

[54] **APPARATUS FOR PROCESSING SUGARCANE**

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Related U.S. Application Data

[60] Division of Ser. No. 714,896, March 21, 1968, Pat. No. 3,567,511, Continuation-in-part of Ser. Nos. 692,185, Dec. 20, 1967, Pat. No. 3,509,293, and Ser. No. 692,237, Dec. 20, 1967, Pat. No. 3,566,944.

[52] U.S. Cl.146/119, 146/116 A

[51] Int. Cl.B02c 18/00, A01d 55/00, B07b 4/08

[58] Field of Search146/117 R, 116 A, 119

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Primary Examiner—Willie G. Abercrombie
Attorney—Burns, Doane, Swecker & Mathis

[57] **ABSTRACT**

A process is provided which transforms randomly oriented sugarcane stalks into their pith, rind and epidermis components which are then treated to obtain sugar juice, pith floc, cane fibers and other sugarcane commodities.

In delivering the sugarcane stalk material to the separating zone, the stalks are aligned longitudinally in their direction of travel and are chopped transversely thereof into shorter lengths. If the cane contains trash such as leaves and rocks, a fluid is directed through it to remove the trash.

At the separating zone the chopped stalks are separated into their pith, rind and epidermis components. This is done by opening up longitudinally each chopped stalk into separate portions which are then flattened. As the flattened stalk material is fed through the zone, pith is milled away from one side and epidermis material is milled away from the opposite side. The components are then recovered and can be further treated.

The treatment of the pith comprises a washing and pressing operation to extract the juice from the pith. The rind is reduced into smaller portions such as chips or shreds which are then contacted with water to extract water solubles from the rind. The epidermis can also be treated to separate wax bearing material from certain other epidermis material.

3 Claims, 24 Drawing Figures

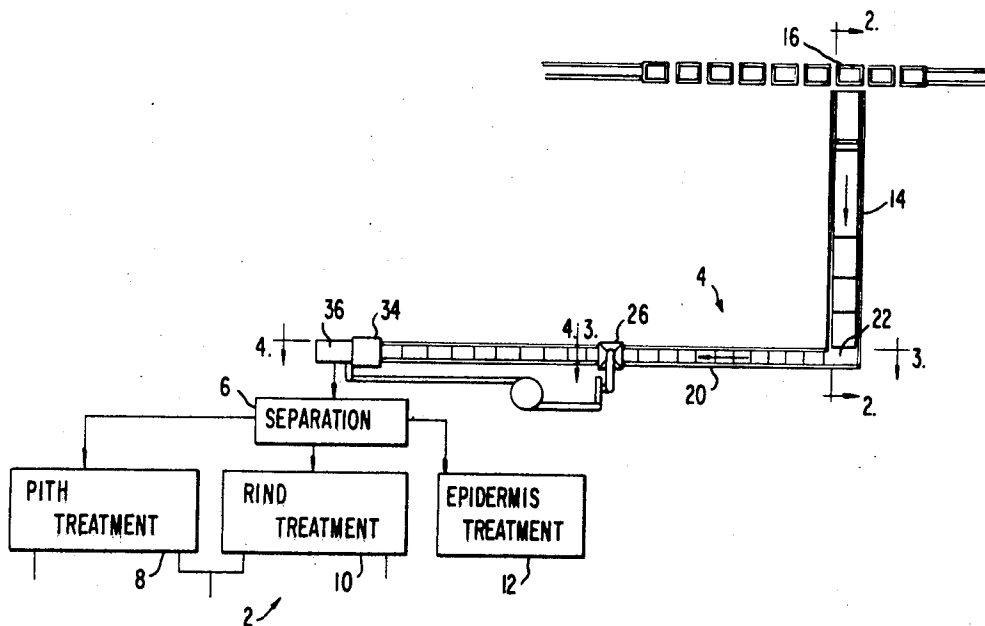


FIG 1

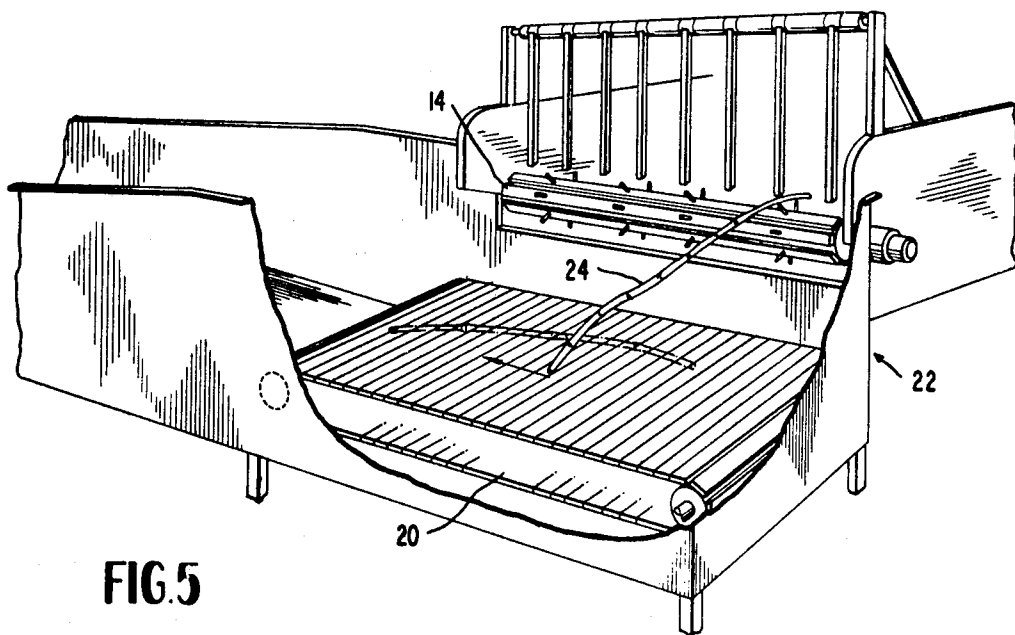
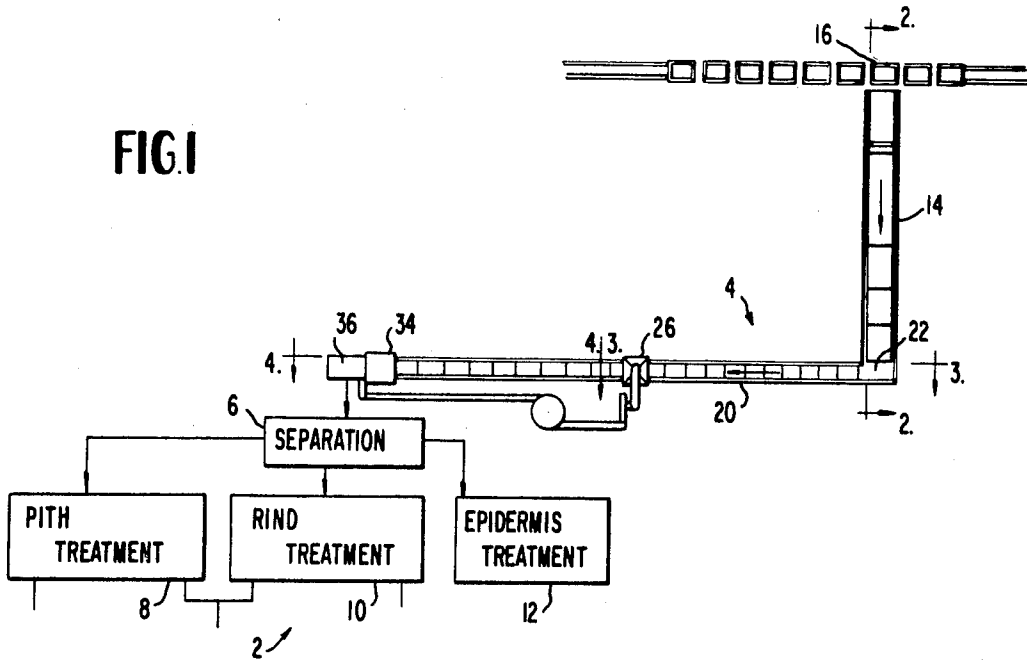


