

Sept. 2, 1969

R. B. MILLER ET AL
SUGARCANE PROCESSING

3,464,877

Filed July 22, 1964

3 Sheets-Sheet 1

FIG. 2

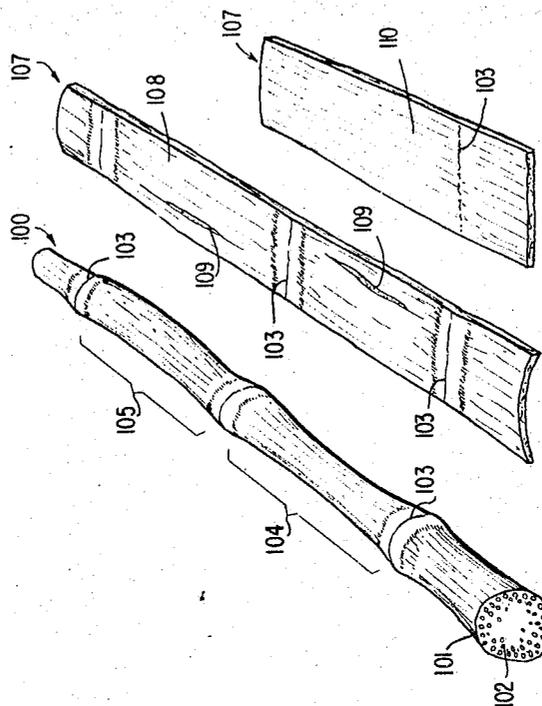
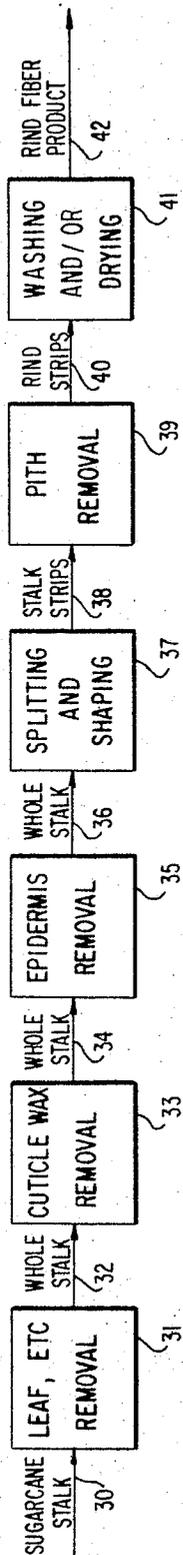
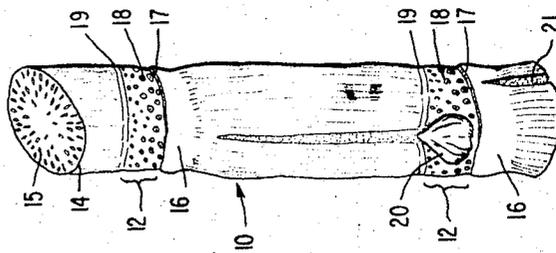


FIG. 7

FIG. 6

FIG. 5

FIG. 1



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FIG. 3

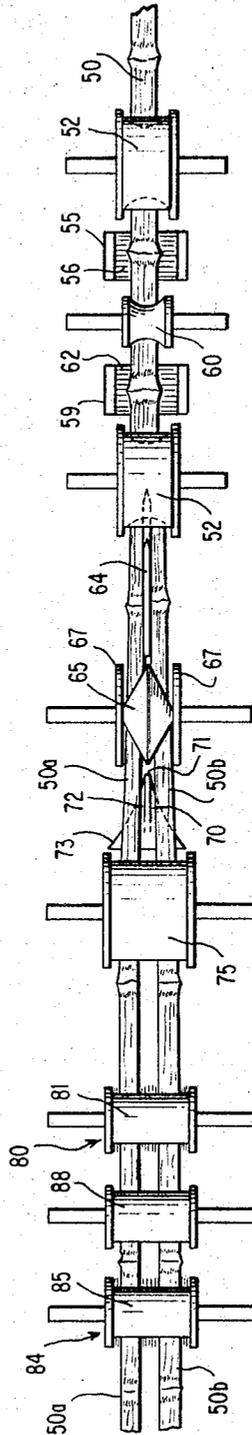
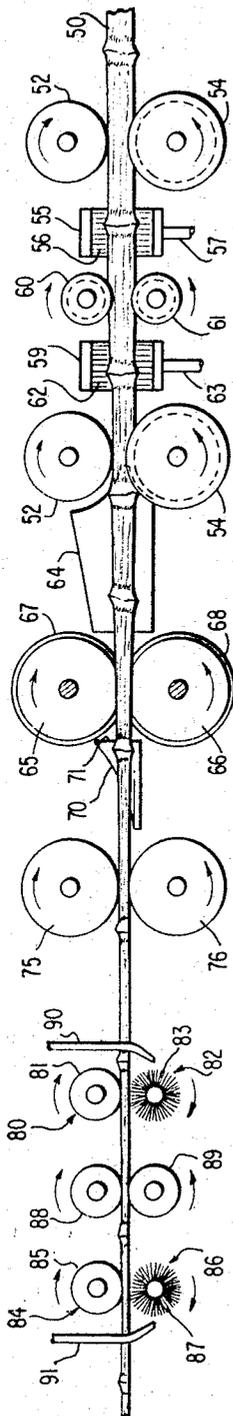


