RESERVE COPY

1,126,491

PATENT SPECIFICATION

DRAWINGS ATTACHED

1,126,491

Date of Application and filing Complete Specification: 19 July, 1965.

No. 30497/65.

Application made in United States of America (No. 384,410) on 22 July, 1964.

Complete Specification Published: 5 Sept., 1968.

© Crown Copyright 1968.

Index at acceptance:—C6 B1; C1 AK4; C5 W6; D1 F(36A, 36BX); D2 W(2, 3A11, X)

Int. Cl.:—C 13 b 1/00, C 13 d 1/00

COMPLETE SPECIFICATION

Sugarcane Processing and apparatus

I, ROBERT BOOTHE MILLER, a citizen of the Dominion of Canada, residing at 12540—126th Avenue, 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 sugarcane processing and apparatus. More particularly, this invention relates to a novel process and novel apparatus for treating sugarcane stalks to remove the natural sugar juices and convert the stalks into various commodities. Such commodities include, for example, wax readily capable of being refined for commercial use, an epidermis material capable of being processed, a rind product containing long plant fibres in relatively undisturbed condition. According to the present invention there is provided a process for treating sugarcane 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.

The present invention also includes apparatus constructed and arranged for use in performing the aforesaid process, comprising stalk-feeding devices for feeding each stalk in a longitudinal direction along a travel path, means for removing wax and epidermis from each travelling stalk, devices for splitting and opening each travelling stalk longitudinally into a plurality of longitudinal portions having their pith-bearing sides exposed, means for separating the pith from the rind of said opened and travelling longitudinal portions, collectors for separately collecting the rind and the pith, and means for extracting the juice from the collected pith.

In this disclosure, the process and products obtained thereby, as well as the preferred forms of apparatus, will be shown and described with reference to the accompanying drawings, in which:

FIGURE 1 is a diagram illustrating the several steps of the novel process of this invention;

FIGURE 2 is a side elevation view showing diagrammatically the main apparatus of this invention;

FIGURE 3 is a plan view, corresponding generally with FIGURE 2;

FIGURE 4 is a side elevation view showing diagrammatically a modified device for expressing the juice from the pith;

FIGURE 5 is an enlarged view taken along line 5—5 of FIGURE 2 showing a stalk propelling device;

FIGURE 6 is an enlarged view taken along line 6—6 of FIGURE 2 showing wheels for separating stalk portions;

FIGURE 7 is an enlarged perspective view of a stalk turning member;

FIGURE 8 is a side elevation view showing diagrammatically a modification of the apparatus of this invention;

FIGURE 9 is a plan view, generally in cross-section, corresponding with FIGURE 8 and taken along line 9—9 thereof;

FIGURE 10 is an end elevation view of a tine box assembly of the modified apparatus;

FIGURE 11 is a plan view in cross-section taken along line 11—11 of FIGURE 10;

FIGURE 12 is a plan view of a splitter assembly of the modified apparatus;

FIGURE 13 is an end elevation view in cross-section of the splitter assembly of FIGURE 12 taken generally along line 13—13 thereof;

[*Price 4s. 6d.*]

Price 25

FIGURE 14 is a side elevation view in cross-section of a depither assembly of the modified apparatus;

FIGURE 15 is an end elevation view in cross-section of a depither wheel of a depither assembly and showing a portion thereof;

FIGURE 16 is a side elevation view of a rind wash assembly of the modified apparatus;

FIGURE 17 is an end elevation view of the rind wash assembly of FIGURE 16; and

FIGURE 18 is a diagrammatic representation of a harvester with the apparatus of this invention transportably mounted therebehind.

FIGURE 1 illustrates schematically the steps of the novel process of this invention. According to this process, sugarcane can be harvested in the fields in the manner practiced heretofore; namely by hand or by mechanical harvesters. Preferably, the leaves are removed prior to further processing of the stalks.

At this initial stage in the explanation of the novel process, one particular advantage which becomes significant should be pointed out at the outset. Normally, the top portion of each cane stalk containing the green leaves is removed. In conventional processes for handling sugarcane, any green leaf portion left on the stalks from the field is subjected to milling whereby any acids in the green leaf portion are expressed into the sugar juice. Acids present in the juice tend to hydrolize the sucrose into glucose and fructose. In the process according to the present invention, however, even though an unnecessary amount of the green leaf portion of the stalks is left in the field, this does not adversely affect the juices since acids from the green leaves cannot reach the juices.

After the stalks are harvested, preferably the cane is washed by the use of conventional cleaning plants or cane laundries. This is not absolutely necessary for the production of the highly desirable saturated juice obtained by this process since field contaminants left on the cane stalks are not transmitted to the juice, but it is desirable for purposes of preparing the rind.

At this point, the process diverges considerably from conventional practices heretofore followed throughout the world in sugarcane processing. Instead of handling the sugarcane from the field in bulk, each cane stalk, in effect, is handled separately. While to some this may seem entirely impractical for the mass production of sugar products, on the contrary, the extremely desirable results obtained overcome any drawbacks to which the handling of cane stalks separately may be subjected.

With reference to FIGURE 1, the stalks, represented at 10, are harvested and the leaves are removed, as designated at 11. The washing of the cane 12 may be carried out by conventional cleaning plants or cane laundries. At 13 in FIGURE 1, the stalks are represented as being processed separately as compared with the present processes of handling the stalks in bulk.

Next, the cuticle wax from the exterior of each separate stalk is removed as represented at 14. This wax naturally adheres to the rind and is removed as a dust or powder. No attempt is made to remove the cane wax which extends through the rind. Since several stalks can be handled simultaneously, a plurality of steps 14 are represented along with a box designated 15 which indicates that each stalk is handled separately rather than in bulk and that several stalks can be handled at one time. The exterior or cuticle wax obtained by the handling of several stalks separately is collected, as represented at 16, and can be refined at 17 into commercial wax products 18. After removal of the wax, the epidermis is removed at 19 and the thin fibres which for the most part make up the epidermis are collected at 20 for further processing at 21 to recover the constituents 22 including silica and other substances.

Each whole stalk 13 with the exterior wax and epidermis removed is further processed by subjecting it to a mechanical device which divides the whole stalk by cutting it longitudinally throughout its length into two parts to expose the pith. The cutting of the stalk longitudinally 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 to the juice laden pith. While the process has been carried out successfully by severing the stalk longitudinally into two parts, it is possible to split each stalk longitudinally into more than two parts or to make a cut into one side of the rind only.

The reference to processing whole stalks means that the stalks are not cut or severed longitudinally prior to the removal of the wax and epidermis. Since sugarcane seldom grows perfectly straight, those stalks which are extremely crooked can be cut crosswise as necessary into shorter pieces for easy handling. Such shorter pieces of stalk, as well as full-length pieces, are referred to as whole stalks.

