# THE DECORTICATION OF FIBROUS PLANTS, WITH SPECIAL REFERENCE TO THE BELGIAN FLAX INDUSTRY.

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IT is probable that many of those present, more or less intimately connected with the cotton trade, have never had cause to realise the amount of labour which must be expended in producing spinnable material from most fibrous plants other than cotton. The cotton fibre has merely to be plucked from the seed upon which it grows and presented to the spinner, but other vegetable fibres, from coir to the finest flax or ramie, are not ready for the spinner until the product of their harvest has had a very considerable amount of labour, and that generally most disagreeable labour, expended upon it.

It is this labour which is termed decortication or the separation of flax, hemp, jute, and ramie fibres from the woody or pulpy matter with which they are associated as they come from the field or plantation.

There are two distinct classes of fibrous plants producing the fibres commercially, but often erroneously, called hemp. There is but *one* species of the true hemp plant (Cannabis sativa), the species grown in England, France, Germany, Italy, Russia, United States of America, and India, although the fibre produced from the plant in India, for instance, differs considerably from the European-grown fibre, owing to the difference in the climate.

Other fibres commercially called hemp are "hard" cordage fibres, forming the structural system of the leaves of tropical and sub-tropical plants such as the several species of Musa, chiefly Musa texilis, Agave, Phormium tenax, Furcroya, etc.

With the exception then of coir, which is extracted from the husk of the cocoa-nut and the "hard" fibres just mentioned, the fibres with which we have to deal are found in the stems of plants, usually surrounding the woody matter as an envelope and bound to it by pectic or gummy matter, being besides generally covered by a skin of varnish which it is necessary to remove.

Those fibres found in the leaves of plants are usually covered up by a more or less succulent pulp, which must be removed before the fibre can be seen.

The separation of stem fibres is much more easily accomplished than is the separation of leaf fibres. In the former case it is only necessary to dissolve the gummy matter which binds the fibre to the boon or harl, and then to break up and knock or shake out this woody matter, or in other words, scutch the fibre. This gummy or pectic matter is, however, insoluble until it has been decomposed by fermentation, or retting, or by boiling in alkaline liquors. Flax, the oldest vegetable fibre, has been decorticated by retting and scutching for thousands of years, as has also hemp and jute as long as we have known of them. It is only quite recently, however, that producers of ramie fibre have realised that their stems might be successfully treated in a similar way, they having for years, to their cost, clung to the idea that they must copy by machinery the hand methods of the producers of China grass, and afterwards boil out the pectic gums with alkali. It seems to me that all those who strive to remove

FIG. 1.

from a round stem an envelope of fibre by scraping, are doomed to failure, the right way being to render it possible for the inside core to break through its fibrous envelope and for the latter to be peeled off.

Jute is probably the most easily decorticated of any of the bast fibres. After being cut with a sickle as shown in Fig. 1, the bundles of stems are placed in tanks or pools of stagnant water, or even in running water if more convenient. The bundles are covered with straw, etc., to preserve them from the direct rays of the sun, which would make the fibre specky. Sods are used to keep the bundles under water, but this practice is to be condemned as the sods discolour the fibre. Logs of wood should be used in preference. The retting process usually lasts from 10 to 20 days. During this time fermentation has been set up and softens the tissue in which the fibre is embedded and renders the gummy matter soluble until the fibre comes away quite readily from the woody portion of the stem. The stalks are examined periodically to test the progress of the retting operation, and when it is found that the fibre peels off easily the operation is complete and the bundles are withdrawn. If under-retted, gum remains, and sticks the fibres together. Over-retting makes the fibre weak and dull in colour. The water used has a considerable effect upon the quality of the fibre. If steeped in clear

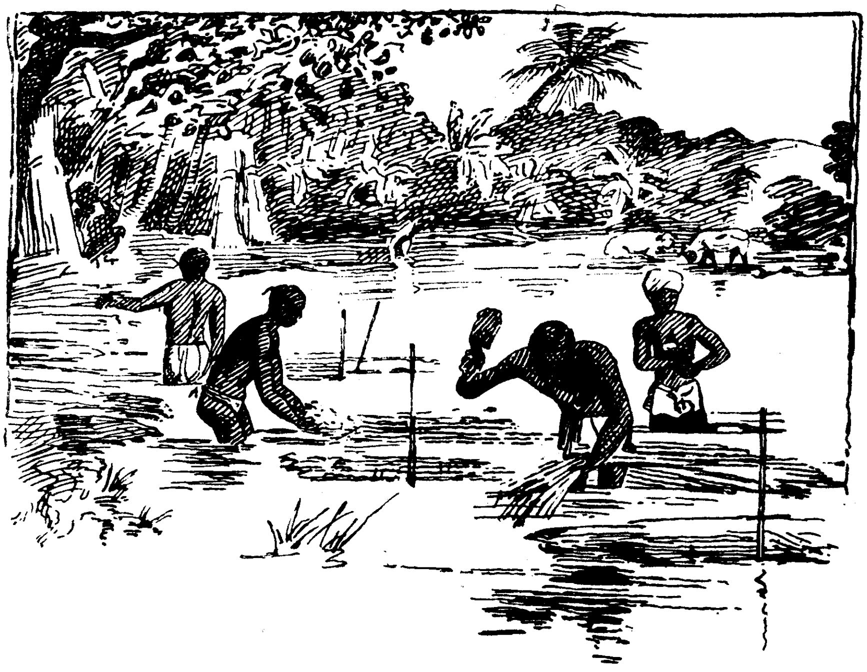

FIG. 2.

water the fibre is of a light colour, while if steeped in muddy water the fibre takes a dark grey colour. Retting in running water takes longer than in stagnant water. In running water the inside bundles of the heap rot quicker than the outside bundles, producing fibre of uneven quality. The heap is, therefore, broken up and the inside bundles removed when ready, the outside bundles being kept for two or three days longer in the water.

Separation or stripping of the fibre from the stem must be accomplished within a couple of days of the finishing of the retting process. Fig. 2 shows the most usual method. Standing up to the waist in the fœtid water, the " raiyat " proceeds to take as many stalks as he can grasp in his hand and with a piece of wood in his right hand to beat them flat at the end. Then he gives them a few more blows, deftly turning the bundle with the left hand meanwhile. He then breaks the bundle about 12 inches from the end—first one way and then the other. A few more blows on the water and the boon falls out, leaving the fibre clear. He now takes hold of the separated fibre with both hands and jerks the stems backwards and forwards on the surface of the water. After a few jerks the fibre is cleared off the stalks. Next, after dashing the fibre repeatedly on the water to wash it and remove impurities, and wringing as much water as possible from the handful of fibre, he passes it out on to dry land to be hung out and dried in the sun as seen in Fig. 3. A man can thus separate about 70 lbs. (dry weight) of fibre in 10 hours. The percentage of fibre is only about $4\frac{1}{2}$ per cent. of the green weight

FIG 3.

of the stems, in fact, the yield in fibre from all the plants with which we have to deal will, no doubt, strike many of you as being extremely small. Sisal 3 to $4\frac{1}{2}$ per cent., Furcroya $1\frac{3}{4}$ to $2\frac{1}{2}$ per cent., Sanseveria 2 to 3 per cent., Phormium 12 to 15 per cent., Flax 5 per cent.

The question of improved methods of decortication has come very much to the front within the past year or 18 months. At the present time the encouragement of flax cultivation on a larger scale is being brought to the front not alone in England, but in Russia, Canada, and France. Our Department for Agricultural Development is getting the Yorkshire and Somersetshire farmers to take up its cultivation again, and is looking round for improved methods of treating the straw which will shortly be available. Several up-to-date flax spinners are of the opinion that there will shortly be a revolution in that end of the trade and methods found of getting better fibre and more of it per acre sown. Just think what the application of such improved methods in a country like Russia would mean. Russia is the largest flax-producing country in the world, supplying 80 per cent. of the world's consumption, yet no country produces such poor and common fibre. Even a small improvement there would give the public better and cheaper linen. It is the dream of the flax man to compete with cotton in price.

The Government of New Zealand are still offering a bonus of nearly £12,000 for improved methods or machinery which would result in the increased prosperity of their native flax or hemp industry, which feels very keenly the competition of the rival fibres, manila and sisal, which are produced under cheaper labour conditions, the workmen employed being coloured and working under conditions of semi-slavery. Besides, as we shall shortly see, decorticating machines have been devised for sisal which produce large quantities of fibre with the minimum of labour, many of the operations being automatic.

In case some of the gentlemen present should care to take a hand in solving the difficulties of improved decortication, I will continue to describe the methods at present in use for the various fibres, so that they may not waste their time, as Cartwright once did, being quite surprised to find when he had made his first loom that existing machines were as good and simpler than his own.

New Zealand hemp is a plant resembling our flag or sedge, and, like it, grows in swampy ground. The leaves are sword-like and from 5 ft. to 8 ft. long and from 6 in. to 8 in. wide, the fibre being distributed throughout the leaf as a support. The outer surface of the leaf is of a bright siliceous character and very hard. The other portions are also hard and difficult to remove.

The leaves are cut with a sickle, about 6 in. from the crown of the plant and are tied in bundles averaging about 90 lbs. in weight. If cut nearer than 6 in. to the root, gummy matter and strong red dye in the butt of the leaf deleteriously affect the fibre, as it is difficult under present conditions to eliminate the gum and colour.

When the trucks of phormium leaves reach the mill they are stacked in the yard to be sorted and prepared for stripping. In sorting, the leaves are graded into several qualities. They are also divided up into different lengths to be stripped separately, so that the fibre in each bundle may be as uniform as possible, both as regards quality and length. The leaves weigh on the average about 17 oz. each. In the work of stripping, several bundles are placed on a table or bench to the right of the operator, who feeds the machine with two or three leaves at a time, as I will show you later, when we start the lantern. An expert operator provides an even supply of leaves for the machine so that it may work uniformly and effectively, or give its maximum production and yield. An expert feeder will feed, on the average, 24 cwt. of leaves per hour.

