Nov. 1, 1955 J. McCRAE 2,722,039

APPARATUS FOR OBTAINING FIBERS FROM PLANT LEAVES

Filed Dec. 14, 1951 4 Sheets-Sheet 1

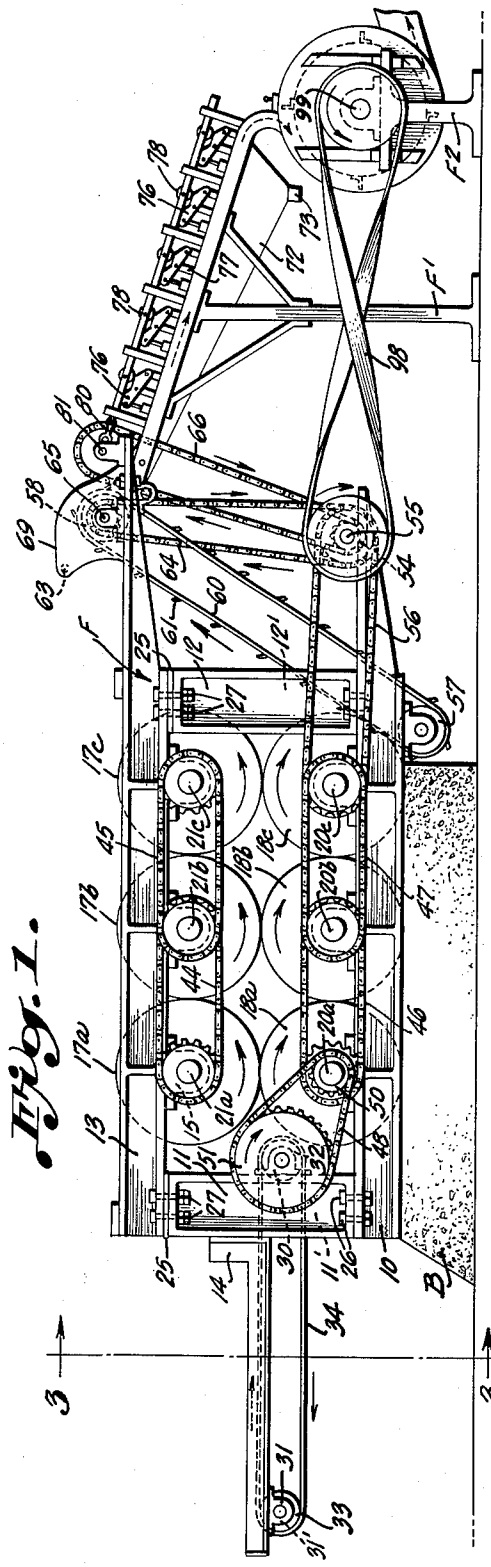


Fig. 1.

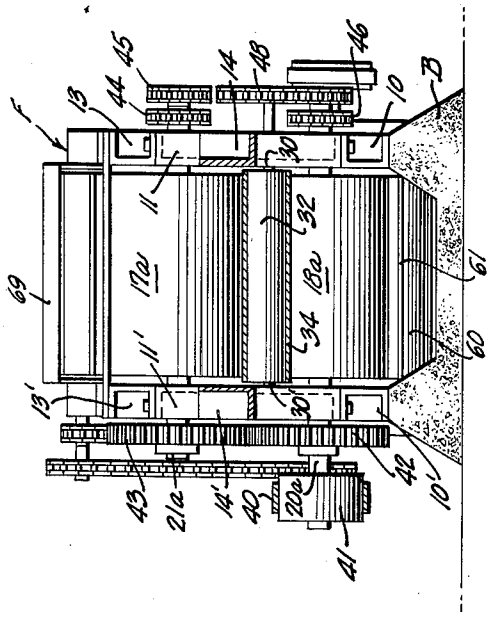


Fig. 3.

INVENTOR

J. McCRAE

BY Samuel Solomon

ATTORNEY

Nov. 1, 1955 J. McCRAE 2,722,039

APPARATUS FOR OBTAINING FIBERS FROM PLANT LEAVES

Filed Dec. 14, 1951 4 Sheets-Sheet 2

Fig. 2.