FIG. 4

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FIG. 8

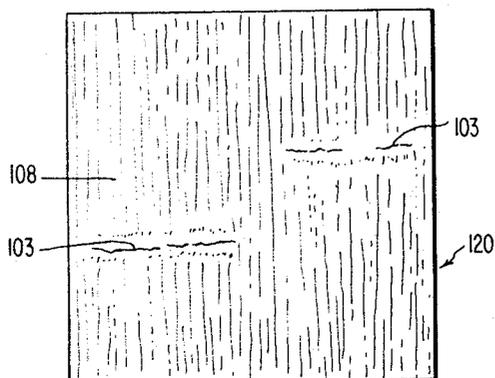


FIG. 9

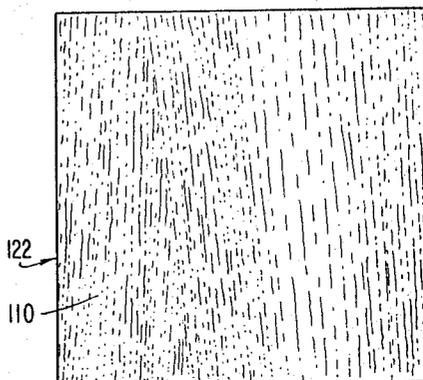


FIG. 10

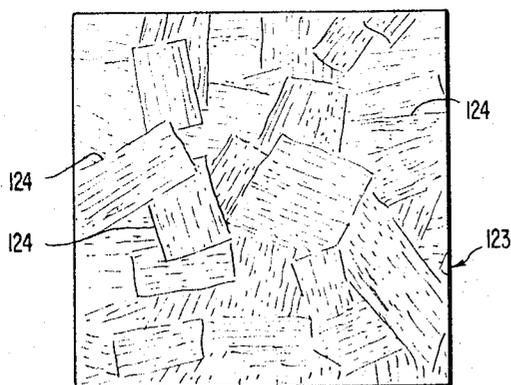
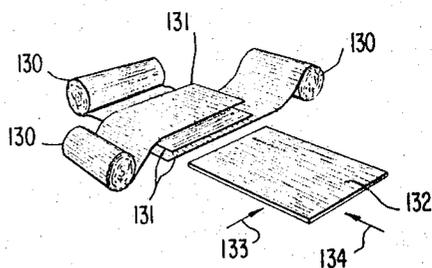


FIG. 11



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SUGARCANE PROCESSING

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5 Claims

ABSTRACT OF THE DISCLOSURE

A process for treating sugarcane to obtain unitized strips of laterally interconnected fibers of sugarcane rind by removing the pith from one side of the rind and the epidermis material from the other side of the rind without disturbing the rind fibers. The rind fiber strips are subjected to forming pressure and unitized in a desired configuration.

This invention relates to the manufacturing of products from the stalk of sugarcane. More particularly, the invention relates to a novel process and apparatus for treating sugarcane stalk to manufacture a commercial fibrous product from the outer rind of the stalk and further to manufacture from this fibrous product a variety of building products.

Sugar from sugarcane is produced by a process which initially requires the violent destruction of the whole cane stalk by the use of massive machinery that cuts, crushes, shreds and breaks the whole cane stalk, and then, under enormous pressure, forcefully squeezes out the natural juices. This is referred to as milling; and while it has been used successfully in the extraction of the juices from the whole cane, it destroys many desirable structural characteristics of the rind portion of the stalk. The primary commodity sought from the usual methods of processing sugarcane, and in fact the only commodity normally derived from sugarcane, is the actual sugar itself with little or no regard to the recovery of other products. A by-product of conventional sugarcane processing is bagasse, or megasse as it is called in some areas, which is the fibrous or woody portion of sugarcane. A major quantity of the bagasse produced at the various sugarcane mills throughout the world is used as fuel for generating steam power for running the mills or it is burned merely to get rid of it. Since considerably more bagasse is produced than can be used as fuel, disposal of the excess is a serious problem. Large sums have been spent on trying to find ways of readily disposing of the bagasse or developing it into a commercial product. Efforts in this direction have not been completely satisfactory.

It has been discovered that the fibrous structure of the rind of sugarcane has special desirable physical and structural characteristics when the fibers are used in the form of fiber bundles. In the milling required by conventional processes for handling sugarcane, these desirable fiber characteristics are totally destroyed, and it is not possible under any circumstances in conventional sugarcane processes to preserve these characteristics. The problem concerns more than processing the rind alone, since it is necessary at the same time to consider the recovering of the juice from the stalk as well as the recovering of the rind fibers in such a condition as to preserve these characteristics. With conventional processes and apparatus it is virtually impossible to extract the juice from the sugarcane and at the same time maintain the rind fibers in a substantially discrete, continuous or undisturbed rind form so that the rind fibers can be utilized in the manner contemplated by this invention.

The rind portion of sugarcane stalk contains numerous fiber bundles, sometimes called fibrovascular bundles, which are groups of elemental fibers in discrete elongated units. The elemental fibers of sugarcane rind resemble somewhat the elemental fibers of ratan and hackberry, but differ materially from the bast fibers as found in certain dicotyledonous plants as flax, hemp, ramie and jute. The fiber bundles in the rind of the sugarcane differ materially from the fibrovascular bundles of certain monocotyledons as sisal, hemp, raffia, pineapple and ristra, manila hemp and other such plants. Although there are similarities between the elemental fibers of these plants and elemental sugarcane fibers, sugarcane rind contains fiber bundles which have been found to make the sugarcane rind particularly useful in the manufacture of products as will be explained.

The rind produced by this novel process and apparatus is a highly useful product not heretofore obtainable by conventional processes and apparatus for handling sugarcane. The fiber bundles can be processed into a variety of different forms; for example, building boards, planks, mats, flexible sheets, and the like, having a variety of uses. The rind product of this invention has fiber bundles which, in effect, are unbroken and undisturbed. When the rind strips are laid side-by-side and subjected to suitable pressure, an action takes place termed fiber flow. While normally the fiber bundles make up discrete strips, when subjected to pressure, the fiber bundles flow or move transversely with respect to their length and can be pressed into a continuous homogeneous mass of aligned long fiber bundles wherein each strip loses its identity as such.