After the pith is exposed by splitting the stalk longitudinally, the pith is carefully removed from the rind without squeezing the pith to express the juice therefrom. Prior to this, the stalk has not been subjected to pressure so as to express a significant amount of juice; and, furthermore, the rind has not been subjected 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 original stalk pieces. In FIGURE 1, the whole stalks leaving the epidermis removal step are represented at 23. The pith separation step is represented at 25. The pith collected from the

handling of a plurality of sugarcane stalks is represented at 26 and the depithed rind is represented at 27.

The pith which is carefully removed from the rind so as not to squeeze out any significant amount of the juice has been found to constitute 75—80 per cent of the cane stalk and contains about 16—18 per cent by weight of sugar dissolved in various forms in the juice portion. This pith is in a fluffy, loose form of celluar constituents or parenchymatous tissue. When squeezed, the pith readily yields its juice content and, accordingly, the desirable sugar juice can be expressed from the pith by a limited amount of pressure applied thereto, as represented at 28. The juice can be removed from the pith either in a dry process, that is without the use of water, or the pith can be suspended in water and then squeezed so that the sugar in the pith cells may migrate through the walls of the pith cells and into the water for subsequent recovery. Normally, the addition of large amounts of water to the juice is not necessarily desirable because this reduces the sugar concentration and requires processing for removal of such additional water in order to obtain the sugar in crystalline form. If a mechanical squeezing operation is used, it is advantageous, therefore, to keep the amount of added water as small as possible.

The need for adding water in this process compares favorably with the present processes wherein vast amounts of imbibition water are added to the crushed cane stalk material during the milling process in order to extract from the solid material all of the sugar contained in the stalks. It has been found essential in conventional processes to add water, whereas in this process it is not necessary to add water in order to obtain a suitable extraction of the juice from the pith, although it may be desirble to use small amounts of water for nearly total sugar recovery.

Pressure (psi)	First Expression Sugar (%)	First Wash Sugar (%)	First Wash Water Added (%)	Second Wash Sugar (%)	Second Wash Water Added (%)	Third Wash Sugar (%)	Third Wash Water Added (%)
100	7.1						
200	2.6	1.5	5	1.2	10	0.3	15
		1.0	10	0.6	20	0.3	30
		0.7	20				
300	2.7	1.7	5	1.3	10	0.9	15
		1.2	10	0.4	20		
		0.8	20				
300	2.6	1.5	5	1.2	10	0.8	15
		1.0	10	0.6	20	0.3	30
		0.7	20				
1000	1.1	0.3	5	0.1	10		
		0.2	10				
		0.1	20				
1500	2.2	1.2	5	0.9	10		
		0.8	10	0.4	20		
		0.6	20				
2000	2.4	1.4	5	1.0	15		
		1.0	10	0.5	20		
		0.7	20				
2500	1.1	0.3	5	0.1	10		
		0.2	10				
		0.1	20				
4000	2.2	1.2	5	0.9	10		
		0.8	10	0.4	20		
		0.6	20				
6000	2.2	1.2	5	0.9	10		
		0.8	10	0.4	20		
		0.6	20				
8000	2.2	1.2	5	0.9	10		
		0.8	10	0.4	20		
		0.6	20				
10000	2.2	1.2	5	0.9	10		
		0.8	10	0.4	20		
		0.6	20				
12000	2.1	1.1	5	0.8	10		
		0.7	10	0.4	20		
		0.4	20				
15000	2.1	1.1	5	0.8	10		
		0.7	10	0.4	20		
		0.4	20				
25000	1.1	0.3	5	0.1	10		
		0.2	10				
		0.1	20				

The solid material after the expression of the sugar juice therefrom is a light, fluffy, floc-like material. This pith floc is readily dryable when exposed to air and rapidly reaches ambient moisture. The pith floc can be manufactured into desirable commercial commodities or can be used as fuel.

Table I discloses data relating the pressure requirements to the percentage of juice expressed from samples of pith removed from cane stalk by this process. The pith after being separated from the rind was subjected to pressure in a piston-type press to separate the juice from the solids of the pith. The designation "First Expression" indicates the per cent of sugar by weight obtained from the raw pith without the addition of any water. Data under the columns "First Wash," "Second Wash" and "Third Wash" were obtained as follows. The pith was wetted evenly with water, allowing the water to penetrate into it, and then placed into the press. The liquid in the pith was expressed under the same pressure corresponding with the first expression as indicated in the table. Since it is often convenient in sugar technology to represent the amount of water added as percentage by weight of cane milled, this convention was adopted in the table.

Table I reveals some of the advantageous results obtained by this process. At pressures higher than 100 p.s.i., the sugar content of the resulting pith floc is in the range of 1.1 per cent to 2.7 per cent with one expression and no subsequent washing with water. This can be compared with data available concerning conventional processes. The data in Table I show further that without using any water at all, the sugar can be recovered from the pith in amounts equal to or better than present processes where water is added. In addition, by using smaller amounts of water than are currently being used in known processes, virtually all of the sugar can be recovered from the pith produced by the process. The data in Table I also show that in this process equal or better sugar recoveries may be obtained at much lower pressures compared with known milling practices. This means that less cumbersome and expensive equipment is required for the production of sugar juices. It must be pointed out that the hydraulic pressure sometimes employed in conventional milling equipment may be as high as 550 tons. It has been found that an efficient range of pressures in this process is between 100 p.s.i. and 1,000 p.s.i. Within this range of pressures, a satisfactory percentage of juice can be obtained from the sugarcane stalks suitable for further economical processing. The percentage of juice recovered can be increased by using higher pressures but not necessarily pressures as high as those needed to recover juices according to known milling practices. In addition to the less cumbersome equipment required, the raw pith as it is separated from the whole stalk and put into the press equipment for the extraction of juice, produces less wear and tear on the machinery than the entire stalk which is introduced into the conventional mill train equipment. As represented in FIGURE 1 the juice from the pith 29 is clarified and filtered at 30, whereafter the clarified juice 31 is subjected to evaporation, crystallization and separation at 32 in order to produce crystalline sugar 33.

As an alternative to a mechanical squeezing of the pith, the sugar can be removed from the pith by diffusion alone, that is, by flowing water through the pith and recovering the sugar from the water without applying a mechanical pressing action. Since the effectiveness of a diffusion process is related to the area of the material actually exposed to the water, the removal of juice from pith, when the pith alone is subject to the water, is considerably more effective compared with previous attempts to remove sugar from crushed-up pieces of the entire stalk. When crushed-up stalks are subjected to water, the rind obstructs the flow of the water to, around and away from the pith. Furthermore, contaminants from the rind are washed into the water. By first removing the pith from the rind and then subjecting only the pith to the diffusion bath, a more complete exposure of the pith to the water is effected, a smaller ratio of water to solids is required, the time required for removal of the sugar is reduced considerably, fewer contaminants are carried away with the sugar, and the diffusion process in other respects is more effective and economical. This method of recovering sugar from the pith is extremely advantageous compared with previous diffusion procedures which treat the entire stalk.