Fig. 4 gives a sectional view of the most important organs of the stripper: (1) is the mouthpiece through which the leaves are fed, (2) are fluted feed rollers, which hold the leaves as they are fed in against a stationary bar or ribble (3), while the stripping drum (5) is beating out the vegetable matter as the leaf passes between it and the beater bar 4. The beating or stripping drum (5) is 18 in. in diameter and 6 in wide on the face, and is driven at a speed of about 2,000 revolutions per minute. It consists of a cast-iron cylinder, to the periphery of which are attached diagonally and at opposite angles, 22 beaters or plates, $\frac{1}{4}$ in. wide and $1\frac{1}{2}$ in. deep, cast upright upon the face of the cylinder. The

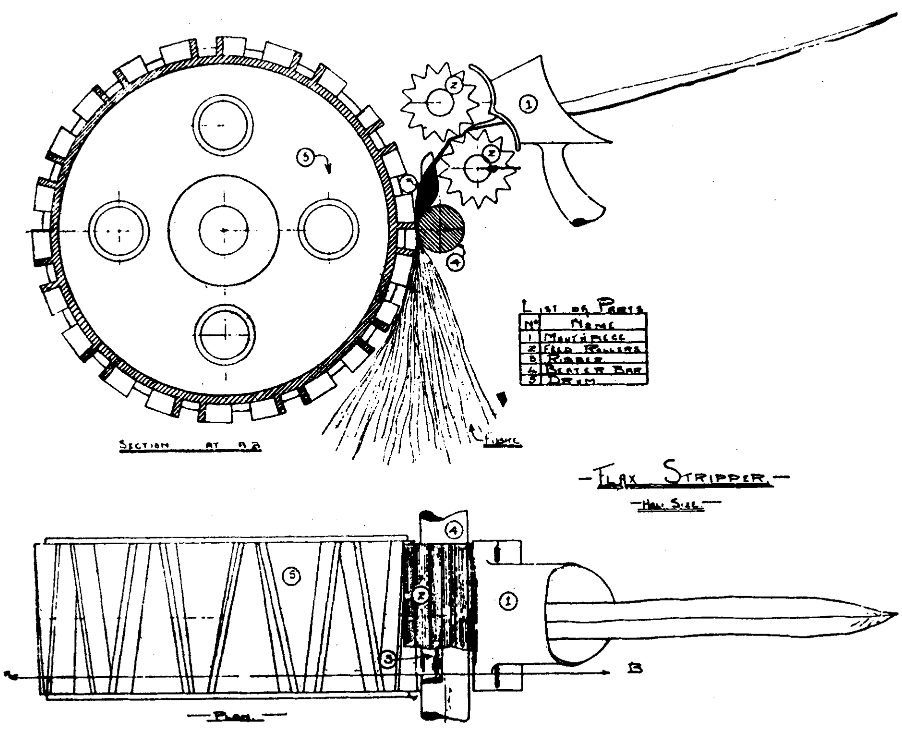


FIG. 4.

drum, scraping against the leaf, held in position by the beating bar and feed rollers, which deliver it in at the rate of about 360 ft. per minute, beats off the bulk of the vegetable matter and leaves the fibre somewhat roughened and with a residue of vegetable matter remaining upon it.

On leaving the stripper, the fibre is caught by a pair of holding chains, or bands, held by which it is passed between washing drums, consisting of two sets of four-armed beaters (covered with galvanised iron) having a diameter of about 48 in. and geared so that they intersect one another. A constant stream of water flows over the beaters as they revolve, and a considerable amount of vegetable matter is in this manner washed away. As the fibre leaves the washing machine the carrying chains release their grip, and the fibre is automatically lifted off the chain by a divider (simply a piece of wood or iron fixed at an angle against the chain), when it is taken by an operative and formed into hanks or stricks (each representing the fibre from about 15 leaves), which are thrown over a pole so that the water may drain away.

When fairly dry the fibre is taken to the bleaching and drying fields, that its colour may be made lighter or clearer by exposure to the weather. I might here say in passing that except on rare occasions, when a Dutch or dark colour is required for a special

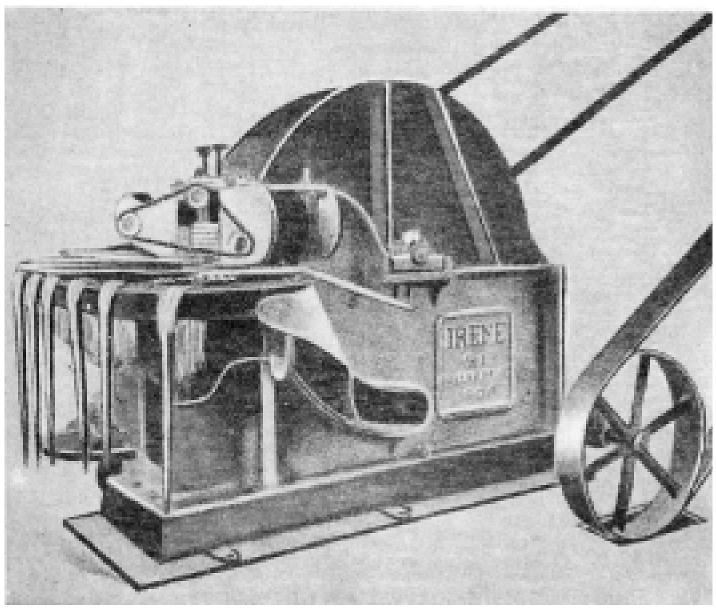

FIG. 5.

purpose, a light yellow colour adds to the commercial value of all these fibres.

The hanks or stricks are spread to the width of 18 inches in extending rows and allowed to remain thus for six or seven days, which is the time usually required if the weather is favourable to good bleaching.

If the weather is then unfavourable to completely dry it, the fibre is lifted off the grass and hung on wire fences until the wind and sun dry it thoroughly, when it is hanked or twisted into heads and carted to the scutch mill.

The object of the next process is to remove any dry surplus vegetable matter which may still remain attached to the fibre.

The scutching machine consists of a skeleton drum lying horizontally and built like the swift of a reel or warping mill, about

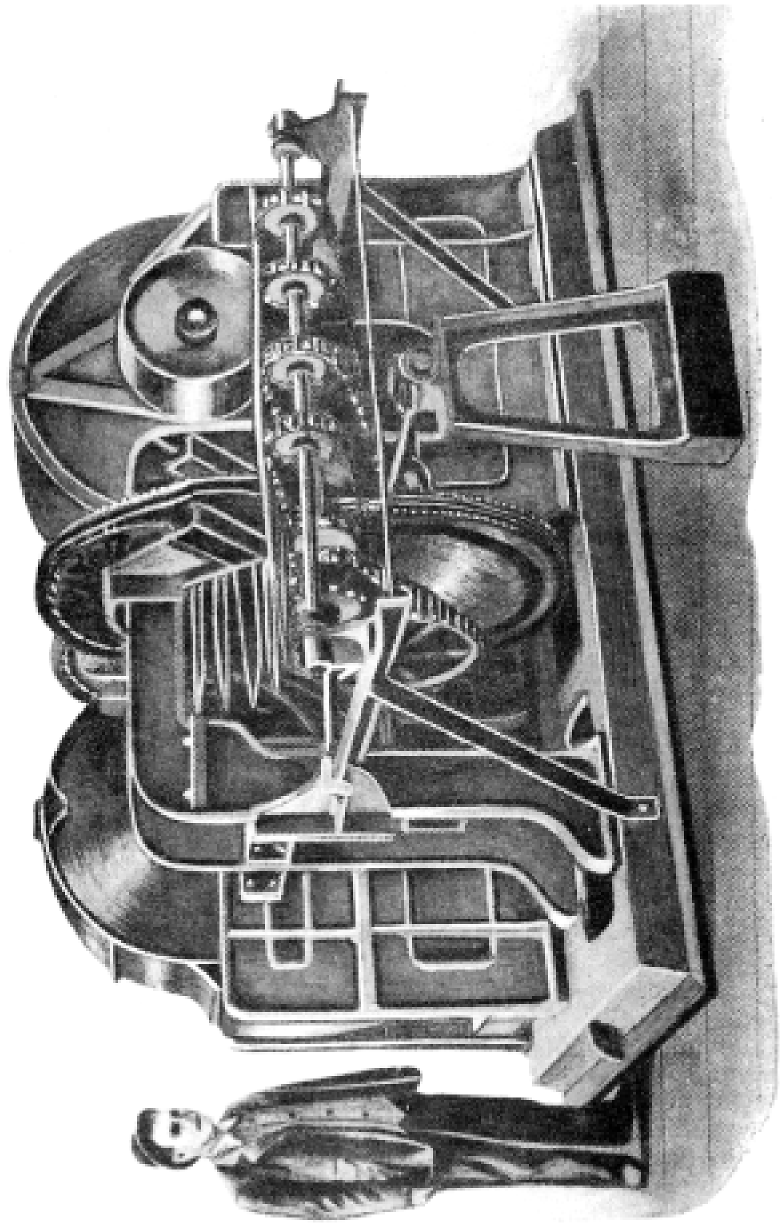

FIG. 6.

5 ft. in diameter and 6 ft. face and having six rails or beaters. It revolves at the rate of about 230 revolutions per minute. The

scutchers subject the fibre to the action of the drum in such a way that the hanks or stricks hang in front of the drum, which knocks off loose extraneous matter and the rough tail ends. The short fibres and the dust fall behind the drum and after being well shaken to remove the dust and rubbish, constitute what is known as New Zealand tow, which is also exported and sells at a very fair price as it contains many of the finest fibres. One of the things which is wanted, however, is a scutching machine which will make less tow or give a better yield of long fibre. Another by-product are "stripper-slips" or fibre that is lost in stripping and carried away in the washing process. It is caught by an iron grating as the wash water leaves the washing machine and is then dried and bleached like the long fibre.

The New Zealand hemp millers consider that the methods just described require considerable improvement, especially in con-

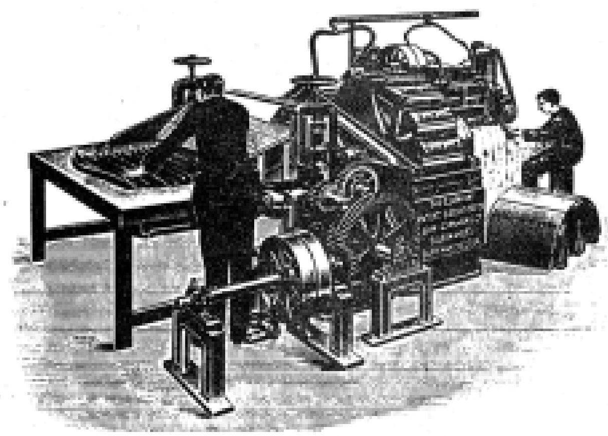

FIG. 7.

nection with the extraction of the fibre in an unimpaired condition. The vital part of the process is the stripping, and here it is that improvement is most desired. The extraction of the fibre from its vegetable covering by means of a hard beating process is not thoroughly effective, as it reduces the strength of the fibre, and produces a large amount of waste material. It is with the object of bringing to the aid of millers of the phormium fibre some process which would enable the fibre to be secured in an unimpaired condition, at the same time assuring this at a minimum cost, that the New Zealand Government have offered the substantial bonus of £12,000 for an improved process.