FIG 5

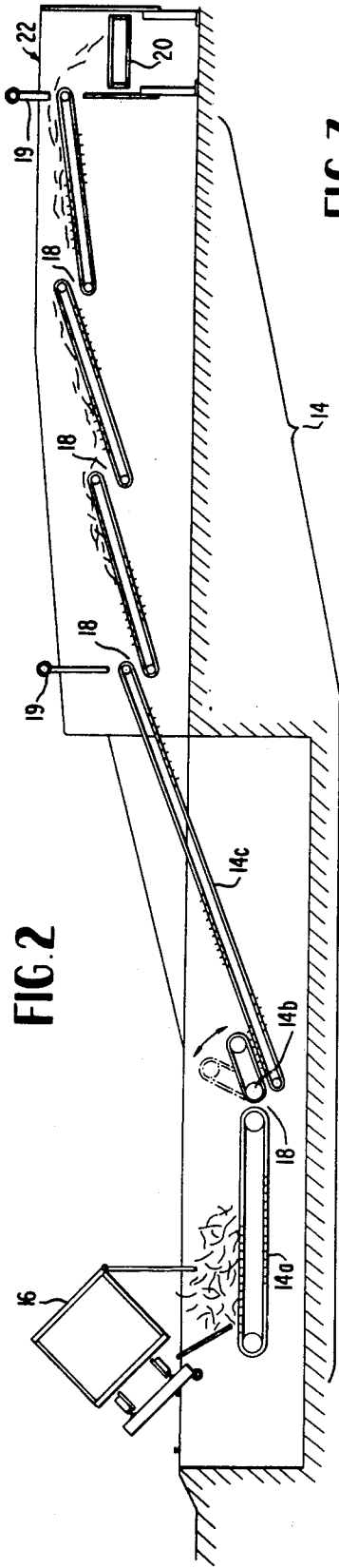


FIG. 2

FIG. 3

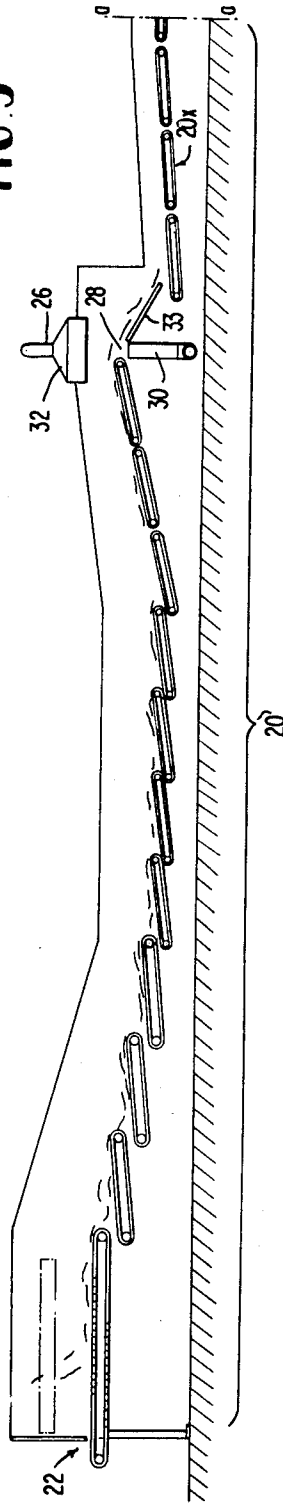
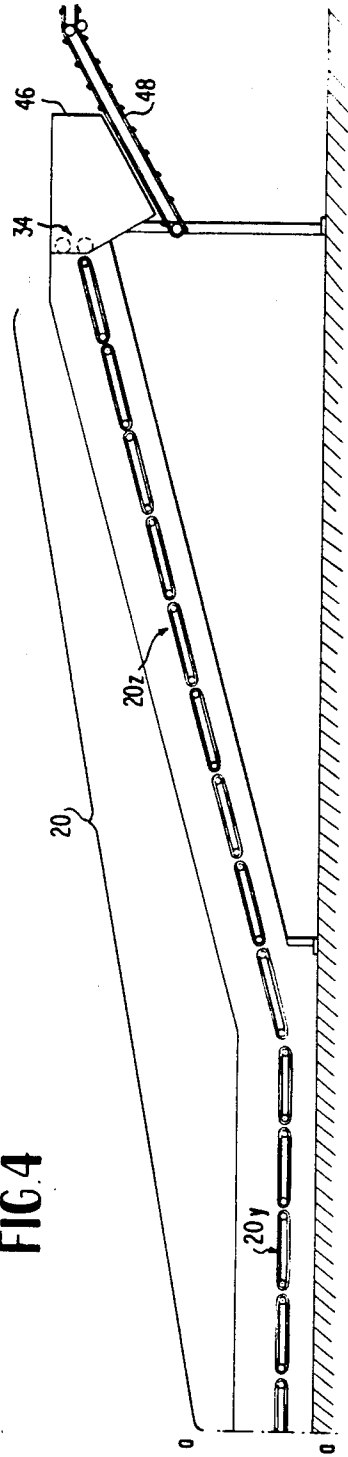


FIG. 4



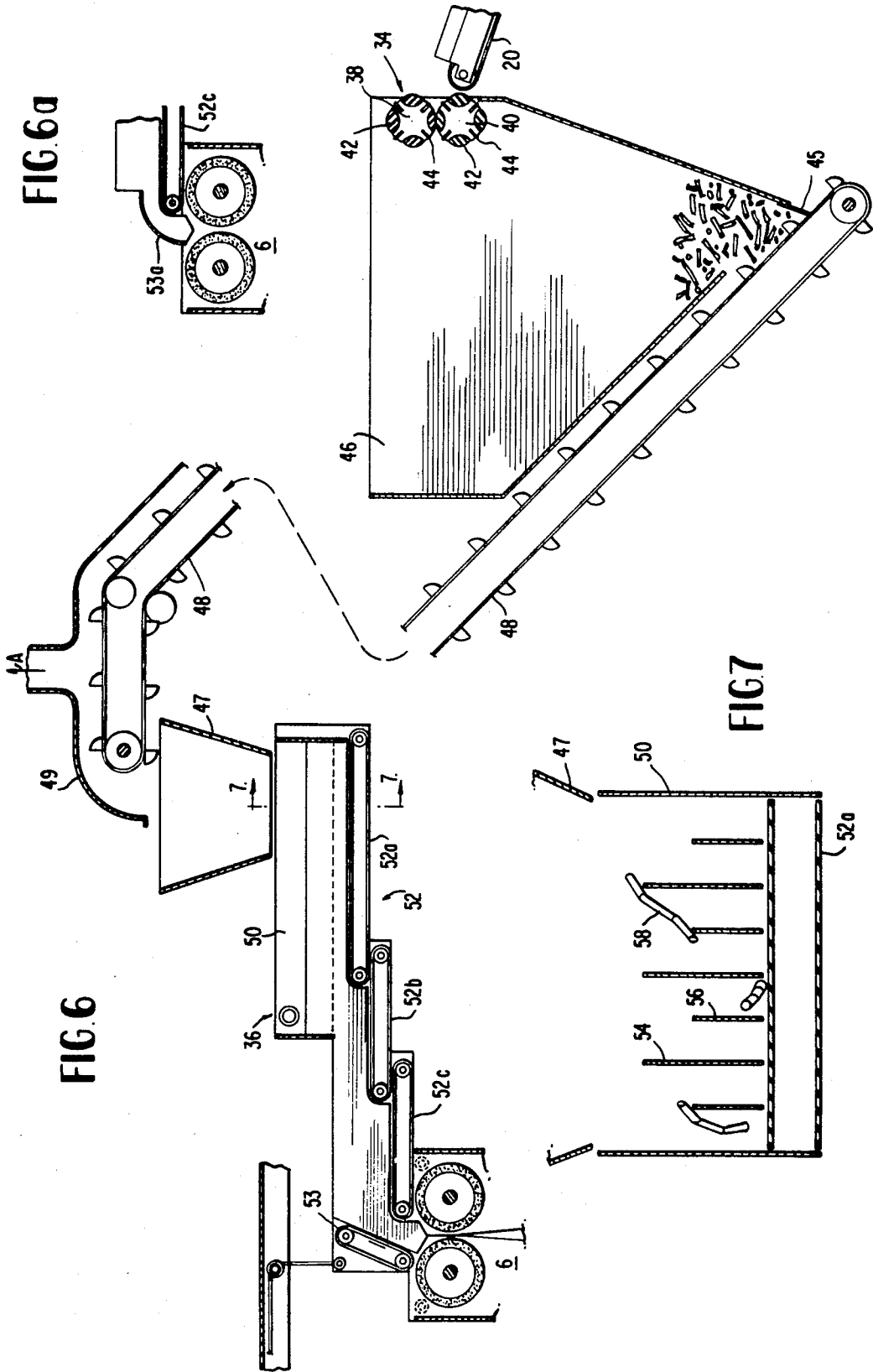


FIG. 8

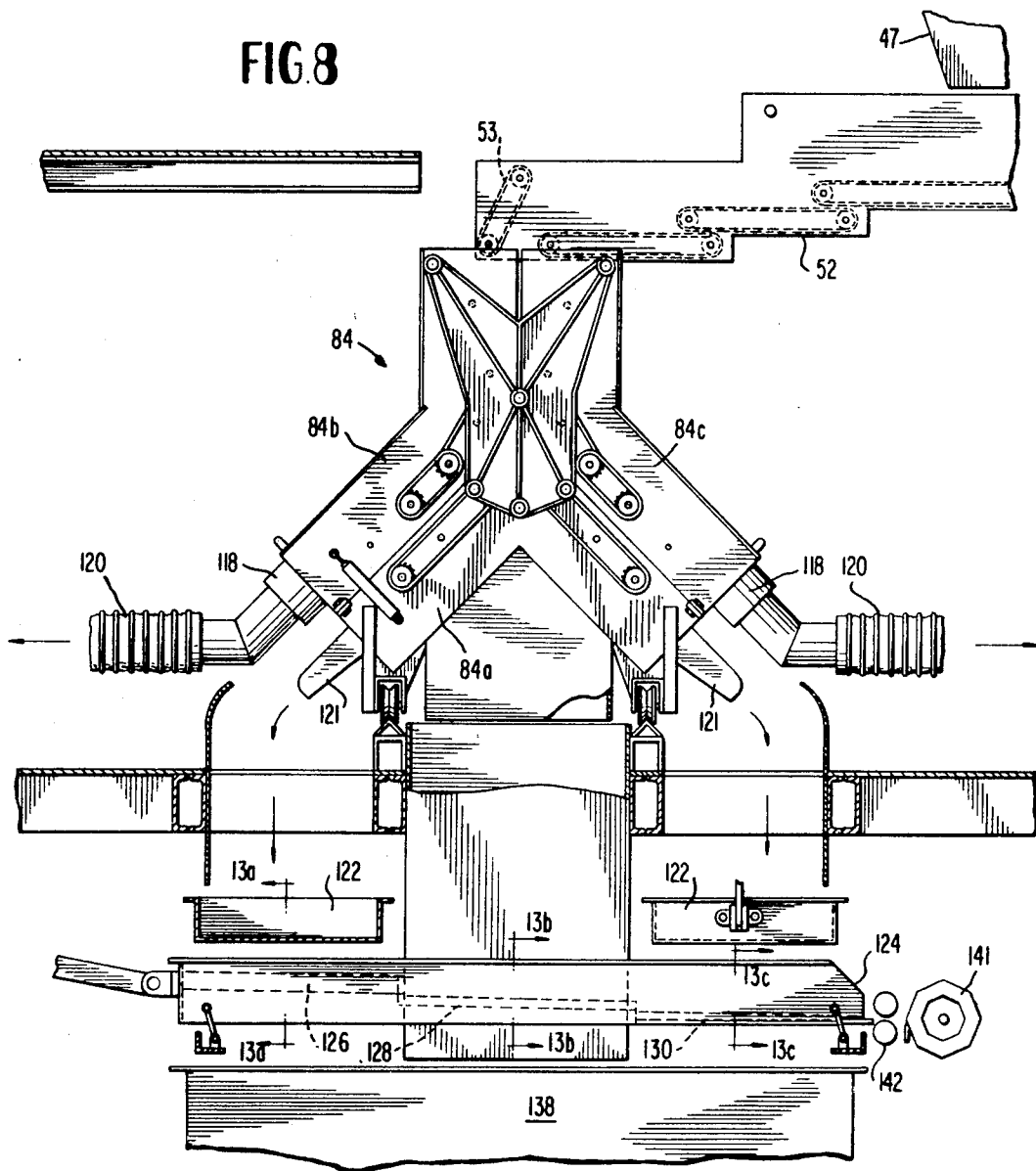


FIG. 13a

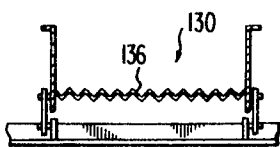
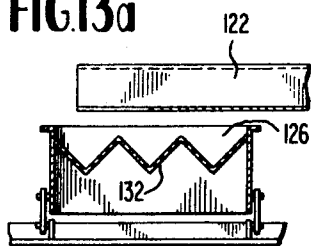