The rind portion of the stalk constitutes about 20—25 per cent of the stalk. It has been found that after the pith has been removed from the rind, the remaining rind may contain about 1 or 2 per cent of the sugar in the whole cane stalk. For the most part, the sugar that is in the rind comes from the pith cells that were fractured alowing some of the juices to drain into the rind. The sugar in the rind may be readily recovered by various ways. It has been found that the sugar content of a properly depithed rind can be readily lowered to and below the value of that currently found in most bagasse which is usually 2.4 per cent of remaining sugar based on the weight of bagasse. The removal of the sugar juice from the rind is represented at 34 and the sugar juice at 35. Juice 36 extracted from the rind may be added directly to the juice 29 from the pith or may be processed separately prior to being added to the juice 29. In some commercial operations, it may not be feasible to attempt to extract the juice from the rind.

FIGURES 2 and 3 illustrate diagrammati-

cally apparatus for handling sugarcane according to this invention. Whole cane stalks, such as the stalk 40, are introduced into the front of the apparatus after being de-leaved and preferably after being washed. Suitable means such as a funnel-shaped device 41 may be employed to guide the stalk. The cane stalk 40 immediately is gripped between a pair of power-driven rollers 42 and 44 which are part of a drive and guide roller assembly 45 shown in FIGURE 5. The assembly 45 serves to hold the stalk 40 in properly aligned position and to advance the stalk through the apparatus. The roller 42 has a flexible circumferential surface like a balloon tire and is mounted on a rotatable shaft 46 power driven by a gear or sheave 47. The shaft 46 may be supported by suitable brackets 48 slidable up and down on brackets 49. The roller 44 has a concave circumferential surface 50 spaced from the roller 42 far enough to receive therebetween the stalk 40. The roller 44 is mounted on a rotatable shaft 51 power driven by a gear or sheave 52. The roller 42 can move toward or away from the roller 44 to accommodate stalks and node and internode portions of different diameter. Gravity or suitable light spring means 53 are employed to keep the rollers 42 and 44 close enough together so that the surface of the roller 42 may grip and propel the stalk 40 while guided and held in alignment by the concave surface 50. The flexible surface of the roller 42 assures that the stalk 40 will not be squeezed hard enough to rupture the cells of the pith in the stalk. The rollers 42 and 44 may be reversed, that is the roller 42 could be on the bottom with the roller 44 on top.

The whole stalk 40 is propelled by the assembly 45 to the first of a series of treating stations comprising a rotating brush 55 having wire bristles 56 or bristles formed of another suitably stiff material, for example nylon. The bristles 56 extend radially in respect to the longitudinal axis of the cane and rotate in a plane normal to the path of the stalk. Their inner ends define a travel path opening through which a stack passes. As the bristles 56 rotate around and scrape over the outside surface of the stalk 40, they remove the cuticle wax as the moving stalk passes. As the bristles 56 pick up the wax, which is in the form of dust or powder, suction, or differential air pressure, applied through a pipe 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. The bristles 56 are of such length and of such a pliable nature as to remove the wax but not to penetrate the rind. It has been found that bristles having 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 instead of or together with bristles 56.

A second rotating brush 59 similar in construction to the brush 55 is spaced therefrom and receives the stalk 40 after it passes through a pair of idler guide rollers 60 and 61. The brush 59 has bristles 62 which are slightly longer and slightly less flexible compared with the bristles 56. The bristles 62 scrape over the surface of the stalk to remove the thin epidermis layer from the harder fibrovascular bundles comprising the rind. However, the rind is not penetrated and the fibres are not broken.

The whole stalk 40 then is engaged by another assembly 45 which forces the stalk 40 into a stalk severing station in the form of a stationary vertical knife or blade 63 positioned in the path of the stalk. Other stalk severing devices may be used instead of the particular stationary blade 63, for example a moving e.g. rotating saw may be used. 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 as possible be retained 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, illustrated in FIGURE 6. The two halves of the stalk 40 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 40 are shown in cross section in FIGURE 6 and designated 40a and 40b. 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 squeezed out. A single wheel such as either wheel 65 or 66 may be used with a cylindrically shaped wheel to handle the stalk halves.

The stalk halves 40a and 40b leave the spreader wheels 65 and 66 and are forced to the next station comprising a stalk turning or aligning member 70 which serves to twist the two stalk halves 40a and 40b about one-quarter turn so that the pith or inner portions face downwardly and the outer curved rind portions face upwardly. The aligning member 70 has a vertically extending thin plate portion 71 curving at 72 Fig. 7 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 flatten-

ing 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 have a flexible surface (e.g. an) air-inflated byre, which together serve to flatten the rind somewhat to spread the stalk halves further open 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 40a and 40b 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 transmitted substantially to the pith. The longitudinal forces are applied externally to the rind. The rollers 42 and 44, 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 fibrovascular bundles 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 edges of the two halves along which the cut was made are turned in opposite rotational directions 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 command 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 amount of juice from the pith.

At the next station, the stalk halves engage an assembly 80 for separating the pith from the rind. The 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. Rotation of the bristles 83 may be either clockwise or counterclockwise with respect to FIGURE 2; however, it has been found that a clockwise rotation is most effective. The bristles 83 may be of wire or of other suitable material and of suitable length to gently scrape with pith from the inside of the rind. The pith, in effect, is engaged head-on by the bristles 83 for the most effective removal. The bristles contact the rind in a tangential relationship. Little or no compressing action is applied by the bristles to the pith in a direction normal to the 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 86 is spaced from the first assembly 80 for separating the pith from the rind and includes a control roller 87 and a lower brush-type roller 88 similar to the brush roller 82, but which may have bristles 89 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 86 may be employed as necessary to remove adhering pith. A pair of idler rollers 91 and 92 are positioned between the assemblies 80 and 86 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 89, a fluid, such as air, may be forced through conduits 94 and 95 and adjusted to blow the pith off of the brushes and onto conveyors 96 and 97 for removal of the pith for further processing. The conveyors 96 and 97 extend downwardly from the brushes 82 and 89 and converge to a point where a pair of scrapers 99 and 100 remove the pith from the conveyors so that the pith may fall into the nip between two elongated rollers 102 and 103. The rollers 102 and 103 are held together and each is rotatably driven so as to squeeze therebetween the pith after it leaves the conveyors 96 and 97. The squeezing action applied by the oppositely ro-

tating rollers 102 and 103 expresses the juice from the pith as it passes between the rollers and falls onto a conveyor 104 which carries the pith floc away for further processing. The juice remains on top of the rotating rollers in the V-shaped trough or nip formed by adjacent top surfaces of the rollers, and by suitable conduits such as the conduit 106 is removed from on top of the rollers to be accumulated for further processing.