New Zealand fibre has, as we have said, to compete with Manila fibre extracted in a most primitive and laborious fashion but by cheap native labour. Manila hemp is obtained from the long leaves which envelop the stem of the plant Musa texilis, the cultivation of which forms an important industry in the

Philippine Islands. The plant grows to a height of from 12 to 20 ft. The stems, weighing from 20 to 80 lbs., are, when cut, separated into their individual leaf stalks, the inner leaves producing the most valuable fibre. To extract the fibre from the

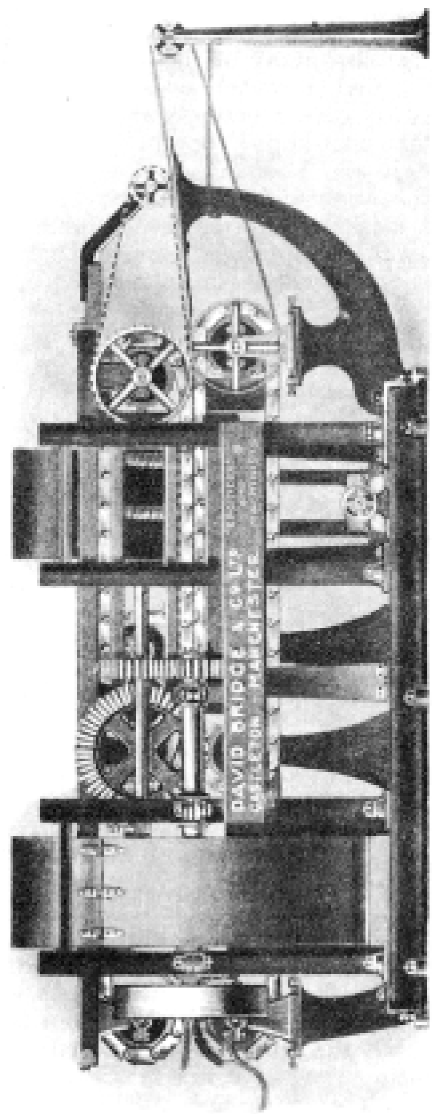

FIG. 8.

leaves, the native first makes a slight incision just beneath the fibre at the end and giving a sharp pull brings away a strip or ribbon of the outside skin containing the fibre. When a sufficient number of ribbons are thus obtained they are carried to the knife machine.

This apparatus, which is used to clean the fibre, is of a most primitive character, consisting of a rough wooden bench with a long knife blade hinged to it at one end and connected at the other to a treadle, by means of which the operator can raise the knife for a moment in order to insert one end of a fibrous ribbon, which being twisted round a small piece of wood in order to afford a good hold, is dragged through between blade and block and all the pulp, weak fibre and pithy matter scraped off. The leaves must be drawn several times between the blade and the bench before the fibre is sufficiently clean. The unscraped end, which is held by the operator, is then scraped by a boy, the fibre being then cleansed by washing, dried in the sun and packed for shipment. **One man can clean about 50 lbs. of fibre per day.**

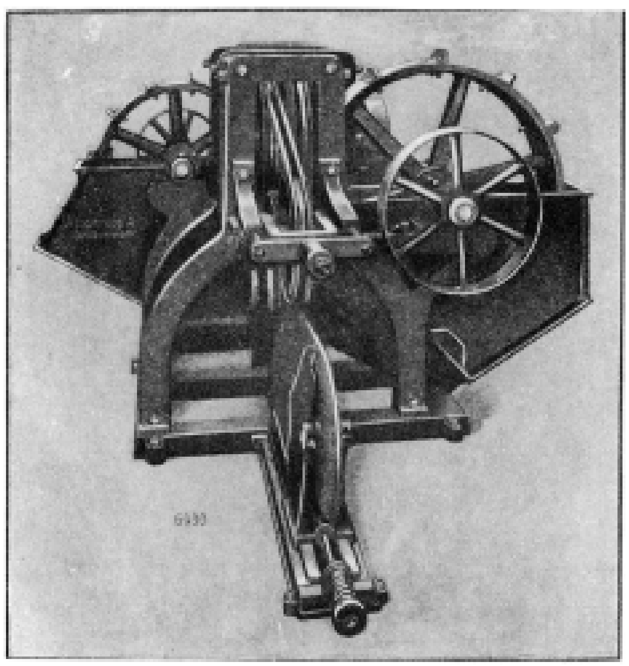

FIG. 9.

Sisal is practically the only one of the leaf fibres which is being successfully decorticated mechanically to-day, Figs. 5, 6, 7, 8, 9, and 10 showing some of the machines which may be used. Crushing rollers, either forming a separate machine as in Fig 11, or combined with the decorticator, as in Fig. 7, being generally used to soften the cortex as a preliminary treatment, and being especially necessary in treating Sanseveria. Sisal hemp or agave, known as henegren in Mexico, is indigenous to Yucatan and is also cultivated in the Bahamas, Florida, and North East India. Figs. 12 and 13 show a typical plantation. The leaves of the plant, which contain the fibre, average 5 to 6 ft. in length and are cut down every year after the plant is about four

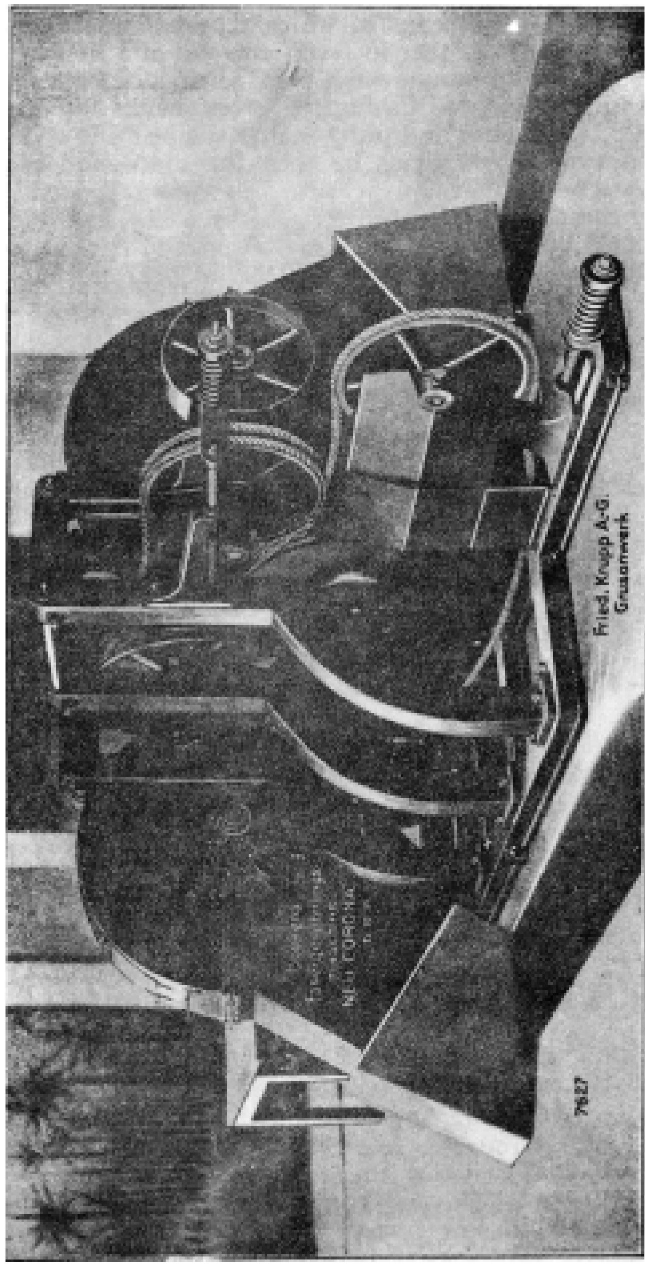


FIG. 10.

years old. A leaf weighs from 1 to 2 lbs. It is lance shaped, about $4\frac{1}{2}$ in. wide near the centre and $\frac{1}{2}$ in. thick. The fibre is the structural system of the leaf and is surrounded by pulpy matter, the whole being covered by a tough, green skin.

The separation of the fibre from the pulpy matter which surrounds it is accomplished by scraping, either by hand or

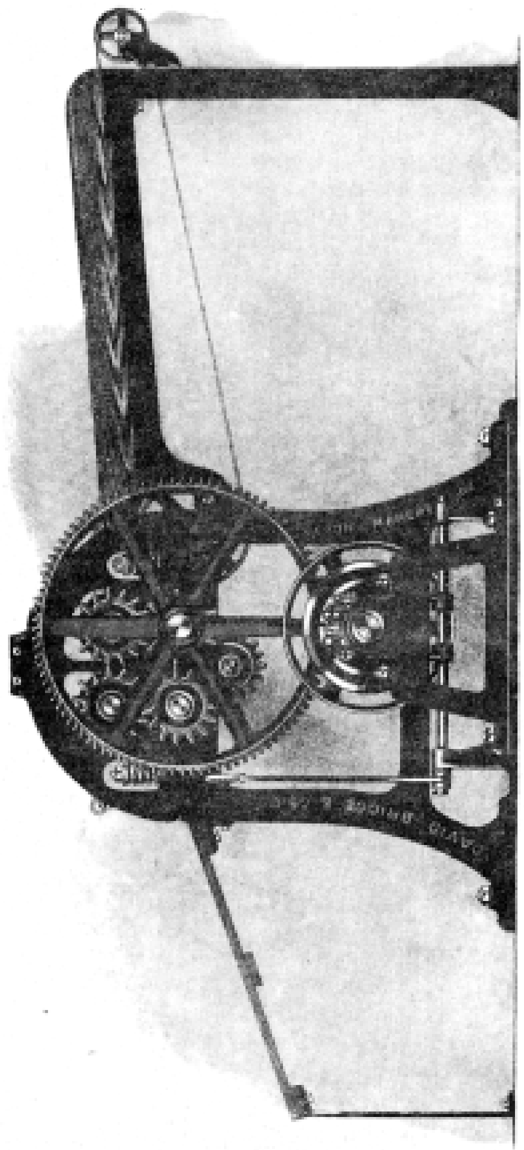

FIG. 11.

machine. In India steeping in water is also resorted to, there being a divergence of opinion as to whether plain water or a mild solution of brine, such as is obtained from springs in the neighbourhood, give the best results. Good results have been obtained with the Prieto machines, Figs. 5 and 6, which will clean

