in length and five rows in breadth. The cost of a new hackle is about 15s.

The "touch pin" is a steel pin of square or triangular section set in a wooden or metal stock which is bolted to the beam to the left hand side of the hackle. The pin is usually of about $\frac{1}{4}$ inch side and projects 2 inches above the stock or block into which, in the case of a wooden block, it is tightly driven. When a metal block is used the pin is held by a bolt as shown in fig. 9.

Good touch pins can be made out of old files. The edges should be smooth, but not sharp.

The roughing process, briefly described, is as follows:—Piecing out.—Cutting open the head of flax, etc., the rougher separates the "stricks," "fingers," or large handfuls of which it is composed, and catching one near the top end, by a dexterous backward flick or throw he untwists and opens it. Holding the root end foremost he then proceeds, while holding the bulk in his left hand, to separate off, with the right, pieces which he can easily grasp between the forefinger and thumb. These pieces will weigh from 6 to 8 per pound according to the nature and length of the fibre. Before starting to rough, he prepares a quantity of these pieces, piling them

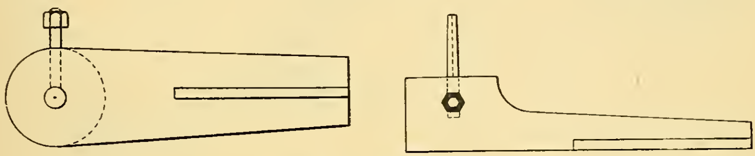


FIG. 9.—Touch pin.

in a particular manner, so that each piece keeps quite separate from the others and may be easily lifted.

He then proceeds to rough. Taking a piece in his right hand, top end foremost and spreading it well out the while, he pulls that end through the hackle, leaving in the latter the deranged fibres which are not held by his hand. He then draws out any which remain upon the corner pins of the hackle, retaining them there with the aid of the first finger and thumb of his left hand. Turning the piece he proceeds in like manner, and then catching the longest of the fibres which remain in the hackle along with the piece, he draws them out in such a way that they are replaced in the piece and level with the root end. He then laps the piece once round his right hand, and spreading the root end well out between his forefinger and thumb, he pulls it through the hackle in order to straighten and render parallel any matted and displaced fibres. Two "blows" upon the hackle usually suffice before breaking off or pulling out any irregular fibres from the end by a sharp tug, after having first lapped them loosely round the touch pin and held them there with the finger and thumb of the left hand. He then turns the piece and proceeds in like manner with the top end. When finished, he lays the pieces down upon his bench, side by side, in layers, withdrawing his hand in such a way that the lap or twist remains, thus effectually keeping the pieces separate and enabling them to be easily lifted by the machine boy without tossing. Forming layer upon layer, he produces a "bunch" weighing about 40 lbs., which he ties round with three cords. When the rougher's hackle becomes filled with tow and fibre too short to be replaced in the piece, he grasps the longest of the fibres which project, and lapping them round the fingers of his right hand he lifts the whole from the hackle, and by a succession of blows upon the latter leaves in it the shortest fibres, separating the longer, which he lays to one side. Again grasping the longest fibres which *now* project from the hackle, he works off the tow upon the top of the pins.

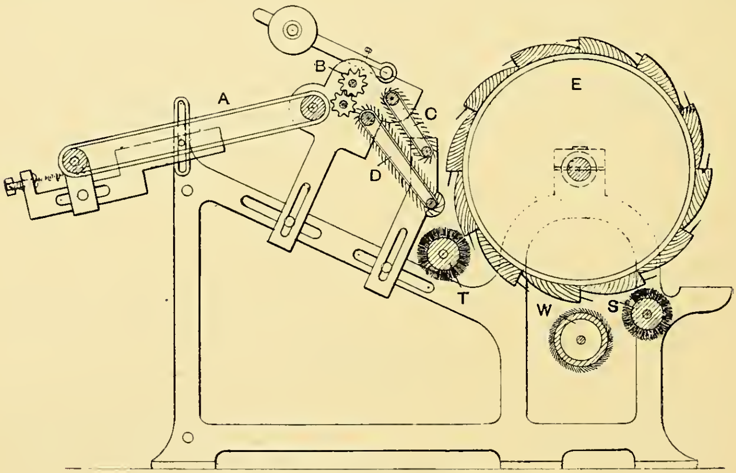


Fig. 10.—Filling engine for ramie.

The short fibres which he has thus saved are called "shorts," and are made into a separate bunch and worked apart upon the machine. When flax, hemp or jute is merely "pieced out," the pieces are crossed one over the other in such a way that they do not intermingle, but are easily lifted without tossing.

Filling Engine for Ramie.—The way in which ramie or China-grass which has been degummed as described on page 7, is prepared by combing or hackling in the largest ramie spinning mill, seems rather a wasteful one. It is that employed for waste silk, and is accomplished as follows.

The fibre, which, after the boiling, steeping and washing treatment it has undergone, is considerably felted and matted together, is spread upon the endless sheet A of the machine, fig. 10, delivered through a pair of fluted feed rollers B to the toothed feed sheets C and D which hold and parallelise the fibres, while the teeth of the cylinder E carry them gradually away. The fibres are still further straightened upon the surface of the cylinder by the action of the worker W. This worker and the feed sheet are kept clean by strippers S and T, which are in turn stripped by the cylinder. The cylinder has no stripping mechanism, so that the fibre accumulates upon it, enveloping it completely, when it is stopped for stripping by hand. The cylinder is clothed with heavy wooden lags bevelled off in the manner shown, leaving recesses, in the edges of which strong teeth are set. When the operative wishes to strip the cylinder he takes a large pair of shears and cuts right across the face of the cylinder at each recess dividing the fibrous envelope into sheets of fibre about 10 inches long, ready to be placed in the "books" of the ramie or silk waste dressing frame, which we will describe in our next chapter.

CHAPTER V.

HACKLING BY HAND AND MACHINE.

Hand-dressing.—Hand-dressing, or hackling by hand, is still continued to a considerable extent. Under certain circumstances, fibre carefully hand-dressed will yield more line than if it were passed over the hackling machine. This is especially the case with very soft and weak flax, which, if properly supported by the left hand of the hand-dresser, as will be presently explained, is less strained and broken than it would be by the hackles of the machine acting at a considerable distance from the nip of the holder. Hand-dressers are now chiefly found in small country mills spinning flax or hemp, and in the farmhouses in the outlying districts of Russia and Italy, whence come the supplies of such tows as Kama and Strappatura.

The hand-dresser's tools are usually three in number, viz:—(1) A rougher's hackle, as already described; (2) a finer hackle or "ten"; and (3) a still finer hackle or switch, all three being screwed to a wooden block which is bolted to the beam which runs along the top of the berth or tow-box. The hackles should be slightly inclined, as, on account of the height of the hackler, his pull is slightly upwards. A very convenient adjustable cast iron and slotted "block" is in use in some mills to replace the old wooden block which is more difficult to adjust to suit hacklers of different heights. The first hand-tool or ten consists of a beech stock $9\frac{1}{4}$ inches long, $3\frac{3}{8}$ inches broad, and $\frac{7}{8}$ inch thick. An area of $7\frac{1}{4}$ by $2\frac{3}{8}$ inches in the centre of it is set with steel pins $4\frac{1}{4}$ inches long over all, and usually of 13 B.W.G. There are often twenty-six pins in the length of the row (the term "ten" being a misnomer), and seventeen or eighteen rows in breadth. The pins are grouped as in a rougher's hackle, the pins in one row being opposite the spaces in the neighbouring rows.

The stock of the switch is usually covered with sheet brass. The stock is $\frac{5}{8}$ inch thick, $8\frac{3}{4}$ inches long, and $2\frac{3}{4}$ inches broad. The pins occupy an area of $7\frac{1}{4}$ by $2\frac{3}{8}$ inches in the centre, and may be $1\frac{1}{2}$ inches long over all. The fineness of the tool is gauged by the number of pins in a row of $7\frac{1}{4}$ inches, 180 being a suitable number for coarse flax and Italian hemp. The switch has usually about twenty-two rows of pins in breadth, the pins being grouped as before. A guard is sometimes applied to support and strengthen the front outer rows of pins. It consists of two bands of steel about ½ inch broad, and rather longer than the tool. They are applied one in front of the first row of pins and the other behind the second or third row, and are then tightened together by means of screws inserted outside the tool. Sometimes about ten pins of strong wire are put into the rows at both ends of the tool in order to bear the "nipping," which, as will be presently explained, is very severe on the pins.

Flax and hemp and jute (cut to a convenient length) may be hand-dressed as follows. The fibre having been divided out into pieces, weighing six or eight to the pound, the latter are thoroughly roughed and cleaned out "up to the hand" upon the coarse rougher's hackle in a similar manner, but even more thoroughly than that in which the rougher does his work. When the fibres have been thoroughly cleaned out and rendered parallel upon the coarse hackle, the hand-dresser either proceeds directly to work them over the "ten," or, if he prefers it, he makes the roughed-out pieces into a bunch, and does not begin the second operation until he has prepared a considerable quantity in advance. Upon the "ten" the piece is again worked well up to the hand, being supported by and passed through the left hand held close up against the front row of pins of the hackle. The proper use of the left hand as a support is, as previously remarked, a very important point in obtaining yield through preventing the breaking of the long fibres.

The finishing tool or switch is employed in a similar manner. In the use of hand hackles it must be remembered that it is only the points of the pins which cut and split up the fibre into finer filaments, hence the piece should be kept well on the surface of the hackle, the proper and equal cutting of both faces of the piece being insured by turning it in the hand and giving a like number of "blows" to either side. In hand-dressing, the end is seldom broken upon the touch-pin, the loose fibres of the end being merely pulled out, and the end crimped and squared by lapping the extremity of the piece around the strong corner pins of the switch, when finishing the dressing operation and "nipping" or withdrawing the piece while pressing against and supporting the pins with the forefinger of the left hand. The piece is now held between the finger and thumb of the left hand, back uppermost, and some of the fibres of the root end lapped around it with the right hand, forming a "lap" which keeps the pieces separate when they are built into a bunch, and enables each to be lifted without tossing the others. A firm bunch about 20 lbs. in weight is built by placing the pieces in layers, one piece overlapping the other. The bunch is tied with three bands, and the ends "tippled up," after which it is ready for the line store or the spread board. "Tippling up" is the bringing together of the ragged ends of the pieces composing the bunch and the lapping around them in the form of a top-knot of some loose fibres drawn out for that purpose.