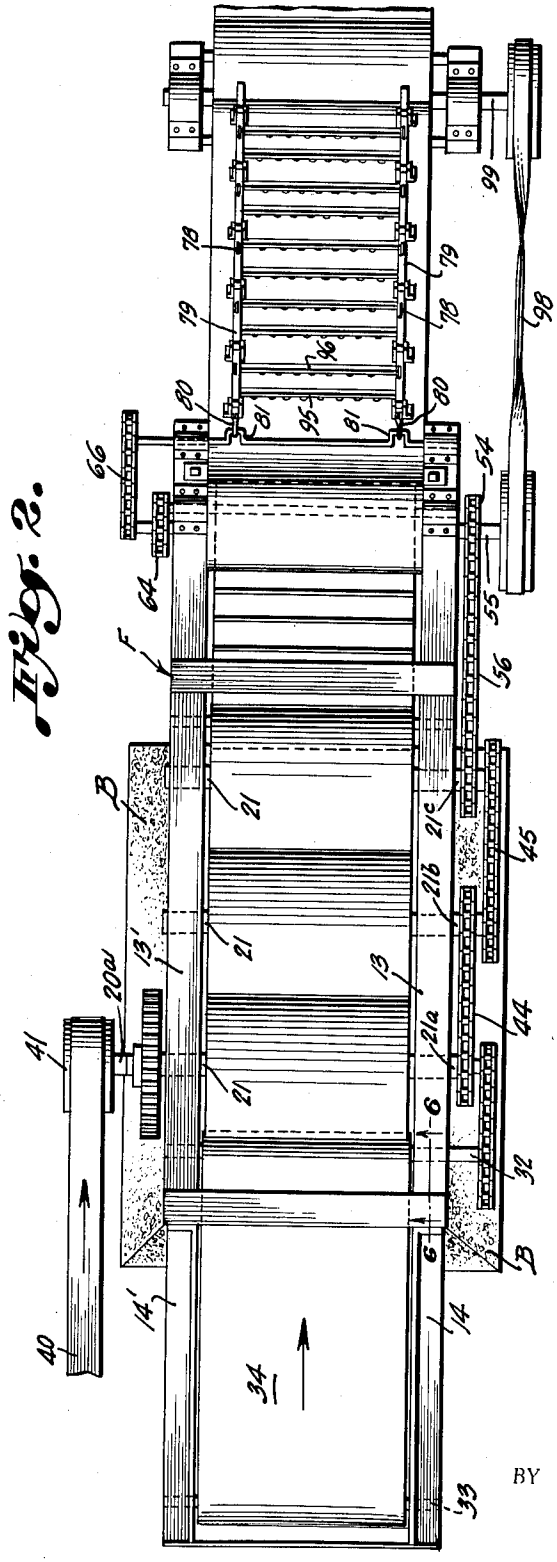
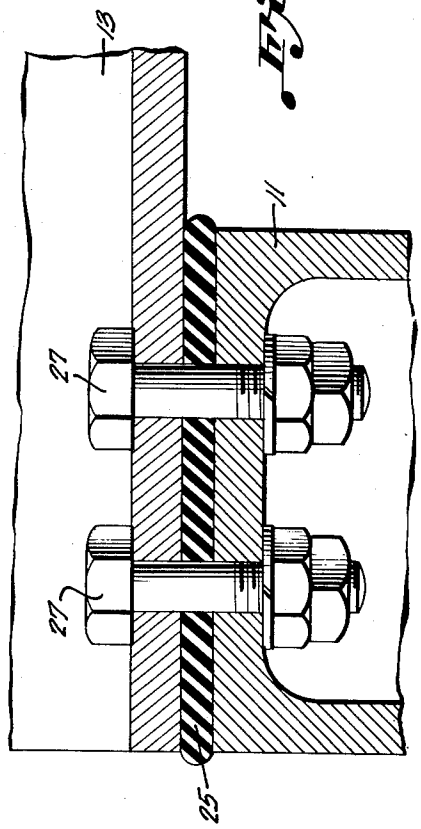


Fig. 6.



