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PATENT SPECIFICATION

DRAWINGS ATTACHED

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Index at acceptance:—D1 F(36A, 36BX); C3 N(3A3E, 3A3K); D2 A1

Int. Cl.:—D 01 b 1/10

COMPLETE SPECIFICATION

Sugarcane Processing

I, ROBERT BOOTHE MILLER, a citizen of the Dominion of Canada, Edmonton, Alberta, Canada, do hereby declare the invention, for which I pray that a Patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a process for obtaining cleaned sugarcane from the rind from sugarcane. More particularly, the invention relates to a novel process for treating sugarcane stalk to obtain cleaned sugarcane rind suitable for the manufacture of a commercial product and to the product of this process.

Sugar from sugarcane is produced by a conventional 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, which is the fibrous or woody portion of sugarcane used as fuel at most mills.

It has been discovered that the fibrous structure of the rind of sugarcane has special desirable physical and structural characteristics when the fibres are used in the form of fibre bundles. In the milling required by conventional processes for handling sugarcane, these desirable fibre 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 fibres 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 fibres in a substantially discrete, continuous or undisturbed rind form so that the rind fibres can be utilized in the manner contemplated by this invention.

The rind portion of sugarcane stalk, as it is referred to hereinafter, contains numerous fibre bundles, sometimes called fibrovascular bundles, which are groups of elemental fibres in discrete elongated units. The elemental fibres of sugarcane rind resemble somewhat the elemental fibres of ratan and hackberry, but differ materially from the bast fibres as found in certain dicotyledonous plants as flax, hemp, ramie and jute. The fibre 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 fibres of these plants and elemental sugarcane fibres, sugarcane rind contains fibre bundles which have been found to make the sugarcane rind particularly useful in the manufacture of products as will be explained.

The present invention provides a process for obtaining cleaned sugarcane rind from the rind of sugar cane comprising:

removing substantially all of the stalk and nonstalk material from the exterior of a stalk of sugarcane to expose the exterior fibre of the rind; and removing from the interior of the stalk substantially all of the pith of the stalk.

The invention also provides cleaned sugarcane rind in the form of strips obtained from sugarcane stalk by removing from the exterior of the stalk of sugarcane, stalk parts and nonstalk parts without substantially penetrating or dis-

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turbing the fibre of the rind and removing pith from the interior of the stalk without substantially penetrating or disturbing the fibre in the rind.

The rind produced by this novel process is a highly useful product not heretofore obtainable by conventional processes and apparatus for handling sugarcane. The rind can be manipulated and 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 fibre 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 fibre flow, which will be explained in detail. While normally the fibre bundles make up discrete strips, when subjected to heat and pressure the fibre bundles flow or move transversely with respect to their length and can be pressed into a continuous homogeneous mass of aligned long fibre bundles wherein each strip loses its identity as such.

In this disclosure, the process and products obtained thereby as well as apparatus relating thereto will be shown and described 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 views of typical rind strips of this invention, showing respectively the exterior and interior surfaces.

Sugarcane is a member of the grass family grown in many tropical and subtropical areas of the world. 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 rind 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 colour 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, cork filled cracks may develop along the internode and separate the fibrous materials of the rind for short distances. Sugarcane ordinarily averages about 9 per cent by weight of rind and about 91 per cent 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 fibre bundles free of foreign matter, loose fibres 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, 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 fibres is removed from the exterior of the rind, as represented at 35, in order to expose the relatively hard, strong fibre 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 fibre 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

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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.

Next, the rind strips are conditioned for utilization of the elongate, individual fibres. This may be performed as part of the pith removal operation. For making veneer and board products, for example, wherein it is desirable to position individual rind fibres into compact and continuous special shapes, it is beneficial to loosen or break mechanically the natural bond between separate fibres without significantly lessening the longitudinal tensile strength of the fibres. This may be accomplished in a number of ways, for example, by passing the rind strips through a pair of rollers which serve to press and flatten the strips and spread apart the individual fibres due to the compression action of the rollers. Another way to accomplish this is to pull the rind strips longitudinally over and firmly against a substantial part of a curved surface, preferably with the exterior of the rind engaging the surface, so that the strips leave the surface at an angle with respect to the direction that the strips engaged the surface. This forces the strips from their normal curved shape to a flat shape. A rotatable wheel or roller may be used instead of a fixed curved surface; and for good results, the rind should engage 180 degrees of the circumference of the wheel, leaving the wheel in the direction opposite to the direction of engagement with the wheel.

In a continuous sugarcane stalk handling operation, the rind will contain a considerable amount of moisture after the pith is removed. The conditioning of the rind to loosen the fibres 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 extremely difficult to handle, particularly for purposes of placing the several fibres into presses or molds.

The rind strips 40 may be washed by spraying or by dipping prior to conditioning the strips to loosen the fibres, as represented at 41. It has been found that the strips dry readily in air, but if the strips are to be baled, it may be desirable first to pass the strips through a mechanical dryer. The rind strips 42 thus obtained are relatively clean, undisturbed elongated groups of long fibre bundles. They may be handled and processed further in the particular manner to be described.

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 therethrough. 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 pick up 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 epi-

dermis 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 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 more 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 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 83 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.