Horner's Hackling Machine.—A modern form of hackling machine is shown in fig. 11. It is a vertical sheet brush and doffer machine, which is the type in most general use, especially for flax. In fig. 11 the fibre to be operated upon, which has been pieced out and perhaps "roughed" and cut as described, is tightened between two flat plates made of tempered steel plate bolted together by means of a screw and nut as shown in figs. 12 and 15. The screw is attached to the back plate by a screw and lock nut. The projecting portion of the screw is about $\frac{3}{4}$ inch in diameter, and is threaded about five per inch. The square nut is tapped out to correspond, both being case-hardened to resist wear. Each holder plate is slightly bent, both as regards length and breadth, so as to form a spring. The lower lips are bevelled off so that they may be brought nearer to the hackles without being struck. The holder, for the make of machine illustrated (Horner's), has two pins C, about 3 inches long and $\frac{5}{8}$ inch in diameter, fitted firmly into the upper corners of the lower plate and projecting 1 inch on the lower side. The lid is plain, with three holes bored in it—one in the centre to receive the screw, and one in each of the upper corners to receive the pins. These holders are placed between the two angular bars B, forming the sides of the "channel" or "head" in which the holders slide along upon the projection C C. The sides of the channel are supported and held together by bridge brackets, and thus form a long slot through which the holders hang, and along which they move at regular intervals. The channel extends the full length of the machine, which is now frequently over 20 feet long. It is suspended vertically over and between the hackling sheets D by leather straps attached at one end to the bridge brackets of the channel by means of a loop and pin, and at the other end to the lever E, to which is also suspended a balance weight W, by means of a strap passing over the guide pulley F. This weight should be sufficient to balance the "channel" with the holders which it usually contains. The head or channel is given a regular up and down motion by means of various mechanical arrangements, the one illustrated being a cam wheel G, which by means of an eccentric channel upon its reverse side, raises and depresses the lever H, which in turn communicates an up and down motion to the head through the connecting rod I. The height of the lift, or the distance required to raise the head to lift the fibre from the hackles, may be altered by changing the effective length of the lever H, or the point of its connection with the rod I. The holders are shifted along the channel, when the latter is at the top of its lift, by means of a catch-bar arrangement actuated by another eccentric groove J upon the cam wheel G. K shows one of the catches or "dogs" which shift the holders. A slot is provided to adjust the catch-bar in such a way that it shall finish

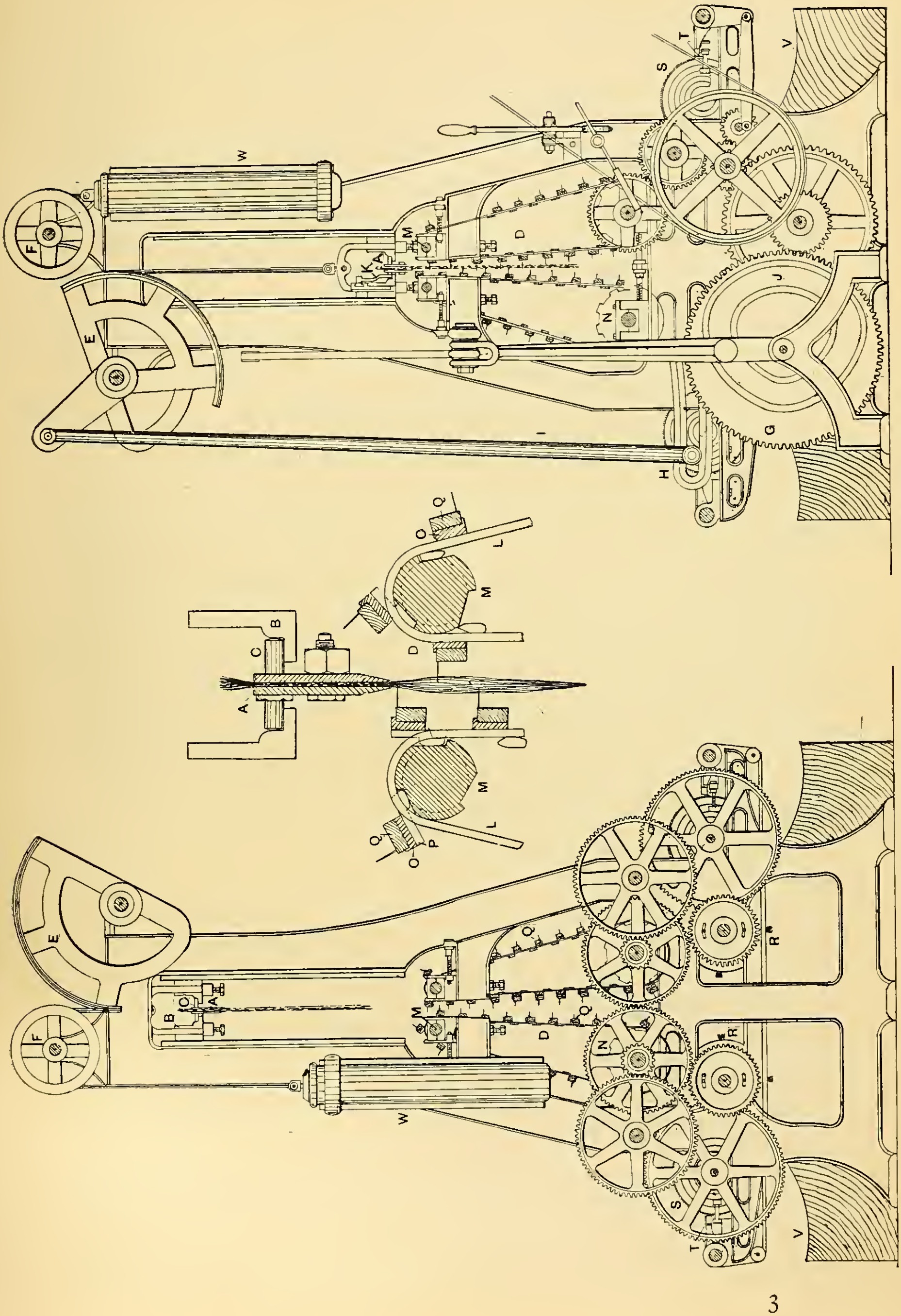


Fig. 11.—Horner's brush and doffer hackling machine.

its traverse in the correct position to bring each holder exactly opposite a tool or section of the sheet.

The channel has almost always a period of rest given to it while in its lowest position and whilst the hackles are operating upon the fibre. The amount of rest or dwell allowed is an important point, as too long a dwell, while the full length of fibre from the holder downwards is under the action of the hackles, causes the fibre to be broken, and reduces the yield, while a rest of too short duration gives insufficient hackling. In the machine illustrated, this period of rest is constant for any given lifts of the head per minute, but in the machines of some other makers it may be varied to suit the requirements of the fibre being worked.

In the cam-wheel head lift shown, a short rest is generally given to the head when raised and during the shifting of the holders, but in some makes of machines there is no rest at all at this point.

The hackling sheets D are formed upon a foundation of endless straps or "leathers," L, running round the top and bottom sheet rollers M and N, which keep them fairly tight, the latter being the driver. Upon these leathers, bars O are attached by screws to wing pieces P, the bodies of which are fastened to the leathers. In the machine illustrated the hackles are attached directly to the bars, so that in this way as the hackles are passing round the top roller the wings stand out at a tangent to the latter, which is also recessed to receive the body plate of the wings, thus decreasing its effective diameter and enabling the hackle to strike close up to the holder without the wings being unnecessarily long and consequently weak. The striking of the hackle close up to the nip of the holder, combined with direct penetration, is a most important point in machine hackling, as it affects the yield in a marked degree, since it determines the length of "shift" required in changing the fibre in the holder. The bosses N upon the bottom sheet rollers are notched, as shown, to receive the body pieces of the wings, and a means is thus afforded for carrying the sheets round without slipping. The pitch of the bars is from $2\frac{1}{8}$ to $2\frac{3}{4}$ inches according to the coarseness of the machine, and there are from twenty-four to thirty-two bars and rows of hackles in the round of the sheet. The length of the leathers or their outside circumference equals the numbers of bars multiplied by their pitch or distance apart—say for twenty-four bars $2\frac{1}{2}$ inches pitch, $24 \times 2\frac{1}{2} = 60$ inches. Both the top and bottom sheet rollers are adjustable horizontally, so that the working side of the sheets can be set more or less parallel.

The hackles Q consist of stocks of wood from 10 to 12 inches long, about 1 inch broad, and $\frac{5}{8}$ inch thick, studded with steel pins usually 1 inch long over all, and set in either one or two rows. The closeness of the pins in the row to each other is from $\frac{1}{4}$ pin per inch, or one pin in 4 inches to sixty pins per inch in the finer hackles used for the finest flax. Hackles with only one row of pins are fast coming into general use, since they are more easily kept clean and free from gum by the brush. The hackle stocks of the finer hackles are covered with thin brass sheet to strengthen them. The brush R, which clears the hackles from tow after they have passed through the fibre, consists of an iron shaft the whole length of the machine, having bosses about 9 inches in diameter keyed upon it at regular intervals. To these bosses are screwed staves of wood, shaped so as to form segments of a circle. In these staves, or in laths attached to them, are set the brushes, formed of bunches of hog's bristles set in holes in the wood. The speed of the brush is made to conform with the number of rows of hair, the speed of the sheet, and the number of bars, so that each row of hair strikes a row of hackles as it comes round and strips off the tow. The position of the brush is below the bottom sheet roller, as shown, and it can be moved in and out to a position corresponding with the length of the hair, and such that the brush strikes the pin at its root and gives it a clear wipe without touching the stock.

The doffer S is a wooden roller rather longer than the brush, and covered with leather filleting set with pins. It revolves at a slower speed and in a direction opposite to that of the brush. The latter beats the tow into the teeth of the doffer, which carries it round until it is struck off by the doffing knife T, which is set quite close to the face of the doffer and has an oscillating motion given to it by an eccentric or crank and connecting rod. The tow falls into the tow-box V, which may be divided into compartments to classify the tows, which increase in fineness and quality towards the fine end of the machine.

Other Hackling Machines.—Other hackling machines in general use are Cotton's brush and doffer, Combe's brush and doffer, Horner's stripping rod, Cotton's stripping rod, Combe's stripping bar machine, Fairbairn's brush and doffer, and Dossche's French brush and doffer machine.

Cotton's Brush and Doffer Machine.—The chief points of difference in Cotton's machine from that just described are the head lifting motion and the method by which the bars and hackles are attached to the sheet leathers.

Cotton's head-lifting motion consists of a crank pin set in a radial slot in the head wheel. The crank pin works freely in another slot in the end of a link which communicates motion to the lifting shaft through the medium of a chain working upon a scroll. As the head wheel revolves, the fixed crank pin comes in contact with the bottom of the slot in the connecting link, and causes the head to rise until the crank pin reaches its bottom dead centre, when the head begins to fall again without rest or delay. It continues to fall until it reaches the end of its course and rests upon the adjustable stops provided. The length of time it remains there depends upon the adjustable length of the link. If the link be shortened, the crank pin comes in contact with the end of its slot and commences to lift the head very soon after passing its top dead centre; while if the link be lengthened the reverse takes place and the head has a long rest at the bottom. In this way the length of rest and height of lift are regulated by the length of the connecting link and the position of the crank pin in its radial slot. If the action of this head wheel be carefully studied it will be seen that the vertical up and down motion of the crank pin varies, reaching its maximum as its path intersects a horizontal line drawn through the centre of the wheel. It is to remedy this defect that the aforementioned scroll is used to equalise the motion of the lifting shaft, and consequently the speed of the head. In consequence of the lack of rest, when the channel is at the top of its lift, the latter must be lifted rather high, if the dragging of the ends of the fibre through the hackles while the holders are being shifted is to be avoided.