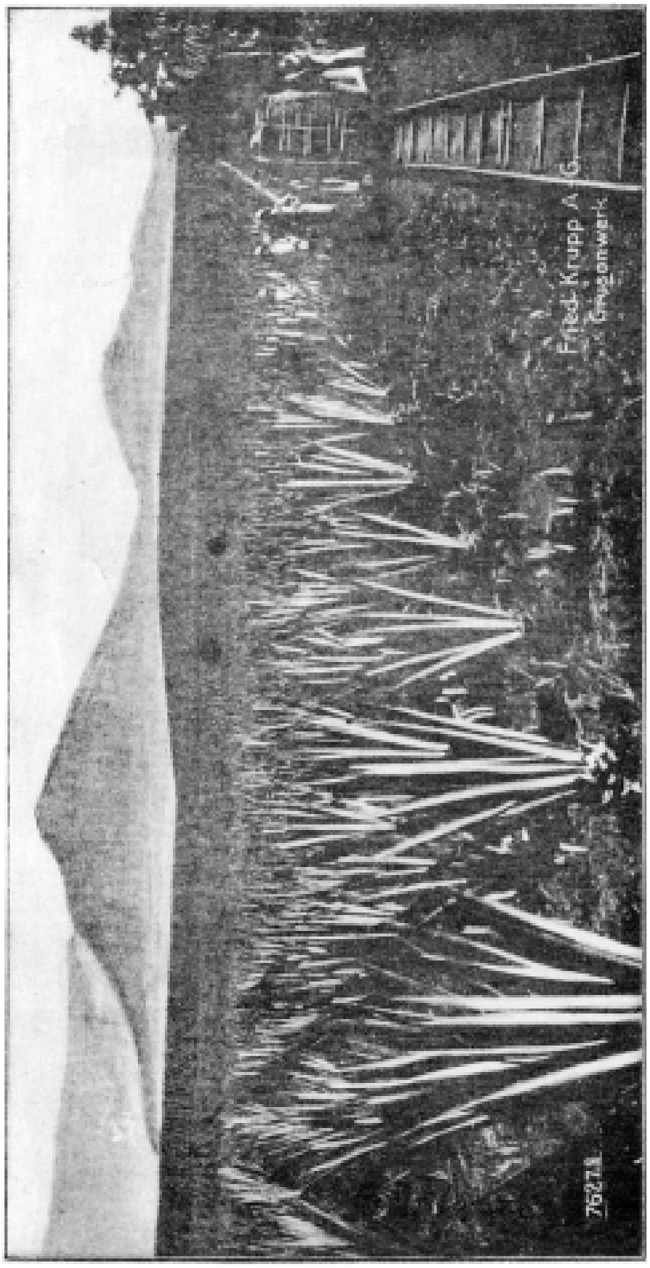


FIG. 12.

from 30,000 to 150,000 leaves per day, according to the size of the machines, which require from 15 to 45 H.P. to drive them. The leaves are run into the machine and held between chains while they are scraped by scrape wheels provided with knives, against

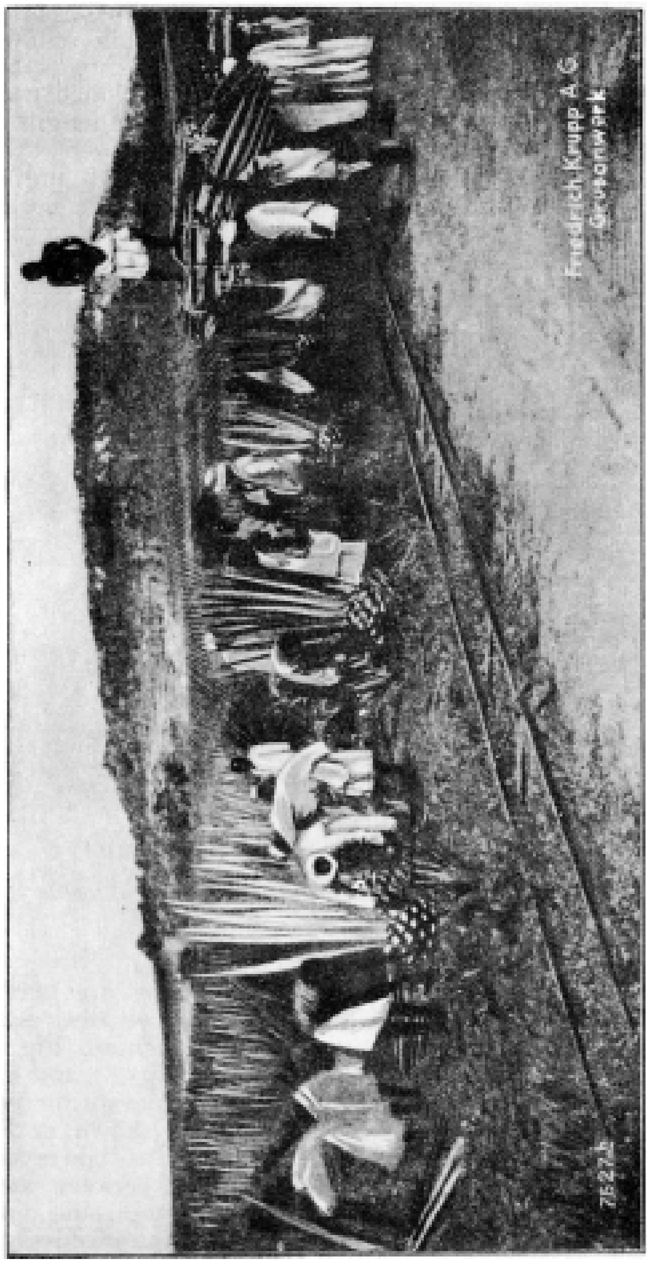


FIG. 13.

which a shoe block presses the leaf being cleaned. The quantity of fibre varies from 50 to 75 lbs. per 1,000 leaves. Where the planters take good care of the machines and the leaves are specially good, they get from 75 to 87 lbs., but this is exceptional. The fibre cut away in the scraping operation and corresponding with the New Zealand "stripper-slips" is called "bagasse," and is usually only about 1 per cent. of the total fibre contained in the leaf. The leaves are spread upon the feed table and at length gripped by the feed chains which grip and pass the leaves into the machine. When half the length of the leaf has been scraped by one drum it is passed automatically to the second scraping drum, which completes the scraping of the whole leaf, the clean fibre being delivered at the rear end.

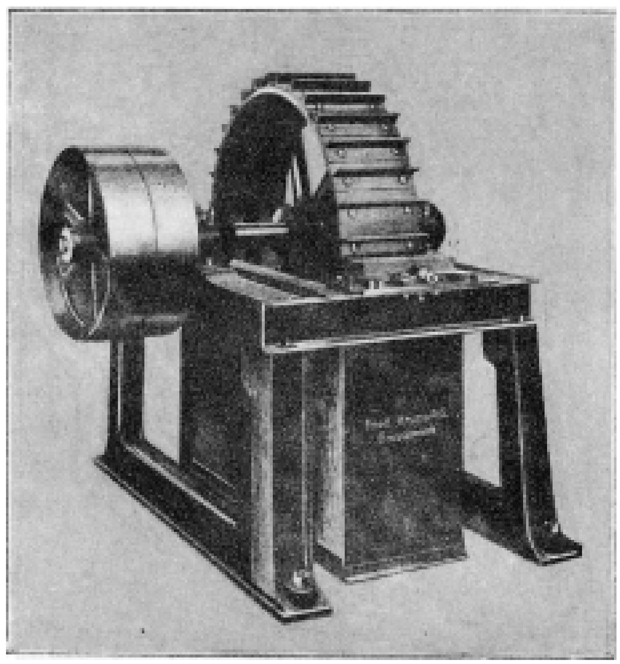

FIG. 14.

In the machine shown in Fig. 5, the leaves are held while being scraped by means of a horizontal notched disc and complementary presser in, while in the double machine, Fig. 6, the holding discs are vertical. In the machines Figs. 7 and 8, holding chains are used and pressed together by spring pressure applied through runners. In the machines shown in Figs. 9 and 10, a series of three ropes are employed as conveyors and holders, two ropes above and one below and between the other two, all travelling at the same speed and in the same direction, the combination holding the leaves and fibre effectively when passed between them. The concave counterpieces, shoes or fixed blocks must correspond exactly with the circle of the scraping drum, both being brass lined and faced respectively, or better still, of solid bronze. The holding chains should also be of solid

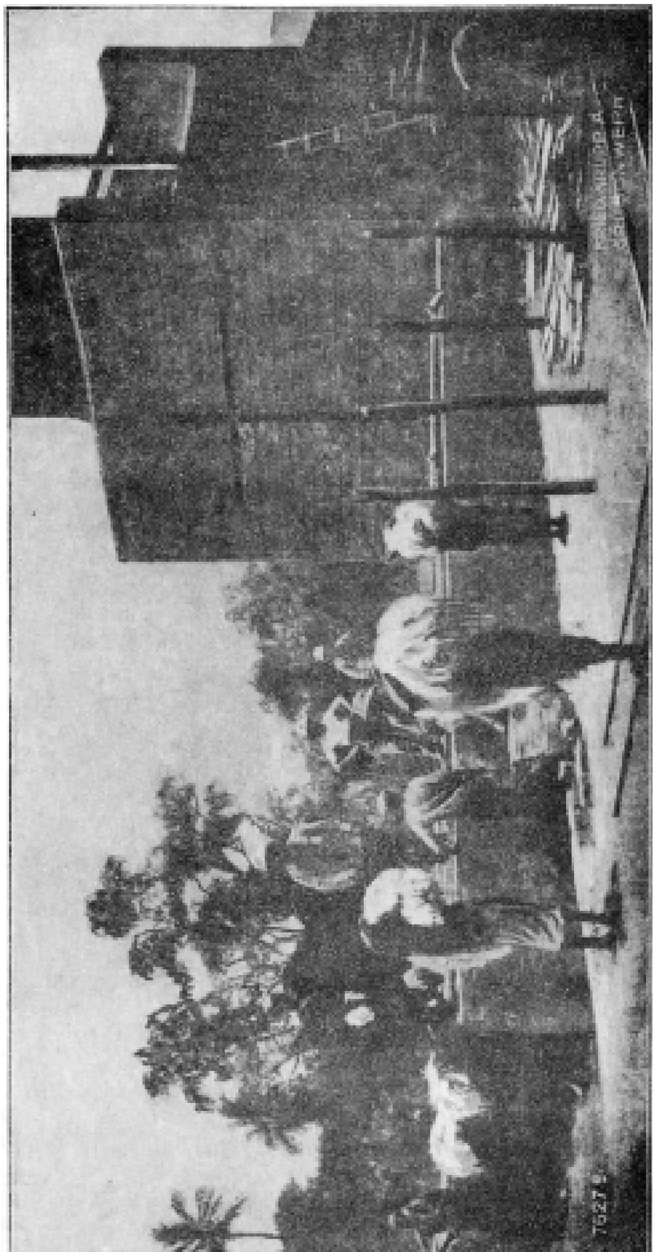

FIG. 15.

bronze as the juices are usually acid and corrosive. There are usually rubber blocks behind either the shoe or the scraper drum pedestals, so that while being closely set they will give and separate as required by the thickness of the material between them.