While two rollers 102 and 103 are illustrated in FIGURE 2 as means for expressing juice from the pith, extraction of the juices from the pith may be accomplished by other apparatus; for example, by a piston type press. A continuous acting screw-type press 110 illustrated diagrammatically in FIGURE 4 may be used wherein the pith drops from the conveyors 96 and 97 into a hopper 111. The pith floc is removed at 112 and the juice is removed at 113. It is also possible to recover the juice from the pith by a centrifugal separator or by diffusion apparatus. These numerous ways in which the juice can be withdrawn from the pith illustrate one of the considerable advantages of this invention. The differences between the massive milling equipment employed in known operations for obtaining dilute juice from the entire stalk and the apparatus of this invention for extracting juice from pith are significant from the standpoint of initial expense alone.

The pith, after the juice has been removed, is slightly moist but it drys readily in the atmosphere. It is substantially free of impurities or foreign matter. It can be used in the production of alpha-cellulose for rayon, inexplosive manufacture and in the manufacture of active absorbent carbon for de-colorizing agents. Its high absorption qualities makes it useful as a carrier for many substances. It is also a suitable source of furfural. While pith from sugarcane has been used commercially in the past, it has first to be separated from the crushed rind portions of the bagasse, and even then it contains many contaminants. Pith obtained from the process and apparatus according to the invention on the other hand, is relatively free of contaminants.

The juice is removed from the rind portions or strips of the de-pithed stalk halves 40a and 40b by passing the rind strips through a wringer or pair of rotating pressure rollers 120 and 121. In certain circumstances, depending for example upon the hardness of the rind, this may be sufficient for removing the major portion of the rind juices. In addition to the single pair of rollers 120 and 121, means for wetting the rind is provided for example spray nozzles 123 and 124 through which water is sprayed or to the rind portions. A second wringer or pair of rotating pressure rollers 125 and 126 squeeze the rind firmly to press out the added water with the residual sugar. The juice expressed from the rind may be collected by any suitable means; for example, suction pipes 128 and 129, although a simple trough might be used as well to collect the juice. The rind juice may be processed separately since it contains more contaminants than the juice from the pith, or it may be added directly to the pith juice collected by conduit 106.

The stalk halves 40a and 40b with the juice expressed therefrom, called rind strips, may be handled in a number of ways. They may be gathered and stored easily since they drip rapidly in the atmosphere without need for mechanical drying. The rind strips present no disposal problem. For example, the strips can be burned quite readily, whereas bagasse, normally recovered as a soggy residue from known sugarcane processes must be burned in specially constructed furnaces. The production of rind strips, instead of bagasse, is a considerable advantage afforded by this invention. While bagasse sometimes is processed to separate the pith from the crushed, shredded rind fibres, this process and apparatus produce pith and relatively undisturbed fibres in the form of rind strips, already separated. Furthermore, the pith produced by this invention is considerably less contaminated than pith separated out of bagasse.

The general arrangement of a modified sugarcane processing apparatus 140 is shown in FIGURES 8 and 9. A series of treating stations for performing the different operations on the sugarcane stalk are aligned generally longitudinally. Stalks, one at a time, are introduced into the apparatus 140 and each stalk is propelled therethrough in continuous rapid movement. As each stalk 142 progresses through the apparatus, it is separated into basic components, namely, wax, epidermis including loose outer fibres, pith with a major portion of the juice retained therein, and rind fibre. These components may be processed further for ultimate utilization of all of the components of the sugarcane stalk, as explained previously.

A whole sugarcane stalk 142 is fed into the front of the apparatus 140, preferably after being de-leaved and washed. Suitable means such as a funnel-shaped device 144 may be employed to guide the stalk 142 which is gripped immediately between a first pair of power-driven rollers 146 and 148. The lower roller 146 has a concave groove extending circumferentially therearound, while the upper roller 148 preferably has a flexible surface and resembles a pneumatic tire. The rollers 146 and 148 cooperate to guide and propel the stalk forward. A second pair of rollers 150 and 152 and a third pair of rollers 154 and 156 are provided similar in construction to the first pair of rollers 146 and 148; and like the first pair of rollers, assist in guiding and propelling the stalk in a path rapidly through the apparatus 140.

The whole sugarcane stalk 142 is propelled

to a first treating station 158 at which the outer or cuticle wax is removed. This station comprises a tine box assembly 160, shown in detail in FIGURES 10 and 11, which includes a suitable frame structure 162 of unitary box-like construction, including channel-shaped members 164 providing open sides. A series of plates 166 are spaced-apart longitudinally of the apparatus 140, that is along the path of the moving sugarcane stalk 142 and held in position by spacer elements and tracks 170 in the members 164 cooperating with notches 172 at the corners of the plates 166. Each plate 166 has a large, centrally located opening 176 within which is suspended a flat ring 178 having an outer diameter somewhat smaller than the diameter of the opening 176. A series of flexible elements, such as coiled tension springs 180, extend at circumferentially spaced points between the ring 178 and the plate 166 to serve as the sole support for the ring, thereby allowing the ring to shift transversely of the path of the moving sugarcane stalk 142 and to have universal movement with respect to the path.

A series of flexible members in the form of tines 184 made of rigid but pliant material such as spring metal are formed in an S-shape and mounted on each ring 178. The forward end 186 of each tine 184 extends over the forward face of the ring 178 and is mounted thereto by welding or by use of removable fastener means. The several tines 184 extend through and rearward of the corresponding ring 178 in cone-like configuration to receive therebetween the whole sugarcane stalk 142 as it is propelled rapidly through the apparatus 140. The rearward ends 188 of the tines 184 extend generally radially with respect to the path of the stalk and cooperate to form a travel path opening which, by nature of the spring metal from which the tines 184 are made, and the S-shape configuration, can be adjusted automatically as to size upon passage of the whole stalk therethrough. The rearward edges of each end 188 of the several tines 184 are sharpened and curved to provide a brushing or scraping surface for direct engagement with the outer surface of the passing stalk.

Each of the several rings 178 of the tine box assembly 160 is provided with a series of these circumferentially spaced, rearwardly extending tines 184 which overlap lengthwise. As between the several rings 178 in the assembly 160, however, the relative radial position of the tines 184 on the different rings 178 is adjusted a few degrees so that the tines overlap but also extend radially beyond one another, in offset or staggered fashion, as represented at 190. This assures that, as a stalk passes through the tine box assembly 160, the entire surface of the stalk will be engaged and scraped by several sharp edges of the tines. A sufficiently large number of rings 178 with tines 184 should be used to allow for adequate scraping of the stalk to remove a significant amount of the cuticle wax.

The tine box assembly 160 is located within a housing 194. The cuticle wax, which is in the form of dust or powder, is removed from the assembly 160 through the open sides thereof and is retained within the housing from which it may be removed by a flow of air at 196 and then collected for further processing.