In Cotton's machine the bars are fixed directly to the sheet leathers by means of brass eyelets, which receive projections upon the bosses of the bottom sheet rollers, and thus afford a means of driving the sheets without slipping. The hackles are attached to wings riveted to the inside of the bars, so that almost the whole sheet is closed. In passing over the top sheet roller, which is as small as possible consistent with rigidity, the wings to which the hackles are attached stand out tangentially and cause the pin points to penetrate the fibre directly and close to the nip of the holder.

Combe's Brush and Doffer Machine.—Combe's brush and doffer machine differs from those already described, chiefly in the head-lifting motion. Like Cotton's, this head motion has a head wheel with a fixed crank pin or stud upon which is a loose runner to diminish friction. This runner bears alternately on either side of a wide and specially shaped slot in a lever arm fulcrumed at one extremity, and connected at the other by an adjustable link with the lifting shaft. In this arrangement the special shape and construction of the lever arm gives a uniform lift and the desired rests without the employment of a scroll.

Horner's Stripping Rod Machine.—In Horner's stripping rod machine the same head and shifting motion is employed as in the machine illustrated in fig. 11. For good work a brush and doffer machine is to be preferred, the sole advantage of the stripping rod machine lying in the fact that it may be made double, the duplex pattern occupying much less floor space than a pair of brush and doffer machines. The stripper rods are wooden laths, 3 to 4 feet long, about 2 inches broad, and $\frac{1}{4}$ inch thick. The wood is shod with metal ends or "stripper cocks," which work in radial slots in the bottom sheet rollers. As these rollers revolve, the stripping rods shoot out by gravity, to the lower extremity of their slots, as they are carried round towards the under side of the roller, falling back again towards the centre as they approach the top. When falling from the centre the rod passes close to the pins of the hackle, loosening the tow from them, the tow being then received upon a "tow-catcher," which deposits it in the tow-box every time the head rises.

Cotton's Stripping Rod Machine.—The stripping rod arrangement employed by Cotton necessitates the use of more rods—their number corresponding with that of the bars in the sheet. They are carried round with the sheet, and act, as do Horner's, on the principle of gravity.

Combe's Stripping Bar Machine.—Combe's stripping bar machine, used chiefly for coarse work, has a sheet of metal bars of the same pitch as the hackle bars, but exceeding them in number. This stripping sheet runs round the outside of the hackle sheet, its bars occupying the spaces between the hackles, its extra length enabling it to be drawn outwards from them at a given point by means of a tension roller, thus clearing away the tow.

Fairbairn's Brush and Doffer Machine.—Fairbairn's brush and doffer machine differs from those of other makers chiefly in the head-raising motion, which consists of a cam and a lever. The former takes the place of the head wheel, and makes one revolution for each rise and fall of the head. The lever is a long arm oscillating on a fulcrum at one end and having a long slot in the other end. In this slot a stud may be fixed in the desired position, a link connecting this stud with the lifting shaft. The lever presses against the surface of the cam and is thus caused to oscillate, and to raise and lower the head at speeds and with rests determined by the shape of the cam. The height of the lift is regulated by the distance of the point of connection of the link from the fulcrum of the lever. Since the slot in which this connection takes place forms an arc of a circle, the centre of which is the upper connection of the link, no change in the position of the rest is produced when the lift is lengthened or shortened.

Dossche's French Machine.—In Dossche's French machine the position of the brush is rather different from that preferred by English makers, and some spinners consider that it produces better tow. Dossche's brushes are placed higher up and considerably more on the outside of the bottom sheet rollers than are Cotton's, for instance, the object being that the brush shall wipe the hackle when the pins are almost horizontal, and that the tow shall be, in consequence, more easily removed and less liable to be beaten into the hackle.

Horner's Improved Lifting Motion.—Horner's improved lifting motion may be briefly described as follows:—Low down at the gearing end of the machine are two spur wheels geared into each other, and having runners working upon studs near the periphery of each. As these wheels revolve, the friction rollers alternately come in contact with either side of one arm of a T-shaped lever arrangement working upon a central stud. The other arms of the lever are slotted to adjust the height of the lift, and connected by rods with a segment upon the top shaft of the machine. The dwell or rest of the channel when at its lowest point can be altered by means of adjustable hinges, through which the revolving wheels communicate motion to the lever, the amount of rest depending upon the point in the path of the stud in the aforesaid wheels where contact takes place with the hinges on the lever arm. The shifting of the holders along the channel is effected by means of a slide bar, upon which "dogs," or detents, are pivoted, which catch upon the bearing pins of the holder when moving towards the fine end of the machine, and slip over them when receding prior to making a fresh shift. These catch bars are actuated either by a cam wheel and connecting levers, as in fig. 11, or by means of mitre wheels transmitting the reciprocating circular motion of the top shaft to a short cross shaft, upon which is keyed a circular slotted disc with adjustable studs actuating the "catch bar" by a lever and connecting rod.

"Casting" or "Throwing-out" Motions.—Machines are often fitted with what is termed a casting or throwing-out motion, by means of which the holder may be ejected without subjecting its contents to the last or two finishing hackles, thus in a measure enabling a fine machine to take the place of a coarser one. Motions to effect this purpose are numerous, one of the simplest consisting in a lever, one extremity of which works upon a stud fixed in the channel, while the other is connected to a long arm which slides in the channel and pushes out the holders. A point nearly midway up the lever is connected by a rod with the catch bar, the traverse of the throwing-out arm bearing the same ratio to that of the catch bar as does the length of the lever to the distance between its fulcrum and the point of connection with the catch bar.

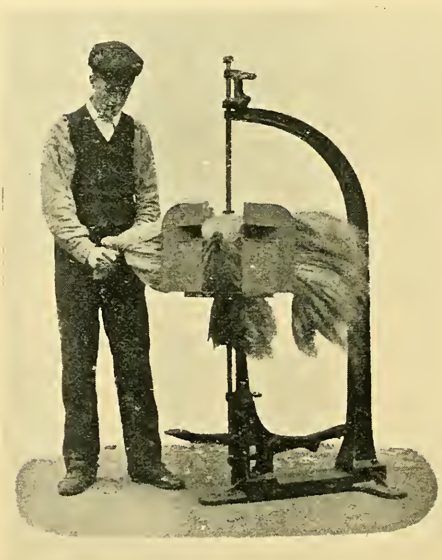
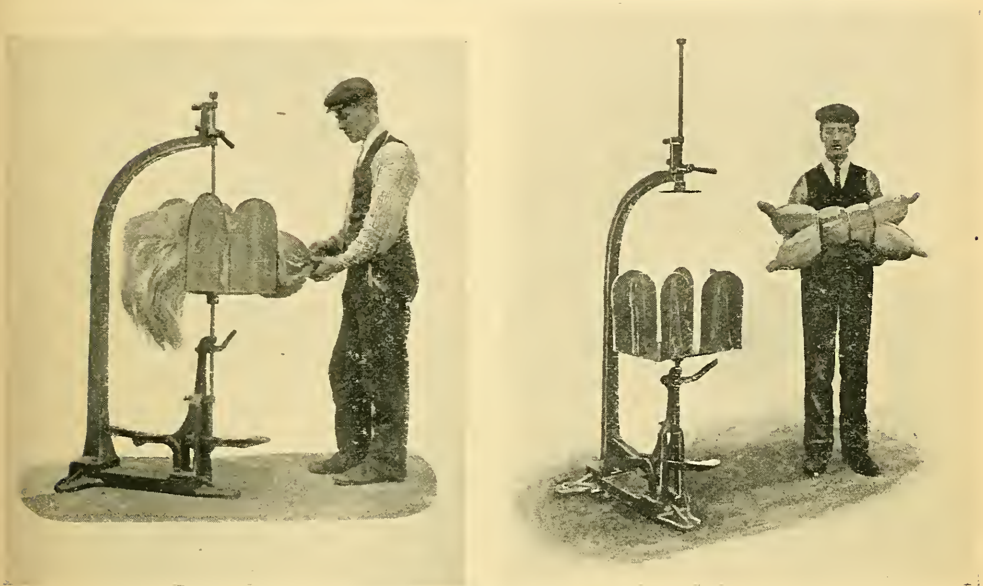


Fig. 12.—Ordinary tippling for hackler.
(Apparatus supplied by W. Carter, 28 Waring Street, Belfast.)

Running a Hackling Machine.—The way in which the hackling machine is employed is as follows:—The "parcels" of fibre are removed from the roughing shop to the machine room as required. The bunches are loosened from their bands and put upon tables at the coarse or filling end of the machine, the root ends being turned from the boys, who take two pieces at a time, and leaving the root ends projecting about 12 inches, place them level and flat, one piece on either side of the central screw, and spreading them well out upon the bottom of the holder, tighten the lid firmly down upon them. The holders are placed one at a time in the channel of the machine when it is approaching its highest point, and are then shifted automatically forward step by step, every time the head rises, over the



FIGS. 13, 14.—Tippling and tying for stores or spread-boards.
(Apparatus supplied by W. Carter, 28 Waring Street, Belfast.)

hackles, gradually increasing in fineness, until they are delivered at the fine end, where the holder is placed in a stand, another holder being placed in a corresponding position about $2\frac{1}{2}$ inches distant. The hackled end of the fibre is tightened into this empty holder, and the other being removed, the new holder, with the top end of the fibre now projecting downwards, is placed in the channel of the other machine, where it undergoes the same process and is delivered finished at the fine end. The boys remove the finished pieces from the holders, and crossing each piece in a "tipple box," such as is shown in fig. 12, form a compact bundle or tipple, the ends of which are tied or "tippled up" and the bundles removed to the sorter or direct to the spread-boards as the case may be.

Tippling.—One of the greatest inconveniences of spreading from the

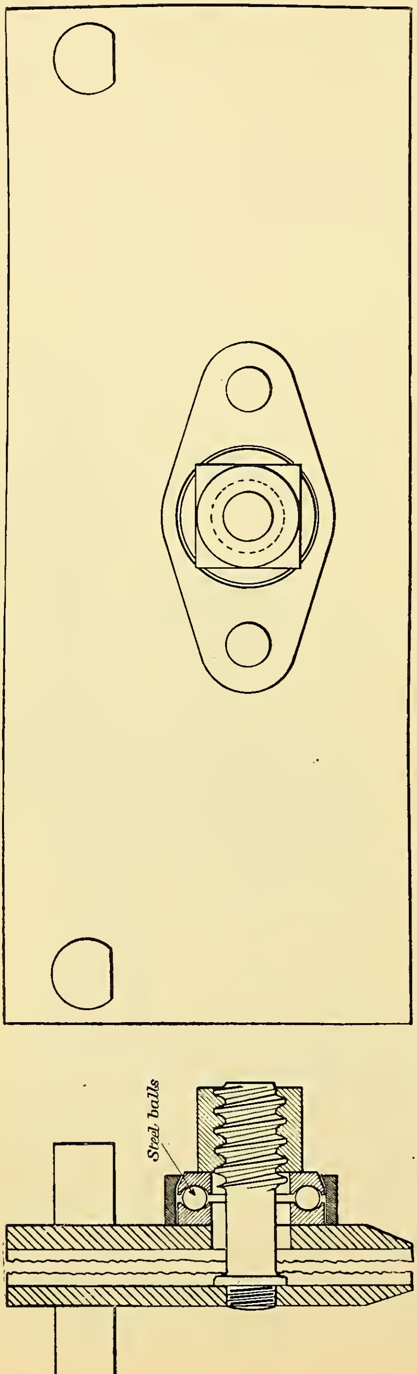


Fig. 15.—Anti-friction washer for hackling machine holder. (Supplied by W. Carter, 28 Waring Street, Belfast.)