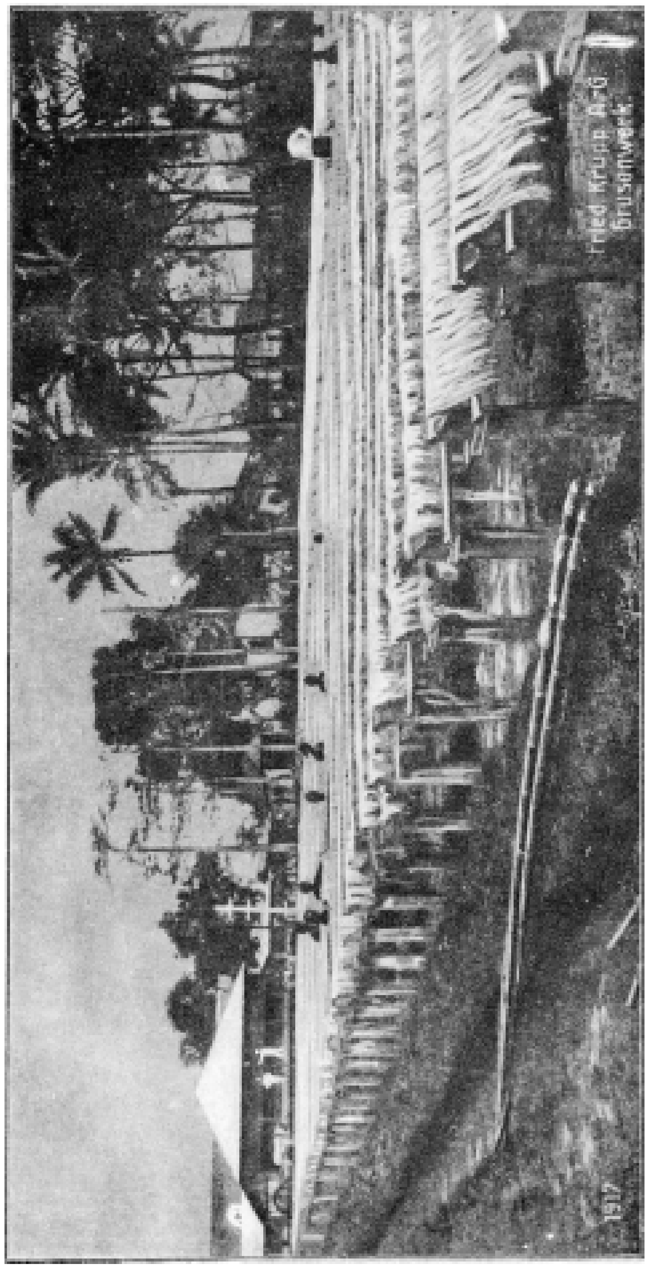

FIG. 16.

Water should stream constantly upon the blocks from an overhead reservoir to wash away the woody pulp as it is removed by the scrapers. In the machine shown in Fig. 7, the shoe block is provided with a diagonal rib, between which and the drum blades the pulp is scraped off, the idea in making the rib diagonal being to attack the leaf gradually and progressively. As regards machines of this description, what fibre cultivators in the Colonies want is a machine small and light enough to be at least as portable as an ordinary threshing machine, an effective machine which can be drawn by a mule. The machine must be run with a comparatively small amount of power, as the power plant must accompany the machine. These qualities are generally essentials. as the fibre must be cleaned within a short time after the plants

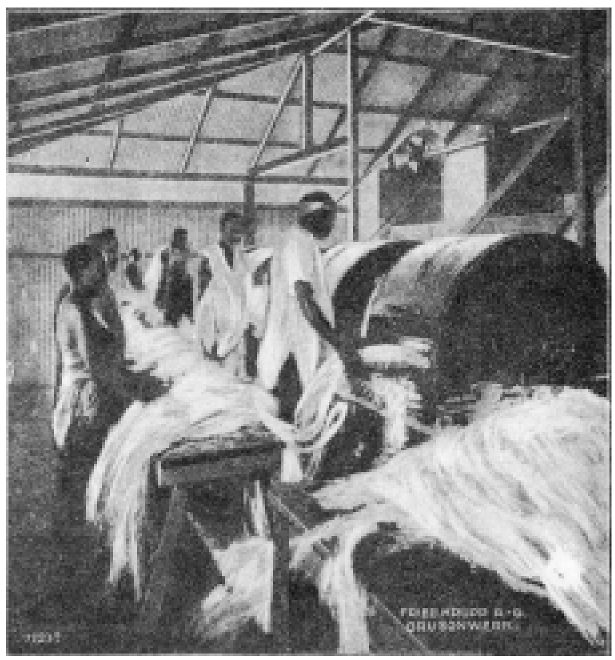

FIG. 17.

are cut, it being frequently impracticable to have large central works to which the heavy leaves can be carted or shipped Inventors must remember that all parts of the machine coming in contact with the fibre immediately after it is cleaned must be free from steel or iron surfaces, which would discolour the fibre. The distance from the scraping knives to the grip holding the leaf must remain practically constant and must not exceed 8 to 10 ins., otherwise the fibre is likely to be strained and broken.

On small plantations yielding an insufficient quantity of leaves for the economical exploitation of one of the large machines already illustrated, preference is frequently given to smaller machines or "Raspadors," as illustrated in Fig. 14. While undergoing treatment by this machine, the leaves are held

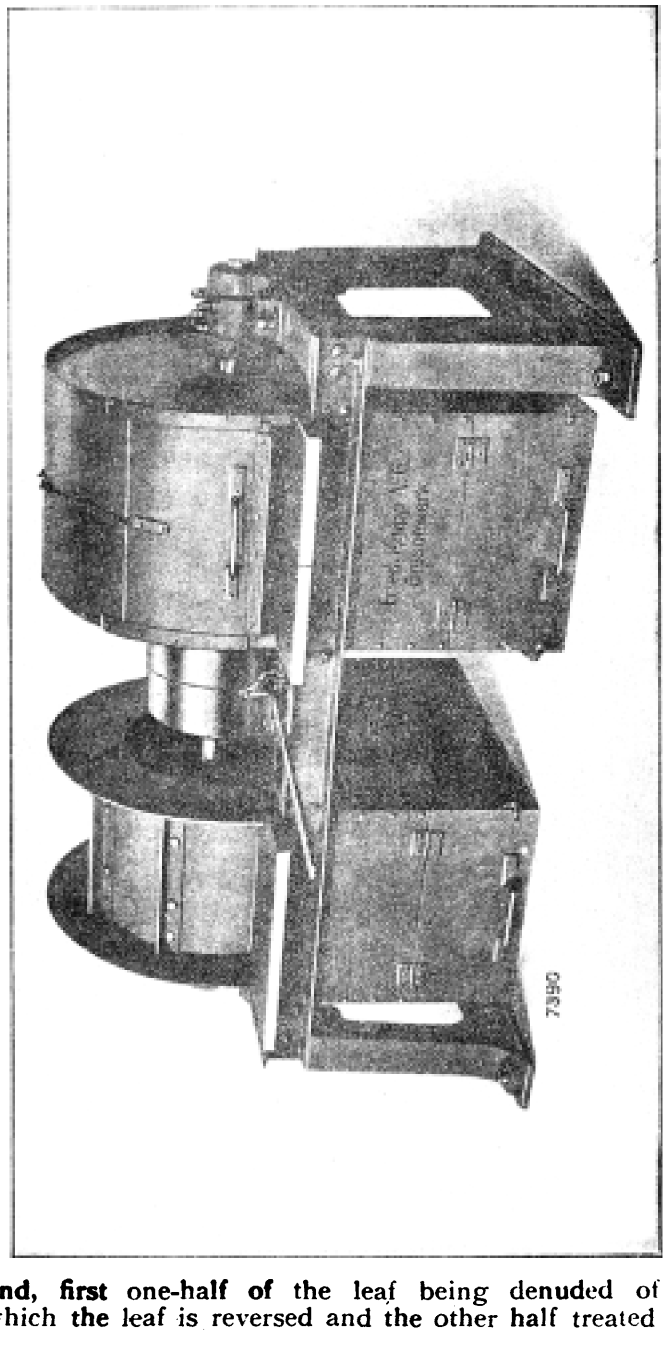

Fig. 18.

by hand, first one-half of the leaf being denuded of pulp, after which the leaf is reversed and the other half treated by the machine in the same way. These raspadors are fitted with one or two beating cylinders, and are respectively described as single and double raspadors. The metal drums are fitted on their circumference with angular blades attached by screws, and run with their shaft in bearings mounted on heavy cast-iron stands or gables, the latter connected at the top by channel irons. Of these, the one in front is fitted with an adjustable rest, against which the leaves are held during the operation of decortication. Each beater drum is cased in, the detachable cover being provided with an opening at the side for the introduction of the leaves.

The leaf fibres discharged by the machines I have described are washed in tanks as seen in Fig. 15, and then dried as shown in Fig. 16, the action of the sun and weather improving the colour in the process. The fibre is finally straightened out and cleaned by brushing or scutching machines, as seen in Fig. 17. The former have one or two cylinders with brushes attached to their periphery, which may be 24-ins. on the face. The brush cylinder usually strikes upwards. When a down striker is used, a counter concave conforming with the curvature of the drum has to be attached to the machine.

The scutching machine is a similar machine provided with beaters instead of brushes, and as shown in Fig. 18.

The natives of Mexico often separate the fibre of the Sisal hemp plant by hand, after thoroughly beating the freshly-cut leaf with a mallet or a wooden block, by drawing the leaf between two metal blades held in contact under a slight pressure. After drawing the fibre is washed and dried in the sun.

In Mauritius the natives extract aloe fibre by striking gentle blows on the leaf with a piece of wood to bruise the pulp and render it less adherent to the fibre, which they then scrape clear by hand.

In the construction of machines for aloe fibre extraction it must be remembered that the juice is strongly acid, and attacks wrought iron and cast iron to a lesser extent and bronze not at all.

The long needle-like points of the Zapupe fibre plant are cut off before the leaves pass to the cleaning machine.

The palm-like leaves of the Palma Pita are boiled or steamed for about four hours before being subjected to the extracting machine.

Before proceeding with the second part of my subject dealing with the decortication of the stem fibres—ramie, rhea, soft hemp and flax, I will ask our lanternist to thrown upon the screen some slides which will serve to further illustrate what I have been saying and what I am about to say.

Slide 1.—Phormium growing in swampy ground, showing the stumps as they appear after cutting, the standing leaves being left to indicate the height of a "bush" of New Zealand hemp.

Slide 2.—Loading the leaves on to trolleys for conveyance to the scutch mill.