One object of this invention is to provide a new method of processing sugarcane and a new apparatus, which method and apparatus make compatible the recovery of substantially undisturbed rind fiber bundles as well as sugar juices.

Another object of this invention is to process substantially all of the sugarcane stalk into products, particularly rind fiber products, not heretofore obtainable by ordinary methods and apparatus and at the same time eliminate the production of bagasse.

Another object of this invention is to provide a novel processing for handling a sugarcane stalk and for separating the stalk into certain components.

Another object of this invention is to produce from sugarcane a highly desirable fiber commodity which is suitable for further processing and use in a variety of industries.

Another object of this invention is to provide from sugarcane a rind fiber substantially free from pith fiber.

Another object of this invention is to provide new building products from the rind fibers of sugarcane which products have superior strength and appearance.

Briefly, these objects are accomplished as follows. The sugarcane is harvested according to usual practices wherein it is customary that the leaves be removed before processing of the cane begins. Preferably, the field dirt is washed off the cane. Instead of handling the sugarcane stalks in mass or in bulk as in conventional processes, the sugarcane stalks are processed individually, although several stalks may be processed simultaneously. This is a radical departure from previous approaches in the processing of sugarcane.

The cuticle was is removed from the outer surface of each whole stalk together with dirt and other foreign matter. The raw cuticle wax may be recovered and processed further. Next, the epidermis is removed. Each whole stalk is then split longitudinally. The two stalk halves are separated, carefully rotated, and flattened, thereby exposing the pith which then is separated from the rind. The handling of the whole stalk and the stalk

halves is done without any effective squeezing of the pith to express therefrom the juice or without materially damaging or disturbing the long fiber bundles of the rind. The pith, only after being separated from the rind, is pressed to extract therefrom the desirable sugar juices. The pith with the juice expressed therefrom may be processed further.

The rind strips then may be collected, baled and stored, and eventually used in the manufacture of paper, chemicals, rayon, insulating board, or a variety of other products. In accordance with this invention, the rind strips can be used to make rigid and semi-rigid building products and flexible mat products by subjecting a series of the rind strips to pressure and a binder. The rind also may be used to provide laminates of finishes of various texture to numerous core or base materials by pressing the strips onto such materials.

The apparatus of this invention includes a series of stations at which the cane is treated. Each stalk is handled separately and is propelled with continuous motion through the apparatus; that is, a whole stalk is introduced into the apparatus and as the apparatus runs continuously, the stalk is separated into its component parts. Generally, the main stations are aligned longitudinally of the apparatus. A series of guide and drive roller assemblies are provided for propelling the stalk in such a manner as to forcefully advance the stalk longitudinally of the apparatus but so as not to compress or squeeze the rind in a transverse or radial direction. The guide and drive roller assemblies include one roller with a flexible circumferential surface cooperating with a second roller having a concave circumferential surface to receive therebetween the stalks.

A series of rotating brushes or scraping means at the first main station remove the cuticle wax from the stalk. These rotating brushes may have metal bristles or bristles made of other material which pass over the exterior of the cane to remove the soft and hard waxes without crushing the rind or squeezing the pith. Two or more groups of brushes may be used to make certain that substantially all of the exterior wax is removed. At a subsequent station the epidermis and foreign matter are removed by additional rotating brushes.

The next station includes a stalk cutting device; for example, a stationary blade. The whole stalk is forced into the blade by a roller assembly and thereby the stalk is divided into two elongated stalk halves. The stalk halves are then separated at the next station by a pair of cooperating roller elements which engage the rind but not the pith. At the succeeding station, a stalk turning member twists each stalk half approximately one-quarter turn so that the pith in each stalk half is loaded beneath the rind. The pair of stalk halves engage opposite sides of a forward, vertically extending plate portion of the stalk guide member and then slide over a curved surface which merges with a horizontally extending rearward plate portion.

The two stalk halves slide off the stalk-turning member side-by-side and move to the next station comprising two rollers having vertically spaced apart cylindrically shaped surfaces for receiving therebetween the stalk halves. These two rollers, in effect, flatten out and lay open the rind of the stalk halves to expose the pith for the next station which includes a series of rotating brushes or scraping means located beneath the path of the stalk halves. The bristles of the brushes are positioned to remove the pith from the rind without significantly compressing the pith. The bristles which engage the pith, in effect, move into or toward the oncoming pith, parallel to the rind in order to separate the pith from the rind. The pith, thus separated from the rind, contains most of the natural sugar juices. The rind strips are then collected for additional handling. Products are made of the fibers of the rind by subjecting the strips to pressure in the presence of a binder.

This invention is further explained with reference to the accompanying drawings in which:

FIGURE 1 is a perspective view of the details of a portion of a stalk of sugarcane;

FIGURE 2 is a schematic diagram illustrating the novel process of this invention;

FIGURE 3 is a side elevation view showing diagrammatically the apparatus of this invention;

FIGURE 4 is a plan view, corresponding generally with FIGURE 3;

FIGURE 5 is a perspective view of a typical portion of a stalk of sugarcane illustrating, among other things, various types of internodes;

FIGURES 6 and 7 are perspective view of typical rind strips of this invention, showing respectively the exterior and interior surfaces;

FIGURES 8, 9 and 10 are detailed views of the surfaces of products made from the strips shown in FIGURES 6 and 7; and

FIGURE 11 is a perspective view illustrating diagrammatically the manufacturing of board products of the fibers from rind strips.

Sugarcane is a member of the grass family grown in many tropical and subtropical areas of the world. In the past, it has been raised primarily and almost exclusively for the production of sugar. The principal part of sugarcane is the stalk which is made up of a number of joints called nodes and the stalk portion between the nodes, referred to as internodes. The leaf of the sugarcane plant consists of the sheath and the blade. The sheath is so situated on the node that it completely encircles the cane stalk. Each leaf usually extends the full length of the internode. The blades vary in width from one to three inches at the point of attachment to the sheath but taper to a sharp point. Leaf blades usually are four to five feet long and when growing on the plant, extend from the top portion. As the plant grows, the leaves along the internodes dry up and fall off.