"tipple" has hitherto been the difficulty of storing and avoiding the tossing of the fibre. This difficulty may be overcome to a large extent by the tipple press, as shown in figs. 12, 13, and 14. It affords a cheap, handy, and expeditious means of compressing the tipples as they are taken from the table of the hackling machine in the ordinary stools or boxes. Tipples intended to go direct to the spread-boards or into store are tied under pressure applied by the foot, the bunches thus made taking up little room.

In the ordinary way four machine boys are required per pair of machine. Two of them, called the "fillers," place the pieces of raw material in the holders and insert the latter in the channel of the machine. At the same time they remove the handfuls of finished fibre from the holders issuing from the fine end of the finishing machine, and place them in the tipple box. The two boys at the other end of the machines are called "changers," their duty being to change the holders from one machine to the other and to change the pieces end about. The machine boy's work is heavy, and boys consequently scarce in many places. Their work may be considerably lightened, and the yield from the machine improved at the same time, by the use of either anti-friction washers or anti-friction nuts for the holders.

Eves' Anti-friction Washers and Nuts.—The former is shown in fig. 15. It consists in a pair of circular steel washers, grooved as shown, to hold a ring of steel balls. The uppermost washer is slightly taper, and is held in place by a cover which is riveted to the holder plate as shown.

Fig. 16 shows the anti-friction nut referred to, which is the invention

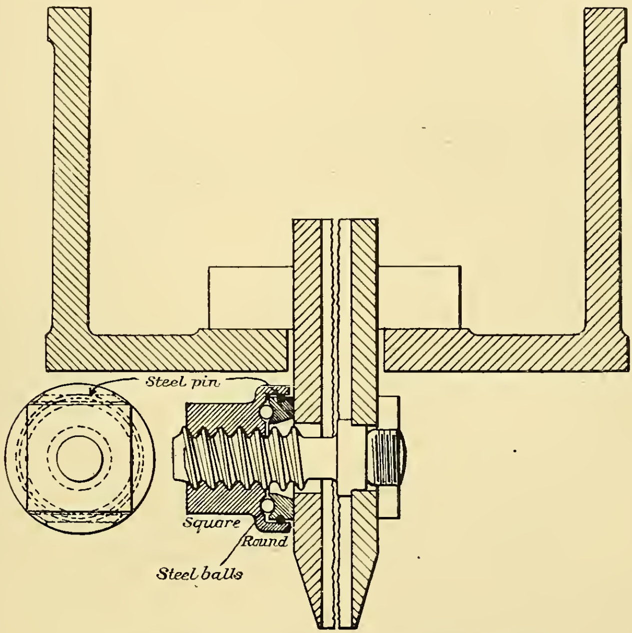


FIG. 16.—Eves' anti-friction nut for machine holders.

of the same gentleman, Mr Joshua Eves of Belfast, to whose inventive genius the flax spinning trade owes a great deal.

It is constructed on the same principle as the washer, the grooved steel washers and ring of steel balls being, however, in this case contained in the nut itself, rendering any work upon the holder unnecessary.

By the use of this washer or nut, the usual friction between nut and holder is so much reduced that with the same effort the holder may be tightened more than three times as tight, leaving no excuse at all for badly tightened or slack holders, which let the fibre slip and diminish the yield of dressed line very materially.

Reade, Crawford, & M'Kibbin's Automatic Screwing for Hackling Machines.—An important improvement in connection with machine hackling

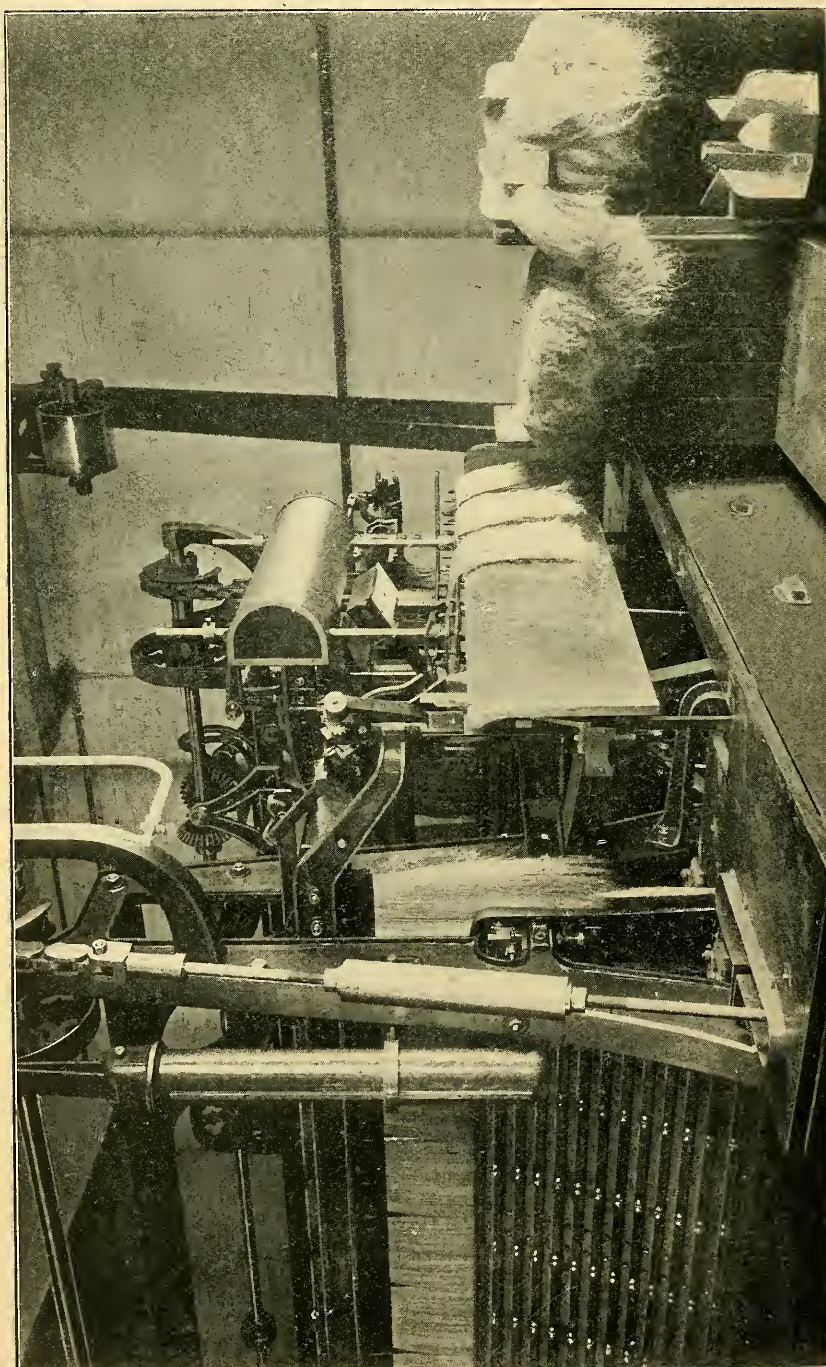


FIG. 17.—Reade, Crawford, & M'Kibbin's patent automatic screwing for hackling machines. (Filling end.)

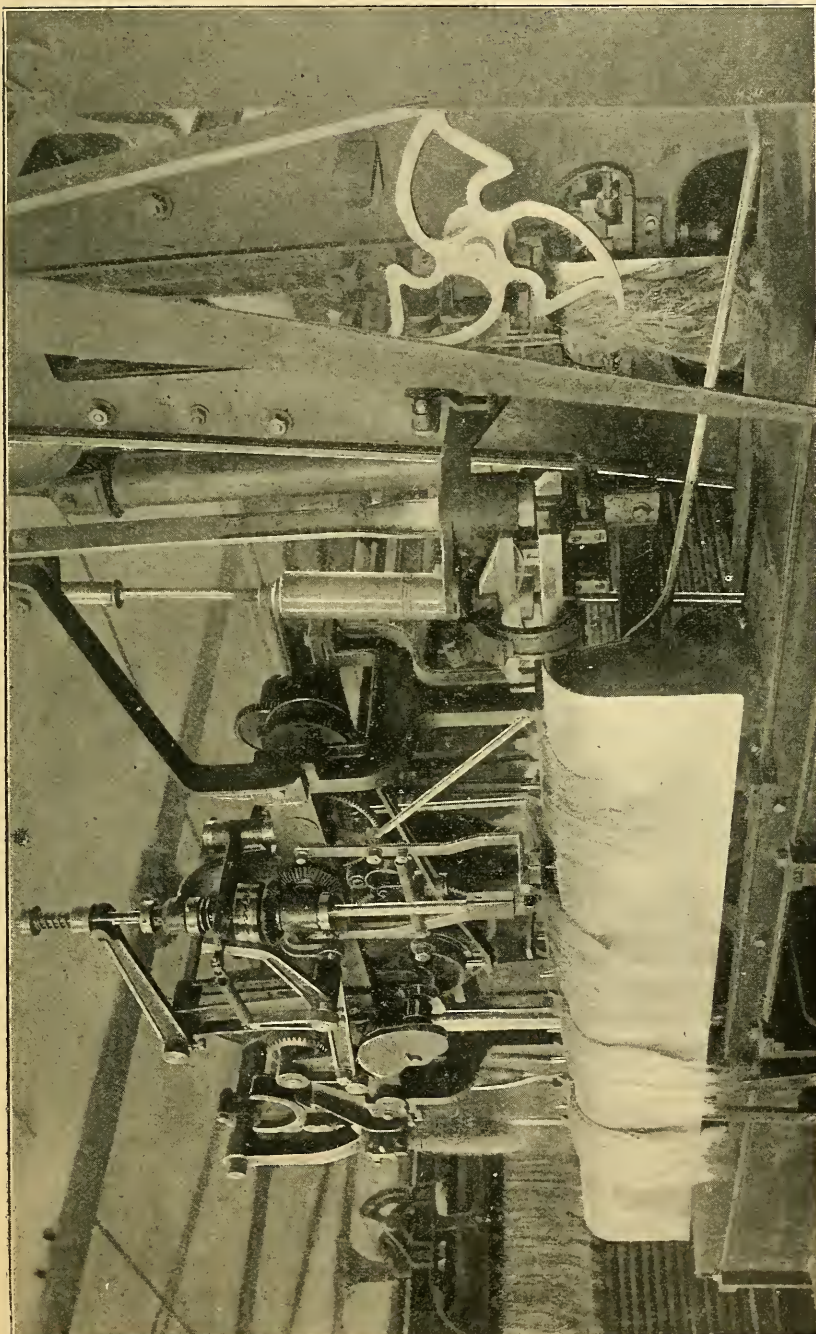


FIG. 18.—Reade, Crawford, & M'Kibbin's patent automatic screwing for hackling machines. (Changing end.)

has recently been patented and introduced by Messrs Reade, Crawford & M'Kibbin of Belfast, with the object of *automatically* screwing and turning the fibre in the holders of the hackling machine.