The next station 200 at which the moving stalk is treated comprises a tine box assembly 202 of substantially identical construction as the tine box assembly 160. At station 200, the epidermis and fibres adhering loosely to the outer surface of the stalk are removed possibly along with some additional wax. The difference between the tine box assembly 160 and the tine box assembly 202 resides in the characteristics of the tines and the size of the travel path opening. The several tines 184 of the tine box assembly 160 are somewhat more flexible than the tines of the second assembly 202 and the diameter of the travel path opening provided by the tines 184 of the assembly 160 is somewhat larger than the corresponding travel path opening of the second assembly 202. The tine box assembly 202 is located within a housing 206 which retains the epidermis and other material removed from the stalk which, in turn, is removed by a flow of air at 208 and collected for further processing.

Station 158 removes from the stalk and collects as much of the cuticle wax as possible, without including any more of the other matter on the outside of the stalk than is necessary. The characteristics of the tines 184 of the tine box assembly 160 are determined with this purpose in mind. On the other hand, station 200 removes from the stalk all such remaining material, as the epidermis, which is extraneous to the hard rind fibres and serves to clean dirt and debris from the exterior of the stalk without breaking or otherwise damaging the rind fibres. Accordingly, the characteristics of the tines 184 of tine box assembly 202 should be determined with this purpose in mind.

The whole sugarcane stalk 142 with the outer surface thereof having been cleaned is propelled by the rollers 154 and 156 to a third station 210 comprising an articulated splitter assembly 212, FIGURES 12 and 13, which serves to sever or cut the whole stalk 142 longitudinally in half endwise. The splitter assembly 212 includes an upper flexible arm assembly 216 and a lower flexible arm assembly 218, the two of which assemblies are substantially identical. The upper assembly 216 includes front arms 220 and 222 and rear arms 224 and 226; the lower assembly 218 includes corresponding front arms 228 and 230 and rear arms 232 and 234. The arms of the assemblies are arranged in parallelogram fashion.

Each arm assembly 216 and 218 has associated therewith an upper slide plate 236 and a lower slide plate 238.

The front arms 220 and 222 of the upper assembly 216 and the upper slide plate 236 are pivotally mounted to a stationary cross member 240 of the apparatus 140 by a bolt 242. The front of the upper slide plate 236 has a slotted opening 244 receiving the bolt 242 so that the plate 236 may slide forward from its position shown in FIGURE 12 as well as pivot about the bolt. In a similar manner, the front arms 228 and 230 of the lower assembly 218 and the lower slide plate 238 are pivotally mounted to another stationary cross member 246 of the apparatus 140 by a bolt 248.

The rear arms 224 and 226 and the upper slide plate 236 are pivotally joined by a rear bolt 250, and in similar manner the rear arms 232 and 234 and the lower slide plate 238 are pivotally joined by a lower rear bolt (not shown). The rear bolt 250 and the corresponding lower rear bolt are movable together toward the bolts 242 and 248 as the slide plates 236 and 238 move forward and also are adapted to swing in an arc about the bolts 242 and 248.

The front arm 220 and the rear arm 224 of the upper assembly 216 are pivotally joined by a vertical shaft 254 which extends downwardly to pivotally join the front arm 228 and the rear arm 232 of the lower assembly 218 along a common axis. Similarly, the front arm 222 and the rear arm 226 are pivotally joined by a vertical shaft 256 which extends downwardly to pivotally join the front arm 230 and the rear arm 234 along a common axis spaced transversely of the path of the moving stalk 142 opposite the shaft 254.

A guide drum 260 is mounted for rotation about the shaft 254 and a guide drum 262 is mounted for rotation about the shaft 256. Spacers 263 are provided as necessary. An upper tension spring 264 and a lower tension spring 266 extend between and constantly urge the shafts 254 and 256 together. A splitter blade 270 extends vertically between the upper slide plate 236 and the lower slide plate 238 and is removably mounted by bolts 272 to holder elements 274 fixed to the respective slide plates. The blade 270 is located rearwardly and directed centrally between the drums 260 and 262.

The articulate nature of the splitter assembly 212 accommodates the twisted and distorted configuration of the stalks of sugarcane and assures that the stalks will be severed into two substantially equal, longitudinal sections regardless of the severity of the kinks or bends in the stalk. In operation, the moving stalk engages the drums 260 and 262, and depending on the twists and curves therein, forces the entire splitter assembly 212 to swing one way or the other about the vertical axes of the front bolts 242 and 248. The stalk forces the drums 260 and 262 apart against the force of the springs 264 and 266. This spreading force draws the slide plates 236 and 238 forward due to the scissor action of the upper and lower arms assemblies, but the splitter blade 270 always will remain centrally located between the drums 260 and 262 regardless of the diameter of the stalk and regardless of the extent of its crookedness. Further, the articulate nature of the splitter assembly 212 offers limited resistance to the movement of the stalk.

At the next station 276, the two halves of sugarcane stalk 142(a) and 142(b) are spread apart and turned by a half-cane turner assembly 282 which serves to twist the two stalk halves 142(a) and 142(b) about one-quarter turn so that the pith or inner portions face downwardly and the outer curved rind portions face upwardly. The turner assembly 282 includes a pair of guide rollers 286 and 288 spaced apart to receive the stalk halves 142(a) and 142(b) therebetween and which rollers may rotate freely about vertical axes. Immediately following the rollers 286 and 288 there is positioned a turner member 290 having a vertically extending thin plate portion 292 facing the direction from which the stalk halves 142(a) and 142(b) come. The opposite sides of the plate portion 292 gradually curve into a horizontally extending plate portion 294. The stalk halves engage and slide along the sides of the vertical portion 292 and by the time they reach the horizontal portion 294, they are properly positioned. At the rear of the turner member 290 the stalk halves 142(a) and 142(b) are received between a pair of rollers 298 and 300 which serve to guide and propel the stalk halves through the apparatus.

The next station 302 at which the stalk halves are treated comprises a de-pither assembly 304 at which the pith is separated from the rind of the stalk without removing from the pith a significant amount of juice and further without breaking or otherwise destroying the natural strength and relative disposition of the rind fibres.

The de-pither assembly 304, shown in FIGURE 14, includes a funnel-shaped guide 306 for receiving and guiding the stalk halves 142(a) and 142(b) into the de-pither assembly 304. A suitable housing structure 308 surrounds the members of the assembly 304 for supporting the members as a unit and for receiving pith as it is loosened from the rind.