FIG. 13c

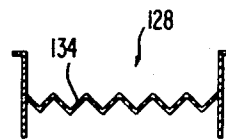


FIG. 13b

FIG. 9

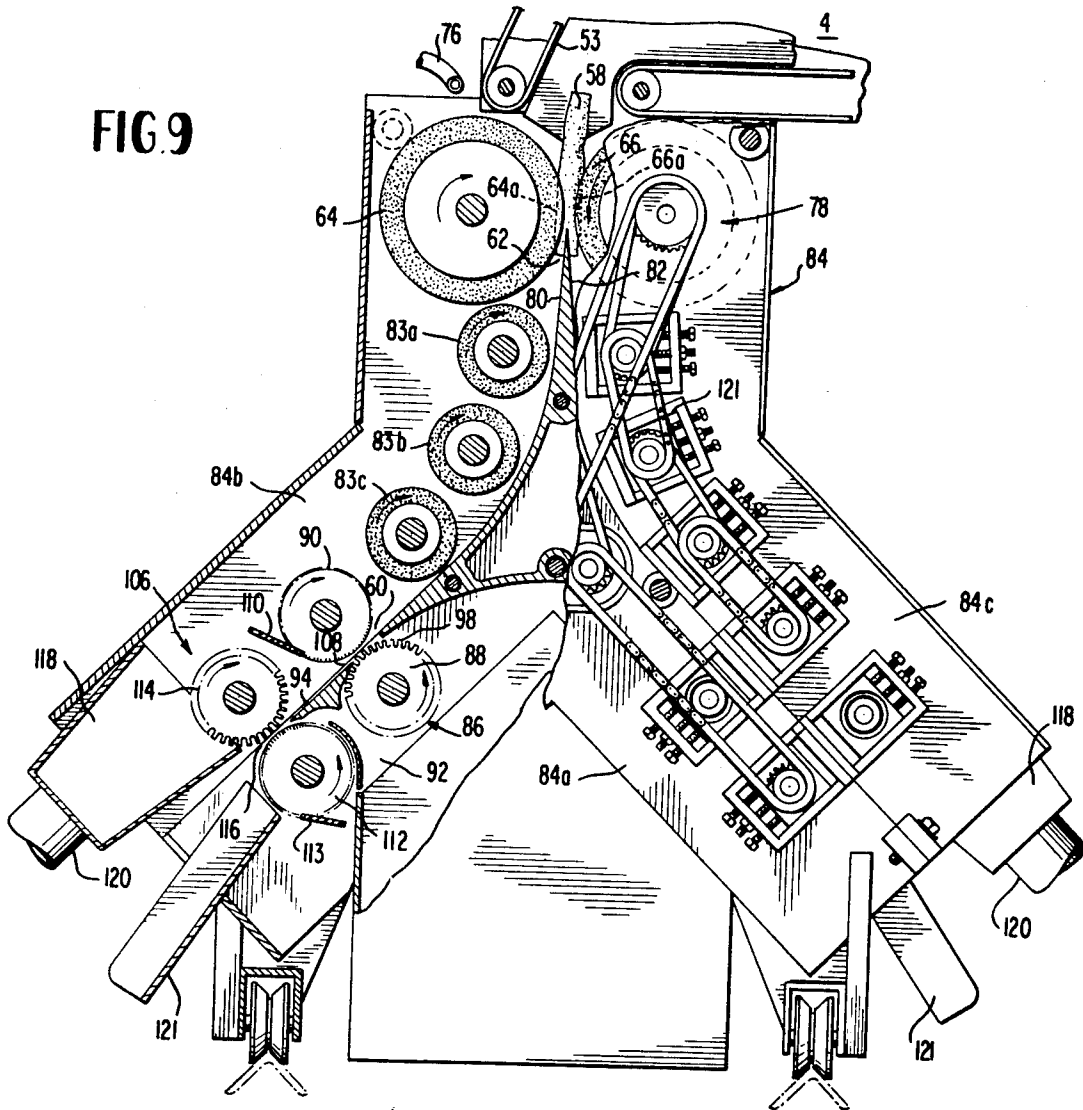


FIG. 10

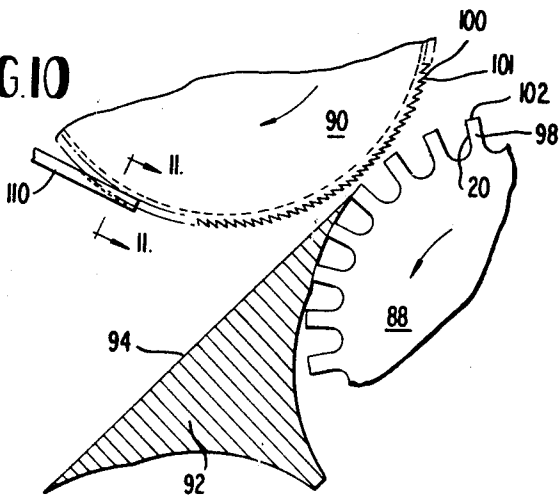
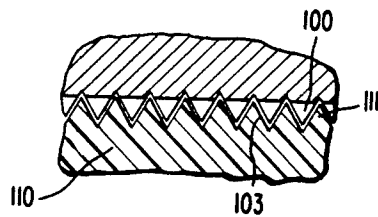


FIG. 11



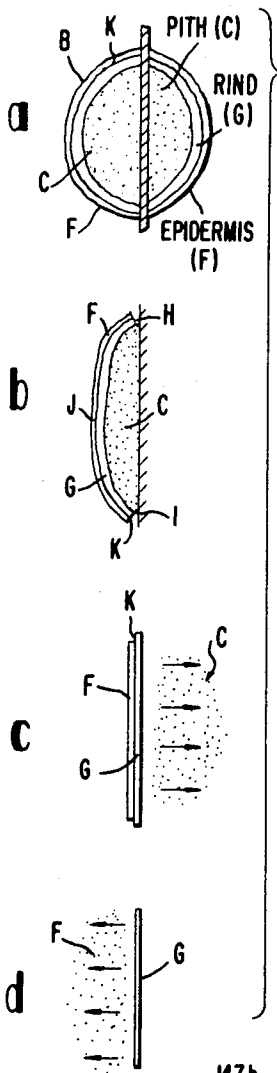


FIG. 12

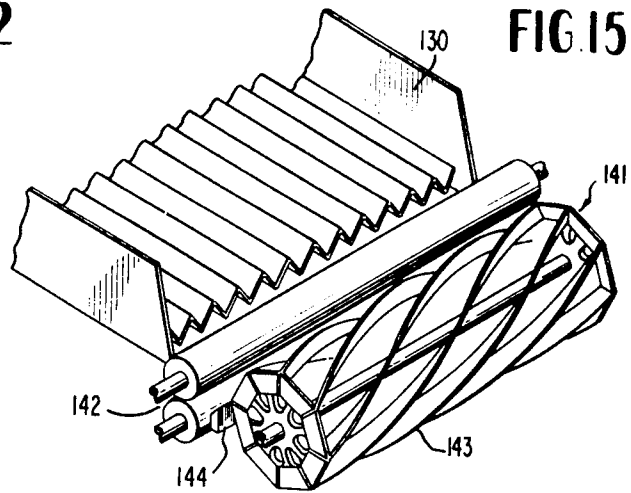


FIG. 15

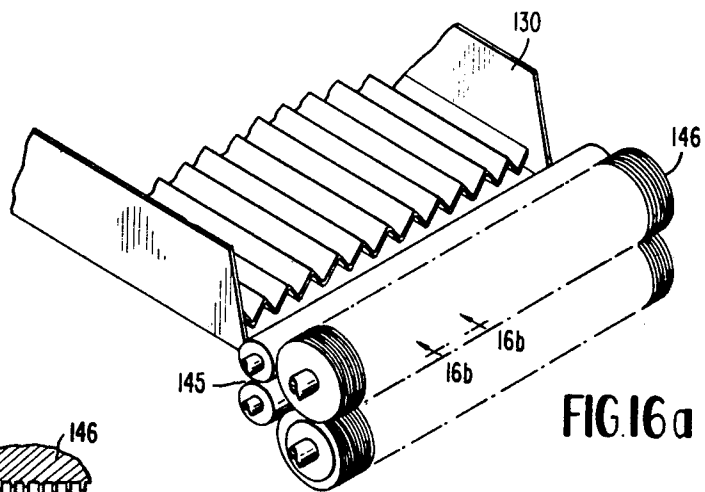


FIG. 16a

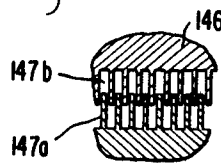


FIG. 16b

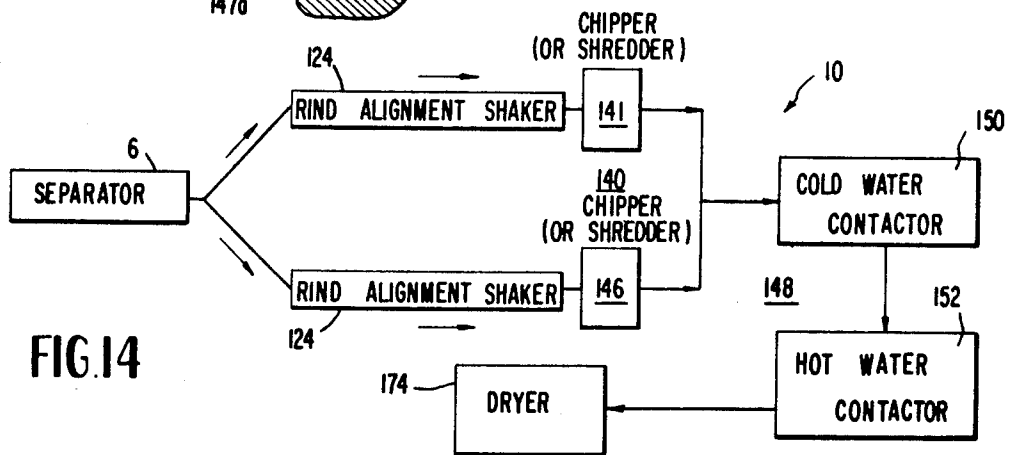


FIG. 14

FIG. 17

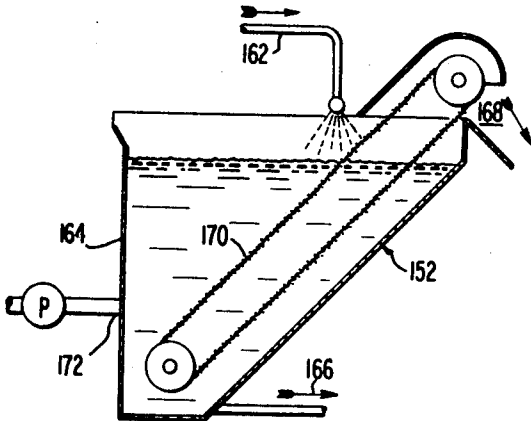
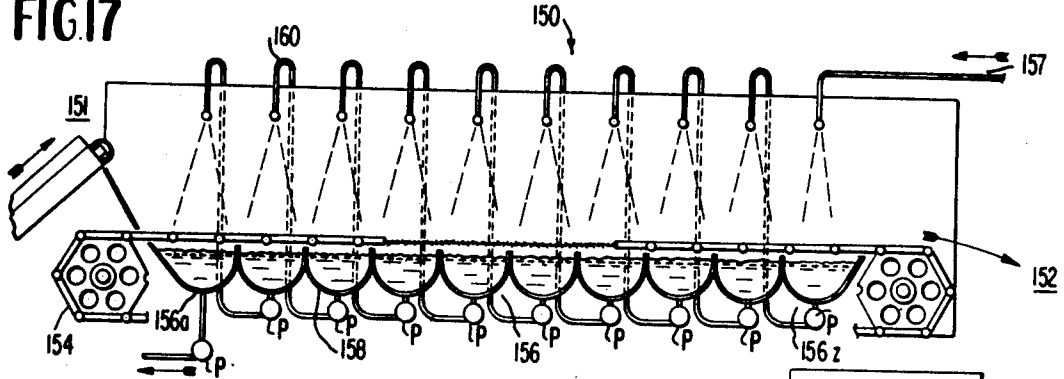