A slight modification of the holder is the starting-point of the automatic machine. The holder screw, instead of being rather nearer to the lower edge of the holder plates, as in fig. 16, is placed exactly in the centre, so that the holder may be used with either of its longitudinal edges downwards. The holder nut also is attached to the cover in such a way that, when the nut is unscrewed, the cover is raised or separated from the bottom plate of the holder.

The machines are placed parallel to each other and are coupled together, one belt driving the pair.

The holder from the finishing end of the second machine is automatically delivered on to a cross channel and unscrewed, permitting the hackled pieces to be removed. The holder is then passed on, and the cover is automatically raised in order that the boy may fill the holder with fresh pieces. When this has been done, the holder passes on under the screwing spindle, and after being tightened up, is automatically raised and placed in the channel of the first machine.

The changing end is completely automatic, and is somewhat similar to the filling end, the chief difference being that the holders are unscrewed and screwed by the same spindle. While the holder is unscrewed, the pieces are drawn through the holder a short distance, corresponding to the shift under the old system.

The pressure under which the holders are screwed is easily regulated, and, once adjusted, all the holders are equally tightened.

Figs. 17 and 18 give general views of the apparatus, the former from the filling and the latter from the changing end.

The chief advantages arising from the use of the machine are saving in wages, since *one* boy can now attend to one pair of machines. The machine boy difficulty ceases to exist, for a single boy or girl can do with ease what was heavy work for four boys. Better yield is obtained owing to the absence of slack holders. The fibre is less tossed, giving less tow in the sorting, or a straighter piece if spread from the tipple. The boy has more time to spread the pieces in the holder, which is of the utmost importance to secure well-cut fibre. The arrangement can be applied to existing machines (except Horner's duplex) without any structural alterations.

How to get the Maximum Yield from the Hackling Machine.—In most mills where the fibre employed is hackled, the yield in long fibre or line is not so large as it might be were more attention paid to the following points. To obtain a good yield, the handfuls of fibre should be no longer than the length of the longest individual fibre—in other words, if the fibre is uncut or unbroken, or in its natural length, the root end should be level and square. Sometimes, in consequence of unskilful pulling, the stalks are allowed to slip, rendering the handful irregular.

In the scutching also the fibre may be spoiled in this respect, and it is the object of the roughing process to rectify these faults. If at least one end is not level and square there is a danger that, when screwed in the holder, some of the fibres will not be held at all, and even if they be held, an unnecessary length will be subjected unsupported to the hackle. The ideal to be arrived at is to have all the fibres square and level at one end at least, and to screw the piece in the holder, for the purpose of hackling the heaviest end in such a way that all, even the shortest fibres, may be perfectly held. In hackling flax, for instance, it will usually be found advantageous to leave about 40 per cent. of the length of the piece protruding from the holder for the purpose of hackling the root end.

The hackling machine should be constructed and set in such a way that the pins enter the piece directly and as near to the nip of the holder as possible, minimising to the greatest extent the length of "shift" required in changing the pieces in the holder for the purpose of hackling the top end.

With the best existing machines, the minimum shift possible is about $(n \times 2) + \frac{1}{2}$ inch, n being the distance from the nip of the holder at which the pin strikes the fibre.

If all the fibres are firmly held in the holder, only those which are cut away and broken will go into the tow. The fibres, unless excessively weak, will not be broken if presented to a sufficiently coarse hackle in a perfectly straight condition. The space between the pins must, of course, be greater or equal to the diameter of the fibre in order that it may pass without being broken. Excessively weak fibre will break owing to the strain put upon it by the splitting and cutting action of the hackle when applied at a distance from the nip of the holder. It is for this reason that in Scotland and in Ireland the spinner gets a better yield from some sorts of Russian flax by hand-dressing it, for the expert hand-dresser, as should also the sorter, so supports the piece with his left hand in drawing it through the hackle that much of the strain is taken off it.

Some flaxes will cut away owing to lack of quality and resistance to splitting produced by the presence of woody matter, branches, "black tick," etc., on the fibre.

If the shove be a loose one, it may be removed without carrying any fibre with it, but if firmly attached to the fibre and too large to pass between the pins, it will be cut away and carry some fibre with it. Black tick, being really engrafted with the fibre, and having a weakening effect upon it, will almost invariably cause it to break at that point in passing through a fine hackle.

The gradation of the hackles is a point of the greatest importance in machine hackling. Beginning with a coarse hackle, the fibre must be gradually operated upon by finer and finer hackles. The greater the length of the machine and the larger the number of rounds of hackles, the easier may be the gradation. A thirty-tooled machine is not unknown. In arranging the gradation it must be borne in mind that an increase of six or eight pins per inch in a fine hackle may be less in proportion and not so severe on the fibre as a rise of half pin per inch in a coarse hackle. In using fine hackles, the fibre is sometimes cut away through not having sufficient space between the pins nor enough accommodation in the hackle to receive the handful of fibre presented to it, for which reason it is impossible to pull the piece through such a hackle without breaking away some fibre. In order that the free spaces and capacity of a hackle may be calculated, we give the diameter in decimal parts of an inch, at their thickest part, of the pins in general use.

B.W.G.	Diameter in Inches.	B.W G.	Diameter in Inches.	B.W.G.	Diameter in Inches.
No. 5	0·212	No. 14	0·079	No. 23	0·028
,, 6	0·192	,, 15	0·071	,, 24	0·025
,, 7	0·176	,, 16	0·064	,, 25	0·021
,, 8	0·160	,, 17	0·056	,, 26	0·019
,, 9	0·146	,, 18	0·048	,, 27	0·017
,, 10	0·130	,, 19	0·041	,, 28	0·015
,, 11	0·116	,, 20	0·037	,, 29	0·014
,, 12	0·103	,, 21	0·034	,, 30	0·013
,, 13	0·092	,, 22	0·031		

In hackling some sorts of flax, especially Courtrai, the pins of the finer hackles become clogged with a species of gum, which contracts or closes the spaces between the pins, prevents the hackle from doing its work, and breaks away the fibres which cannot be accommodated between the pins. For hackles above 20 per inch it is consequently better to use a single row of pins only, since a double row cannot be properly cleared from gum by the brush. Even with a single row it is an advantage that the machine should be provided with a motion by means of which the brush, while working at the same surface speed as the hackles, and striking and wiping each hackle in turn, may at regular intervals slow down and allow the hackle to pass through it, wiping the other side of the pins. The holders of the hackling machine must grip the fibre firmly, and in order that no fibre may escape from the holder, the latter must be kept in perfect order, lined with corrugated indiarubber and flannel to give a good gripping surface, and be free from burrs on the edges, so that their parts may come into perfect contact with the fibre. The handfuls of fibre must be spread in a level manner over the surface of the holder in order that it may be gripped uniformly. Sometimes the boys neglect to tighten the holders and the fibre is pulled out by the hackles. It is here that one of the advantages of the automatic screwing arrangement, to which we referred, comes in. A better yield may be obtained by running the hackling machine slowly, say at half speed, with two boys instead of four. This result is due to the more gradual and easy lift of the head. The head should lift sufficiently high to clear the fibre completely from the hackle before the shift commences, in order that the ends may not be dragged through the hackle and cut away.

In the hackling machine the sheets are generally set more open at the coarse end, and point to point, or slightly intersected at the fine end. In setting them open at the coarse end the points act more gradually on the fibre, first only touching the outside, and then advancing deeper and deeper as the holder advances towards the fine end. The author does not believe in this method of setting, in which the outside of the piece gets more hackling than the inside, resulting in an uneven cut, while the finer hackles often act in the centre of the piece upon coarse fibres, which, until that moment, have been untouched, and which are often broken away by that fine hackle, producing a loss in yield and a mixture of coarse fibres in what should be the finer tows. Certainly, the gradation of the hackles should be so arranged that they may cut through and through the piece from start to finish, producing tow in regular quantities, and thus show that each is doing an equal share in the work. To carry this out, the flax must be well roughed and the first round of hackles rather coarser than they often are, while the pins should be set point to point at the coarse end, and $\frac{1}{16}$ inch intersected at the fine end. The final result will be a better yield, a more regular cut, and better tow. Below, we give a suitable gradation for various lengths of hackling machines with which our ideas may be carried out.

9-tooled machine for very coarse Russian flax, jute or hemp :—

Pins per inch,	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{1}{2}$	$\frac{3}{4}$	1	$1\frac{1}{2}$	2	4	6
No. of wire B.W.G.,	8	10	12	14	15	15	16	17	18

11-tooled machine for coarse Russian flax, hemp and jute long line :—

Pins per inch,	$\frac{1}{4}$	$\frac{1}{2}$	$\frac{3}{4}$	1	$1\frac{1}{2}$	2	3	4	7	10	14
No. of wire B.W.G.,	10	12	14	15	15	16	16	17	18	20	22

11-tooled machine for medium Russian and Italian hemp :—

Pins per inch,	$\frac{1}{4}$	$\frac{3}{4}$	1	2	3	4	6	9	14	20	28
No. of wire B.W.G.,	10	14	15	16	16	17	18	19	22	23	25

11-tooled machine for medium Irish, Flemish, Dutch and Courtrai, and fine Russian flax, and fine Italian hemp :—

Pins per inch,	$\frac{1}{2}$	1	2	3	4	7	12	16	22	28	36
No. of wire B.W.G ,	12	15	16	16	17	18	21	22	24	25	26

16-tooled machine for fine Flemish, Dutch, Irish and Courtrai flaxes :—

Pins per inch,	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	1	$1\frac{1}{2}$	2	3	4	6	8	11	14	22	30	38	48
No. of wire B.W.G.,	12	13	14	15	15	16	16	17	18	19	20	22	24	25	27	28

20-tooled machine for very fine Courtrai flax, etc :—

Pins per inch.,	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	1	$1\frac{1}{2}$	2	3	4	6	8	11	14	18	22	27	32	38	44	50	56
No. of wire B.W.G.,	12	13	14	15	15	16	16	17	18	19	20	22	23	24	25	26	27	28	29	30

The "grouping" of the machine hackles is an important point not generally understood. Grouping is the dividing of the hackles, composing a round, into one or more groups, in each of which the pins are inserted in such a way that each strikes the fibre in a different place. It is evident that if each consecutive hackle is identical, the pins will always strike in the same place and accomplish comparatively little work, while if the hackles be grouped in the following manner, each pin will strike in a different place, and the maximum cutting be obtained. The rounds of coarser hackles on a 24-barred machine may be divided into two groups of twelve each or three groups of eight each, while the finer hackles have usually fewer tools in the group, say four or six, giving six or four groups to the round respectively, in a 24-barred machine. To form the group, mark off the line of the row on a number of hackle stocks, and place 4, 6, 8 or 12, as the case may be, squarely together.