INVENTOR

J. McCRAE

BY

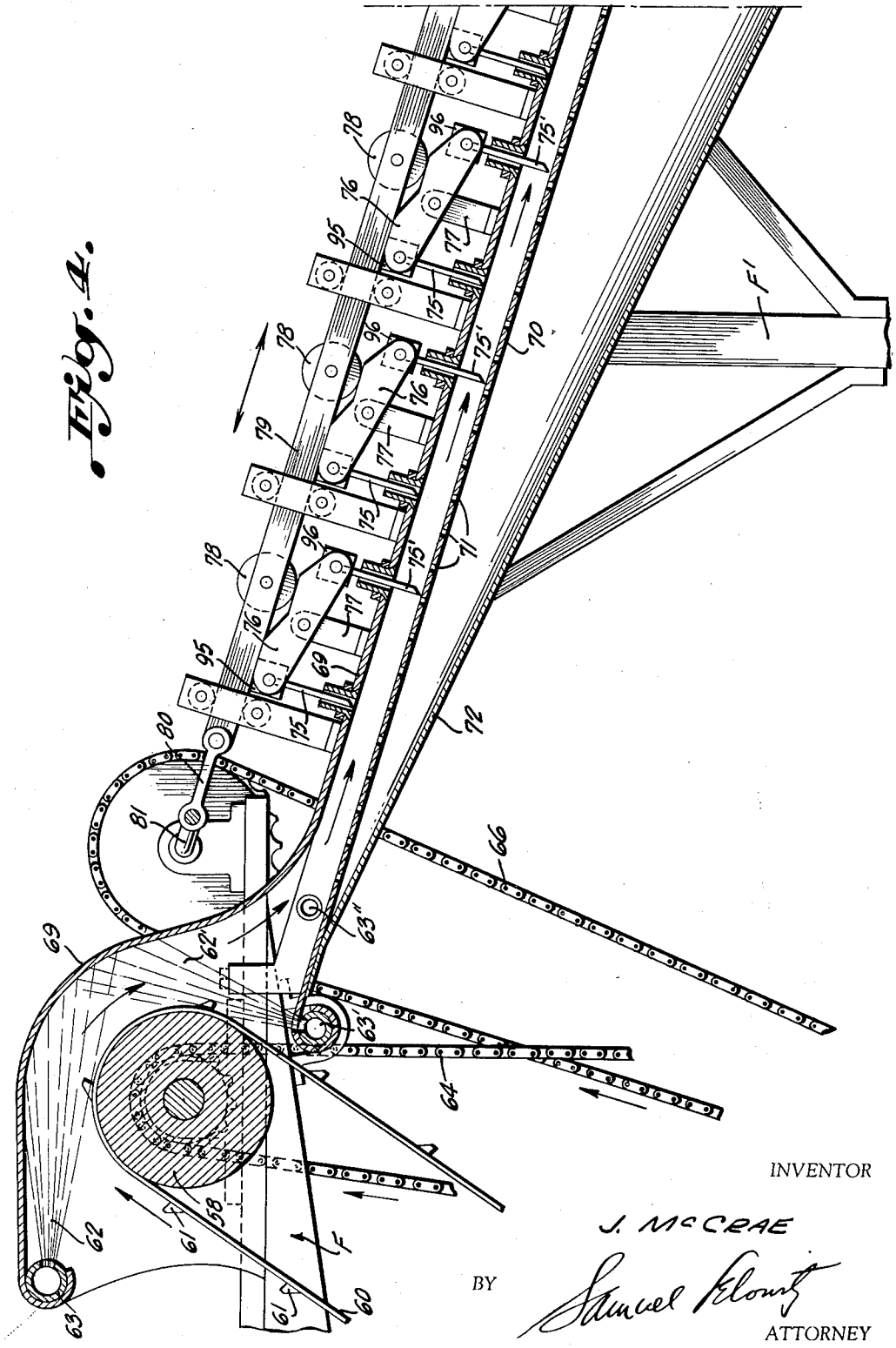
ATTORNEY

Nov. 1, 1955 J. McCRAE 2,722,039

APPARATUS FOR OBTAINING FIBERS FROM PLANT LEAVES

Filed Dec. 14, 1951 4 Sheets-Sheet 3

Fig. 4.