FIGURE 1 shows a typical section of sugarcane stalk. This portion of the stalk 10 has two nodes 12, the part therebetween being an internode. The outer region or rind 14 of the internode is hard and contains numerous fibrovascular bundles that strengthen the stalk. The interior 15 of the stalk is mainly soft pith that contains most of the sweet natural sugar juice. The exterior of the mature internode is usually covered with a thin film of waxy bloom or cuticle wax, as it is frequently called. Wax is also found throughout the rind portion as well as on the surface. A ring 16 beneath the node 12 contains a high concentration of wax. A band 17 above the wax ring 16 is called the leaf scar. A root band 18 is a small section of the node just above the leaf scar 17 that usually differs in color from the internode and has many small dots. Under favorable moisture conditions, a root may develop at each dot, should the section of stalk 10 be placed in the ground. Just above the root band 18, and not usually clearly distinct from it, is a transition area known as the growth ring 19. Elongation and growth of the internode takes place in this area. A bud 20, when exposed to favorable moisture and temperature conditions and with proper stimulus, can develop into a new shoot. Expansion of the diameter of the stalk 10 may result in growth cracks 21 which may extend inwardly through the rind. Smaller, barely distinct, corky cracks may develop along the internode and separate the fibrous materials of the rind for short distances. Sugarcane ordinarily averages about 9 percent by weight of rind and about 91 percent by weight of water and soluble solids found in the pith.

FIGURE 2 shows schematically the novel process for the production of a fibrous article from the rind of sugarcane. The stalks, represented at 30, are harvested, the leaves are removed, and the cane may be washed at conventional cleaning plants or cane laundries, if desired, as represented at 31. In this invention, the stalks are processed separately, as represented at 32, compared with the

present processes wherein the stalks are processed in bulk.

Cleaning of the rind to produce fiber bundles free of foreign matter, loose fibers and other parts of the stalk is begun by removing the cuticle wax from the exterior of each separate stalk as represented at 33. This wax naturally adheres to the rind and is removed as a wax or powder. No attempt is made to remove that wax which extends through the rind—since this would require destroying or weakening the fiber bundles—but only the cuticle wax adhering to the exterior of the rind portion of the stalk along the internodes and at the wax band (see FIGURE 1). Since cane wax has commercial value, it may be collected and refined into commercially usable wax products.

The thin epidermis layer of fine, loose fibers is removed from the exterior of the rind, as represented at 35, in order to expose the relatively hard, strong fiber bundles. The epidermis has no structural value, and if left could materially lessen some of the physical as well as chemical properties of the rind strips ultimately produced. Since the epidermis of some varieties of sugarcane is quite colorful, for special uses, as will be explained, the epidermis may be left on. The important thing is to remove from the outside of the whole cane stalk all of the trash, wax, and loose matter, including the epidermis, although in some cases as just stated, the epidermis only may be left on. This cleaning of the stalk is effected without penetrating or damaging the fiber bundles of the rind.

The whole stalk 36 with the exterior wax and epidermis removed is further processed by cutting it longitudinally throughout its length into two parts to expose the interior pith and by spreading the rind, as represented at 37. The cutting and spreading serves the purpose of ultimately preserving the rind of the stalk in as large pieces as conveniently possible and at the same time opening up the stalk for access and removal of the juice laden pith. While this process has been carried out successfully by severing the stalk into two parts, it is possible to split each stalk longitudinally into more than two parts or to make a single longitudinal cut into one side of the rind only.

After the pith is exposed by splitting the stalk longitudinally, the pith is carefully removed from the stalk strips 38 without squeezing the pith to express the juice therefrom, as represented at 39. The stalk, at this station, is separated into two major components; namely, the soft pith containing most of the juice still held in the pith cells and the cleaned fibrous rind portions. At no point is the stalk subjected to pressure so as to express a substantial amount of juice; and, furthermore, the rind has not been subject to milling or any substantial physical force other than the single cutting action. After this separation step, the pith is ready for further processing to remove the juice. The rind is in the form of strips the length of the stalk pieces. Extremely crooked pieces of stalk can be cut crosswise into shorter pieces for easy handling prior to the start of process, if necessary.

The rind strips 40 may be washed by a water spray, for example, to remove loose particles and then dried, as represented at 41. It has been found that the strips dry readily in air, but if the strips are to be baled immediately after the pith is removed, it may be desirable first to pass the strips through a mechanical dryer. The rind strips 42 are relatively clean, undisturbed elongated groups of long fiber bundles. They may be processed further in the particular manner described below.

FIGURES 3 and 4 illustrate diagrammatically apparatus for processing sugarcane according to this invention. Whole cane stalks, such as the stalk 50, are introduced into the front of the apparatus after being de-leaved and preferably after being washed. The cane stalk 50 immediately is gripped between a pair of power-driven rollers 52 and 54 which serve to hold the stalk 50 in properly aligned position and to advance the stalk through the apparatus. The whole stalk 50 is propelled to the first of a series of treating stations comprising a rotating brush 55

in the shape of an iris with the stalk 50 passing there-through. The rotating brush has wire bristles 56 or bristles formed of another suitably stiff material, for example nylon, or the like. The bristles 56 extend radially from the longitudinal axis of the cane and rotate in a plane normal to the path of the stalk. As the bristles 56 rotate around and scrape over the outside surface of the stalk 50, they remove the cuticle wax as the moving stalk passes. As the bristles 56 pickup the wax dust, suction in a line 57 withdraws the wax from the bristle area and carries the wax off for recovery and processing. The bristles 56 may also remove extraneous matter such as field dirt which may not have been washed off. Preferably, the bristles 56 are of such length and of a pliable nature so that the wax portion only will be removed and the rind will not be penetrated. Bristles with a considerable amount of flexibility and rotating at a rapid speed are suitable for removing the wax. This invention also contemplates that other means such as scrapers may be employed for the removal of wax, as well as the bristles 56.