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 80 and 89 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 fibre bundles are generally unbroken and undisturbed, although the rind has been flattened out somewhat. The strips possess considerable tensile strength longitudinally.

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stalk halves must be advanced relatively forcefully. 65

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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 80 and 89 for guiding the stalk halves. 85 90 95 100

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. 105 110 115

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 fibre bundles are generally unbroken and undisturbed, although the rind has been flattened out somewhat. The strips possess considerable tensile strength longitudinally. 120 125 130

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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. This invention accommodates all types of internode shapes.

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 fibre 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 fibre 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.

For the utilisation of cleaned sugarcane rind produced by the process of the present invention reference is directed to co-pending Patent Application No. 200/68 (Serial No. 1,126,493) (divided herein) which describes the manufacture of various board products such as boards, panels, veneer, planks, and similar articles and claims, in Claim 1, a process for making board products from sugarcane comprising longitudinally opening the sugarcane stalk without damaging the rind, removing the pith from the rind and subjecting the rind thus freed of pith to heat and pressure.

Attention is also directed to co-pending Application No. 30497/65 (Serial No. 1,126,491) which claims, in Claim 1, a process for treating sugarcane stalks having as components a pith core, rind encircling the pith, an outer epidermis, and wax on the exterior of said stalks,

which process comprises the steps of opening each stalk longitudinally into a plurality of longitudinal portions, while the stalk is moving in a longitudinal direction along a travel path, exposing a pith-bearing side of each opened stalk portion, separating from said opened portions at least one of said stalk components from others of said stalk components, collecting said separated component from each of a plurality of stalks, and treating said collection separately from said other stalk components.

As an alternative to utilizing sugarcane rind in the manufacture of articles, the rind may be used as a source of raw material in the manufacture of paper. The fibre of sugarcane stalk is comparable to certain North American pulpwood in this regard. Furthermore, the fibre of sugarcane stalk is highly suitable for use in the manufacture of hardboard of the type wherein relative short individual wood fibres are mixed with a binder and pressed, randomly disposed, into a dense sheet-like material under extremely high pressure.

In order to prepare the rind strips for such ultimate uses and to provide for the practical and efficient handling of the rind, the strips of rind can be processed into the form of dense, elongated, cylindrical pieces, for example, which are easy to store and transport. This is accomplished by subjecting the rind strips to grinding or shredding action and thereafter to a compacting or compressing action which puts the fibres into the desired shape. The grinding action breaks up the fibre bundles into particulate form and the compressing action molds the particulate material into a highly compacted unit. The naturally occurring cohesive characteristics of the rind fibre retain the particulate material in the molded shape.

In order to accomplish this, a continuous extrusion apparatus may be used wherein a screw conveyor rotating in sleeve member applies the grinding action to the rind to reduce it to particulate form and at the same time forces the particulate material into a confined area to apply the compression action. This molds the rind into cylindrical pieces, the lengths of which can be made as desired. The extruding apparatus is explained by way of example. The grinding and compression operations can be performed by other mechanisms as well, and the particulate material may be pressed to shapes other than cylindrical units.

Whereas conventional processes for extracting the juice from sugarcane require the cutting, grinding and shredding of the rind of the stalk into bagasse, this process provides for the recovery of the juice without the destruction of the long fibre bundles of the rind and their ultimate utilization. Accordingly, instead of producing a mass of broken fibres intermingled with the pith of the stalk, this process produces whole rind fibre bundles in the form of rind strips which strips are particularly suitable for a number of uses.

WHAT I CLAIM IS:—

1. A process for obtaining cleaned sugarcane rind from the rind of sugarcane comprising: removing substantially all of the stalk and nonstalk material from the exterior of a stalk of sugarcane to expose the exterior fibre of the rind; and removing from the interior of the stalk substantially all of the pith of the stalk.
2. A process as claimed in Claim 1 wherein prior to the removal of said pith, the stalk of sugarcane is longitudinally opened.
3. A process as claimed in Claim 1 including the additional step of applying mechanical force to the fibre of the rind while the rind contains moisture, to loosen the natural bond between the fibre.
4. A process as claimed in Claim 3 wherein said mechanical force is applied by pressing the rind between rollers.
5. A process as claimed in Claim 3 wherein said mechanical force is applied by moving the rind over and against a curved surface.
6. A process as claimed in Claim 3 wherein said mechanical force is applied by pulling the rind over the circumference of the rotatable roller.
7. A process comprising a process as claimed in Claim 1 and the subsequent step of reducing said rind into particulate form and compressing said particulate fibre material.
8. A process as claimed in Claim 7 wherein the reducing of said fibre is effected by extrusion.
9. A process for obtaining cleaned sugarcane rind substantially as herein described with reference to the accompanying drawings.
10. Cleaned sugarcane rind in the form of strips obtained from sugarcane stalk by removing from the exterior of the stalk of sugarcane, stalk parts and nonstalk parts without substantially penetrating or disturbing the fibre of the rind and removing pith from the interior of the stalk without substantially penetrating or disturbing the fibre in the rind.
11. Cleaned sugarcane rind obtained by the process of any of Claims 1 to 9.
- ERIC POTTER & CLARKSON,
Chartered Patent Agents,
Nottingham, London and Leicester.

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Published by the Patent Office, 25 Southampton Buildings, London, W.C.2, from which
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* C L M S *