Immediately to the rear of the funnel-shaped guide 306 and within the housing 308 is a platform member 310 having a slightly curved floor portion 312 extending rearwardly of the guide 306. The platform member 310 is mounted within the housing 308 to have vertical movement with respect to the path of the moving stalk halves. Such movement is provided by a rod 314 that is fixed to the platform member 310 to extend vertically

above the housing 308. A lower sleeve 316 surrounds the rod 314 and is fixed to the platform member 310. An upper sleeve 318 is fixed to the housing 308 and slidably receives the upper part of the rod 314 above the housing. A lower compression spring 320 surrounds the rod 314 between the lower sleeve 316 and the upper sleeve 318 and bears against washers 322 to force the sleeves 316 and 318 apart longitudinally. An upper compression spring 324 surrounds the upper sleeve 318 and bears against the housing at 326 and a cap 328 threaded on the uppermost end of the rod 314 to force the rod upwardly.

The platform member 310 has vertically extending sides 330 spaced-apart transversely of the path of the moving stalk halves and serving as a stalk guide to guide the halves. Above the floor portion 312 of the platform member 310, the housing is provided with an upper guide 334 having a surface 335 extending downwardly from the funnel-shaped guide 306. The rear portion of the upper guide 334 has a depending stalk folder 336 which is flared outwardly at the front portion 338 and which is generally semi-circular in cross-section to receive one of the stalk halves and which has an inner surface corresponding generally to the outside dimension of stalk halves, as shown in FIGURE 14. There are two such folders 336 mounted side by side on the upper guide 334, each one receiving one of the two stalk halves 142(a) and 142(b).

Following, and aligned longitudinally with each stalk folder 336, is a secondary stalk folder 340, generally of the same cross-sectional configuration and dimensions as the folder 336, as shown in FIGURE 14. The secondary folder 340 is mounted to a bar 342 which in turn is adjustably connected to the housing 304 by threaded connectors 344 held by nuts 345.

Below each stalk folder 336 and secondary folder 340 is a de-pithing wheel 350 which is mounted for rapid rotation on a power driven axle 352 extending transversely of the path of the moving stalk halves. The wheel 350 is provided with a plurality of radially extending blades 354 positioned at generally equally spaced points around the periphery of the wheel. The outermost edge 356 of the blades conform generally to the same configuration as the inner surfaces of the stalk folder 336 and the secondary folder 340. The wheel 350 is positioned so that the several blades 354, upon rotation of the wheel, pass through the stalk folder 336 and the secondary folder 340. The wheel 340 rotates in the direction indicated by arrow A of FIGURE 14 so that the blades 354 pass in tangential fashion with respect to the inner surfaces of the stalk folder 336 and secondary folder 340 in the direction toward the oncoming stalk halves. Different blade structures may be employed. The particular structure shown is merely representative.

The wheel 350 is positioned so as to leave a space between the curved inner surfaces of the stalk folder 336 and the secondary folder 340 as indicated at B, FIGURE 15. The rind of the stalk moves through this space without being contacted to any substantial extent by the blades 354 while the blades engage the oncoming pith and, in effect, gently tear away the pith from the rind. The depth or thickness of the space B can be varied by adjusting the nuts 345 to change the position of the bar 342 within respect to the wheel 350. The space B will determine the thickness of the rind after passing the wheel 350. A follower guide 358 receives the de-pithed rind strips at the rear of the de-pither assembly and, like the stalk folders 336 and 340, is semi-circular in cross-section.

Beneath the curved floor portion 312 of the platform 310, there is a collector plate 360 sloping downwardly between a front panel 362 and side panels 364 of the platform 310. Suitable tracks 366 on the side panels 364 assist in guiding the platform 310 during vertical movement. As the wheel 350 rotates rapidly, pith removed from the rind is carried forwardly by the blades and hurled against the collector plate 360 and then drops to a collection device. This pith contains a major part of the juice of the sugarcane.

The downwardly sloped surface 335 of the upper guide 336 and the relative longitudinal spacing with respect to the upper most extent of the blades is significant in reducing strain on the rind which might cause the rind to be torn longitudinally or broken crosswise, a situation that could interrupt continuous operation of the apparatus. Also this feature reduces a buildup of pith coming into engagement with the rotating blades 354 and thereby eliminating a back pressure, so to speak, within the pith. The automatic vertical movement of the platform 310 serves to continuously force the stalk halves upwardly to properly position them for the blades 354 and to assure that the rind will pass precisely through the space B without contact by the blades 354. After falling from the depithing assembly 304, the pith is collected and transferred for further processing where the valuable sugar juice is removed from the pith.

The rind, in curved strip form, moves from the de-pither assembly 304 to the next station 370 comprising an expresser assembly 372 for removing from the rind any juice retained therein. The expresser assembly 372 includes a first pair of rollers 376 and 378 rotatable about horizontal shafts 380 and 382 figs. 16 and 17. The rollers squeeze and flatten the rind and express therefrom any natural juice. The rind then passes a spray assembly having nozzles 384 for dispensing a mist of water from a conduit 386 onto the passing rind. Then the moist rind strips pass between a second pair of rollers 388 and 390 mounted on

shafts 391 and 392 where the added moisture is squeezed from the rind along with sugar which might be leached from the rind by the added moisture. A pair of final wringer rollers 394 and 396 follows the rollers 388 and 390. The liquid squeezed from the rind by the pairs of rollers 376 and 378, 388 and 390, and 394 and 396 is collected and sent to further processing for recovery of the sugar therein. As an alternative to the squeezing procedure, the rind may be subjected to diffusion, wherein water is caused to flow over and through the rind in order to dissolve out the sugar after which the sugar is recovered from the water.

The axles 380 and 391 of the upper rollers 376 and 388 are mounted by bearing blocks 400 to a bar 402 which is supported by bolts 406 and 408 on a side member 410. Nuts 412 can be adjusted to vary the force that a leaf spring 414 applies downwardly to opposite ends of the bar 402. The leaf spring 414 assures that sufficient pressure will be applied to squeeze the rind. Downward movement of the rollers 376 and 388 is limited by stop bolts 416 to provide suitable clearance between the pairs of rollers so that the rind fibre will not be damaged. The lower shafts 382 and 392 are power driven to propel the rind through the apparatus. A scraper blade 418 removes moisture from the surface of the roller 378, and additional such blades may be used where appropriate.

A final rind treatment station 420 may follow the expresser assembly 372 for chemically treating the rind strips to prevent deterioration or to fireproof the rind. This may include an applicator assembly 422 having a tray 424 located above the rind strips with a perforated vibrating bottom 426 and holding a supply of treating material such as powdered borax. A vibrating screen 430 beneath the tray 424 assures even distribution of the treating material over the rind. The tray 424 and the screen 430 are held within a housing 432 through which the rind passes. A funnel-shaped bottom of the housing collects the excess treating material. Vibrator devices 436 may be attached on the housing 432 to provide the vibrating motion for the tray bottom 426 and the screen 430. A pair of rollers 440 and 442 help propel the rind strips and assure continuous movement of the rind from the chemical treatment station 420. Thereafter the rind may be collected for further handling. As an alternative to the use of a powder, a treating material in liquid form may be applied to the rind as by spraying the material on the rind or by dipping the rind into the liquid.