INVENTOR

J. McCRAE

BY

ATTORNEY

Nov. 1, 1955 J. McCRAE 2,722,039

APPARATUS FOR OBTAINING FIBERS FROM PLANT LEAVES

Filed Dec. 14, 1951 4 Sheets-Sheet 4

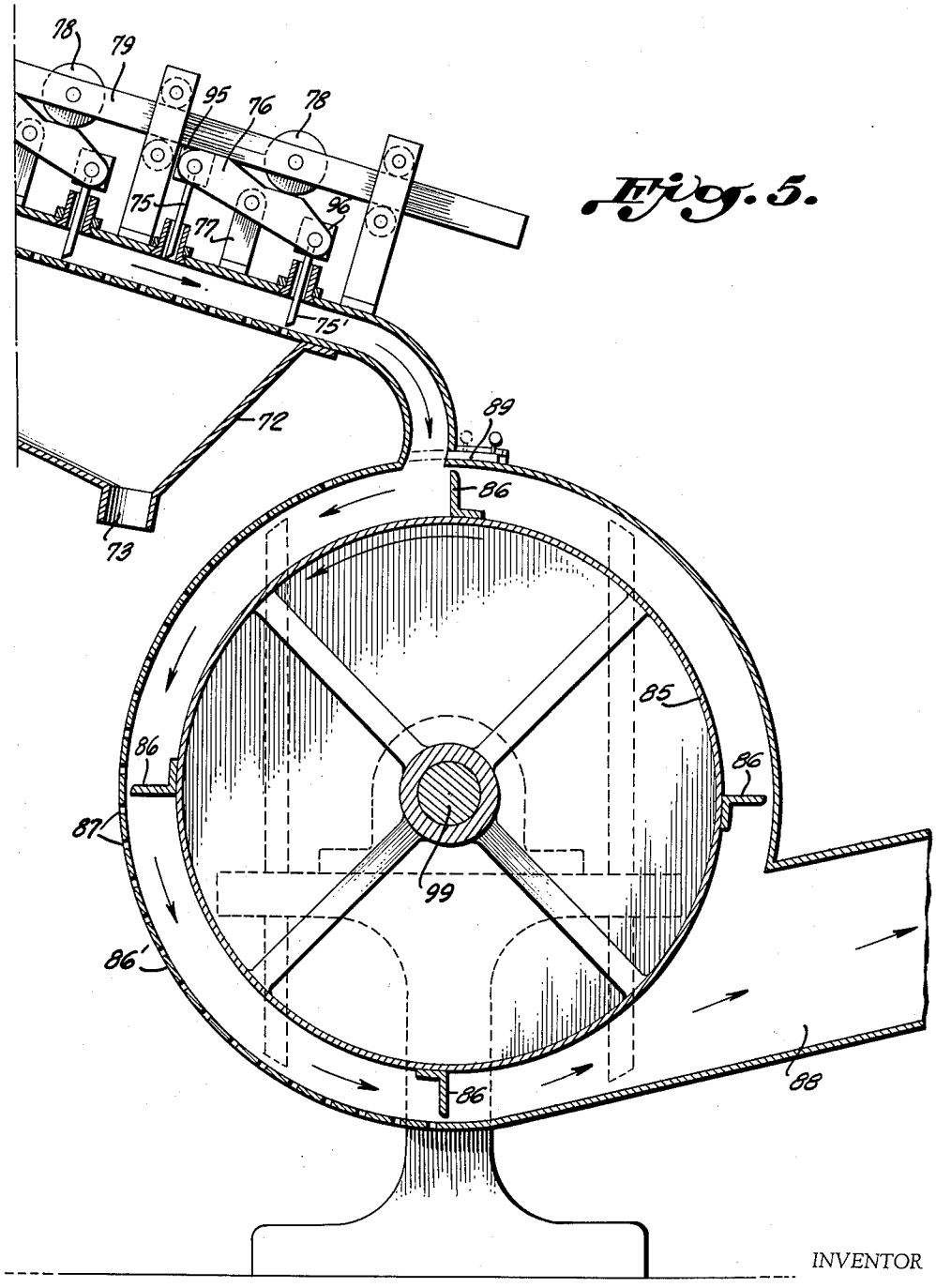


Fig. 5.

INVENTOR

J. McCRAE

BY

ATTORNEY

United States Patent Office 2,722,039
Patented Nov. 1, 1955

2,722,039

APPARATUS FOR OBTAINING FIBERS FROM PLANT LEAVES

James McCrae, Anzures, Mexico

Application December 14, 1951, Serial No. 261,647

4 Claims. (Cl. 19—28)

This invention relates to a method of and apparatus for deriving fibers from plant leaves.

It is the object of the present invention to provide a process for decorticating the leaves of fiber-bearing plants and directly obtaining the fibers entirely and exclusively in the form of tow, without intermediate manufacturing steps.

The invention is applied particularly to the decortication of the leaves of plants to derive the leaf fibers entirely in the form of tow, in contradistinction to the decortication of the stems or stalks of plants which results in the obtention of bast fibers.

It is another object of the present invention to decorticate vegetable leaves to effect a separation between the fibrous content and the pulpy portions thereof with maximum yield of fibers and with minimum damage thereto as a result of the decorticating and separating operations.

The invention is particularly applicable to effect such separation of fibers from fiber-bearing plant leaves which heretofore has presented many difficulties, the invention being applicable particularly to members of the Liliacae family such as various varieties of Sansevieria; members of the Bromeliacae family such as Annas Sativa, commonly known as pineapple; Aechmea Magdalenae, commonly known as silk grass or Columbian pita; members of the Agave family such as Sisalana, Fourcroya, Gigantea, and others; members of the palm family such as Izote; and members of the banana family such as Musa textilis.

This invention is designed to decorticate plant leaves and to produce the contained fibers directly and in their entirety in the form of tow. This fibrous form is in contradistinction to line fibers in which the fibers are of substantially the same length as the vegetable leaf from which the same is derived and in which the fibers are in substantial parallelism. Different textile manufacturing operations require the fibers employed therein to be in these two different forms, namely, in the tow or line form. For example, in the field of textile technology involving the manufacture of burlap or hessian, the fabric used for bagging and commonly made from jute fibers, it is necessary that the fiber be in the form of tow. Therefore, one of the first steps in jute manufacture is to convert the fiber into a form of tow. In accordance with the present invention the fiber from the plant leaves is produced in the form of tow directly, without the necessity of any converting or additional manufacturing steps.

The method of decortication as commonly practiced with plant leaves involves a scraping and beating action to remove matter extraneous to the contained fibers. This action generally is applied in a direction extending longitudinally to the axis of the leaves and transmits stresses in the same direction to the contained fibers. A well known result of stressing fibers longitudinally by this form of decortication is to break, tear, and otherwise damage a substantial proportion of them. It is also well known that leaves of certain plants which contain fibers

of commercial usefulness remain largely unused on account of these longitudinal stresses causing breakage and loss of fibers beyond economical limits.

It is therefore the object of the instant invention to avoid stressing of the fibers longitudinally so that the fibers which are obtained are not broken, torn or otherwise damaged and so that substantially the full and entire fiber content of the plant leaves is recovered without loss or waste or fibers.

The instant invention proceeds upon the principle of exerting a predetermined crushing action on the plant leaves by means of a series of smooth rolls, coupled with a preliminary separation of the fibrous and extraneous components of the plant leaves, which separation is subsequently completed by suitable washing and agitating operations. In order to aprpeciate more fully the functions performed by the crushing rolls and the peripheral movements executed thereby in contact with the plant leaves, it may be helpful to review the physical characteristics of the plant leaves or vegetable units which are processed in accordance with the present invention.