FIG. 18

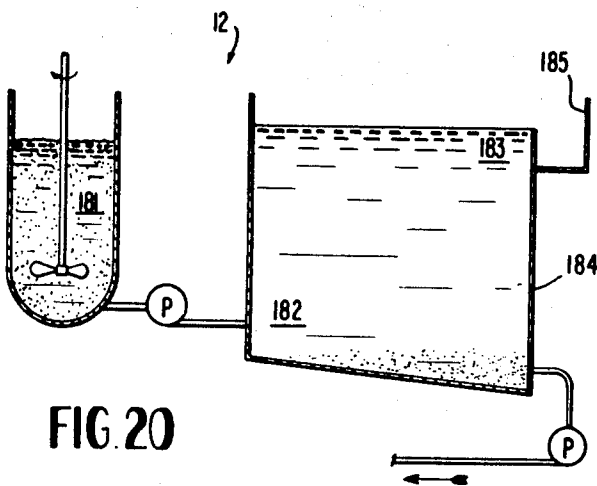


FIG. 20

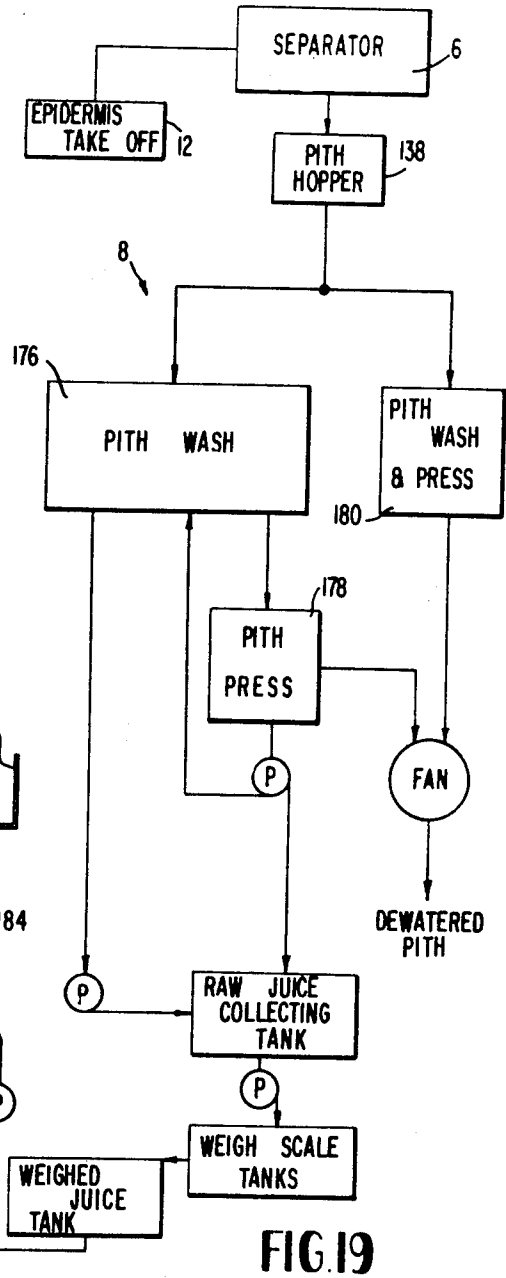


FIG. 19

APPARATUS FOR PROCESSING SUGARCANE

This application is a division of application Ser. No. 714,896, filed Mar. 21, 1968, now U.S. Pat. No. 3,567,511 which is a continuation-in-part of my applications filed Dec. 20, 1967, entitled "Method and Apparatus for Separating Components of Sugarcane," Ser. No. 692,185, and "Methods and Apparatus for Preparing Sugarcane Stalks for Subsequent Processing," Ser. No. 692,237 now U.S. Pat. Nos. 3,509,293 and 3,566,944, respectively.

This invention relates to sugarcane processing, and in particular to a process for treating sugarcane which process, as a whole, embraces the various stages in processing sugarcane including the feeding of the sugarcane to treating stations, separating the sugarcane stalk into its pith, rind and epidermis components, and subsequent treatment of the components to recover the natural sugar juices along with other valuable commodities such as pith floc, cane fibers and cane wax.

BACKGROUND OF THE INVENTION

In conventional systems for treating sugarcane, masses of randomly oriented sugarcane are delivered in bulk to massive machinery that cuts, crushes, shreds, and breaks the whole cane stalk, and under high pressure forcefully squeezes out the natural juices. These operations are referred to as whole cane milling. A by-product of conventional sugarcane processing is bagasse, which is the fibrous or woody portion of sugarcane which is used as fuel at most mills. The juice from the mills is acid, turbid, and dark green in color and usually contains particles of this bagasse which may require removal before the juice goes to a clarification process.

This invention provides a new process or system for treating sugarcane which does not rely upon the above-described conventional milling of the whole cane and which consequently avoids the problems created by whole cane milling. Not only does this process enhance the quality of the natural juices taken from the sugarcane stalk, but it also produces commodities from sugarcane stalk such as wax capable of being refined for commercial use, epidermis material capable of being processed, a rind product containing plant fibers which are relatively undisturbed with respect to one another and in a condition highly suitable for further processing into a variety of commercial products, and a pith floc which has numerous uses.

This system eliminates the production of bagasse, which, for the most part as explained before, is an undesirable residue of conventional sugarcane processes.

Further, past approaches to the various phases of sugarcane processing as more nearly contemplated in the present invention have been uncoordinated and have not generally become techniques commercially used.

For example, while it has been known to utilize machinery adapted to automatically cut the cane stalks into shorter lengths to facilitate further processing, such prior devices would not be suitable for dealing with a large, tangled mass of randomly oriented sugarcane stalks, such as would be dumped from a truck, railway car or the like. And while heretofore the broad concept of the subsequent steps of separating the pith and rind components of sugarcane has been recognized, no particular attention has been given to the coexisting problems of feeding and delivering the cane

to the separating zone, and to the subsequent treatment of the separated components.

For example, one known separation technique inherently contemplates complete disintegration of rind with the commingling of disintegrated rind with pith. Rather obviously, the intermingling of shredded filamentary rind with disintegrated pith presents substantial separating problems. Furthermore, such a process would probably require relatively clean feed for otherwise any trash which may be commingled with the sugarcane stalks would heavily contaminate the separated components. This contamination would further complicate subsequent component treatment steps which might render the whole process commercially useless.

SUMMARY OF THE INVENTION

Accordingly, an object of this invention is to provide a process which utilizes a systematic approach to the transformation of a large tangled mass of randomly oriented sugarcane stalks into their pith, rind and epidermis components which are then treated to obtain valuable commodities such as sugar juice, pith floc, cane fibers and cane wax.

Other objects of this invention will be apparent from the following more detailed description.

In accordance with the present invention, sugarcane stalks are delivered to a separating zone and are separated into their pith, rind and epidermis components. These components can be then further treated to recover commodities such as sugar juice, pith floc, cane fibers and cane wax.

In delivering the sugarcane stalk material to the separating zone, the sugarcane stalk material is transported by conveyor means, and the stalks are aligned generally longitudinally in the direction of travel of the conveyor means and are chopped transversely thereto into relatively shorter lengths to form chopped stalk material. If the cane contains trash such as leaves, rocks and cane roots, a fluid is directed through the stalk material at some point along the conveyor means to remove the trash.

At the separating zone where longitudinally aligned chopped stalk is separated into its pith, rind and epidermis components, the chopped stalk is opened up longitudinally while it is being fed. The opened up stalk portions are separated and the separated portions are then flattened so that the rind component of each portion is confined, while passing through the zone, to a substantially flattened configuration. As the flattened stalk material portion is fed through the zone, pith is milled or ground away from one side, while the other side is gripped by holding surface means to maintain the velocity of the stalk portion, which holding surface means are independent of the forces imposed on the stalk portion by the milling. The milling of pith from one side of the stalk portion is followed by the milling away of epidermis material from the opposite side of the stalk portion while still maintaining the stalk material in a flattened condition. The milling away of pith and epidermis is restricted so that the milling depth is uniform across the stalk portion to yield substantially planar, unitary strips of sugarcane rind having a generally uniform thickness, and containing substantially undisturbed, unitized or laterally interconnected, rind fibers.

The pith and rind are then recovered and can be treated to extract sugar juice from them. The epidermis can be treated to recover wax and other components from it.

The treatment of the pith comprises a pith washing and pressing operation to extract juice from the pith. The pith can be subsequently recovered. Further treatment of the pith such as by abrading it to separate the pith into its fibrous and non-fibrous components may be desirable.

The treatment of the rind comprises a rind breaking operation to reduce the rind into smaller portions such as chips or shreds, and a water contacting operation to extract water solubles from the rind. For example, the rind portions can be contacted with cold water to extract sugar juice, and can then be contacted with hot water to extract hot water soluble materials such as lignin, natural resins, and certain minerals. The rind can then be dried and used in making certain commodities such as paper and pressboard. If desired, residual pith can be removed from the rind by mechanical agitation such as shaking prior to the breaking or reducing of the rind. This residual pith can then be passed to the above mentioned pith treating zone.