By way of further explanation, the processing of sugarcane as provided by the modified apparatus shown in FIGURES 8 to 17 includes, first the removal and collection of wax from the outer surface of each whole sugarcane stalk, which step also removes trash and other loose extraneous matter clinging to the outside of the stalk. This is accomplished, for example, by passing the whole stalk through an orifice or opening of predetermined size but self-adjustable to accommodate the stalk in such fashion as to remove a major portion of the wax without removing or disturbing a substantial amount of the epidermis or rind.

The next step is to remove and collect the epidermis by passing each whole sugarcane stalk with the wax removed through a second orifice or opening of predetermined size and also self-adjustable to accommodate the stalk in such fashion as to remove the epidermis from the rind. This leaves the hard, strong fibres of the rind exposed on the outside of the stalk.

Next, the whole stalk is split lengthwise, that is along its longitudinal dimension, into two sections that are substantially semi-circular in cross-section. Then, the stalk halves are turned and aligned with the flat portions, that is the portions with the pith exposed, facing the same direction, preferably downwardly.

The rind and pith are then separated before the rind is flattened by moving the halves past rapidly rotating blades which engage and, in effect, sweep the pith away from the rind without engaging or disturbing the rind fibres. Carefully controlled guiding and supporting of the stalk halves past the blades is important. The halves, in effect, are floated or stalled into the blades by the combined action of three forces. (1) Each half is propelled rapidly in a generally horizontal direction toward the blades. (2) A fixed guide forces the leading end of the moving half downwardly into tangential alignment with the blades; and because the half stalk is rigid longitudinally, the major portion of the half, as it approaches the blade, remains generally horizontally disposed. (3) A constant spring force is applied upwardly against the half in front of the blades. This keeps the half resiliently biased upwardly in tangential alignment with the blades and prevents the half stalk from hitting the blades head on. Preferably the blades rotate against the oncoming pith.

The pith, which contains a major portion of the juice, is collected from the blades and sent to further processing. The previously described operations are performed on the rind without changing the original, natural shape of the rind, that is, without significantly moving the rind fibres with respect to one another. Removal of the pith from the rind occurs, for example, when the rind is curved. This maintaining of the stalk in curved configuration provides for control regarding the separation of the components, particularly the separation of the pith and the rind without causing separation of the juice from the pith.

Next, the rind strips are flattened and pressed by passing them between a first set of rotating rollers in order to shape the strips and to squeeze out juice. A controlled amount

of water is then added to the strips and then are squeezed again to remove any remaining sugar. This wetting and wringing operation may be repeated as necessary in order to remove as much of the sugar from the rind as possible. The rind may be subjected to diffusion, as an alternative. After this, the rind is treated chemically to prevent deterioration, dried and then collected.

The process and apparatus of this invention provide for a departure from conventional methods of transferring sugarcane stalk from the fields to the factories and for removing the juice from the cane soon after cutting. The apparatus of this invention may be employed at or near the fields in separator depots so that only short hauls of the freshly cut cane are required. The relative small size and inexpensiveness of the apparatus allow for a large number of separator depots to be used compared with conventional apparatus wherein a single factory serves a large area. The cane is cut and takes immediately to a separator depot where the pith is separated from the rind. The pith, still holding the natural juices, may be treated with an alkaline solution such as milk of lime to neutralize the natural acidity of the juice thereby controlling inversion of the sucrose. Then the pith alone is transported to the factory for the subsequent removal of the neutralized juice whereafter the juice is refined into sugar products. Also, if desired, the juice may be separated from the pith at the separator depots so that only the juice need be transported to the refinery. By this process, inversion of the sucrose is checked very shortly after the cane is cut, and it is necessary to transport only the juice or the juice laden pith to the refinery. This can be accomplished considerably more efficiently than transporting the entire cane stalk. The pith with the juice still in it, or the raw juice after it has been removed from the pith, can be stored.

The comparatively small size of the apparatus enables it to be attached to or become an integral part of a mobile mechanical harvester. In this respect, the apparatus can be mounted on a suitable transportable structure behind a conventional cane harvester so that as the harvester and apparatus travel through the cane fields together the cane stalks are immediately converted into the several commodities as described above. This arrangement is illustrated diagrammatically in FIGURE 18 wherein a conventional harvester 444 cuts the growing cane 445 which then is fed immediately to the apparatus 446 of this invention mounted upon a suitable transportable platform 447. The wax, the epidermis, the pith containing the juice, and the rind are collected separately from the apparatus as the harvester and apparatus move through the fields. If desired, provision may be made for separating the juice from the pith by apparatus mounted on the platform 447. The dry products can be bagged or baled and the raw pith or the juice can be put into suitable containers 448 and then left behind after being filled for subsequent pickup and transportation to the appropriate locations for further processing or handling. This arrangement, made possible by the apparatus of this invention, eliminates much of the equipment and consequently a proportionate amount of the cost heretofore encountered in heaping and loading the cane stalks in the fields after cutting, and the subsequent transporting and further handling of the whole stalks at the factories.

Because of the past practice of milling sugarcane, considerable study has been given to developing of sugarcane with a soft rind and with a minimum of wax. This process and apparatus are suited for handling almost any variety of sugarcane, even those with extremely hard rind; and, furthermore, the high wax content of some sugarcane can be an advantage since can wax is a valuable commodity.

This process and apparatus can be employed advantageously in connection with existing refining equipment. Since the juice contains fewer contaminants and has a high Brix value, the sugar maufacturing process is greatly enhanced. As pointed out previously, the sugarcane stalk is processed into five primary components; namely, wax, epidermis, rind fibres, pith floc and juice. Bagasse is not produced, and this in itself can be considered an extremely valuable improvement over existing processes.

Co-pending Patent Application No. 30498/65 (Serial No. 1126492) claims 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.

Co-pending Patent Application No. 200/68 (Serial No. 1126493) claims 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.

WHAT I CLAIM IS:—

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 sepa-

of water is then added to the strips and then are squeezed again to remove any remaining sugar. This wetting and wringing operation may be repeated as necessary in order to remove as much of the sugar from the rind as possible. The rind may be subjected to diffusion, as an alternative. After this, the rind is treated chemically to prevent deterioration, dried and then collected.

The process and apparatus of this invention provide for a departure from conventional methods of transferring sugarcane stalk from the fields to the factories and for removing the juice from the cane soon after cutting. The apparatus of this invention may be employed at or near the fields in separator depots so that only short hauls of the freshly cut cane are required. The relative small size and inexpensiveness of the apparatus allow for a large number of separator depots to be used compared with conventional apparatus wherein a single factory serves a large area. The cane is cut and takes immediately to a separator depot where the pith is separated from the rind. The pith, still holding the natural juices, may be treated with an alkaline solution such as milk of lime to neutralize the natural acidity of the juice thereby controlling inversion of the sucrose. Then the pith alone is transported to the factory for the subsequent removal of the neutralized juice whereafter the juice is refined into sugar products. Also, if desired, the juice may be separated from the pith at the separator depots so that only the juice need be transported to the refinery. By this process, inversion of the sucrose is checked very shortly after the cane is cut, and it is necessary to transport only the juice or the juice laden pith to the refinery. This can be accomplished considerably more efficiently than transporting the entire cane stalk. The pith with the juice still in it, or the raw juice after it has been removed from the pith, can be stored.