The plant leaves which are designed to be processed in accord with the invention, and particularly those of the classes mentioned above, consist mainly of fibers and substances extraneous to such fibers, both of which components possess widely differing physical characteristics. Extraneous substances consist mainly of a mass of sacks or cells containing plant elements in a more or less liquid state. The containing sacks are of a delicate membranous-like nature, rupturable by relatively slight pressure. It has been determined that by rupturing all the sacks of extraneous substances, the contained elements may be liberated, and also that those substances adhering to the fibers may be completely detached therefrom in such manner that the fibers are separated in a more or less complete state from all extraneous substances by washing in water.

Fibers contained in the plant leaves are of relatively denser structure than the extraneous substances. A physical characteristic of those fibers is one of relative elasticity. This property may be understood from an examination of the structure of a fiber strand. A strand is a built up structure composed of ultimates or fibrils, held together by the binding or gummy property of ligneous substances. Those ultimates are cotton-like in appearance, are long in relation to their thickness, pointed at both ends, and enclose a cavity, presenting a cellular structure, thick-walled in relation to the enclosed cavity. The cushioning effect thus presented permits pressure to be applied to them of a degree greater than that required to rupture the aforesaid sacks, and upon release of pressure, the cellular ultimates recover their original dimensions. Ligneous substances binding the ultimates together are of a more or less viscid nature, and an appreciable time elapses before pressure causes them to flow.

The combination of elasticity and cumulative cushioning property derived from the many ultimates forming a strand of fiber, and the appreciable time taken for viscous ligneous substances to begin to flow, permits pressure of a momentary nature to temporarily depress or flatten the fiber strands from which they recover their original dimensions upon release of said pressure, at the same time preserving the original tensile strength of the fiber strands by avoiding flow or displacement of the binding ligneous substances.

The sacks of extraneous substances are generally smaller than the thicker and denser fiber strands, therefore those occupying positions between the strands are protected from the pressure required to rupture them. The object of depressing or flattening the strands is to expose those sacks to pressure, thereby causing them to be ruptured

and to be detached from adhering to the fibers in so complete a manner that the fibers are separable from the extraneous substances by washing in water.

In order that no longitudinal stresses be imposed upon the fibers of the leaves in order to obtain such fibers in unbroken and undamaged form, specific apparatus is necessary, operating in a critical manner in order to attain these results. Therefore, the invention contemplates the application of pressure to the plant leaves of such a nature as to cause a temporary flattening of the fibers as well as the exposing of the sacks of extraneous substances to the rupturing and detaching action of such pressure, these two results being executed simultaneously. This simultaneous differential action upon the fibers of the plant leaves and upon the extraneous plant matter surrounding them is preferably exercised by means of a series of rotary cylindrical rollers, preferably of metal or other rigid surface, presenting a plurality of successive gaps between sets of superposed rollers, which gaps are constant irrespective of the thinness of the material passing between the rollers. The gaps between these rollers are adjusted for the particular material being handled and generally corresponds to a space which is less than the thickness of the sacks of the extraneous substances of the plant leaves being processed and approximately equal to the thinnest part of the thinnest fibers contained in the vegetable leaves. This arrangement permits the flattening of the fibers for the purpose of presenting the sacks of extraneous substances to the rupturing and detaching effects of the pressures exerted by the rolls.

It has been determined that a cooperative relationship exists between the peripheral speed of the hard-surfaced rollers and the material passing through the gaps formed by the successive pairs of rollers. While such speeds may vary from 1,000 to 3,000 feet per minute, the optimum speed in the handling of the leaves of the Sansevieria plant is approximately 2,000 feet per minute. At such speeds the fibers which are depressed or flattened temporarily regain their original dimensions upon the release of pressure and the ligneous elements contained within the fibrous strands remain undisturbed in view of the insufficient time for such elements to begin to flow, whereupon the fiber strands retain their original tensile strength unimpaired. Speeds in excess of the optimum speeds are desirable in order to increase the capacity of the apparatus. However, these speeds are limited by the capability of the operators to feed the successive leaves into the first set of rollers for the pressing operation. Speeds materially lower than the optimum speed have the disadvantage of prolonging the duration of the pressure between the rollers which results in the displacement of the ligneous elements and their consequent flow, which is responsible for a reduction in the tensile strength of the fiber strands. Another disadvantage of slower speeds is the creation of stresses of a longitudinal nature in the fibers which produce a weakening and possible tearing thereof. This action results from the tendency of the extraneous substances to flow backwards as the vegetable leaves pass between the rollers. These substances, as they accumulate at the entry of the rollers, present a resistance against forward pull of the fibers which have already been grasped between the rollers which gives rise to the undesired stressing of the fibers in a longitudinal direction.

The lowest permissible peripheral speed of 1,000 feet per minute may be employed in the processing of plant leaves of greater succulence than Sansevieria, for example, some of the Agaves.