As stated above, the epidermis can be treated to recover wax. In this treatment the wax is separated from the epidermis such as by mechanical agitation or by a water contacting treatment to separate wax bearing material from certain other epidermis material.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a simplified, plan view of a representative sugarcane processing plant utilizing a system in accordance with the present invention to feed cane, initially delivered in bulk, in aligned, cleaned, chopped condition to a separating zone where the cane stalks are separated into their pith, rind and epidermis components which are recovered and subsequently delivered to various treating zones;

FIG. 2 is a simplified side view of a first series of conveyors forming part of the system shown in FIG. 1 taken along the lines 2—2 therein;

FIG. 3 is a side view of a first part of a second series of conveyors forming part of the system shown in FIG. 1 taken along the lines 3—3 therein;

FIG. 4 is a view of a second part of a second series of conveyors shown in FIG. 3 extending continuously from the portion shown therein;

FIG. 5 is a perspective, partially broken-away view of a right angle junction between the first and second series of conveyors shown in FIG. 1;

FIG. 6 is a simplified, cross sectional side view of chopping and re-aligning apparatus forming a part of the system shown in FIG. 4;

FIG. 6a is a simplified side view of an alternative component of the apparatus shown in FIG. 6;

FIG. 7 is a cross sectional end view of a re-aligning apparatus shown in FIG. 6 taken along the lines 7—7 therein;

FIG. 8 is an elevational, partially sectioned, view of a separating unit of the present invention;

FIG. 9 is an enlarged, partially sectioned, view of the separator of FIG. 8;

FIG. 10 is an enlarged, partially sectioned, elevational view of a milling unit incorporated in the FIGS. 8 and 9 separator and operable to separate rind and pith components;

FIG. 11 is an enlarged, transverse, sectional view of a longitudinally extending portion of the rind gripping roll shown in FIG. 10, as viewed along the section line 11—11;

FIG. 12 is a schematic, sequential illustration of the cross section of a representative sugarcane stalk section, illustrating the changes which occur to the stalk material during the various stages of the component separation operation;

FIGS. 13a, 13b and 13c are sequential transverse sectional views of shaking or vibrating rind handling apparatus which serves to convey and screen rind and residual pith components;

FIG. 14 is a simplified block diagram of the rind treating zone;

FIG. 15 is perspective view of rind chipping apparatus which can be used to break or reduce the rind into chips;

FIG. 16a is a perspective view of shredding apparatus which can be used to break or reduce the rind to shreds;

FIG. 16b is a sectional view of a portion of the shredding apparatus shown in FIG. 16a taken along the section line 16—16;

FIG. 17 is a simplified side view of water contacting apparatus which can be used to extract juice from either rind or pith;

FIG. 18 is a simplified side view of a hot water contacting unit which extracts hot water solubles from rind;

FIG. 19 is a simplified block diagram of the pith treating zone;

FIG. 20 is a simplified side view of a representative epidermis treating zone.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Delivery of Sugarcane to Separating Zone

Referring to FIG. 1 of the drawings, the overall sugarcane processing system includes a cane processing zone, generally designated 2, utilizing a feed system 4 to supply sugarcane to the separating zone 6.

The sugarcane processing zone 2 includes a separating zone 6 for splitting individual cane stalks longitudinally and separating the cane rind from the pith (core material of the cane), and adapted to feed the separated pith, rind and epidermis components to separate pith and rind and epidermis treating zones, 8, 10 and 12 respectively.

Referring to FIG. 2, the feed system of the present invention includes a first series of successively related, separated conveyor means 14 adapted to convey cane stalks in large, randomly oriented, bulk mass dumped from rail cars 16 onto conveyor means 14a. The canes can also be dumped from other conventional forms of transport for sugarcane in bulk from the fields, such as, for example, trucks, carts, crane and sling, and the like.

The separate conveyors in the first series 14 run at successively higher speeds. Adjacent delivering and receiving portions of the successive conveyors in the series are arranged in partially overlapping relation so that as the canes pass from one conveyor to the next, they are subjected to an abrupt vertical deflection or cascade. The leading cascaded portions of individual canes in the mass, when engaged by higher velocity downstream conveyor, are subjected to jerking forces

in the downstream direction. The combined effect of the deflecting motion and jerking force causes an initial loosening of the tangled mass of canes. The cascade junctions cause heavy debris mixed with the cane, such as boulders and cane root masses from the fields, to gravitate through the gaps 18 downwardly between adjacent conveyors, in a direction rearwardly of the direction of travel of the canes. As the canes travel progressively along the first series 14 of conveyor means, the progressive acceleration tends to cause the mass to become thinned out in the direction of travel. Thinning is further effected by the provision of a plurality of rakes 19 spaced in the direction of travel which overhang and extend transversely of the path of travel of the mass of stalks.

This thinning out of the sugarcane stalks is quite substantial when passing from the first conveyor 14a to a second or metering conveyor 14b. The metering conveyor 14b moves considerably faster than the first conveyor (for example, a speed differential of about 200 feet per minute is suitable) which causes a sudden acceleration of the stalks in passing between conveyors 14a and 14b. The metering conveyor 14b which has its lower end adjacent and on a level with the delivery end of the conveyor 14a, is mounted to adjacent supporting structure for pivotal motion in the vertical plane about its lower end. The upper, delivery end of the conveyor 14b may be elevated vertically by conventional means (not shown) under the control of an operator or automatic sensing means to vary the inclination of the metering conveyor 14b relative to the first conveyor 14a. As sugarcane stalks move off the first conveyor 14a normally in heaps or clumps, the speed and inclination of the metering conveyor 14b can be selectively controlled to break up the heaps and distribute the mass of stalks evenly onto the next succeeding conveyor 14c in the series 14.

The cane stalks are transferred from the first series 14 of conveyors to a faster moving, second series 20 of conveyors (FIGS. 3 and 4). Series 20 is disposed transversely of the first series 14 to define a right angle junction 22 (FIG. 5) between the first and second series of conveyors.

At the junction 22, the canes 24 are subjected to another vertical displacement and at the same time, the leading portions of the canes falling onto the first of the second series 20 are subjected by frictional contact therewith to a downstream accelerating force. This force imparts a strong, jerking force to the leading portions of the canes, which force is inclined transversely of the direction of cane travel upstream of the junction 22. At this time, any canes which have so far been entangled in such relation as to be unaffected by the preceding jerking motions in the direction of travel of the first series 14 of conveyors, are suddenly subjected to a jerking force in a direction at right angles to that previously experienced. In addition, the rearward ends of the canes tend to be relatively retarded, not only by the inertia of the stalk itself, but frequently because of engagement of the rear end of the stalks with other canes in the mass. The net effect of these forces has been found to contribute very substantially to a disentangling and breaking up of the mass of canes at the junction 22.

At the same time, centrifugal force acting on the canes in the top part of the mass at the junction 22 during the turn causes the upper canes to topple laterally outwardly onto the conveyor downstream of the junction 22 to cause considerable lateral spreading of the canes. The succeeding conveyors in the second series 20 are also arranged in successively, more rapidly moving relation so that the individual stalks continue to be progressively thinned and aligned until substantially all of the stalks are aligned in the direction of travel of the second series 20 of conveyors.

Preferably, the speed of the final conveyor in the final series 20 is at least 1,500 feet per minute, with speed differentials between some of the various preceding conveyors in the various flights and series on the order of or in excess of about 100 feet per minute. These figures are exemplary and other speed ranges may be chosen.

During their travel along the second series 20 of the conveyors, the stalks are passed through a de-trashing station 26. At this station, the stalks are projected at high velocity across a vertical discontinuity 28 of the second series 20 of conveyors to cause the stalks to become at least partially airborne. At this time, fluid from nozzle 30 is directed upwardly through the stalks to remove trash therefrom with the partially airborne relation between the stalks preventing clogging of the trash among them, thus facilitating removal. The trash is subsequently conducted away through a cowl 32, separated and disposed of.

In addition to forced air detrashing stations, a water spray or "laundry" station can be interposed along the second series of conveyors which would wash mud and the like off of any particular cane or canes which may require it from time to time. Additional water sprays can be provided to wash off trash adhering to the returning underside of the conveyor.

Downstream of the gap or discontinuity 28, the cane stalks, still moving rapidly in the direction of travel in the second series 20, fall onto a downwardly inclined, transversely extending, receiving plate 33 by means which they are directed to a group 20_x of conveyors 20 which are aligned in an upwardly inclined relationship. The last conveyor in group 20_x feeds the cane to the conveyor group 20_y, which are disposed in horizontally aligned relationship. The last of conveyors in group 20_y feeds to conveyor group 20_z which is aligned in upwardly inclined relationship relative to conveyor group 20_y.

At the junction between conveyor groups 20_y and 20_z, the leading ends of the cane stalks are lifted when engaged by the first conveyor in group 20_z. Since the conveyors in groups 20_x, 20_y and 20_z are driven at successively higher speeds, the lifted stalk ends are accelerated or jerked in the feed direction so as to further longitudinally orient the stalks.

At the downstream end of the second series 20 of conveyors, the stalks are delivered to a chopping unit 34 (FIG. 6) where they are chopped transversely of their length into shorter portions, of substantially uniform length, while moving longitudinally of their length. The chopped portions of stalk are then realigned at a realigning unit 36 into parallel relation, moving longitudinally in the direction of travel for delivery to the separating zone 6.

The chopping unit 34 includes two mating, transversely extending power-driven, cutting rolls 38 and 40 provided with alternately spaced, transversely extending, peripherially mounted, gripping and cutting members 42 and 44. Members 42 and 44, alternately, grippingly advance the individual canes, and sever them transversely. As the leading end of each cane leaves the last of the conveyor 20, it moves towards the rolls 38 and 40 where it is engaged by whichever pair of gripping members 42 is currently moving into gripping relation. As the rolls 38 and 40 continue to rotate, members 42 are deformed about the cane to grip it securely and to hold the cane firmly between the rolls, while at the same time, simultaneously advancing the cane longitudinally.

To cut the stalk while it is engaged by the gripper portions 42, each of the rolls 38 and 40 is provided with four, transversely extending, radially projecting, knives 44, spaced equally about the cutter roll periphery and located intermediate the gripping members 42. The knives 44 of the rolls 38 and 40 move into intermittent radial and contiguous alignment to sever each stalk transversely of its length while it is moving longitudinally. Thus, rolls 38 and 40 produce chopped portions of stalk of uniform length. The chopped portions of stalk fall into a hopper 46 from which they are delivered by an upwardly inclined bucket conveyor 48 to the realigning unit 36. A flexible or pivotally mounted flapper 45 can be provided to allow conveyor buckets, but not chopped cane, to pass therethrough.

At the upper delivery of the conveyor 48, the chopped stalks are passed by a hooded chamber 49 to which suction is applied as indicated by arrow A in FIG. 6. The air flow, induced by the suction, serves to remove trash from chopped stalks falling from the end of the conveyor 48.