Slide 3.—Stripping the fibre—present process showing the feeder at work.

Slide 4.—Bleaching the fibre—spreading it in the field and drying it on wires.

Slide 5.—Scutching New Zealand hemp.

Slide 6.—Manila plantation.

Slides 7, *a* and *b*.—Harvesting the leaves.

Slide 8, *a* and *b*.—Stripping Manila.

Slide 9.—Cleaning Manila.

Slide 10.—Drying the fibre.

Slide 11.—Sisal hemp plantation.

Slide 12.—Sisal hemp plant—cutting the leaves close to the stem of the plant. The stalk becomes longer each year, until in time the lower leaves are produced at the height of a man's head from the ground.

Slide 13.—Sisal decorticating plant at work in Mexico. Capacity 125,000 to 150,000 leaves per day of 10 hours by the machine, shown in Fig. 6. The leaves are carried from the plantation to the mill on tram trolleys and deposited in bundles of 50 leaves on the table. The elevator arms take up the bundles to the top and drop them upon a rather steep incline, where the strings which hold the bundles are removed and the leaves drop on to the less inclined table where they are spread and pushed along until the feed chains which pass the leaves into the machine are reached. The machine passes the leaves automatically from one disc to the other and the clean fibre is delivered at the rear end. An inclined wooden rail is placed near the rear disc from which a boy transfers the fully cleaned fibre to the rail, and as the latter is sharply inclined, the fibre slides down to the lower floor where it is received by the men who take it to the drying racks.

Slide 14.—Natal Aloe plantation.

Slide 15.—Flax plant—20 to 40 ins. in height, with alternate sessile leaves, narrow and lance-shaped. It bears a cluster of blue or white flowers on the top, which in course of time produce capsules, having 5 cells containing 10 flat oily seeds.

Slide 16.—Pulling flax straw.

Slide 17.—Rippling off the seed in Ireland and Flanders.

Slide 18.—Dew retting in Brittany.

Slide 19.—Flax retting dams as in Ireland and elsewhere.

Slide 20.—Retting blue Dutch flax. Note the black mud and scum on the surface, the presence of which gives the flax its characteristic colour.

Slide 21.—Drying green straw for storing.

Slide 22.—Seeding flax straw on the Lys—the straw is spread flat upon the ground, the top ends being struck with the implement shown, which knocks off the bolls.

Slide 23.—Putting the straw in retting crates or "ballons," usually 3 to 4 ft. deep and containing say 150 bundles of flax straw.

Slide 24.—Weighting the crates as they tend to rise when fermentation sets in.

Slide 25.—Retting flax on the Lys.

Slide 26.—Taking the retted straw from the crate.

Slide 27.—Drying the retted straw.

Slide 28.—Breaking the retted straw.

Slide 29.—Flax rollers.

Slide 30, *a*, *b* and *c*.—Flax scutching handles. Blades of walnut wood, projecting 11 ins. beyond the rings.

Slide 31.—Views of a Co-operative rettery and scutch mill.

Slide 32.—View in a Dutch scutch mill.

Slide 33.—European hemp plant.

Slide 34, *a*, *b*, *c*.—Retting hemp straw in Italy.

Slide 35.—Removing the retted stems.

Slide 36.—Drying the retted stems.

Slide 37.—Breaking the retted stems.

Slide 38.—Scutching hemp in Russia.

The cultivation, retting, scutching, and spinning of flax are among Belgium's greatest industries. The funny thing is, that although she produces the finest flax in the world, she prefers to export it almost all and to spin the cheap coarse Russian fibre into coarse and medium yarns from which the bulk of Belgian linens are made. To weave handkerchiefs and other fine goods, they import fine yarns spun from the flax which they send out of the country.

Courtrai, which I understand we are to visit before returning home, is the centre of the raw flax industry of Belgium. Not only is the straw grown in the immediate neighbourhood employed but the factors go out and buy up the best Dutch, Flemish, and French straw and bring it home to be retted in their river which gives particularly good results. From 12,000 to 15,000 labourers are employed during the season, April to October, and pass about 90,000 tons of flax through their hands annually.

Some of you may have already seen the excellent diorama of the flax industry shown in the Belgian section of the Exhibition. For the benefit of those who have not seen it I will give a short description of Belgian methods as representing the best practice. The flax straw before it becomes quite ripe, is pulled up by the roots in handfuls and spread on the ground in rows, the handfuls laid with tops and roots alternating, which prevents the seed bolls from becoming entangled when the handfuls are again lifted. The laborious operation of the hand pulling of flax is likely to be pretty generally superseded in the near future by machine pulling. Fig. 19 shows an ingenious machine for the purpose which contains some of the brain of our fellow member, Mr. J. G. Crawford. It will be seen that essentially it consists of a drum or reel with rails, like a horizontal warping mill. As this reel revolves its rails come in contact with the upstanding flax straw and press the stems into the flutes of a

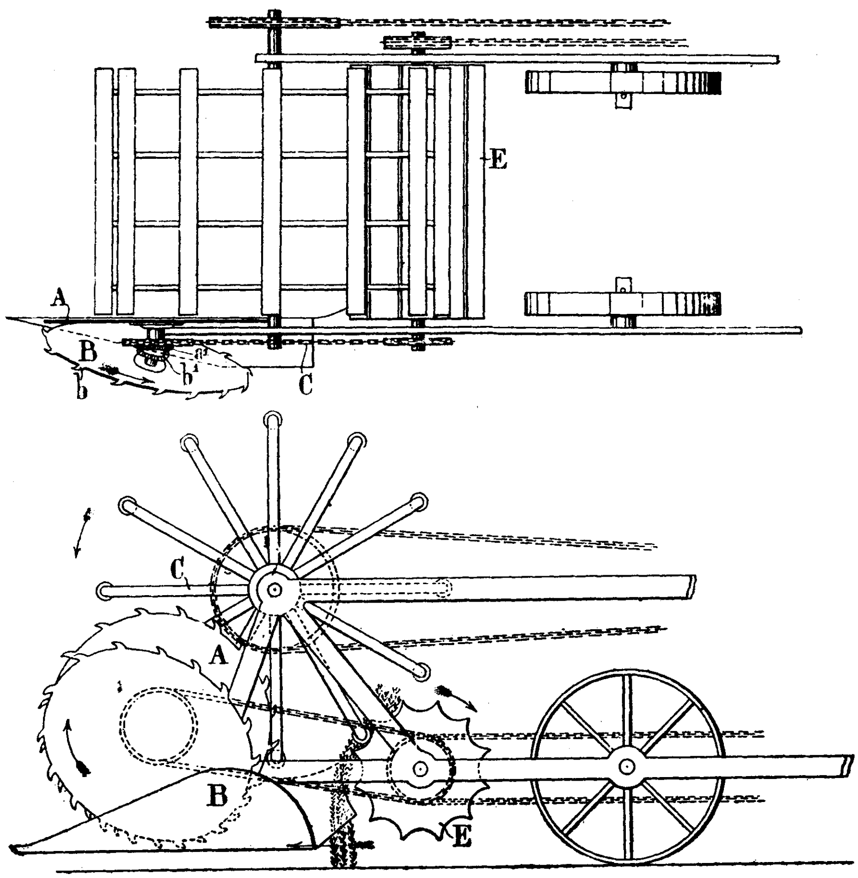


FIG. 19.

revolving roller, the result being that the stems are torn up by the roots. The objects of the revolving discs A and B is to separate the stems, which the machine is about to pull from those that are to remain unpulled. The straw is stacked as soon after pulling as possible, the handfuls resting against each other, the root ends well spread out and the tops joined like the letter A. In six or eight days the straw is dry enough to be tied into sheaves like corn sheaves. It is then ricked and allowed to stand in the field until the seed is dry enough for stacking. Under the Courtrai system the seed is taken off during the winter and the straw restacked or kept under cover until the spring when it is sometimes retted. It is generally considered better, however, that the flax straw be kept for at least a year, and it is sometimes kept for two years before steeping. The seeders bind the straw into parallel bundles about 12 in. in diameter, which for steeping are packed either horizontally or vertically in the large wooden crates or ballons lined with straw. The upright position is usually adopted, as it is said to be more favourable to the production of light coloured fibre, as no sediment or deposit can rest upon it at any stage of fermentation. Straw and boards are afterwards placed on top, and the crate thus charged slid into the river and anchored in the stream, and weighted with stones so that it is submerged a few inches below the surface. In a few days fermentation begins and as it proceeds additional stones must be added from time to time in order to prevent the rising of the crates through the evolution of gas. As a rule, after steeping for a few days, the flax is removed from the crates and set up in hollow sheaves to dry, the advantage of the interruption of the retting process at this stage being, that exposure to the sun and air kills the microbes of putrefaction which have developed so that the strength of the fibre remains unimpaired. When dry, or later, it is repacked in the crates and again steeped until retting is complete, in 7 to 12 days, according to the temperature, quality of flax, etc. The duration of steeping is from, say, about 7 days in August, 10 in May, and 12 in October, when the temperature of the water is much lower. Fine thin stems require a longer time to ret than do stouter stems. The end of the process is accurately determined by occasionally examining the appearance of the stems and applying certain tests. The bundles of straw should feel soft and the stems be covered with a greenish slime, easily removed by passing them between the finger and thumb. When bent over the forefinger, the central woody portion should spring up readily from its fibrous envelope. If a portion of the fibre is separated from the stem and suddenly stretched it should draw asunder with a soft and not a sharp sound.

When retting is complete the flax straw is carefully removed from the crates and again set up in sheaves to dry, this time in the shape of a hollow cone.

The retted and dried straw is then stored in barns and sheds until winter, when "scutching" or cleaning the fibre from the woody part of the stem takes place.

The scutch mill machinery consists first of all of a "breaker" or crushing rollers, a series of pairs of fluted rollers which crush the straw and break up the "boon" into small pieces, which in the case of Courtrai and other flax which has been skilfully retted, are easily separated from the fibre by the strokes of a beater. The best flax rollers are in sets of 5, 6, or 8 pairs, the rollers being about 8 in. in diameter and having from 16 to 24 flutes, ½ in. to 1 in. deep.

The broken up woody matter is then knocked out of the fibre, as the scutchers hold it in handfuls in a notch in an upright plank or stock, by revolving beaters or handles of wood, which, fixed upon a cast-iron rim keyed upon a shaft making about 175 revolutions per minute, make about 2,100 strokes per minute, there being 12 blades to the round in a Belgian scutch mill. The effective diameter of the circle being 4 ft. 6 in., their speed is nearly 2,500 ft. per minute

An acre of fairly good flax is estimated to weigh "on foot," or when freshly pulled, about 5 tons. In drying it loses about 55 per cent. of its weight. Rippling or seeding reduces its weight by another 25 per cent., steeping by another 25 per cent., and if the yield of fibre in scutching be taken at 20 per cent., the yield of fibre is only about 5½ per cent. of the weight of the green straw.