A second rotating brush 59 similar in construction to the brush 55 is spaced therefrom and receives the stalk 50 after passing through a pair of idler guide rollers 60 and 61. The brush 59 may have bristles 62 which are similar to the bristles 56, but which have characteristics suitable for removing the thin epidermis layer on the exterior of the stalk. The epidermis and other foreign matter is carried away by a conduit 63.

The whole stalk 50 then is engaged by another pair of rollers 52 and 54 which force the stalk 50 into a stalk severing station in the form of a stationary knife or blade 64 positioned in the path of the stalk. Other stalk severing devices may be used instead of the particular stationary blade 64, for example a moving saw may be used as well. Whatever form of stalk severing member is used, the pith within the stalk should not be subjected to sufficient pressure to express a material amount of the juice. It is desirable that as much of the juice remain in the pith at this point of the operation for extraction at a subsequent station.

After the stalk, which now is in two pieces, leaves the stalk severing station, it is propelled to the next station where it is spread apart and advanced by a pair of power-driven spreader wheels 65 and 66. The two halves of the stalk 50 are spread apart by back-to-back frusto-conical shaped surfaces of the wheels 65 and 66, and held in proper position by discs 67 and 68. The two halves of the stalk 50 are designated 50a and 50b. The frusto-conical shaped surfaces on corresponding sides of the spreader wheels 65 and 66 serve to engage the rind portion of one-half of the stalk rather than the inner soft pith portion. Since the rind is hard and rigid compared with the pith, little pressure if any is applied to the pith; and, consequently, juice is not extracted.

The stalk halves 50a and 50b leave the spreader wheels 65 and 66 partially spread and are forced to the next station comprising a stalk turning or aligned member 70 which serves to twist the two stalk halves 50a and 50b about one-quarter turn so that the pith or inner portion faces downward and the outer curved rind portions face upwardly. The aligning member 70 has a vertically extending thin plate portion 71 curving at the midsection 72 into a horizontally extending plate portion 73. The stalk halves engage and slide along the vertical portion 71 and by the time they reach the horizontal portion 73, they are properly positioned.

The next station comprises a pair of flattening wheels 75 and 76 which guide the stalk halves and prepare them for the succeeding station. Wheel 75 may have a flat, cylindrical surface for engaging the rind while wheel 76 may be a soft, surfaced air-inflated wheel, which together serve to flatten the rind somewhat to spread the stalk halves open farther in order to move completely expose the pith, yet which do not exert sufficient pressure to express a material amount of juice from the pith. These two

wheels 75 and 76 additionally serve to propel the stalk halves 50a and 50b into the succeeding station, at which time the stalk halves must be advanced relatively forcefully.

The forces applied to the stalk to effect the opening and preparation of the rind for removal of the pith are as follows: The whole stalk is pushed forward longitudinally by stalk guiding means which apply a limited pressure radially to the whole stalk and which are not substantially transmitted to the pith. The longitudinal forces are applied externally to the rind. The rollers 52 and 54, for example, apply a force to the stalk which is tangential rather than radial. The whole stalk is severed by a limited cutting action it being necessary to cut through the rind to expose the juice laden pith. The severing or cutting forces are applied to the rind, with as little pressure as possible applied to the pith. The cutting action should be applied longitudinally of the rind since the fibers extend longitudinally and a minimum of force is required. The rind is then pushed transversely of its path and rotated or twisted about one-quarter turn in such a manner that corresponding inner edges of the two halves along which the cut was made are turned inwardly so that the freshly exposed pith in both halves face the same direction. The forces causing the stalk halves to move in this manner are applied to the rind. Next, the rind is spread open or, in effect, flattened out from its naturally curved configuration in order to more completely expose the pith and to get the pith and rind oriented with respect to one another for separation of the pith and the rind. This handling of the stalk is accomplished without expressing a significant or material amount of juice from the pith.

At the next station, the stalk halves engage an assembly 80 for separating the pith from the rind. This assembly 80 comprises a top roller 81 which is a control or backup roller having a flat, cylindrical surface for engaging the top of the rind and a lower brush type roller 82. The bristles 83 of the brush roller 82 rotate into the path of the moving stalk halves. The bristles 82 may be of wire or of other suitable material and of suitable length to gently scrape the pith from the inside of the rind. The bristles contact the oncoming pith in tangential relationship with respect to the rind. Little or no compressing action is applied by the bristles to the pith in a direction normal to path of the rind. This prevents or substantially limits the amount of juice that will be forced out of the pith. This invention contemplates that devices other than the specific assembly 80 may be employed to remove the pith from the rind.

The action which effectively separates the pith from the rind comprises continuously moving the rind past a point beyond which the pith does not move, the actual separation being accomplished by mechanical means, for example brushes moving in a direction different from the direction of movement of the rind. The brushes engage the pith, and then move the pith away from the rind, rather than toward the rind. Since some pressure must necessarily be applied to actually force or tear the pith from the rind, some pith cells may be broken and juice released therefrom; but because of the relative movement of the mechanical means with respect to the pith, and the subsequent movement of the pith away from the rind, a major portion of the juice released, if any, will be absorbed by the oncoming pith and carried away with it; and very little juice, if any, will be pushed into the rind.

A second assembly 84 is spaced from the first assembly 80 for separating the pith from the rind and includes a control roller 85 and a lower brush type roller 86 similar to the brush roller 82, but which may have bristles 87 slightly stiffer and slightly shorter than the bristles 83 to assure that substantially all of the pith is separated from the rind. The speed of the rotating brushes also may be set differently so that forces of a different nature are applied to remove the pith. Additional assemblies such as the

assemblies 80 and 84 may be employed as necessary to remove adhering pith. A pair of idler rollers 88 and 89 are positioned between the assemblies 120 and 126 for guiding the stalk halves.