The realigning unit 36 includes a realigning cage 50 (FIG. 7). Cage 50 is positioned above a delivery conveyor 52, moving longitudinally of the cage 50. The cage 50 includes a plurality of longitudinally extending ribs 54 and 56 with alternate ribs 54 being relatively high and spaced transversely apart by a distance slightly more than the length of the chopped portions of stalk. With this arrangement, the chopped stalk 58 cannot fall in bridging relation across any two relatively high ribs. The ribs 56 intermediate the high ribs 54 are relatively low and spaced from the adjacent high ribs 54 by a distance substantially less than the chopped cane length. The cane lengths are thus induced to fall downwardly between adjacent high and low ribs and are then skewed toward longitudinal alignment. The conveyor 52 carries the lengths between adjacent ribs, which are progressively, longitudinally converged, in the feed direction of the cane lengths and which may extend up to guiding conveyor 53.

Delivery conveyor 52 comprises a series of partially overlapping conveyors 52a, 52b, and 52c which run at successively higher speeds to thin out and further align chopped stalks received from bucket conveyor 48. Stalks which are propelled out from conveyor 52c strike guiding conveyor 53 which directs the chopped stalk downward to the stalk component separating zone 6.

The number and speeds of the conveyors making up delivery conveyor 52 can be varied according to a par-

ticular operation. For example, when using three conveyors as illustrated, conveyor 52c can have a speed of about 150 to 350 fpm, e.g., about 300 fpm, and the preceding conveyors 52a and 52b will operate at lesser speed, e.g., about 100 fpm and 200 fpm, respectively.

The speed and angle of inclination of guiding conveyor 53 will vary at least in part according to the speed of conveyor 52c. For example, when operating delivery conveyor 52c at about 300 fpm, guiding conveyor 53 may be inclined at an angle of about 30° to 45° from the vertical and may operate at a speed of about 900 fpm.

Of course, various modifications in the relative positioning of various parts of the layout just described may be made. For example, the chopping unit 34 could be positioned at some point in the second series of conveyors 20 intermediate the detrashing unit 26 and the hopper 46 and the realigning unit 36. Detrashing units may be provided between the chopping unit and/or the hopper 46.

Further, guiding conveyor 53 may alternatively be replaced by a guiding chute 53a as shown in FIG. 6a. Guiding chute 53a is curved so as to direct cane propelled at high speeds from conveyor 52c via the chute's concave side into stalk component separating zone 6. In this embodiment conveyor 52c can have speeds on the order of or in excess of 500 fpm.

Further details and modifications of the above-described delivery of the sugarcane to the separating zone may be found in aforementioned copending application Ser. No. 692,237, filed Dec. 20, 1967, entitled "Method and Apparatus for Preparing Sugarcane stalks for Subsequent Processing."

Separating Zone

Referring to FIGS. 1 and 9, the aligned, short stalk sections 58 are thus fed from feed system 4 to stalk component separating zone 6. It is contemplated that stalks being fed by the feed device will be supplied in a substantially single layer form, even though plural, laterally displaced stalks may issue simultaneously.

In the separating zone 6, as shown schematically in FIG. 12, the stalk portions are split longitudinally into halves. Each split half is treated so as to separate the pith, rind and epidermis components without materially damaging the fibers of the rind component of each stalk half.

The pith component of the stalk material separated from the flattened rind in the separating zone, as shown schematically in FIG. 12c, is conveyed to a pith treatment station 8. As will be understood, by reference to FIG. 12a, the pith core C of each stalk A includes a nonfibrous matrix D through which longitudinally extending fibrous elements E are dispersed. The separation of the pith layer C from a flattened stalk half B is schematically shown in FIG. 12c. Suffice it to say that pith, as used in this disclosure, relates to the core material of sugarcane, including both the fibrous constituents E and the nonfibrous constituents D.

The epidermis material F, separated by separator 6, which may include the wax component of the sugarcane stalk and which is schematically labeled in FIGS. 12a through 12d, may be subjected to further treatment in an epidermis treatment station 12.

Epidermis material F is that material found in the outer periphery of sugarcane stalk which is comprised of fine, relatively loose and often colored, fibers.

Usually cutical wax adheres to the outer epidermis layer.

Rind material G separated in the separator station 6, and illustrated in FIGS. 12a through 12d, is conveyed to a rind treatment station 10. This material is substantially free of pith and epidermis, shown in FIG. 12d.

Sugarcane rind G is made up of fiber bundles, the fibers of which extend longitudinally of the stalks.

The overall function of the separator station 6 is to produce a separation of pith and rind components without damaging the rind fibers or impairing the pith as a source of sugar. The epidermis removal is also intended to be performed without damaging the rind fibers.

FIG. 9 schematically demonstrates a structure 84 which can be used for receiving stalk sections 58 deflected from the conveyor or chute unit 53.

With this arrangement, whole stalk 58 is fed from the feed unit 4 into the nip zone 62 between the resilient, peripheral portions 64 and 66 of the feed rolls. This whole stalk 58, which is substantially vertically aligned, is resiliently engaged by the roll coverings 64 and 66 and grippingly held while it is fed downwardly in a vertical direction into splitting engagement with the stalk splitting edge 72, as shown generally in FIG. 9. The resilient roll coverings 64 and 66 will be flattened because of their compressive engagement with the whole stalk portions. This flattening will produce a resilient stabilizing action tending to maintain the whole stalk in near perfect vertical alignment with the splitting blade 72. Forces generated by the splitting action of the blade edge 72 which might tend to cause skewing of the whole stalk out of this vertical alignment will be resisted by the flattened portions 64a and 66a of the roll coverings 64 and 66. These flattened portions 64a and 66a shown in FIG. 9 yielding and grippingly engage the whole stalk as it is being fed into splitting cooperation with the blade edge 72.

As is shown in FIG. 9, one or more water nozzles 76 may discharge small amounts of water onto stalk material being fed into the splitting unit 78. This water may be advantageous in tending to minimize the generation of dust and effect lubrication of the cane material so as to increase the efficiency of the pith and epidermis milling operation.

The stalk material 58, after being split in two by the edge 72, is deflected so as to travel along the deflecting surfaces 80 and 82. One stalk half B will travel along the deflecting surface 80 and the other will travel along the deflecting surface 82. Each split stalk section B travels along its associated deflecting surface, with the exposed pith C facing the deflecting surface.

Continuous movement of the split cane portions B along the deflecting surface may be enhanced by feeding and guide rolls such as the rubber-covered driven rolls 83a, 83b and 83c. Through appropriate sizing of the gears and sprockets wheels, the peripheral speed of the interconnected drive roll 64, feeding and guide rolls 83a, 83b, 83c, and gripping rolls 90 and 112, in this order, are driven at slightly increasing velocities to ensure feeding of stalk material through the separator 84 without jamming.

The separation of the sugarcane stalk components previously described is effected in separator unit 84 which includes a pith separation unit 86 as shown generally in FIGS. 9 and 10 through 12.

Note here, as shown in FIGS. 8 and 9, that separator unit 84 includes a generally shaped base 84a, and a pair of pivotally mounted wing units 84b and 84c. Wing unit 84b and base 84a cooperate to support components corresponding to those supported by wing unit 84c and base 84a.

Pith separation unit 86 includes a pith milling roll 88, a rind gripping roll 90, and a rind-supporting and pith-deflecting shroud 92.

Milling roll 88 includes a plurality of generally radially projecting, longitudinally extending, peripheral milling ridges 98. Each milling ridge 98 extends longitudinally of the periphery of the roll and includes a pair of planar, parallel, symmetrically disposed milling side faces 96. Milling face 96 is parallel to a radial plane of the roll 88, i.e., raked neither forwardly nor rearwardly.

Milling ridge 98 also includes a circumferentially curved, longitudinally extending, rind-contacting periphery 102. Peripheral face 102 is curved in an arc having a radius equal to that extending to the outermost radial periphery of the ridge 98, which periphery defines the outermost radius of extending roll 88. Curved rind-contacting surface 102 intersects each planar milling side 96, the peripheral direction.

As shown in FIG. 10, gripping roll 90 is fabricated so as to include a plurality of rind-gripping teeth 100 raked rearwardly of the direction of rotation of the roll 90. Rind-gripping teeth 100 are defined in part by a series of longitudinally extending V-shaped cuts 101 which extend longitudinally of the outer periphery of the roll 90 which are raked or inclined rearwardly of the peripheral direction of movement of the roll 90.

A series of longitudinally spaced, circumferentially extending, annular grooves 103 are also cut in the outer periphery of the roll 90 to complete the forming of teeth 100. The depths of these grooves 103 slightly exceed the depth of cuts 101 as shown, for example, in FIG. 11.

As shown in FIG. 10, the teeth 100 are spaced somewhat from the rind-contacting surfaces 102. This spacing is such as to ensure that the teeth 100 will partially penetrate the epidermis side of the rind, while the gripping surfaces 102 of the milling roll 88 are engaging the pith side of the split stalk material.

As stated, cane stalks are fed longitudinally into the nip zone 60 between the rolls 88 and 90. The cane stalk material supplied to the nip zone 60 is in the form of longitudinally split cane portions B, i.e., one longitudinally extending half of a chopped cane length. The cane halves may be fed along a planar guiding surface 80 and 94.

Split cane stalk portions moving along surface 80 are oriented with the pith side facing the surface 80 and the rind side facing outwardly as shown in FIG. 9. Desirably, surface 80 supports the thus positioned stalk sections so that the rind portion moves into the nip zone 60 substantially tangentially of the outer periphery of the milling roll 88.

The rotary speed of the milling roll 88 substantially exceeds that of the gripping roll 90. Thus, split stalk portions moving into the nip zone 60 and between rolls 88 and 90 will be simultaneously gripped and depithed, and the high rotary velocity of the milling roll 88 will ensure that the milling sides 96 of the milling ridges 98 perform a thorough pith milling or removing function.

The teeth 100, which partially penetrate the rind portion of the split stalk sections, will function as holding surface means, transversely intersecting a portion of the rind so as to positively hold the rind and limit its velocity to the peripheral speed of the gripping roll. The milling or planing roll surfaces 102 will lightly pass the rind against the teeth 100 of the gripping roll. This pressing will cause the teeth to partially penetrate the rind without doing any significant damage to the fibers of the rind strip.

As the split stalk sections B move into the nip zone 60, the converging peripheries of the rolls 88 and 90 will tend to induce a flattening of the rind layer G into a substantially planar configuration as shown generally in FIG. 12c. This flattening will result from engagement of milling ridge extremities 102 with rind edges H and I, concurrent with engagement of rind-gripping teeth 100 with the outermost stalk periphery J.

Thus, as the stalk half B moves forward into the nip zone 60, the rind layer G will be progressively flattened until, in the zone where the radii of rolls 88 and 90 are radially aligned, the rind will be completely flattened. This flattening in sequence is shown in FIGS. 12b and 12c, the rind being gripped on the epidermis side by the rind-penetrating teeth 100 while pith is being milled away from the opposite side of the milling ridge sides 96, as shown in FIG. 12c.