Of the various systems of retting, that effected in the slow current of running water undoubtedly gives the best results as regards colour and quality of the fibre produced. There are very few rivers like the Lys, with a slow enough current of soft water, while the poisonous effect of the flax water upon the fish in the river causes flax steeping to be prohibited in a number of other rivers. It has long been supposed that the waters of the Lys possessed a virtue of their own. Samples have been taken and analysed time and again without discovering the secret. Foreigners have come and taken away barrels of the water to empty into their own rivers and canals in the hope of imparting to them the unknown virtues of the Lys. My own opinion is, and it is shared by others who have studied the subject, that the waters of the Lys have no virtue beyond being soft, slow running and usually in summer at a temperature near to that which forms the optimum of the microbe of fermentation with which the water of the river as it flows through Courtrai is saturated to the most favourable degree, after they have developed themselves among the flax in the upper reaches of the river. The presence of quantities of fermenting flax in the river is a most important factor as well as the degree of saturation of the water with the microbe developed, both these factors explaining why less favourable results are obtained upon the upper and lower reaches of the river than are obtained at an intermediate point and why the field of operations along the Lys cannot be indefinitely extended, resulting in an inability to extend the industry to cope with demand.

Of recent years, however, Continental experts have studied the question of producing the same effects by other means, and a most practical system introduced by Messrs. Legrand and Vansteinkiste has been adopted by a number of flax factors, both on the

Lys and far from it and a number of retteries built, some of which you will probably see before you leave. These retteries, whether using Lys water or not, produce even better flax, both as regards colour and quality, than that produced on the Lys, over which steep it has the further advantage that it can be carried on the whole year round, whereas flax steepers on the Lys must discontinue operations during the winter months.

This retting system is one which might be advantageously adopted in all flax and hemp growing countries and carried on by a rich and large grower, such as the Russian "Gospodine," a company, the Government, or by a co-operative society of farmers. It is just what our Agricultural Development Department want for Selby, Yeovil, and Prickwillow. Briefly described, the process is as follows:—A set of 4 or less retting vats about 8 ft. deep and each capable of containing 3 tons of flax straw in the usual bundles, 2 vertical layers deep, is built of reinforced concrete about 5 in. thick. The straw is introduced into and removed from the vats through water-tight manhole doors just above ground level, this being done when there is no water in the vat. When full the manhole doors are closed and water admitted through distributing pipes, which lie below a perforated false bottom with which the vat is provided. A wooden grating is fixed on top at such a level that the flax cannot rise above the surface of the water, the level of which is maintained by a constant feed and overflow. The water is supplied from an overhead tank, the contents of which are kept at a uniform temperature of about 90 deg. Fah. by means of a water heater. The water issues from the distribution pipes in such a way that a circular motion is given to it. At the same time it rises through the stems and eventually flows off over the edges of vertical overflow pipes. A constant and gentle circulation of water is thus kept up. The heavy brown liquor, saturated with the acids and products of fermentation, sinks through the false bottom, collects in a channel in the base of the vat and at length is forced up through its own overflow pipe which carries it off. This liquor may be collected with advantage as it forms a valuable liquid manure, containing a large percentage of phosphoric acid and potash. When retting has once been started the proper degree of microbe saturation is given to fresh waters by the introduction of a small proportion of saturated water from another vat, the pipes and valves being suitably arranged for this purpose. As the most advantageous conditions are maintained throughout, five days completes the retting process.

These retteries are usually combined with an up-to-date co-operative scutch mill. A capitalist provides the money to build and fit out the plant, and the co-operators pay him back by annual instalments for his outlay upon the scutch mill and pay a fee of £2 8s. 0d. for the use of a retting tank for the double process. If retted in one operation the fee is only £1 16s. 0d. A rettery complete costs £5 per square yard of floor surface, the ground and drying fields not included. The revenue of a rettery, let at the same rate as those on the Lys, *i.e.*, 5d. per cwt., is 25 per cent. on the capital sunk. Since factors are only too glad to pay 7½d. per cwt. for the patent ret, the true revenue is 33⅓ per cent.

The quantity of water necessary per cwt. of straw to be retted either in 1 or 2 operations, *i.e.*, single or double retting, is 108 cubic feet. The heating of these 108 cubic feet of water, waste steam being utilised, costs on the average 3¾d., this cost being made up for by the diminution of labour, compared with retting in the Lys.

In Ireland and Russia the flax straw is pulled and retted by

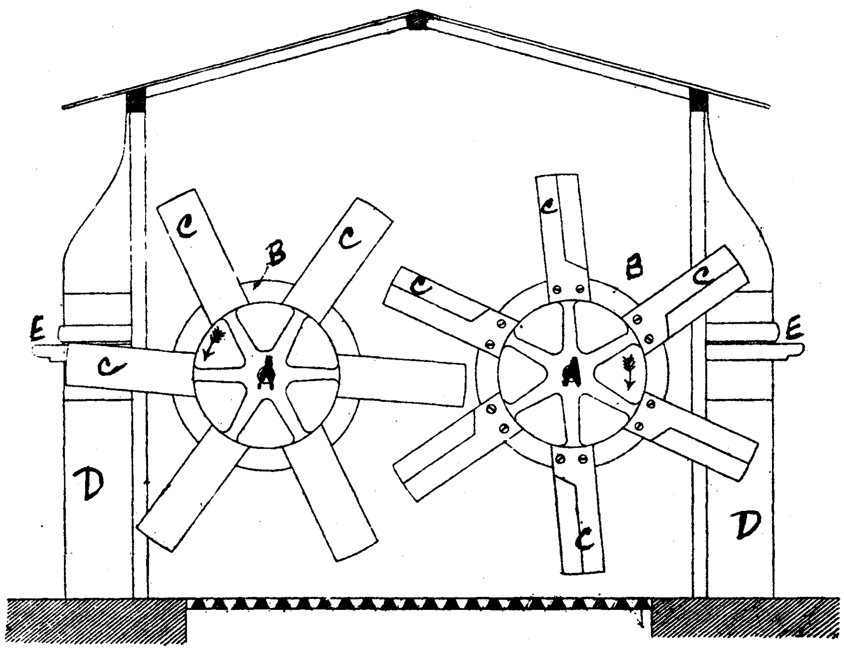


FIG. 20.

the farmers and peasants themselves. The consequence is that through lack of skill, care, and scientfic knowledge, dirty, poor, irregular, over and under retted, water stain and badly handled fibre is produced, which fetches less than one-half the price which the same flax would if otherwise treated. The establishment of retteries such as we have described would, I believe, make a great change both in the quantity and quality of the supply of raw flax and make us more independent of Russia. The cotton famine should teach us what would happen should supplies from that country be cut off by war, famine, or pestilence.

In Ireland and elsewhere flax straw is retted in dams 9 to 10 ft. wide and 40 to 50 ft. long, and not more than 4 ft. deep. When rain water is available it should be used as being free from mineral impurities. Bog water is liable to cause discolouration and spring water is generally too hard. Water containing lime is unfit for flax steeping and should on no account be used.

Dew-retting of flax and hemp is practised to a large extent in Russia and combined with water retting in the Walloon district of Belgium and in Brittany. It consists in spreading the freshly-pulled flax or hemp straw lightly over the field and allowing it to remain there until the combined action of the sun, rain, and dew has accomplished the partial dissolution of the gummy matter which binds the fibre to the wood.

Even when the straw is water retted, it is in Ireland spread upon a meadow, in a similar manner, after it has been removed from the water. Grassing causes the fibre to contract and leave the boon and renders the succeeding mechanical operation of scutching much more easily accomplished.

Fig. 20 gives an end section of the central part of an Irish scutch mill, and shows the horizontal shafts A, upon which the armed rims B are keyed. CC are the scutching blades or wypers of wood, screwed or bolted to the rims. The stocks D, consist of an upright board or iron plate, in a slot E in the side of which the flax is held by the scutcher, who stands on one side while the revolving blades C strike the flax in rapid succession on the other. You will see that the Irish scutch mill handles are fewer in number and much heavier than those used in Belgium. They are more severe on the flax and make more tow, but until retting becomes a science, as it is in Courtrai, they must be preserved. There are two sets of handles—one for doing the rough work or cleaning, and the other for finishing or buffing. The buffing handles are bevelled on both sides of their face while the cleaning handles are rounded off on the side away from the scutcher only.

In order that the maximum yield may be obtained in scutching and hackling flax and hemp it is advisable that in pulling, the long and short stems should be kept separate as much as possible and the root ends even. To ensure the evenness of the root ends of stricks of flax straw, an ingenious machine, shown in section in Fig. 21, has been devised and is being successfully used in several Irish scutch mills. The machine comprises a slightly sloping table *b*, with a back *h*, against which the flax straw is placed root end down on the table and leaning against the back. A vibratory motion is given to the table bv the crank *e*, and connecting-rod *f*, which motion causes the individual stems to settle down by gravity, being prevented from falling sideways by a horizontal bar *i*, fixed to the back and having projecting spikes *l* which enter the bundles of flax straw. The table is mounted on springs and the spiked bar is vibrated by a crank and connecting-rod *k*.

Sunn and Bombay hemps are separated in a very similar manner to jute, the former being combed when dry in order to separate the filaments.

Just as Belgium produces the best flax, Italy produces the best hemp. In Italy the male plants are pulled first, the female plants being left for the seeds to ripen, when they are uprooted in a similar manner. The roots are then cut off and the leaves, seeds, and branches stripped off in the ripple, a sort of very coarse hackle through which the top ends of the stems are drawn in handfuls. The hemp is retted in dams or in substantial stone basins or tanks called *maceratojo*. The fibre is cleaned in the usual way and is then sometimes softened by rolling or beetling, such treatment splitting up the reeds and rendering it finer and

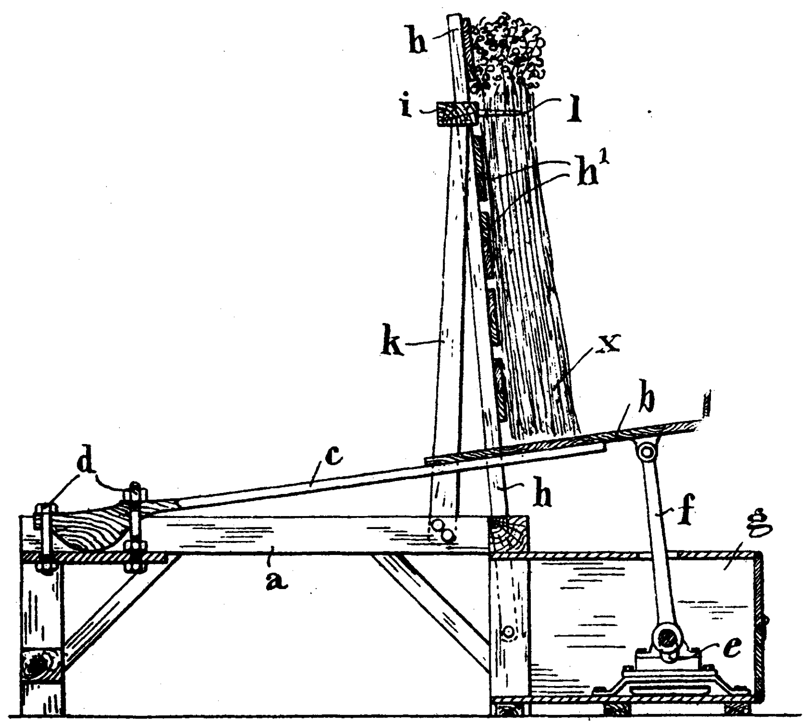


FIG. 21.

of better spinning quality. I might here say that in Ireland flax straw is likewise sometimes beetled by machine, instead of being crushed by rollers, softer and finer fibre being thus obtained.