The pith removed from the inside face of the rind contains most of the sugar content of the cane stalk. To assist in the removal of the pith from the brushes 82 and 86, a fluid such as air may be forced through conduits 90 and 91 and adjusted to blow the pith off of the brushes and off the rind onto suitable conveyors for transfer of the pith for further processing to remove the juice. While apparatus for handling only one stalk is illustrated, the apparatus may be duplicated and aligned transversely side-by-side so that the same power supply may drive the various parts and several stalks may be handled simultaneously.

FIGURE 5 illustrates a typical section of whole rind stalk prior to processing. FIGURES 6 and 7 illustrate typical strips of rind produced by this process and apparatus wherein the exterior wax, as well as the thin epidermis layer, and the pith have been removed. The separate fiber bundles are generally unbroken and undisturbed, although the rind has been flattened out somewhat. The strips possess considerable tensile strength longitudinally.

The stalk portion 100 shown in FIGURE 5 has an outer rind 101 surrounding the inner pith 102. The stalk nodes are shown at 103 defining the internode portions 104 and 105. The internodes of sugarcane are not always cylindrical, that is the diameter at different points lengthwise tends to vary rather than be constant. Internode portions of sugarcane stalk take various forms and have been termed, for example, tumescent, bobbin-shape, conoidal, obconoidal and concave-convex. The internode portion 104 of the stalk 100 may be termed bobbin-shape since the middle of the internode is of a diameter smaller than the ends of the internode adjacent the nodes 103. The internode 105 of the stalk 100 may be termed concave-convex.

FIGURE 6 shows the exterior 108 of one-half of that portion of strip 107 which may be obtained from the stalk portion 100 of FIGURE 5. If there are growth cracks in the rind originally, such growth cracks may appear in the strip 107; for example, as at 109. Such growth cracks may extend all the way through the thickness of the rind strip. Because of the generally flattening of the strips, due to the action of the rollers of the apparatus, the nodes tend to disappear. There may be a discontinuance of the identity of the individual fiber bundles but not necessarily a reduction in the longitudinal tensile strength of the strip at each node. The outer surface of the strip 107 has the same general appearance as the outside surface of the stalk 100; however, the corky cracks tend to disappear upon flattening of the strip whereas they might be predominant in the whole stalk 100. The inside surface 110 of the rind strip 107 is shown in FIGURE 7 and has an appearance considerably different from that of the exterior. Various individual fiber bundles are not as pronounced and the surface is not as hard as the outer surface. The nodes are less noticeable on the inside; although, upon careful observance, they can be detected.

It has been found that a very desirable action or phenomenon takes place between the long fiber bundles of the rind making the strips highly suitable for the manufacture of boards, planks, mats, rolls and the like. When rind strips, such as the strips 107, are subjected to pressure, a movement of the fiber bundles takes place which for the sake of convenience hereinafter is called fiber flow. This has advantages considering both structure appearance. When the strips are subjected to pressure as by a press or by rollers, there is a tendency for the fiber bundles to separate and to move laterally of the longitudinal axis of the strip. The flow is dependent somewhat upon the moisture in the rind; that is, the fiber bundles in a slightly moist strip of rind flow more readily than the fiber bundles

in a completely dry strip of rind. While originally the strips are clearly distinguishable as discrete rind sections, once subjected to sufficient pressure the strips lose their separate identity due to the flow laterally of the fiber bundles, particularly those adjacent the edges. When several strips are laid side-by-side and pressure applied, the fiber bundles overlap and tend to intermingle thereby combining the strips into uniform, homogeneous mass of fiber bundles aligned generally in the same direction. The fiber flow, in addition to combining adjacent strips into a homogeneous mass, closes up the growth cracks and corky cracks so that they are no longer readily visible and, in some cases, actually nonexistent and the different shapes of the original internodes or the crooked configuration of the stalk disappear.

FIGURES 8, 9 and 10 illustrate the surface of board material made from the rind strips produced by this novel process and apparatus. FIGURE 8 shows the surface of a board 120 wherein the exterior surface 108 of the rind strips 107, for example, was placed so as to form the exterior of the board. A node can be detected at 103. Certain individual fiber bundles are easily recognized. FIGURE 9 shows the exterior face of a board 120 made from rind strips such as the strips 107 wherein the inner surface 110 was used as the exterior face of the board. A very close arrangement of fiber bundles is quite evident in the texture of this surface. FIGURE 10 illustrates a type of chipboard 123 made from strips such as the strips 107. The strips first were cut crosswise into short lengths approximately one inch long. A layer of the resulting chips 124 was subjected to pressure with a binder. The appearance of the board on both sides is essentially the same. This type of board represents the versatility of the rind strips. In addition, the rind strips can be broken up to make a board resembling conventional hardboard.

Boards, of substantial but varying thickness, can be made out of the long fiber bundles of the rind strips. Also, relatively thin, flexible sheets or mats can be made. Generally, these are formed by aligning a number of strips side-by-side on the lower plate of a press. The desired thickness of the resulting product can be selected by the depth to which the strips are piled in the press. When making the board or mats, the node 103 can be aligned alternately so that adjacent strips do not have nodes located side-by-side. While there is no noticeable decrease in strength of the strips at the nodes, since a number of fiber bundles on the inside of the rind continue through the nodes, the overlapping of the nodes adds considerably to the appearance of the resulting boards or mats, particularly if the exterior of the stalk is to become the exterior of the board or the mat.