At the critical optimum speeds, the unpressed part of the vegetable leaves, as they begin to enter between the rollers, present an obstacle to the slower backward flow of the extraneous substances and by arresting this backward flow these extraneous substances are deflected and caused to flow in lateral directions relative to the forward passage of the vegetable leaves. The lateral movement of the extraneous matter prevents a build-up of this matter at the rolls to preclude the possibility of undesirable longitudinal stresses being imposed upon the fibers.

The material discharged from the roller crushing apparatus consists of a mixture of fibers together with extraneous substances which have been more or less completely detached from the fibers, and are in a more or less fragmented condition. Separation of the fibers from those extraneous substances can be effectively carried out by a simple operation of washing in water, and may be carried out as a separate operation.

The final separation of extraneous matter from the fibrous matter is effected by washing the fibers with water and repeatedly entraining the fibers while permitting the extraneous matter to be washed therefrom. In addition to the washing effects by the current of water, the separation between the two components of the plant leaves is aided by the difference in density between the fibers and extraneous matter, and the separation is ultimately effected by a centrifuging operation which accelerates the separating effects.

Other objects and purposes will appear from the detailed description of the invention following hereinafter, taken in conjunction with the accompanying drawings, wherein

Fig. 1 is a front elevation of a preferred embodiment of our invention;

Fig. 2 is a plan view thereof;

Fig. 3 is a vertical sectional view along line **3—3** of Fig. 1;

Fig. 4 is an enlarged longitudinal section of the initial part of the washing and separating apparatus;

Fig. 5 is a longitudinal sectional view of the final part of the washing and separating apparatus; and

Fig. 6 is a sectional view of the frame at the roll spacing adjusting means thereof, taken along line **6—6** of Fig. 2.

In the drawings the main frame of the machine F is shown anchored to a foundation B of any suitable design. A pair of longitudinally extending horizontal frame members **10** and **10'** are laterally displaced on the foundation B. Vertical pillars **11** and **12** are mounted at the forward end and at an intermediate point of frame member **10** and vertical pillars **11'**, **12'** are mounted at corresponding points of frame member **10'**. The vertical pillars **11** and **12** are superposed by a horizontal frame member **13**, and another frame member **13'** of the same length as member **13**, extends between posts **11'**, **12'** and beyond the latter in order to provide mounting space for the driving elements of the washing and cleaning unit of the apparatus. The parts of the frame assembly described above are maintained in integrated relation by means of bolts and nuts. The connections between the lower frame members **10**, **10'** and the vertical posts are designated by numerals **26**, while the connections between the upper frame members **13**, **13'** and the vertical posts are designated by numerals **27**. Spacers **25**, of natural or silicone rubber or of resinous or solid fibrous material, are disposed between the upper frame members **13** and **13'** and the posts **11**, **11'** and **12**, **12'** in order to provide a variable but unyielding displacement between the hard-surfaced cylindrical crushing rolls **17***a*, **17***b* and **17***c* mounted upon and extending between the upper frame members **13**, **13'** and corresponding rolls of the same size, **18***a*, **18***b* and **18***c*, mounted upon and extending between the lower frame members **10**, **10'**. Journal bearings **15** are mounted on the underside of the frame members **13** and **13'** and corresponding journal bearings **16** are mounted upon the upper side of the frame members **10**, **10'**, in order to mount the axles **21** of the upper rolls and the axles **20** of the lower rolls in the respective upper and lower sets of frame members so that the gaps formed between the rolls bear a fixed predetermined relation with respect to the plant leaves adapted to be passed

therebetween. The gap corresponds to the thinnest part of the fibers of the leaves and is smaller than the thickness of the extraneous matter surrounding the fibers, so that as the material is passed between the rollers the thicker parts of the fibers will be compressed temporarily while the extraneous matter will be pressed and broken and flow laterally of the fibers to effect a detachment of the extraneous matter from the fibrous material.

At the front end of the machine a pair of frame members **14**, **14'** are mounted on the front end of the vertical posts **11**, **11'**, respectively. Journal bearings **31** and **31'** are mounted on the front end of the underside of these frame members and are adapted to receive the journals of a roller **33** operating as a companion to roller **32**, which is mounted in journal bearings **30**, **30'**, fixedly attached to the rear edges of the vertical posts **11**, **11'**, respectively.

An endless band **34** is entrained over rollers **33**, **32** so that operators standing on opposite sides of the endless band **34** may present the leaves of the plants to be decorticated to the action of the first set of crushing rolls **17***a* and **18***a* with the points of the plant leaves foremost with the plants in a series of overlapping layers disposed in parallel.