Decortication should be practised upon the stems of the ramie plant just after they have been cut down and while still in a green state, because when they become dry the outside skin becomes hard and brown and most difficult to remove. It is doubtful if any machine will ever be found to give such good results as regards yield and clean fibre as the manual processes practised by the Chinese women and children who produce, from the ramie or rhea plant, by scraping the stems on a flat board with a piece of wood, a few pounds per day of the fibre known as China grass.

Probably the most successful machine yet introduced to decorticate ramie is that shown in section in Fig. 22. The stems are first crushed flat and the ribbon thus produced then split up

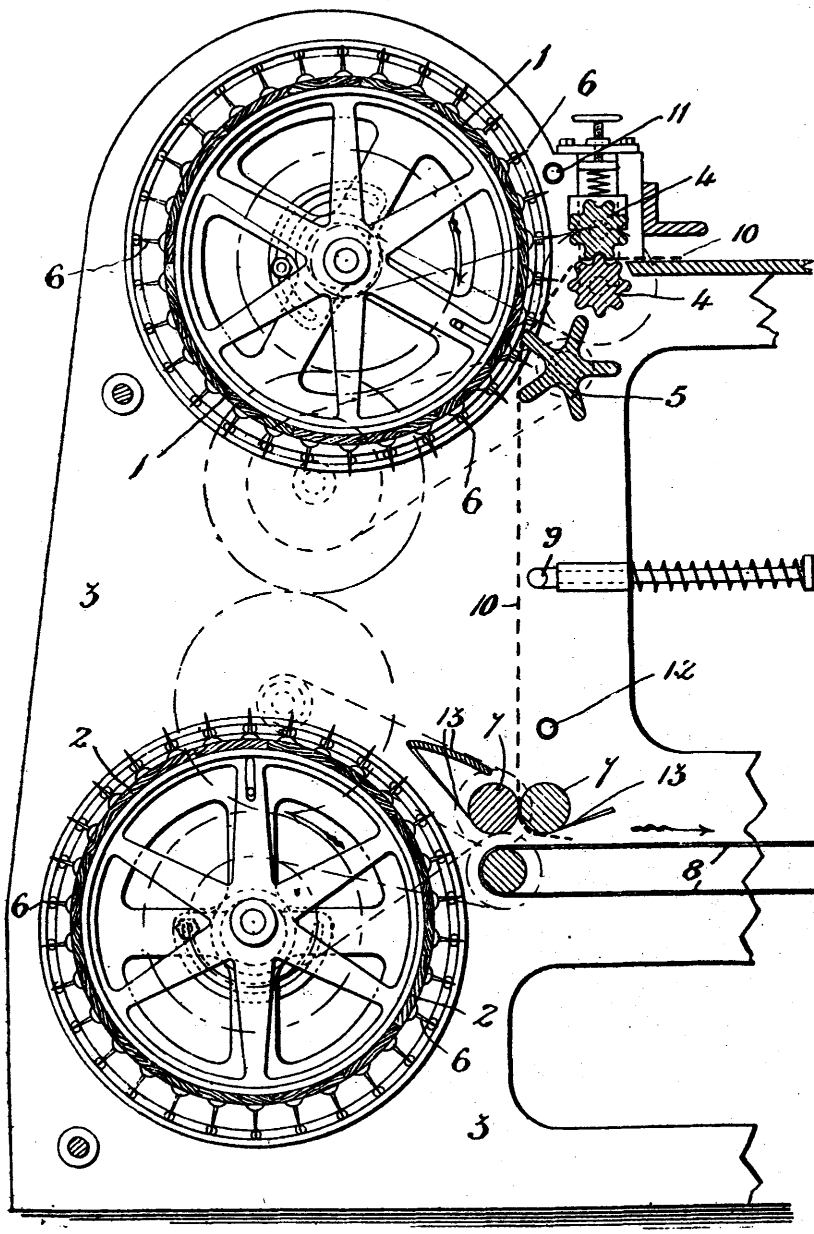


FIG. 22.

by the teeth of the spiked cylinder which at the same time combs away a considerable amount of woody matter.

Time will not permit me to go into such questions as how rhea fibre may be separated by chemical treatment, the artificial production of the retting ferment, bacilli or microbes, nor to describe the degumming of ramie. I will be glad to answer, if I can, any questions which may be asked and to show you some samples and curiosities connected with my subject which you may find of interest.

I have to thank Messrs. John Downham and Co., Messrs. David Bridge and Co., Messrs. The Prieto Machine Co., Messrs. Krupp, Messrs. Wigglesworth and Co., and the authorities of the Technical Institute, Belfast, for the loan of electros, slides, and photos, etc.

## SAMPLES EXHIBITED.

(1). Unretted flax straw.
(2). Retted flax straw.
(3). New Zealand hemp.
(4). New Zealand tow.
(5). American flax.
(6). Dutch flax.
(7). Courtrai flax.
(8). Yarn from unretted Canadian flax.
(9). Rafia.
(10). Manila trawl twine.
(11). Manila binder twine.
(12). Superior white jute.
(13). Bombay hemp.
(14). Bernares hemp.
(15). Manila fibre.
(16). Aloe fibre.
(17). Sisal hemp.
(18). China grass.
(19). Sanseveria.

## DISCUSSION.

Mr. McCONNEL said that Mr. Carter's paper had been most interesting, and it gave evidence of very careful preparation. He thought they would all agree with him that the object of the Textile Institute was to raise their thoughts away from mere detail and away from the mere routine of their own productions, and to try and encourage a wider view and a more statesmanlike view amongst those engaged in the textile industries. A great many subjects for thought were contained in the paper which had been submitted by Mr. Carter. Take, for instance, the growing of the various plants and fibres which had been described. Was it not a matter of the utmost importance not only for the agriculturist, but for the statesman, to see that the fibre which was most suitable for a district should be grown, and, if it was grown, that the best care should be taken to make it as good as possible? Why should not Irish flax approximate to some of the most beautiful specimens of flax obtained elsewhere if the same care was taken in the cultivation of the seed, the retting, and other details? And there were side products, such as linseed, to be considered also; and when they came to manufacturing a totally different set of considerations had to be brought in. Manufacturers had to deal with fibres with a view to their effect and their capability of working together. They had heard a good deal about wonderful fibres and how they were obtained, but in practice, if they wished to work them together, they had to find out their characteristics. Take, for example, the characteristics of cotton, with its elasticity, and the characteristics of flax, with its want of elasticity; they might be able to work them together satisfactorily as warp and weft, but if they tried to twist them into the same thread they arrived at troubles which they might not have contemplated. The Textile Institute numbered amongst its members gentlemen who were interested in the making of textile machinery. Surely there was enormous scope for working out better and more scientific machinery for carrying out the different processes in dealing with flax than the machinery they had seen illustrated by the lantern slides that afternoon. The modern machine maker spent enormous trouble and care in perfecting machinery for things that were well known, whereas there were many little "side" machines which exercised perhaps a far greater effect upon the percentage of waste or upon the quality of the production that were too often left unattended to. Then amongst their textile experts they had the chemist. Was there not room for the bacteriologist and the chemist to apply their skill to a greater extent than they had done in the direction of searching out the secrets as to why the retting at Courtrai had produced such striking results? These were some of the points that the Textile Institute had to try to impress upon the members. There was one point upon which he would like Mr. Carter's opinion. He knew from his own experience in days gone by how important it was for certain classes of linen manufacturers, especially to those dealing with thread, to get the perfect levelness or uniformity of strength as well as the wonderful splitting power of the fibre, if he might call it such. In the flax fibre, a great deal was used by first splitting it up to get the fibre as fine as possible, in order to be able to spin it as regularly as possible. A far greater success was attained at Courtrai than elsewhere in splitting it up finer and in keeping the levelness of strength. He would like to know whether, if the scientific mechanical method of retting were applied in Ireland, they could attain to anything like the same success as that attained by the natural process adopted at Courtrai.

Mr. CARTER said it was necessary that the flax should be uniform from the very start. The maximum of care had to be taken in every department. There had to be careful choice and preparation of the soil. A level seed bed must be prepared in order to get uniform stems and fibre. Unless that were done the seeds, even if they were all the same, would not be able to spring up together, and the result would be stems that were coarse and fine, and long and short. The seed which had more room would produce a coarser stem, and the finest stems were obtained by sowing the seed thick. If all the points he had mentioned were carefully looked after, a uniform straw would be produced which gave the retter a chance of producing a uniformly retted fibre. If the retter got thick and thin stems he had to take out the straw and strike an average. The thick stems were more quickly retted than the thin stems, but if he retted the thin stems properly the thick stems would be unequally retted and there would not be uniformity. The whole thing rested in getting uniform straw and taking it out with care so that it would have the maximum strength. Flax grown thick came up straight; it was the side branches which caused breakage of the fibre in hackling, and short and weak fibre also. The maximum quality of fibre was produced by attention to all these details by the farmer, the retter, and the scutcher.

Mr. BLEAKLEY asked whether it was possible to gain anything by bleaching raw flax to get rid of the pectic gums, and whether that would improve the fibre.

Mr. CARTER said that if they bleached raw flax they removed the effective matter—the gums which united the fibre together. They must preserve a certain amount of that effective matter. If they took all the gum away the fibres opened, they came apart, and became like cotton. Cotton fibres had a curl in them, and had more elasticity and could be spun into a strong thread, whereas flax fibre could not. The bleaching of raw fibre was a mistake, and all people who talked about cottonising flax were, in his opinion, going on the wrong track.