Mark off a good position, as regards strength, for the first pin to the left of the first hackle, and similarly, of the last pin to the right of the last hackle. Join these two points by a line which will cut the line of the row on each hackle in a point where a pin should be placed, and the other pins spaced off from this base. If, now, these groups be screwed upon the bars with the hackles in their proper order, and the first tool of the group on one sheet be caused to follow the middle tool of the group on the other sheet, the maximum result as regards cutting will be obtained.

To obtain the maximum yield the fibre should be neither damp nor dry as tinder. If the fibre be damp, it will offer more resistance to the passage of the hackles, more tow will result, and a nappy line and tow be produced, for when the material is damp, the fine fibres will run up between the pins, and form themselves into balls or naps. If the fibre be too dry, it will not split from end to end so well, but will tend to be cut away in the process. As a rule, the blue and yellow Flemish flaxes are quite damp enough, and may often be advantageously dried a little prior to hackling, while some stove-dried Russian flaxes may sometimes be advantageously cooled or worked in a moist atmosphere, obtained by a suitable humidifying system.

In setting the sheets of the hackling machine, it must be remembered that it is of the utmost importance that the pins of either sheet penetrate the piece to the same depth, or, in other words, that their points be equidistant from a vertical line dropped through the centre of the bundle of fibres contained in the holder. If this be not the case, the piece will not be worked to the same degree on both sides. The construction of the holder and channel of the Horner type is rather different from those of the Cotton machine. In the former the position of the vertical line through the centre of the piece depends upon the thickness of the piece, while in the latter, with springs on both sides of the channel, its position is constant and corresponds with the centre of an empty holder. In setting the intersection of a Horner's machine, then, clamp a plumb-line in the centre of a holder packed with wood or cardboard representing the average thickness of the bundle of fibres to be hackled. In Cotton's machine it is not necessary to pack the holder, for the reason stated above. Place the holder in the resting channel at either end of the machine, with the plumb-bob hanging down, and set the sheets to their correct position.

In fixing the hackles upon the bars, No. 1 hackle in each group should be on the same bar and the others follow round in consecutive order, so that if, say, the No. 1 hackles on each sheet be placed point to point and the sheets geared and turned round, the numbers upon each sheet may correspond each to each. In working, the hackles must be "turned into group" so that the No. 1 hackle on the one sheet follows the middle number of the group on the other sheet. Thus with ten in the group, No. 1 hackle on one sheet follows No. 5 on the other, the hackles striking tho fibre alternately, so that when intersecting they cannot strike one another. It may be seen at once if the hackles be correctly set by looking down from above between the two sheets. The pins in one sheet must appear to divide the spaces between the pins in the other. When viewed from the same point they will also appear in parallel rows, both extending from right to left, or *vice versâ*.

The sheets are usually run at from nine to fifteen revolutions per minute, putting the pins through the fibre at the rate of 120 to 18,000 per inch per minute, according to the number of bars in the sheet and the fineness of the hackles. From five to six lifts of the head per minute, delivering the same number of the holders, is the usual speed working with four boys. At this speed a machine should put through 6 to 10 cwts. per day according to the size of the pieces and the length of the fibre. With the automatic screwing apparatus described on p. 44, a long line machine may be safely driven up to seven lifts per minute. The total lifts divided by the number of pieces to the pound will give the total pounds machined.

Cost and Speed of Machining.—The actual cost of machine hackling may be taken at about 9d. per cwt. In hackling flax the yield from the machine usually runs from 60 lbs. to 80 lbs. per cwt., or from 53 to 71 per cent.; the remainder, with the exception of 1 or 2 per cent., being tow, which is divided into four or more qualities (1, 2, 3, 4, etc.), according to the position on the machines where it is taken off. The tow may be spoiled by having the parts of the doffing mechanism improperly set or in bad working order. If the fibre be badly roughed, very long or not sufficiently tightened in the holder, "ropey" tow is often the result. It is produced by the long fibres encircling the brush and keeping it from doing its work properly, they themselves failing to be stripped off by the doffer. Then, again, the doffer may be driven too fast or the knife too slow. The "card" or doffer should make about one revolution for every ten of the sheet, and the knife about a hundred oscillations per minute. In order that the brush may strike every hackle, the number of teeth in the bottom sheet roller wheel must bear the same relation to the number of teeth in the brush wheel as the number of times the pitch of bars is contained in the circumference of the bottom roller does to the rows of hair in the brush. Thus in a 27-barred machine, $2\frac{1}{2}$-inch pitch, circumference of bosses on bottom roller 25 inches, roller wheel 65 teeth, eight rows of hair on brush, the number of teeth which the brush wheel must have in order that the hair may strike every hackle, will be 52, or as—

$$\frac{25}{2\frac{1}{2}} = 10 : 8 \ :: \ 65 : 52.$$

The speed of the doffer, taking the same particulars in conjunction with roller pinion 24 teeth, stud wheel 110, stud pinion 27, doffer wheel 144 teeth, and speed of sheets ten revolutions per minute, is

$$\frac{10 \times 27 \times 24 \times 27}{10 \times 110 \times 144} = 1{\cdot}1.$$

The speed of the knife taking the speed of the driving pulley at 72 revolutions per minute, the wheel on the boss of the driving pulley 50 teeth, and the eccentric or crank pinion 35 teeth, is $\frac{72 \times 50}{35} = 103$ oscillations per minute.

The lifts of the heads per minute, taking the speed of the line shaft at 120 revolutions, diameter of drum 16 inches, diameter of pulleys 16 inches, head pinion 30 teeth, stud wheel 108 teeth, stud pinion 16 teeth, and head wheel 120 teeth, will be

$$\frac{120 \times 16 \times 30 \times 16}{16 \times 108 \times 120} = 4{\cdot}4 \text{ lifts per minute.}$$

The revolutions of the sheet per minute, taking the sheet pinion as having 20 teeth, brush shaft pinion 56 teeth, brush shaft wheel 54 teeth, roller wheel 84 teeth, catches in roller $\{(3+4) \times 2\} = 14$ and bars in sheet as 30, will be

$$\frac{120 \times 16 \times 20 \times 54 \times 14}{16 \times 56 \times 84 \times 30} = 12{\cdot}8.$$

The Ending Machine.—When flax is to be sent to the spread-boards direct from the machine room, without being subjected to the hand hackling and sorting process, which we will treat of in our next chapter, another small machine is often employed to remove bad ends and loose fibres from the ends of the pieces. It is called an ending machine, two types being shown in figs. 19 and 20.

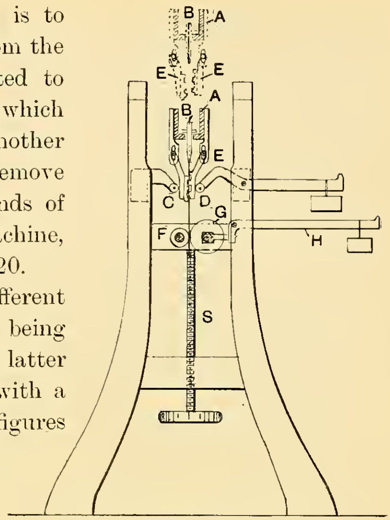


FIG. 19.—Erskine's ender.

These machines work on two different principles, the object of the former being to cut off the bad end, and of the latter to improve it by additional hackling with a fine and quick hackle. A in both figures represents the extended end of the "channel" of the hackling machine, while B is the holder. In Erskine's ender, fig. 19, a pair of clamps E are hung from brackets attached to the channel A. While the head is raised these clamps hang clear of the bundle of fibres, but as it descends they are brought together by the friction rollers C and D, the latter upon the end of a lever as shown. The object of the clamps E is to hold the piece firmly in close proximity to the place where the revolving ending rollers F and G grip it, draw away any loose fibres, and cut away the remainder. To act properly, the ending rollers must be accurately ground to secure a perfectly parallel face. In order that they may bite the better, one or both of them is often scored spirally. The smaller roller F works in fixed brasses, while the bearings of the larger roller G move in a slide, the two rollers

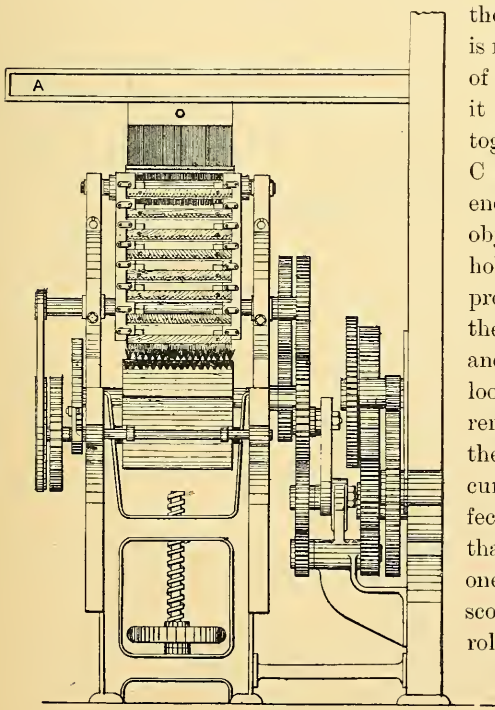


FIG. 20.—Cotton's end comb.

being pressed together by the thrust of the tail end of the weighted lever H, as shown. The rollers are driven by a chain from a sprocket wheel upon the extremity of the brush shaft, and may be raised or lowered bodily by means of the screw S, to suit various lengths of fibre, or to remove more or less of the end.

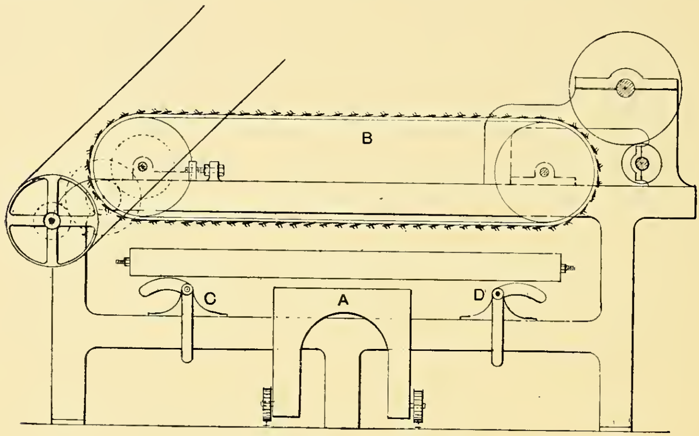


FIG. 21.—Flat dressing frame for ramie.

The ending machine or comb, fig. 20, is a brush and doffer hackling machine in miniature. Like fig. 19, it is applied to the fine end of the hackling machine, and is often particularly useful in removing "naps"

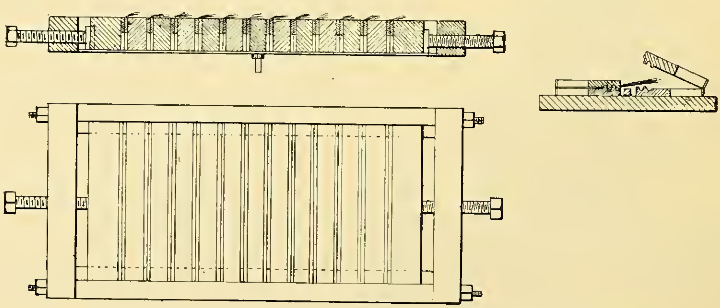


FIG. 22.—Book frame and books for flat dressing frame for ramie.

from the end of fine fibre. The height of the sheet may be adjusted, as in the Erskine machine, so that any required part of the end may be operated upon.