The crushing rolls are driven from any suitable prime mover such as an electric motor, internal combustion engine or the like, by a transmission belt **40** driving a pulley **41** which may be coupled to the drive shaft **20***a* of the first roll **18***a* either directly or through the intermediary of a clutch. The drive to the other rolls, operating at the same speeds, may be transmitted in any suitable way. As shown in Fig. 3, the drive to the superposed upper roll **17***a* is transmitted by the intermeshing gears of the same size **42** and **43** mounted upon the respective roll shafts **20***a* and **21***a*. The drives to the next successive upper rolls **17***b* and **17***c* are transmitted through the intermediary of sprockets mounted on the front end of the shafts **21***a* and **21***b* and sprocket chain **44** extending between the aligned sprockets of the latter, and sprocket chain **45** extending between aligned sprockets on the shafts **21***b* and **21***c*. Likewise the transmission from the first lower roll **18***a* is transmitted to the other rolls by means of sprocket chain **46** extending between aligned sprockets on the forward end of shafts **20***a* and **20***b* and sprocket chain **47** extending between aligned sprockets on the forward end of the shafts **20***b* and **20***c*. A second sprocket **50** is mounted on the extreme end of shaft **20***a*, in alignment with a sprocket **51** mounted on the shaft of roller **32** in order to transmit the drive to roller **32** and the conveyor belt **34** entrained thereby by means of chain **48**.

A second sprocket is also mounted near the right end of shaft **20***c* in alignment with a sprocket **54** on a shaft **55** mounted on the far end of lower frame members **10** and **10'** for the purpose of transmitting the drive through sprocket chain **56** to the movable parts of the washing and final separating units of the installation. This installation consists of a flighted conveyor **60** trained over lower and upper rollers **57**, **58**, and inclined to the vertical. This conveyor operates at the outlet end of the roll crushing apparatus wherefrom emanate the fiber in wisp form together with fragmented tissue or extraneous matter and juices in spray form. The conveyor travels at a higher speed than the peripheral speed of the crushing rolls and serves to carry up on the conveyor flights **61** successive batches of the components of the leaves in a separated condition for introduction into the washing and cleaning units of the installation, as shown in Figs. 1, 2, 4 and 5, which are mounted on frame supports F' and F''.

The fibers with some of the extraneous matter attached thereto are carried into the field of operation of water sprays **62**, **62'** acting in diverse directions under a spray shield **69** forming part of the washer housing. These sprays are fed by conduits **63**, **63'** at the upper ends of the unit which are responsible for the initial washing away of the extraneous matter from the fibers and the removal thereof from the washer casing.

The washer frame consists essentially of an inclined reticulated sluice **70** provided with openings **71** of sufficient size to carry away the flowing water with the particles of extraneous matter intermixed therewith. The openings **71** are so small that they do not cause any loss of the fibers which are travelling along the sluice. A sump **72** forms the base of the washing unit for carrying off the wash water and particles of extraneous matter to a suitable point of disposition through the outlet **73**, which may be provided with a regulating valve. The effluent not only carries away the plant juices including chlorophyll but also the tissues which are in highly fragmented state and of a much higher density than the fibers. The greater density of the extraneous matter gives rise to a stratification between this matter and the fibers so that the tendency for the removal of the latter is enhanced as the material travels along the washing channel along the openings **71**.

In order to supplement the cleaning action afforded by the water sprays, the fibers are repeatedly arrested in their travel down the sluice by means of sets of pin members **75** and **75'** mounted in cross-bars **95** and **96**, respectively, extending across the width of the machine, along spaced parts therealong. Five sets of cross-bars **95**, **96** are shown, but a greater or lesser number may be used, depending upon the length of the washing channel and the degree of cleaning sought. Each set of cross-bars **95**, **96** is mounted at the opposite ends of rocker arms **76**, which arms are pivotally mounted on posts **77** disposed along opposite sides of the roof of the washing channel. Oscillating movements are imparted to the rocker arms **76** by means of rollers **78** which are mounted on a common bar **79** on each side of the machine, and which execute a limited to-and-fro movement by virtue of a yoke or terminal strap **80** connected thereto and actuated by an eccentric **81** formed adjacent to each end of shaft **81**, mounted on the end of the frame member F. The pins **75**, **75'** operate within openings in the cover **69** of the washing apparatus and are displaced successively along the width of the washing apparatus in the successive rocking unit assemblies.

The rollers **78** alternately act upon the high points of the rocking bars **76** to alternately depress sets of pins **75** and **75'** to give them a rapid up and down movement, separated by a pause in time caused by the dwell in the rocker arms **76**. The pins **75'**, which are shown as extended within the sluice, cause an entrapment of the fibers in their downward travel while the water flow serves to wash away the extraneous particles therefrom. The raising of the pins **75'**, occasioned by a rocking of the bar **76**, results in a release of the fibers for travel down the floor **70** of the sluice until they are again entrapped by a lower row of pins **75** which are now rapidly lowered into the field of flow of the water with the fibers suspended therein. This intermittent entrapment and release of the fibers results in their effective entanglement in tow form while releasing most of the extraneous matter therefrom. The rapidity of the movement of the pins **75**, **75'** causes them to come into position in the channel before the fibers which have been released from a higher group of pins pass the points where they may be engaged by the succeeding set of pins. The pause in the movement of the pins provides for the retention of the fibers while they are subjected to the washing action of the water current in the channel.