An adhesive or binder substance is used to bond the strips. The binder can be applied to each strip before it is placed in the press or it can be applied to the strips as necessary for consistency after the strips have been positioned in the press. The binder can be in wet or dry form and can be applied to the strips by dipping, spraying, dusting, painting, etc. Pressure is then applied to the group of strips. Depending on the binder, heat may or may not be used. The dimensions of the resulting board or mat depend on the size of the press and arrangement of the strips. A board or mat structure can be formed by aligning all of the strips in one direction, by aligning strips crosswise in alternate layers, or by placing the strips in random fashion.

Boards with an endless variety of surface textures and patterns can be created. Different designs can be made by varying the alignment of the strips. The strips can be cut into different shapes to produce different designs or textures.

Rind strips can be made with the epidermis left on, and since the epidermis of certain varieties of sugarcane have considerable color this can be used to advantage. Boards having colorful surfaces can be manufactured by

using rind strips with the epidermis left on as the exterior surface of the resulting board product. By using whole strips with long undisturbed fiber bundles as the interior of the board, the strength of the board can be maintained even though the fibers on the surface add little or no strength to the board.

The strips can be made up in rolls 130, illustrated in FIGURE 11. Such rolls consist of continuous fiber bundles aligned adjacent one another in uninterrupted fashion throughout the length of each roll. The fibers may extend lengthwise or transversely when the strips are manufactured into the rolls, and the rolls can be made into practically any length or width desired. The long fiber bundles in the form of the rolls 103 can be manufactured further into boards of considerable strength by aligning the bundles of several different rolls alternately in opposite directions, as illustrated in FIGURE 11, and then bonding the overlapping portions 131 of the several rolls in a composite board structure 132 having the bundles of alternate laminates extending in opposite directions as represented by arrows 133 and 134. The number of such laminates employed may vary depending on the desired thickness of the finished board and the thickness of roll material used. It has been found that the boards manufactured by this method exceed the strength of plywood of comparable dimensions.

Boards of various characteristics have been made in accordance with this invention as follows: Example 1: Twenty parts of liquid phenol-formaldehyde resin was applied on the surface of eighty parts of sugarcane rind strips. The resin coated strips were then placed between platens of a heated press and pressure was applied and the resin was allowed to cure bonding the strips together, resulting in a strong, hard board. Example 2: One hundred parts of sugarcane rind strips was coated uniformly with two-tenths of one part of phenolic resin powder, then placed in a heated press, and pressure applied. A hard smooth board of good strength and excellent appearance resulted. Example 3: One hundred and twenty parts of sugarcane rind strips was coated with ten parts of malamine-resin fortified urea-formaldehyde resin, placed in a heated press and the mixture cured, forming a board of exceptional hardness and strength. Example 4: A board made up of two parts of melamine-formaldehyde resin and ninety-eight parts of sugarcane rind strips in the manner described above was very hard and strong. A cleat of this material was made and driven by a hammer through a one-inch pine board. Example 5: One hundred parts of sugarcane rind strips was coated with eight parts of urea-formaldehyde resin. The composition was allowed to cure in a hydraulic press under heat and pressure. A strong board resulted. Example 6: One hundred parts of sugarcane rind strips was coated with three parts of phenolic resin, and the composition was placed in a heated press and heated under pressure. The resin cured bonding the strips together, resulting in a strong hard board. Example 7: One hundred parts of sugarcane rind strips was coated with thirty parts of epoxy resin, to which was added three-tenths of one part of curing agent triethylenetetramine. The composition was cured into a hardboard under heat and pressure. Example 8: One hundred parts of sugarcane rind strips was boiled for twenty minutes in 500 ml. of three percent sodium hydroxide solution, then washed and allowed to dry at room temperature. The dried sugarcane rind strips were coated with five parts of phenol-formaldehyde resin and formed into a board under pressure between platens of a heated hydraulic press. A beneficial effect on strength and a smooth board of coarse grain resulted by treating sugarcane rind with aqueous alkali. Example 9: The rind strips were treated as in Example 8 with sulfuric acid, and then formed into a board as in Example 8. A much weaker board resulted.

The rind strips, because of their unique and distinctive appearance, can be used effectively as an exterior laminate

over ordinary plywood or other base or core material. This has been done by taking an ordinary sheet of plywood, laying strips of rind thereon and applying a pressure after coating the strips with a binder material. This adds an extremely unique and ornamental surface to ordinary plywood. It has been found that plywood can be strengthened if the plywood is used as a base and a veneer of fiber bundles is applied thereto. This was accomplished by placing one quarter-inch, three-ply plywood in a press, laying a cover of rind strips in one direction over the plywood, applying a binder thereto, and then subjecting the strips and the plywood to pressure, then adding a second cover of strips aligned in perpendicular fashion to the first veneer of strips, applying a binder thereto, and then subjecting the plywood and first veneer, along with the second cover of strips, to pressure to make a composite board. The resultant board structure possessed considerably greater strength than the original plywood board. While this was carried out in two steps, it could be done in one operation.

In the manufacture of boards and mats, and similar products, it is necessary only to place the rind strips loosely in position in a press and no special care or careful alignment of the strips is necessarily required. This is because of the fiber flow action which allows the individual fiber bundles to move into close proximity to one another and fill the spaces therebetween. Only a minimum amount of binder need be used to obtain exceedingly strong products, as the preceding examples show. The fiber bundles of the sugarcane rind obtained by this invention appear to possess a natural coherence capability when subjected to pressure. The pressure applying apparatus may comprise a conventional stationary press of the type having cooperating flat platens. Alternatively, the pressure applying apparatus may comprise cooperating rotating roller elements.