Flat Dressing Frame for Ramie.—The flat dressing frame used by the most successful ramie spinners is shown in figs. 21 and 22. The narrow sheets of fibre, obtained by cutting across the lap formed upon the cylinder of the filling engine, fig. 10, page 28, are placed in wooden holders or "books," as shown in fig. 22, a number of these "books" being then tightened together in an oblong frame as shown, with the ends of the fibre projecting. The book frames are then placed upon a carriage A, fig. 21, and run under the dressing or combing sheet B, which is stretched between and runs round two pulleys at either extremity of the machine, as shown.

The book frame is then raised from its carriage and into close proximity to the dressing sheet by means of cams C and D. When one end of the fibre has been combed it is turned in the "books," and the other end subjected to the dressing sheet in a similar manner. The dressing sheet may be stripped and kept clean by a brush and doffer arrangement, or merely by a toothed doffer stripped by a pair of fluted drawing-off rollers which deliver the noil in a sheet.

CHAPTER VI.

SORTING, AND THE MANAGEMENT OF THE HACKLING DEPARTMENT.

Sorting.—A thorough sorting of hackled fibre only pays when really valuable material intended for fine yarns is being dealt with. For coarse yarns the rough classification of the raw fibre is all that will be required. For medium and coarse flax yarns the line from the machine and ender may be roughly classed by the machine boys, who can put to one side any dirty pieces, etc. For fine and superior flax yarns the machine-room tipples must be passed on to the hackler or sorter, who, besides giving the pieces an additional combing over hand tools, usually breaks and squares the ends on a touch pin, puts a lap upon the pieces, and builds them into bunches, according to the quality and cleanliness of the fibre.

Sorter's Tools.—The sorter's touch pin and hackles are similar to those of the hand-dresser which we described on pages 26 and 27. Of course he requires no rougher's hackle, his coarsest being the "ten" or "eighteen." For fine work his switch has often 300 pins in the row, $7\frac{1}{4}$ inches long. In addition, he often requires a nap extractor to remove the naps from the ends of fine flaxes. A "nap extractor" is a single row of flat pins set edgewise and very close together, in order that they may retain the naps when the fibre is pulled through them. A nap extractor may have as many as fifty pins per inch in length. Were these pins set in holes in a stock in the ordinary way their foundation would have no strength, consequently it is usual to solder them together at the base and upon a brass strip. They may be further secured by another strip of brass placed at the back and dovetailed into the first. The nap extractor used to be placed apart, to the extreme right of the sorter, who gave the ends an additional blow or two upon this tool before putting on the lap. Now, in order to avoid paying the sorters more for this extra work, the nap extractor is usually fixed in front of the first row of pins of the switch. We do not like to see it there, however, for if the hackler works up to the hand, as he should do, the middle of the flax receives an unnecessary amount of work and too much tow is produced. A satisfactory result will be obtained with much less tow if the nap extractor be used separately and merely upon the extreme ends of the piece

Sorting Operations.—The finishing, hackling, and sorting operation, briefly described, is as follows. The sorter takes a piece of flax from the tipple, which he has previously loosened and placed in front of him to the left, and spreads it as flat as possible, root end foremost, upon his "ten." He grasps it as tightly as possible with his right hand close to the holder mark, keeping the root end well spread out between his first finger and thumb, and after one pull through his coarsest hackle, laps the piece around the fingers of his right hand and the extremity around the touch pin, with the first finger and thumb of his left hand, taking care to keep the fibres straight and untwisted. Now, with a quick jerk of his right hand he breaks off the extremity of the piece containing loose fibres and flat and coarse ends, and places it beside his touch pin ; while unwrapping the piece from around the fingers of his right hand, he again spreads out the root end, and, giving it several blows upon the ten, right up to the hand, he finishes both sides of the piece upon the switch, nipping the end or leaving the loose fibres of the end in the corner pins of the tool in the way we described in speaking of hand-dressing. If the end is much worse than the middle of the piece it must be heavily broken, the ease of the operation depending upon the skill of the hackler in lapping the end loose and straight around the touch pin. The root end being finished, the hackler turns the piece on his knee, and, spreading the top end flat upon the hackle, proceeds to break and hackle it in a similar manner, giving, however, the extremity of the top end even more work upon the switch and even one or two blows through the nap extractor, if necessary. In turning the piece he must allow sufficient shift to ensure that the piece is thoroughly hackled from end to end, when, if allowed, it would drop asunder, the fibres being perfectly free and parallel. He then puts a lap upon the piece in the way described in our last chapter, and builds it into a bunch according to the quality which he has found in it during its manipulation. When a bundle of ends has accumulated, he forms them into pieces, combs out the tow, and builds them into a separate bunch of "breakings" which may be mixed in for a low weft number.

There are two usual bases of dressed line numbering. The one, sometimes used in coarse mills, has its origin in the Scotch trade in which the lbs. per spyndle of 14,400 yards indicates the number of the yarn. The line is then classed as Nos. 1, 2, 3, 4, 5, etc., according as it is supposed to be equal to spinning 1 lb., 2 lb., 3 lb., 4 lb., 5 lb. yarn, etc.

The other usual way of dressed line numbering, and that usually adopted in fine mills, is generally known as "warp numbers," because the line thus classed is supposed to be capable of spinning a fair warp yarn of the lea indicated by the number. Thus we have the numbers 25 to 80, ranging from a coarse dirty flax to the finest Courtrai line.

The sorter's bunches usually weigh 20 lbs., and are carefully tied up and covered, if of valuable quality, with paper or linen to keep out the dust and light, the latter of which affects the colour.

They should be stored away in a dry but cool line store kept in semi-darkness, and communicating, if possible, with both the hackling department and the preparing room.

A good large line stock should be kept, as it enables flaxes, of the same number and quality, but hackled at different times and belonging to different lots, to be well mixed together, avoiding annoying changes in colour or striping of the yarn.

The line is furthermore improved by being allowed to "come to" after the hackling process. The same remark applies to the scutching and preparing processes as well, for the friction of the scutching blades and of the gill pins, as the line is drawn through them on the preparing frames, dries or sets up frictional electricity which renders the fibres stiff and intractable.

The Society rate of wages for hacklers in Ireland is 25s. per week. The men are usually paid so much per 100 lbs., say 10s., 9s. 3d., 6s. 11d., 5s. 5d., 5s. 3d. or 4s. 11d., which, taking 25s. per week as a basis, amounts to their working 45, 50, 65, 80, 85 or 90 lbs. per day respectively. It is usual to say that the dressing of a certain class of flax is paid for at the rate of 80 lbs. per day, not 5s. 5d. per 100 lbs. In weighing the sorter's parcel into the line store, it is usual to deduct 1 lb. or so for the weight of the bands and paper, if any, with which the bunches are secured. The resulting shorts and tow are entered upon the parcel ticket, the contents of which are afterwards transferred by the hacklers' clerk to the "lot book." The finished flax or "dressed line," as it is now called, should be placed in separate bins in the line store. The bins may be numbered and the number entered in a book kept for the purpose. Any quality of flax is thus easily found when required for the preparing department.

The "lot book" referred to is a complete record of the results of the working of each individual parcel. These results are entered from the parcel tickets under their respective lots and upon the line corresponding with the parcel number. When all the parcels belonging to any lot have been got in, the lot must be "made up." First, all the columns must be added up and the totals checked. Thus the sum of the rougher's "longs," "shorts," tow and waste must equal the flax weighed off. The sum of the machine tows, tipples, and waste must equal the rougher's longs and shorts. The sum of the hackler's "sorts," tow, and waste must equal the tipples, and the sum of the hackler's sorts, total tows and wastes—the flax weighed off. Thus the additions must be checked and the errors located. The average yield of dressed line per cwt. is next to be found by dividing the total line by the cwts. in the lot. The yield per cwt. of sorted flax seldom exceeds 70 lbs., while for unsorted fibre it may be as high as 80 lbs.

Average Sort or Lea.—The average sort or lea is found by dividing the sum of the products of the lbs. of each sort and that sort, by the total line. Thus if 70 lbs. of dressed line were made up of 6 lbs., 35's; 10 lbs., 45's; 24 lbs., 50's; 30 lbs., 55's, the average sort or lea is—$[(6 \times 35) + (10 \times 45) + (24 \times 50) + (30 \times 55)] \div 70 = (210 + 450 + 1200 + 1650) \div 70 = 3510 \div 70 = 50{\cdot}14$.

This result may be checked by the following method:—Divide the sum of the products of the lbs. of each sort and that sort minus the base sort (in this case 35's), by the total line, and add the base sort to the result, thus—$\{[6 \times (35 - 35)] + [10 \times (45 - 35)] + [24 \times (50 - 35)] + [30 \times (55 - 35)]\} \div 70 = (0 + 100 + 360 + 600) \div 70 = 1060 \div 70 = 15{\cdot}14$. Add 35, and the average lea $= 50{\cdot}14$, is found as before. This may be further shortened by multiplying by 1, $1\frac{1}{2}$, and 2, instead of 10, 15 and 20 as above, and then multiplying the result, 1·514, by 10, or shifting the decimal point one place to the right, making it 15·14 as before.

The average tow per cwt. of each sort and of the total, and the average waste per cwt., are found in the same way as the average yield, and the results checked by the knowledge that, allowing for the loss of, say, ·02 in neglected decimals, the sum of the average yield of line, tow, and waste must equal 112, and the sum of the average tows of the various sorts must equal the average total tow. In some places these results are made up on the flax weighed off, and elsewhere on the flax paid for. In the latter case the waste shows more or less according to whether good or bad weight was received, whether the flax was damp and had "dried in" or not, and, in the case of Russian flaxes, according to the weight of ropes and the difference between the actual weight of mats, if any, and the tare which is allowed. The latter item need not be included in the waste, but may be brought out separately.

The result of a lot may be obtained approximately in a short time by working a parcel of each farmer's lot, and dividing the sum of the products of the result of each parcel and the cwts. in each buying, by the total cwts. in the lot.

The object of these calculations is to obtain the cost of the dressed line per lb., and, for the sake of comparison, to find from it the cost of a given sort. It is thus easy to see if the lot be dear or cheap, and the figures obtained serve as the basis of the yarn costing.