As split sugarcane stalk material is passing between rolls 88 and 90, there may be a tendency for fibrous detritus to accumulate between the teeth 100 of the gripping roll 90.

As shown in FIGS. 10 and 11, a detritus-removing nylon blade 110 may be provided to prevent a buildup of such detritus. Blade 110 is mounted in generally tangential engagement with the gripping roll 90, and may be provided with fingers 111 operable to project into the circumferential groove 103 and remove detritus. Detritus removed by the fingers 111 is discharged downwardly onto the rind supporting surface 94, and is carried along with the rind moving on the surface 94 to the epidermis-removing unit 106. An identical nylon blade 113 cooperates with gripping roll 112.

With the pith component C of the split stalk section having been removed, the epidermis-containing rind is now conveyed along the rind-supporting surface 94 of the shroud 92 to an epidermis-removing unit 106.

As will be understood, epidermis-containing rind issuing from the zone 108 will be traveling with a velocity sufficient to enable the rind to continue along the surface 94 until it is grippingly engaged by the elements of the epidermis-removing units 106.

Epidermis-removing unit 106 includes a gripping roll 112 and a milling roll 114. Gripping roll 112 is identical to gripping roll 90 except that it is mounted on the underside of the flow path of the stalk material, with the milling roll 114 mounted on the top, epidermis bearing, side of the stalk material.

The radial spacing between the milling ridges of the milling roll 114 and the gripping teeth of the gripping roll 112 is such as to ensure that the teeth of the gripping roll 112 partially penetrate the underside of the rind, while the ridges of the milling roll grip the opposite side of the rind and mill away epidermis material.

Thus, as the epidermis milling operation proceeds, the gripping roll 112 serves to positively control the velocity of the rind. This enables the milling roll 114 to rotate in the feed direction of the stalk material at a substantially faster rate than the gripping roll 112. In this fashion, a high velocity of the milling ridges of the roll 114 is made possible so as to produce a complete and efficient epidermis removal as the stalk material proceeds through the epidermis-removing unit 106.

As will be appreciated, the depithed rind material, moving into the nip zone 116, is maintained in a flattened condition as it is engaged for the epidermis removing operation by the rolls 112 and 114. The longitudinally extending milling ridges of the milling roll 114, in cooperation with the teeth of the gripping roll 112, provide a rind-flattening action which ensures that the rind layer D is maintained in a flattened condition while the epidermis material is being removed, as shown generally in FIG. 12d.

The milling away of both the epidermis and the pith is restricted in milling depth uniformly across the stalk to yield substantially planar unitary strips of sugarcane rind having a generally uniform thickness. The essentially radial and planar milling ridges of the milling rolls 88 and 114 effectively remove either pith or epidermis without disrupting or damaging the rind fiber structure.

The epidermis material removed by the roll 114 is light and fluffy in character. Because of its light and fluffy character, the epidermis material which has been removed by the milling roll 114 may be conveyed away from the separator unit 84 by a vacuum-induced fluid stream.

Thus, as shown schematically in FIG. 9, a vacuum hood 118 may partially surround the milling zone defined by the milling roll 114.

A vacuum-induced flow of air within the hood 118 enables epidermis material, which has been milled away from rind, to be conveyed away from the hood 118 through a conduit 120.

Modifications and details such as the various drive means 121 for the above described separator 84 may be found in aforementioned copending application Ser. No. 692,185, filed Dec. 20, 1967, entitled "Method and Apparatus for Separating Components of Sugarcane."

HANDLING OF SEPARATED STALK COMPONENTS

FIGS. 8 and 14 illustrate auxiliary apparatus designed to perform a secondary separation of residual pith from rind. For the most part this residual pith consists of pith already milled from the rind but which is still adhered or commingled with it. This residual pith can be effectively separated from the rind by a shaking or vibrating action. This secondary "shaking" separation may be avoided, however, where separation achieved by the milling rolls is of sufficient efficiency for a particular operation.

In the shaking operation, rind from the separating zone 6 is fed to a rind receiving plate 122 which functions as a shaker conveyor. This shaking action will move rind along the plate 122 to the aligning and pith separating, rind handling unit 124 which also utilizes a shaker type feeding action.

This secondary separator 124 includes a series of progressively lower elevated, laterally divided sections 126, 128, and 130 as shown in FIGS. 13a, b and c. Each of these sections serves both to orient the rind strips longitudinally of their feed direction and to shake loose limited amounts of residual pith which cling to the rind after the milling operations. This can be done by fabricating the sections from screen defining perforate sheet metal, bent to form a series of transversely extending triangular pockets. Pith shaken free will thus drop through the perforations.

As shown in FIG. 13a, the perforate base of the section 126 provides three such triangular pockets 132. As shown in FIG. 14b, the base of the section 128 provides six such triangular pockets 134. As shown in FIG. 14c, the perforate base of section 130 provides 12 such triangular pockets 136.

This progressive increase in the number of triangular, rind orienting, pith screening pockets 132, 134, and 136 coupled with the illustrated progressive dimensioning depth of the pockets, enables the rind to undergo lateral spreading at the junction between each section, as the rind is moved along the separator 124. Thus, rind material discharged from a single pocket of section 126 will be distributed laterally into two pockets of section 128. A similar laterally spaced spread of rind will occur when rind material is discharged from section 128 onto section 130.

This shaken free pith is passed to a pith receiving zone 138 along with the pith which has been milled away from the rind in the pith separating unit 86. The thus substantially pith-free rind will be discharged from the rind handling shaker conveyor 124 to the rind treating zone 10.

FIG. 14 shows the rind treating zone 10, where rind passes to a rind breaking zone 140 to reduce the rind into smaller portions such as by shredding the rind longitudinally or by chipping it transversely.

In a continuous sugarcane processing operation, the rind will contain a considerable amount of moisture after the pith is removed. This conditioning of the rind should occur soon after the pith is removed and before the rind is dry; otherwise, if the rind is allowed to dry to ambient moisture or is dried artificially, it will curl and twist into distorted shapes and become difficult to handle.

As shown in FIGS. 8 and 15, the rind chipper 141 is of a revolving spiral cutter or reel lawn mower type whose speed of rotation along with the rind feed rate determines the length of the rind chip. The rind is impelled from aligning troughs 130 into the nip zone of feed rolls 142 and is then fed across stationary bar or anvil 144 where it is broken or chipped by the shearing action of spiral blades 143 cooperating with the stationary bar edge 144. This is not unlike a reel lawn mower operation as described in U.S. Pat. No. 2,329,952. Of course, other types of chipping or cutting apparatus such as a vertical reciprocating rectangular cutter can be used.

The chips are suitably cut into one to three inch lengths, and more preferably into about 1-½ to 2 inch lengths. These rind chips then can be used as a source of raw material in the manufacture of paper, for the fiber of sugarcane stalk is comparable to certain North American pulp wood in this regard. Further, the fiber

of sugarcane stalk is also highly suitable for use in the manufacture of hardboard of the type wherein relatively short randomly disposed individual wood fibers are mixed with a binder and pressed into a dense sheet-like material under high pressure.

As shown in FIGS. 16a and 16b, rather than the chipping unit 141, the rind can be shredded longitudinally by a reel shredder 146. As in the chipping operation, the rind is impelled from aligning troughs 130 into the nip zone of feed rolls 145 and is fed to the shredder 146 where the individual fibers are spread apart due to the compressive shearing action of cooperating revolving projections 147a and grooves 147b which are somewhat spaced apart vertically and laterally. This action loosens or breaks mechanically the natural bond between separate fibers without significantly lessening the longitudinal tensile strength of the fibers. This is beneficial when making, for example, veneer and board products.

Of course, it is within the scope of the system to break the rind by chipping and shredding concurrently, such as by separating the rind feed from the stalk component separating zone 6 into more than one input to the rind breaking zone 140.

Referring again to FIG. 14, after the rind has been broken or reduced to chips or shreds or the like, the rind is passed to a water contacting zone 148 to extract residual sugar juice and other water solubles from the rind. This rind may contain about 1 to 2 percent of the sugar in the whole can stalk. For the most part, the sugar that is in the rind comes from the pith cells that were fractured which allowed some of the juices to drain into the rind.

The previously described rind breaking or reducing operation aids in the extraction of sugar from the rind, for it allows more rind surface to be exposed to the contacting water, and ruptures rind cells allowing the water to wash away the sugar juices.

The water contacting or sugar extraction treatment for the rind usually comprises a cold water contacting zone 150 to extract sugar juice from the rind, and a hot water contacting zone 152 to remove lignin, natural resins, and certain minerals. When using both a cold water contacting treatment and a hot water contacting treatment, the cold water contacting zone 150 is the first treatment unit after the rind has been broken or reduced. Cold water unit 150, described below, is of the same type as the water contacting unit used for extracting sugar juice from the pith, as will be discussed later.

Referring now to FIG. 17, the rind from the chipping and/or shredding operation is discharged at 151 onto a perforate screen type, endless conveyor 154 which moves across a series of troughs 156 to discharge the sugar juice exhausted rind to the hot water unit 152. In this cold water unit 150 sugar and water solution is circulated by pump P out of the base 158 of each trough to an overhead distributor or spray 160 which discharges onto the adjacent upstream trough. This upstream circulation pattern of the water is designed to build up an increasing concentration of sugar to the first trough 156a at the rind feed inlet of the unit 150 where a sugar and water solution is drawn off with a maximum sugar content. At the last trough 156z at the downstream end or rind exit of each cold water con-

tacting unit 150, make up or fresh water is added at 157.

The fluid from the first trough 156a, which is the discharge fluid and contains the sugar removed by the cold water extraction, is conveyed to settling tanks (not shown) which also receive the stream of sugar-containing fluid coming from the water contacting unit associated with the pith treating zone 8.

Of course various modifications such as the using of two or more parallel screen conveyors, common troughs for two or more distributors, and control means such as flowmeters, and flow responsive pumps and conveyors may be incorporated into the above apparatus.

In the cold water contacting unit 150 for the rind, the water temperature should be on the order of about 60° to 80° F. Water of ambient temperature can be conveniently used.

After leaving the cold water contacting zone 150, the rind passes to a hot water contacting zone 152 to extract hot water soluble materials such as lignin, natural resins, and certain minerals. Alternatively, in some commercial operations, it may not be feasible to attempt to treat the rind any further, and the rind may be discarded at this point. At the hot water contacting zone 152, the rind is contacted with hot water in a suitable manner to extract the hot water solubles.