Any number of adhesive or binder substances and proportionate amounts thereof can be used to make board and similar products from the rind strips, and different pressures can be applied depending upon the characteristics desired of the resulting product. A pressure of less than 100 p.s.i. with about .2 percent by weight of binder has produced boards entirely satisfactory for certain uses. A pressure of about 500 p.s.i. with as little as 2.0 percent by weight of binder produces an extremely strong, hard surfaced board comparable to some hardwoods. Higher pressure can be used to increase the density of the board to the point desired. The strength of the board products is attributed to the exceptional strength of the long fiber bundles of the rind strips prepared by this invention wherein the fiber bundles are unbroken and relatively undisturbed, and to the fact that the fiber bundles are cleaned of substantially all foreign and loose material, for example the exterior rind wax, the epidermis and the pith. The removal of the epidermis clearly enhances the apparent natural bonding obtained between fiber bundles. Since the natural bond between the epidermis and the rind is generally quite weak, failure to remove the epidermis will introduce points of weakness throughout the board product. Furthermore, the epidermis can obstruct the penetration of the adhesive or the binder substance and prevent contact between the fiber bundles of different rind strips.

The surface hardness of various board products made according to this invention is comparable to polyester glass or aluminum. Board products can be manufactured which exceed certain hardwoods in strength. The cane wax left remaining throughout the rind reduces the water swelling of the board products. In this connection, the tendency of the boards to absorb moisture can be reduced further, if necessary, by using wax-based sizes, for example. Flame retardance of the boards can be obtained by treating the strips with compounds of boron, phosphorus, chlorine and bromine.

Whereas conventional processes for extracting the juice

from sugarcane require the cutting, grinding and shredding of the rind of the stalk into begasse, this process and apparatus provide for the recovery of the juice without the destruction of the long fiber bundles of the rind. Accordingly, instead of producing a mass of broken fibers intermingled with the pith of the stalk, this process and apparatus produce whole rind fiber bundles in the form of rind strips which strips are particularly suitable for the manufacture of building products such as boards and mats, as described above.

We claim:

1. A process for treating sugarcane stalk to obtain unitized strips of laterally interconnected fibers of sugarcane rind, said process comprising:

longitudinally opening sugarcane stalk to provide a plurality of longitudinally extending sugarcane stalk segments each having a unitized periphery strip of sugarcane rind;

removing substantially all of the sugarcane pith material from said sugarcane stalk segments without substantially penetrating and disturbing the fiber bundles of such sugarcane rind periphery strips, and while maintaining the rind periphery strips of said segments unitized;

collecting the unitized rind periphery strips from which said sugarcane pith material has been removed;

prior to the collecting of said sugarcane rind periphery strips, removing material from the exterior of the sugarcane rind to expose the exterior fiber bundles of the rind; and

limiting the forces applied to said sugarcane rind to effect the removal of material from the exterior of the sugarcane rind and the forces applied to said sugarcane stalk segments to effect the removal of sugarcane pith from the sugarcane stalk segments so as to maintain fiber bundles of said sugarcane rind periphery strips laterally interconnected and unitized.

2. A process for treating sugarcane stalk to obtain unitized strips of laterally interconnected fibers of sugarcane rind, said process comprising:

splitting sugarcane stalk to provide a pair of longitudinally extending sugarcane stalk segments, each having a unitized periphery strip of sugarcane rind; removing substantially all of the sugarcane pith material from said sugarcane stalk segments without substantially penetrating and disturbing the fiber bundles of such sugarcane rind periphery strips, and while maintaining the rind periphery strips of said segments unitized;

collecting the unitized rind periphery strips from which said sugarcane pith material has been removed;

prior to the collecting of said sugarcane rind periphery strips, removing material from the exterior of the sugarcane rind to expose the exterior fiber bundles of the rind;

limiting the forces applied to said sugarcane rind to effect the removal of material from the exterior of the sugarcane rind and the forces applied to said sugarcane stalk segments to effect the removal of sugarcane pith from the sugarcane stalk segments so periphery strips laterally interconnected and unitized; and

throughout the removal of sugarcane pith from said sugarcane stalk segments, maintaining the rind periphery strips substantially uncontaminated by sugar juice contained within said sugarcane pith.

3. A process as described in claim 2 including the additional step of applying mechanical force to the fiber bundles of the rind while the rind contains moisture, to loosen the natural bond between the fiber bundles.

4. A process as described in claim 2 comprising the additional step of reducing the fiber bundles of said sugarcane rind periphery strips into particulate material and compressing said particulate material.

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5. A process for treating sugarcane stalk, said process comprising:

splitting sugarcane stalk to provide a pair of longitudinally extending sugarcane stalk segments each having a unitized periphery strip of sugarcane rind; removing substantially all of the sugarcane pith material from said sugarcane stalk segments without substantially penetrating and disturbing the fiber bundles of such sugarcane rind periphery strips, and while maintaining the rind periphery strips of said segments unitized;

collecting the unitized rind periphery strips from which said sugarcane pith material has been removed; prior to the collecting of said sugarcane rind periphery strips, removing material from the exterior of the sugarcane rind to expose the exterior fiber bundles of the rind;

limiting the forces applied to said sugarcane rind to effect the removal of material from the exterior of the sugarcane rind and the forces applied to said sugarcane stalk segments to effect the removal of sugarcane pith from the sugarcane stalk segments so as to maintain fiber bundles of said sugarcane rind periphery strips laterally interconnected and unitized; throughout the removal of sugarcane pith from said sugarcane stalk segments, maintaining the rind periphery strips substantially uncontaminated by

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sugar juice contained within said sugarcane pith; reducing the moisture content of said collected, sugarcane rind periphery strips; and subjecting said sugarcane rind periphery strips, subsequent to said moisture reduction, to heat and pressure to form said sugarcane rind periphery strips into a unitized configuration.

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19—34; 156—296

UNITED STATES PATENT OFFICE CERTIFICATE OF CORRECTION

Patent No. 3,464,877 Dated September 2, 1969

Inventor(s) Robert B. Miller, et al

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

In Claim 2, column 12, the following sentence has been omitted and should be inserted between lines 61 and 62 of this column:

"as to maintain fiber bundles of said sugar cane rind "

SIGNED AND
SEALED
MAY 5 1970

(SEAL)

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