Cost of Average Sort.—In order to make out the cost of the dressed line per lb., the market values of the various tows must be ascertained. Say that the market values per cwt. of Irish mill-scutched or milled tow are:—Roughing, 32s.; No. 1, 35s.; No. 2, 38s.; Nos. 3 and 4, 41s.; and sorting, 46s.; or an average value of 4·14 pence per lb. The cost of hackling must also be known. For ordinary long line sorted flax in Ireland it may be made up as follows:—Roughing, 1s. 7d. to 1s. 9d. per cwt., depending upon the size of the pieces, lifts per minute, etc. ; sorting, 2s. 6d. to 4s., depending upon the yield and the length of flax; overlookers, clerks, and odd hands, 1s. 4d. per cwt. ; total, 6s. 2½d. to 7s. 9d. per cwt., or say an average of 7s. per cwt. Coarse undressed flax may be hackled for 3s. 3d. per cwt. ; while the finest Courtrai may cost as much as 8s. per cwt. To find the average cost of the dressed line per lb., take the average cost of the lot per cwt. from the flax invoice book, and to that add the average cost of dressing per cwt. Deduct the value of the tow per cwt., and divide the result, reduced to pence, by the average yield of dressed line. The result is the cost of the average sort. Taking our previous figures for example : average yield 70 lbs. per cwt., and average lea 50·14. Suppose the total tow per cwt. to have been 40 lbs., with an average value of 4·14 pence per lb., the average cost of the lot 72s. per cwt., and the cost of dressing 7s. per cwt. The average cost of the line per lb. is $[\{(72+7)\times 12\} - (40\times 4{\cdot}14)] \div 70 = 948 - 165{\cdot}6 \div 70 = 782{\cdot}4 \div 70 = 11{\cdot}17$ pence per lb. This cost is for the average lea. For the sake of comparison, all the results of lots may be reduced to the value of a common base, say 40's. The ways of doing this are various, and more or less arbitrary, since the actual value of 40's depends upon what would have to be paid for flax which would give that average number. This, of course, depends upon the season, and whether the crop runs coarse or fine. One way is to deduct the value of 40's by simple proportion, and another, by adding to or subtracting from the cost of the average "lea" or number, an amount (based on the average of former years or on a number of previous lots) for each number which that average lea is below or above 40's. Thus, taking our former figures, viz., 50·14 lea, costing 11·17 pence per lb., we find by proportion that 40's are worth $\frac{11{\cdot}17\times 40}{50} = 8{\cdot}93$ pence per lb. Suppose we find by experience that the average cost of numbers above or below the base, say 40's, is the cost of the base $\pm \frac{1}{5}$ penny per number. The cost of our 40's reckoned in this way is now $11{\cdot}17 - \frac{50{\cdot}14-40}{5} = 9{\cdot}14$ pence per lb. The methods of calculation in the flax department of a Continental mill are the same in principle, in France and Belgium the average cost per cwt. being replaced by the cost in centimes per kilo, the cost of the dressed line brought out in francs or centimes per kilo, and the average yield being per cent. or per 100 kilos. Roughers and hacklers are paid in centimes per hour, but have to keep their share of machines going. Roughing is not general, the flax being merely pieced out in many mills. In Germany, home-grown flax, which resembles Irish hand-scutched, is frequently re-scutched prior to roughing. This, if carefully done, is well worth the cost and trouble. Fine and first grade warp yarns are nearly all spun in Ireland, where the hackling and dressing of the flax has reached a high state of perfection. With the exception of a few fine mills in the north of France, the numbers spun upon the Continent are chiefly of heavy and medium counts, for which Russian flaxes are much used. Some French and Belgian spinners produce a nice yarn from Slanetz flaxes, as they take much more care in the hackling and sorting of the fibre than we do under like circumstances. Cheap labour, protective duties, and long hours of labour give them a decided advantage which, however, is fast disappearing under progressive legislation and socialistic movements. The hours of labour per week in the chief flax-spinning countries are now—Ireland, 56; Belgium, 69; France, 60; Germany, 65; and Russia, 67.

Running Numbers for Spinning.—It is a very good practice to spin yarns in lots of so many tons, bundles, spyndles, or paquets as the case may be, either to order or merely for stock and sorting-up purposes. In giving these lots a running number, mixes may be avoided, and when the lot is finished a calculation made to show the waste made and the actual cost in material used per lb. or bundle, etc., of yarn. It is convenient to calculate the waste per cent. on the yarn spun, and not on the raw fibre weighed out. For flax line yarn, starting with the fibre in the form of dressed line, an average waste of 20 per cent. on the yarn spun may be taken in calculating the quantity of material required to spin a bundle of yarn, for instance. Since, under the Irish system of numbering flax yarn, the number indicates the number of cuts or leas per lb., and there being 200 cuts per bundle, the probable weight of dressed line required to spin 300 bundles of 60, for instance, will be

$$\frac{(200 + 20 \text{ per cent.}) \times 300}{60} = \frac{240 \times 300}{60} = 1200 \text{ lbs.}$$

Under the Scotch system of yarn numbering, which is universal in the jute trade, the number indicates the weight in lbs. of a spyndle or four hanks. Thus on the same basis the weight of line required to spin 10,000 spyndles or 2400 bundles of 4 lb. or 12 lea yarn, will be $(10,000 \times 4) + 20$ per cent. $= 48,000$ lbs. The weight of *lin peignée* required to spin 100 French paquets of No. 40 flax yarn, which weighs 14 kilos per paquet of six Irish bundles, will, on the same waste basis, be $(14 \times 100) + 20$ per cent. $= 1680$ kilos. Since there are only three Irish bundles in the Belgian paquet, which, furthermore, weighs rather less than half the weight of a French paquet, the weight of dressed line required to spin a like number of Belgian paquets will be only $(6{\cdot}8 \times 100) + 20$ per cent. $= 816$ kilos.

In the case of tow yarns, the quantity of card waste is so variable that anything between 30 and 50 per cent. may be taken as the probable waste on the yarn spun. Rope yarns may, of course, be run through with comparatively little waste. Thus, on the basis of 5 per cent. waste, 105 tons of Manila will be required to spin 100 tons of binder twine.

Stocktaking and Mixing.—The hackler's clerk or storeman should supply the manager with a stock sheet every week, showing the quantities weighed out and in the present stock, so that he may see at a glance if the material is being used and mixed in the proper proportions, and also arrange for the supply of fibre for present and future requirements, or, that being impossible, to adapt his spinnings to the material in hand. It is generally found advisable to mix flaxes, except in the case of the better qualities of Courtrai, which are of a nice clear colour, and when spun pure, produce a valuable light-coloured yarn. Specially dark-coloured yarns, produced from Dutch or Flemish flax, are also occasionally in demand for lines. Mixing is convenient when it is impossible to get a sufficient quantity of flax of uniform quality and colour, or of a value which may be spun into yarn at a given price, leaving a fair margin of profit. A judicious blend may in some cases give a better spin than even the best of its component parts spun alone. Weak and strong, or small and big "boned" flax, however, should never be mixed together, as they tend to draw unevenly in the spinning, and produce "shiry" if not "beaded" yarn. Suppose that it is desired to spin a quantity of 100's weft, the market price being at the time 3s. 3d. per bundle, less 9 per cent. Suppose the result of a series of trials of waste made in the preparing and spinning to be 20 per cent. on the yarn spun, the weight of material required per bundle will be 2 lbs. + 20 per cent. = 2·4 lbs. Suppose the margin of profit to be made per bundle be 3d., then the bundle must be produced for (3s. 3d. − 9 per cent.) − 3d. = 2s. 11½d. − 3d. = 2s. 8½d. Suppose the average cost of preparing and spinning per bundle, taken from a lengthened period of working and including wages, cost of coal, gas, furnishings, etc., to be 1s. 3½d., that leaves us 2s. 8½d. − 1s. 3½d. = 1s. 5d. for the 2·4 lbs. of material, or an average price of $\frac{17}{2 \cdot 4} = 7 \cdot 1$ pence per lb., for the line. We have taken the price of 100's weft at almost its lowest price. Even during a depression in trade the better spinnings can command 1½d. more, and producers have often to spin without profit or at a loss to keep up their quality. We have previously mentioned the way of sending the flax to the spread-boards in the machine-room tipple, dispensing with dressing, and thus reducing the cost of the line by the cost of sorting, say, ½d. or more per lb. If the flax is fairly level in quality, and if the machine boys have picked out and machined again the dirty pieces, and also pulled off the loose ends, or if ending machines have been used, fairly good results will be obtained from unsorted flax. We have now to arrange the blend or mix, to average 7·1d. per lb. in price. Irish flax is, as a rule, too good and expensive to use alone in this class of yarn. We will use some, however, to give strength to the mixture. Dutch flax is almost invariably a weft flax, and must be used in yarns of this sort. It macerates easily in the hot water of the spinning trough, and gives the yarn a good "skin" and appearance. Riga flax also is more suited to weft than to warp yarns. It comes in cheap, and the better marks will spin to 100's. Under the warp number classification, it will require 40's Irish and Dutch to spin 100's. We will suppose the cost of 40's Irish in the tipple to be 9d. per lb., 40's Dutch $8\frac{1}{2}$d. per lb., and the Riga $5\frac{1}{2}$d. per lb. If we then arrange the mix to be $\frac{1}{2}$ Riga, $\frac{1}{4}$ Irish and $\frac{1}{4}$ Dutch, the average price of the line will be

$$\frac{(2 \times 5\frac{1}{2}) + (1 \times 9) + (1 \times 8\frac{1}{2})}{4} = 7 \cdot 1\text{d. per lb.}$$

The best way to find the necessary proportions to average 7·1d., if we determine upon using Irish at 9d., Dutch at $8\frac{1}{2}$d., and Riga at $5\frac{1}{2}$d., is to place the respective values of the simple parts under each other, and the desired average price to the left of them, thus :—

7·1d.	Irish . .	9d.	1·6	or	1	$\frac{1}{4}$
	Dutch . .	$8\frac{1}{2}$d.	1·6		1 or	$\frac{1}{4}$
	Riga . .	$5\frac{1}{2}$d.	1·9 + 1·4 = 3·3		2	$\frac{1}{2}$

Then link a greater and a less value than the desired average together. Find the difference between each value and the desired average, and place it opposite the value *to which it is linked.*

Thus in the present example, there are *two* greater and only *one* less value than the desired average, so link *each* of the greater to the less; $9 - 7 \cdot 1 = 1 \cdot 9$, which place opposite Riga, $8 \cdot 5 - 7 \cdot 1 = 1 \cdot 4$, which also place opposite Riga, and add to 1·9, making 3·3. $7 \cdot 1 - 5\frac{1}{2} = 1 \cdot 6$, which place opposite Irish and Dutch. Thus the flaxes must be mixed in the proportions of Irish 1·6, Dutch 1·6 and Riga 3·3, or 1, 1 and 2, or $\frac{1}{4}$, $\frac{1}{4}$ and $\frac{1}{2}$. We will therefore put in $\frac{1}{4}$ Irish, $\frac{1}{4}$ Dutch and $\frac{1}{2}$ Riga. In practice the proportions in which flaxes can be conveniently mixed depend upon the number of leathers on the spread-board, since it is by spreading a certain number of leathers of each that the mixture is accomplished. Thus there may be two four- or two six-leather boards, or one eight-leather board to the system, so that the only possible divisions are $\frac{1}{12}$, $\frac{1}{8}$, $\frac{1}{6}$, $\frac{1}{4}$, $\frac{1}{3}$, $\frac{1}{2}$ and their complements, unless the fibre be mixed on the same leather, which is unsatisfactory.