For example, referring to FIG. 18, hot water at about 180° to 210° F is introduced into the top 162 of a tower or tank 164 in a hot water contacting unit. The hot water containing the soluble materials is taken out of the lower region 166 of tank 164. The rind from the cold water contacting zone 150 is pumped as a slurry into the middle portion 172 of tank 164 and is taken, counter current to the movement of the hot water, out of the top 168 of the tank 164 via endless perforate conveyor 190 and is then dried.

After leaving the water contacting zone 148, the rind can be dried in a conventional air dryer 174 or the rind can be dried in the atmosphere without any mechanical drying means.

The production of these rind portions, instead of bagasse, is a considerable advantage afforded by this process. The rind fiber bundles can be manipulated and processed into a variety of different forms, having a variety of uses, e.g., building boards, planks, mats, flexible sheets and the like. Rind chips can be used for paper manufacture. If commercially desirable, the rind portions may be burned as fuel rather readily, whereas bagasse, normally recovered as a soggy residue from other sugarcane processes, must be burned in specially constructed furnaces.

FIG. 19 shows a block diagram of the pith treating zone 8 or unit. Pith from the milling unit in the separating zone 6 and residual pith from the shaker 124 are combined in a pith receiving hopper or unit 138.

From this hopper or unit 138 the pith is passed to a pith treating zone 8 to extract juice from the pith. The juice can be extracted from the pith by washing and pressing the pith. The washing and pressing can be done serially, concurrently, or both by splitting the pith feed.

As shown in FIG. 19, the pith is transported to a water contacting unit 176 which can be of the same type as the rind/cold water contacting unit 150, shown

in FIG. 17, except that the temperature of the water which contacts the pith can vary from relatively cold to relatively warm water. More particularly, the water in the pith contacting zone can vary from about ambient temperature, i.e., about 70° F., to about 170° F.

As in the rind/cold water contacting zone, conveyor means move the pith progressively across a series of longitudinally displaced but contiguous troughs. From the base of each trough the water is circulated by pumps to an overhead distributor or spray which discharges into the adjacent upstream trough. The input or make-up water which is added to the upstream trough can be made up of both fresh water as well as water which may be expressed from the pith in a later downstream pressing operation.

The wet pith discharge from the water contacting zone 176 is transported such as by conveyor means to a pressing operation 178 to express sugar water from the pith. A representative roller type continuous press which is suitable, is described in U.S. Pat. No. 2,146,158.

The dewatered pith is light, fluffy, floc-like material. This pith floc is readily dryable when exposed to air and rapidly reaches ambient moisture content. The pith floc can be manufactured into desirable commercial commodities or can be used directly as fuel.

For example, the pith can be subjected to an abrading or rubbing operation using disks or plates to abrade the separate pith into its fibrous and nonfibrous constituents. Representative disk abrading machinery is illustrated in the *Chemical Engineers Handbook*, John H. Perry, Fourth Edition, McGraw Hill, 1963, pages 8/39 to 8/40. This mass of fibrous and nonfibrous material can then be segregated such as by an air/gravity method. The nonfibrous pith is essentially loose cellulose which can then be used for commodities such as raw material for explosives, etc. Fibrous pith can be baled or pelleted for use in pulp and paper manufacturing.

The diluted sugar juice from the first downstream trough of the rind/cold water contacting unit and the pith/water contacting unit is then recovered. This raw juice can be collected in a suitable container such as a tank or vat and treated in yet another operation to purify it.

In one method of treating raw juice (not shown), the diluted sugar juice goes to a settling tank to separate certain insoluble solids such as fine soil, sand, and ground rock. The raw juice can also be screened one or more times. The juice is then passed to a mixing tank where slaked lime is added to clarity or purify the juice. In general, sufficient lime is added to neutralize the organic acids present in the juice, after which the temperature is raised to about 180° to 210° F. This lime and heat treatment forms a heavy precipitate of complex composition, part lighter and part heavier than the juice, which contains insoluble lime, salts, coagulate albumin, and varying proportions of fats, waxes and gums. The flocculent precipitate carries with it most of the finely suspended material in the juice that has escaped mechanical separation. The separation of this precipitate from the surrounding juice can be accomplished by subsidence and decantation or by centrifuging.

In some operations the jaw juice collected may be of sufficient purity so as to eliminate the above mentioned clarifying operations and it may be passed directly to a further juice treating operation step, evaporation of the juice to syrup and sugar crystals.

Of course, automatic control can be used in appropriate parts of the system. For example, the addition of lime to the juice in the clarification operation can be controlled by monitoring the pH of the juice solution with suitable actuating mechanisms to control the addition of lime.

In addition, many additives can be used to aid clarification such as soluble phosphates, clay, and synthetic water soluble polymers.

After the sugar juice is purified, sugar juice is crystallized to develop satisfactory sugar crystals from the syrup or molasses. This is usually accomplished by a vacuum process.

As for the epidermis material which has been milled away from the rind in the separating zone 6, it can be further treated to obtain valuable wax bearing materials from it.

Referring to FIG. 20, epidermis which has been transported from the separating zone 6 is delivered to an epidermis treating zone 12 to recover wax therefrom. In one method of separating the wax bearing materials from other epidermis material, a slurry 181 of the milled epidermis is fed to the lower portion 182 of a water filled separating tank 184 with the wax bearing material floating to the top 183 and being recovered by a skimming or weir mechanism 185 and the heavier epidermis material settling to the bottom of the tank 184.

The epidermis can also be subjected to mechanical agitation to separate the wax from the epidermis. For example, the epidermis may be air agitated and gravity separated.

MAJOR ADVANTAGES AND SCOPE OF THE INVENTION

Thus, the sugarcane processing described above utilizes a systematic approach to the transformation of a large tangled mass of randomly oriented sugarcane stalks into their pith, rind, and epidermis components which are then treated to obtain valuable commodities such as sugar juice, pith floc, cane fiber and cane wax.

In one embodiment, this invention is particularly suitable for receiving bulk masses of randomly oriented cane stalks and delivering them for subsequent processing in cleaned condition and chopped into short uniform lengths which are aligned longitudinally in their direction of travel.

In connection with this, an aspect of the invention resides in the manner in which cane stalks are subjected to a number of diverse forces which efficiently disentangle the stalks. These diverse forces include the dropping with simultaneous acceleration of leading portions of the stalk; a right angle junction effect which provides, in addition to the first effect, a lateral toppling or spreading of the canes; and an upward acceleration of the stalks to further disentangle and spread them.

Another delivery feature of the invention lies in the chopping rolls which cut the stalks with a high degree of uniformity of length. In this connection, the resilient

portions on the chopping rolls which both grip and advance the stalks during chopping are significant.

Other delivery aspects of the invention include the provisions for cleaning the mass of sugarcane stalks. Here, the gaps between the conveyors along with fluid laundries are quite significant.

Other and further advantages are gained, through the present invention, in the cane component separating zone.

An advantage of the invention resides in the utilization of the disclosed milling rolls as devices for removing both the epidermis and rind components of sugarcane stalk. The essentially radial and planar milling ridges of these rolls provide an easy to fabricate, yet structurally rugged and highly reliable milling device which effectively removes either pith or epidermis without disrupting or damaging the rind fiber structure. The relatively small character of the milling roll, coupled with the radial configuration of the milling ridges, contributes to ease of and economy in fabrication of the milling rolls. The operating life of such rolls is quite long so as to produce unusually sustained periods of separator operations.

The toothed gripping roll which cooperates with the milling rolls to limit the velocity of stalk material being milled is also significant.

In positively controlling stalk material velocity without significantly damaging the rind fibers, the toothed gripping mills provide effective feed control of the stalk material as it is being milled. This velocity control and overall stabilizing of the stalk material provides for positive control throughout the milling operation with minimum structure. Obviously, this arrangement, through its simplicity and reliability, contributes to the ability to effect high-speed milling of stalk material.

The combined effect of the milling and gripping rolls of producing rind flattening and either pith or epidermis removal is significant. It completely avoids recourse to separate, stalk flattening equipment.

Even further advantages reside in the treating of the separated components so that sugar juice, cane fibers, and other valuable commodities can be obtained.

Residual pith can be removed from the rind by a shaking operation which would result in a higher percentage of the pith being recovered.

The breaking of the substantially de-pithed rind significantly increases the rind surface area as well as ruptures rind cells which allows direct contact with the extracting liquid to increase yield.

By treating the broken de-pithed rind with first relatively cold water and then hot water, it is possible to obtain most of the water solubles present in the rind without a subsequent operation to separate sugar from the lignin, minerals, and other hot water soluble material.

Since the separated pith is substantially rind-free, it may be used directly in other applications after the sugar has been taken out without any pith purifying or cleaning operation.

Principal advantages are gained through the overall system, for maximum sugarcane component separation is achieved with minimum expense of energy, space, processing time, and waste.

In describing the invention, reference has been made to preferred embodiments. Those skilled in the sugarcane handling and processing art and familiar with this disclosure, however, may well recognize additions, deletions, substitutions, or other modifications to the system which would fall within the purview of the invention as defined in the appended claims.

I claim:

1. Apparatus for treating sugarcane, said apparatus comprising:

conveyor means adapted to convey the mass of stalks in a feed direction,

aligning means operatively connected with said conveyor means adapted to align the stalks longitudinally in the direction of travel of said conveyor means,

chopping means operatively connected with said conveyor means adapted to chop the stalks transversely thereof into relatively shorter lengths while the stalks are traveling longitudinally,

a series of separate conveyor means adapted to successively receive and convey the chopped stalk material, said conveyor means further including:

at least one pair of successively related conveyor means defining a first junction, said first pair of conveyor means having their respective directions of travel thereof upstream and downstream of said first junction linearly aligned, said pair of conveyor means adapted to subject the chopped stalk material to a vertical deflection at said first junction and to simultaneously subject the leading edge portions of individual chopped stalks to a force in the

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direction of travel of the one of said pair of conveyor means receiving the stalks downstream of said first junction, and

a second pair of successively related conveyor means defining a second junction, said second pair of conveyor means having their respective directions of travel thereof upstream and downstream of said second junction disposed in transverse relation, said second pair of conveyor means being adapted to subject the chopped stalk material to an abrupt vertical deflection and to simultaneously subject the leading edge portions of individual chopped stalks to a force in the direction of travel of the one of said second pair of conveyor means receiving the stalks downstream of said second junction.

2. The apparatus of claim 1, said apparatus further comprising fluid directing means operatively connected with said conveyor means for directing fluid through the stalks to remove trash at some point during their conveyed motion.

3. The apparatus of claim 2, said apparatus further comprising conveying means including a transversely extending vertical discontinuity in said conveying means across which the mass of stalks are adapted to be projected at high velocity by said conveyor means causing the mass of stalks to become at least partially air borne, and said fluid directing means being operatively connected with said conveyor means for directing fluid transversely through the mass of stalks during their air borne condition to remove trash.

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