The separating action is carried out in its final stages by the presentation of the fibers and water with whatever portion of the extraneous matter is retained thereby to the field of operation of a rotary drum **85** provided with vanes **86** projecting from the periphery thereof, which drum rotates in a counterclockwise direction within a shell **86'** which is perforated at the left side thereof with openings **87**. These openings may be ⅛" in diameter

with a scattered pitch of about ¾". The water and extraneous particles are thrown out centrifugally through the openings **87** for reception by a suitable sump while the fibers are entrained by means of the vanes **86** and are delivered to the channel **88** in wisp form for delivery to a suitable conveyor or repository for final drying. The resultant product is the fibrous content of the plant leaves in tow form and having but insignificant amounts of extraneous matter adhering thereto which fly or break away from the fibers in the course of the subsequent spinning and yarn manipulating operations.

A regulating valve **89** may be provided at the outlet end of the washing channel to regulate the flow of the water therethrough. This baffle element may be used to control the degree of flotation of the fibrous material above the layer of the particles of extraneous matter as the same flow down the channel while being subjected to the arresting movements of the pins **75**, **75'**.

The drive for the movable units of the cleaning apparatus may be taken from the drive of the roll crushing unit. Thus the conveyor **60** may be driven from transmission shaft **55** at the rear lower end of the frame by means of sprocket chain **64** extending between a sprocket on this shaft and another smaller sprocket mounted on shaft **65**. A second sprocket is mounted on shaft **55** for transmitting rotary movement to shaft **81** by means of sprocket chain **66**. Shaft **81** carries the eccentrics **81** for imparting reciprocating movements to the rocking rollers **78** for actuating the fiber entraining pins **75**, **75'**.

The rotary drum **85** is driven by means of a reverse belt **98** trained over a pair of pulleys mounted on the ends of shaft **55** and the rotary shaft **99** supporting the rotary drum **85**.

Variations in the drive for the several moving elements of the apparatus may be made in dependence upon the needs of individual installations.

It is contemplated that guard housings be used wherever such may be necessary, as well as additional sumps for conducting away the liquid components of the material operated upon by the machine. For example, a sump may be provided on the outside of reticulated screen **86** which may, if desired, be combined with sump **72**. Likewise a screen or sump may be provided at the bottom of the conveyor **60** for the purpose of carrying away the plant juices which issue from the last of the crushing rollers and which are not entrained by the solid matter carried on the conveyor **60** to the washing unit.

The amount of wash water employed in the washing of the fibers may be controlled by the introduction of water through the water inlet pipes **63"** at each side of the head of the washing channel (Fig. 4) to supplement the quantity of spraying water fed through conduits **63**, **63'**.

The installation as described represents a preferred embodiment of the invention for obtaining the fibers from plant leaves, for example, the leaves of the Sansevieria plant, the processing of which has heretofore proven uneconomical.

While I have described my invention as embodied in a specific form and as operating in a specific manner for purpose of illustration, it should be understood that I do not limit my invention thereto, since various modifications will suggest themselves to those skilled in the art without departing from the spirit of my invention, the scope of which is set forth in the annexed claims.

I claim:

1. An apparatus for decorticating of plants leaves to obtain the fibers therefrom directly and exclusively in a condition of tow, which comprises a machine frame having lower and upper frame parts supporting rotary members for crushing the plant leaves only, said rotary members comprising a plurality of hard-surfaced cylindrical rolls mounted at displaced points along the lower part of said frame, a plurality of companion hard-surfaced rolls identical to said first-mentioned rolls mounted on the upper part of said frame in overlying relation to said last-mentioned rolls, spacers between the upper and the lower parts of said frame to fix the extent of the gap between said rolls to correspond to the thinnest dimension of the fibers in the plant leaves and less than the thickness of the extraneous substances surrounding said fibers, and means for rotating all of said rolls at a substantially uniform peripheral velocity which crushes the plant leaves with no transverse strains or breakages and which induces no harmful obstruction to the travel of the fibers through the gaps of said rolls to cause their tensile stressing with a consequent tearing and damage thereof.

2. An apparatus as set forth in claim 1 wherein said rolls have a diameter of approximately eighteen inches and a peripheral velocity of 1,000 to 3,000 feet per minute.

3. An apparatus as set forth in claim 1 wherein said spacers are formed of thin sheets of rubber to impart a slight degree of springiness to the roll mountings.

4. An apparatus as set forth in claim 1 wherein is provided three sets of heavy rolls to effect a crushing of the plant cells containing the extraneous substances.

References Cited in the file of this patent

UNITED STATES PATENTS

738,668	Ellis	Sept. 3, 1903
1,021,269	Schlichten	Mar. 26, 1912
1,089,261	Pos	Mar. 3, 1914
1,601,977	McHenry	Oct. 5, 1926
1,983,454	Haynes	Dec. 4, 1934
2,238,225	Lang	Apr. 15, 1941
2,355,999	Patterson	Aug. 15, 1944
2,408,749	Berg	Oct. 8, 1946
2,567,938	Hoffman	Sept. 18, 1951
2,571,108	Burkardt	Oct. 16, 1951