The comparatively small size of the apparatus enables it to be attached to or become an integral part of a mobile mechanical harvester. In this respect, the apparatus can be mounted on a suitable transportable structure behind a conventional cane harvester so that as the harvester and apparatus travel through the cane fields together the cane stalks are immediately converted into the several commodities as described above. This arrangement is illustrated diagrammatically in FIGURE 18 wherein a conventional harvester 444 cuts the growing cane 445 which then is fed immediately to the apparatus 446 of this invention mounted upon a suitable transportable platform 447. The wax, the epidermis, the pith containing the juice, and the rind are collected separately from the apparatus as the harvester and apparatus move through the fields. If desired, provision may be made for separating the juice from the pith by apparatus mounted on the platform 447. The dry products can be bagged or baled and the raw pith or the juice can be put into suitable containers 448 and then left behind after being filled for subsequent pickup and transportation to the appropriate locations for further processing or handling. This arrangement, made possible by the apparatus of this invention, eliminates much of the equipment and consequently a proportionate amount of the cost heretofore encountered in heaping and loading the cane stalks in the fields after cutting, and the subsequent transporting and further handling of the whole stalks at the factories.

Because of the past practice of milling sugarcane, considerable study has been given to developing of sugarcane with a soft rind and with a minimum of wax. This process and apparatus are suited for handling almost any variety of sugarcane, even those with extremely hard rind; and, furthermore, the high wax content of some sugarcane can be an advantage since can wax is a valuable commodity.

This process and apparatus can be employed advantageously in connection with existing refining equipment. Since the juice contains fewer contaminants and has a high Brix value, the sugar maufacturing process is greatly enhanced. As pointed out previously, the sugarcane stalk is processed into five primary components; namely, wax, epidermis, rind fibres, pith floc and juice. Bagasse is not produced, and this in itself can be considered an extremely valuable improvement over existing processes.

Co-pending Patent Application No. 30498/65 (Serial No. 1126492) claims 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.

Co-pending Patent Application No. 200/68 (Serial No. 1126493) claims 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.

WHAT I CLAIM IS:—

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 sepa-

24. Apparatus according to any of Claims 21—23, having means for removing the wax component of each sugarcane stalk which comprises a brush having bristles mounted to rotate in a plane transverse to the path of said stalk.

25. Apparatus according to Claim 21, having means for removing the wax, which means comprises a plurality of spring devices, each spring device having a sharp stalk-engaging edge.

26. Apparatus according to Claim 21, having means for removing the epidermis which means comprises a brush having bristles mounted to rotate in a plane transverse to the path of the stalks.

27. Apparatus according to Claim 21, having means for removing the epidermis, comprising a plurality of spring devices, each spring device having a sharp stalk-engaging edge.

28. Apparatus according to Claim 21, wherein the means for removing the wax and epidermis comprises a plurality of flexible members extending generally radially of the travel path of said stalk, free ends of said flexible members being spaced apart to form a stalk-receiving opening.

29. Apparatus according to Claim 21, wherein the means for removing the wax and epidermis comprises, a housing, a plurality of parallel spaced rings, resilient mounting means securing said rings to said housing, and a plurality of flexible stalk-engaging members carried by each ring, spaced circumferentially on each ring generally radially of each ring to terminate in a sharp stalk-engaging edge.

30. Apparatus according to Claim 21, having means for longitudinally opening up and turning each stalk to expose the pith component thereof, comprising a vertical cutting blade positioned in the path of said stalk followed by a vertically extending front portion in said path which faces the oncoming opened-up stalk and has sides which curve gradually into a horizontally extending rear portion.

31. Apparatus according to Claim 21, wherein the means for splitting each stalk comprises a stalk-splitting blade, a support for said blade movable transversely of the travel path of said stalk, and a stalk guide connected with said blade.

32. Apparatus according to Claim 21, wherein the means for splitting each stalk comprises a plurality of pivotably interconnected arms defining a parallelogram, a pivot mount for said parallelogram, a stalk splitting blade carried by said parallelogram, a pair of guide rollers carried by said parallelogram on generally opposite sides of said blade, and a spring mounted on said parallelogram to bias said rollers toward each other.

33. Apparatus according to Claim 21, wherein the stalk-feeding devices comprise a pair of rollers, each roller including opposed, frustoconical surfaces having a common large diameter, the large diameters of each of said rollers being substantially coplanar, said frustoconical surfaces of said rollers defining V-shaped rind-engaging surfaces opening outwardly away from the travel path of said stalk.

34. Apparatus according to Claim 21, wherein the means for separating the pith from the rind comprises a rind-engaging roller mounted on one side of the travel path of each longitudinally opened-up stalk, and a pith-engaging brush mounted on the other side of said travel path of each opened-up stalk.

35. Apparatus according to Claim 21, wherein the means for separating the pith from the rind of each longitudinally-opened stalk comprises a rind-engaging support having a generally concave cross-section transverse of the travel path of said stalk, and a wheel having pith-engaging blades received within the concave side of said support.

36. Apparatus according to Claim 35, comprising a stalk guide resiliently biased towards said support.

37. Apparatus according to Claim 35, comprising a stalk guide having an upper surface sloping downwardly in the travel direction of the stalks and a lower surface resiliently biased upwardly towards said upper surface, and a pith receptacle beneath the wheel, the wheel and the rind-engaging support being disposed at opposite sides of the travel path of the stalks.

38. Apparatus according to Claim 21, wherein the means for extracting the juice from the pith comprises a pair of horizontally aligned, and contiguous, pith crushing rollers, and a juice reservoir defined, in part, by upper adjacent surfaces of said rollers.

39. Apparatus according to Claim 21 having means for expressing juice from the rind after removal of the pith.

40. Apparatus according to Claim 39, wherein said expressing means comprises a first and second pair of rollers spaced longitudinally of the travel path of longitudinally opened-up sugarcane stalks, and a spray device disposed longitudinally between said first and second roller pairs.

41. A process for treating sugarcane stalks substantially as herein described with reference to Fig. 1 of the accompanying drawings.

42. Apparatus substantially as herein described with reference to Figs. 2 to 7, or 8 to 9, or 10 to 18 of the accompanying drawings.

By ERIC POTTER & CLARKSON,
Nottingham, London and Leicester.

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1968.
Published by the Patent Office, 25 Southampton Buildings, London, W.C.2, from which copies may be obtained.