Jan. 28, 1969 R. B. MILLER 3,424,611

SUGARCANE PROCESSING AND APPARATUS

Filed July 22, 1964 Sheet 1 of 5

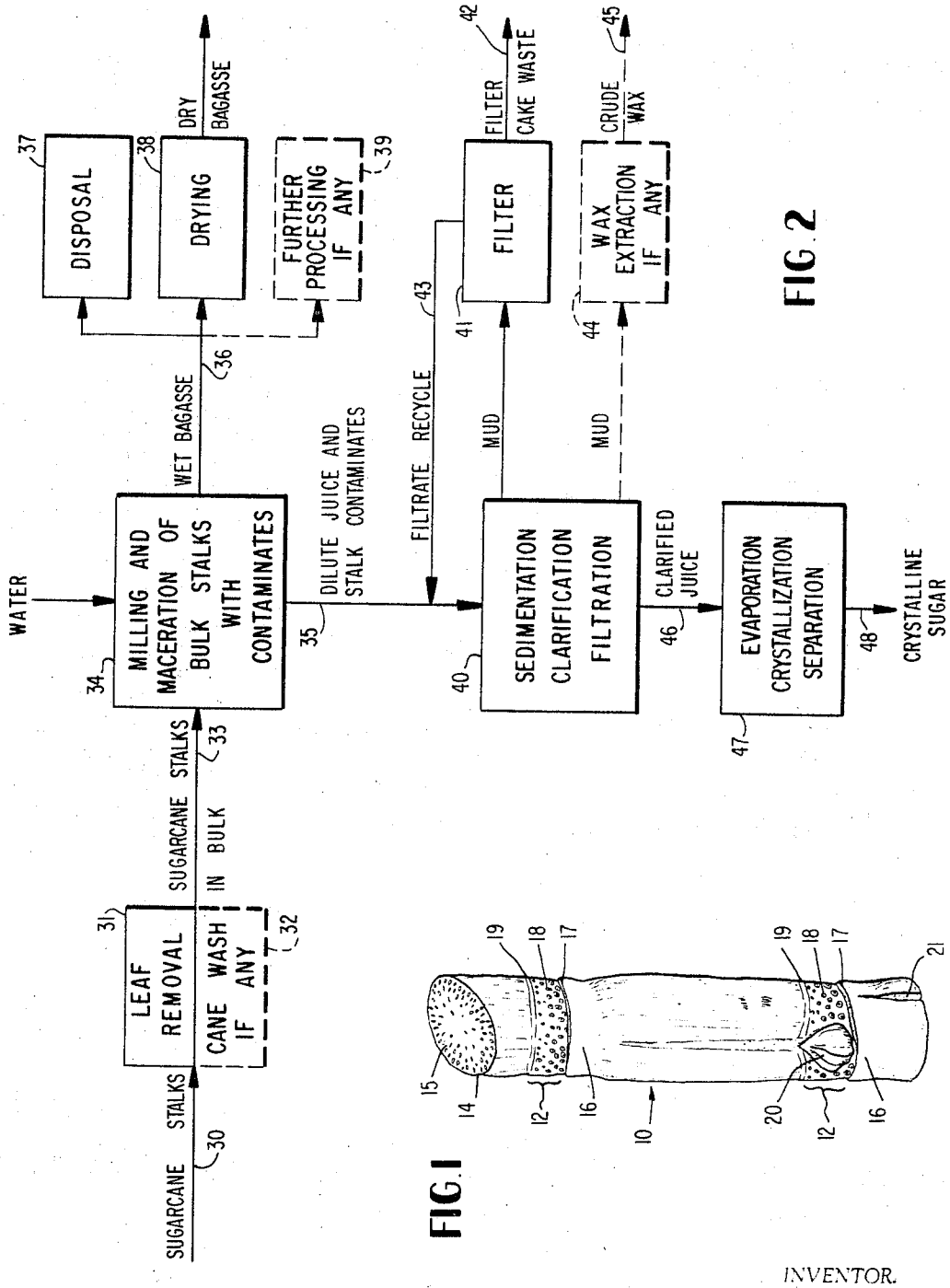


FIG. 2

FIG. 1

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SUGARCANE PROCESSING AND APPARATUS

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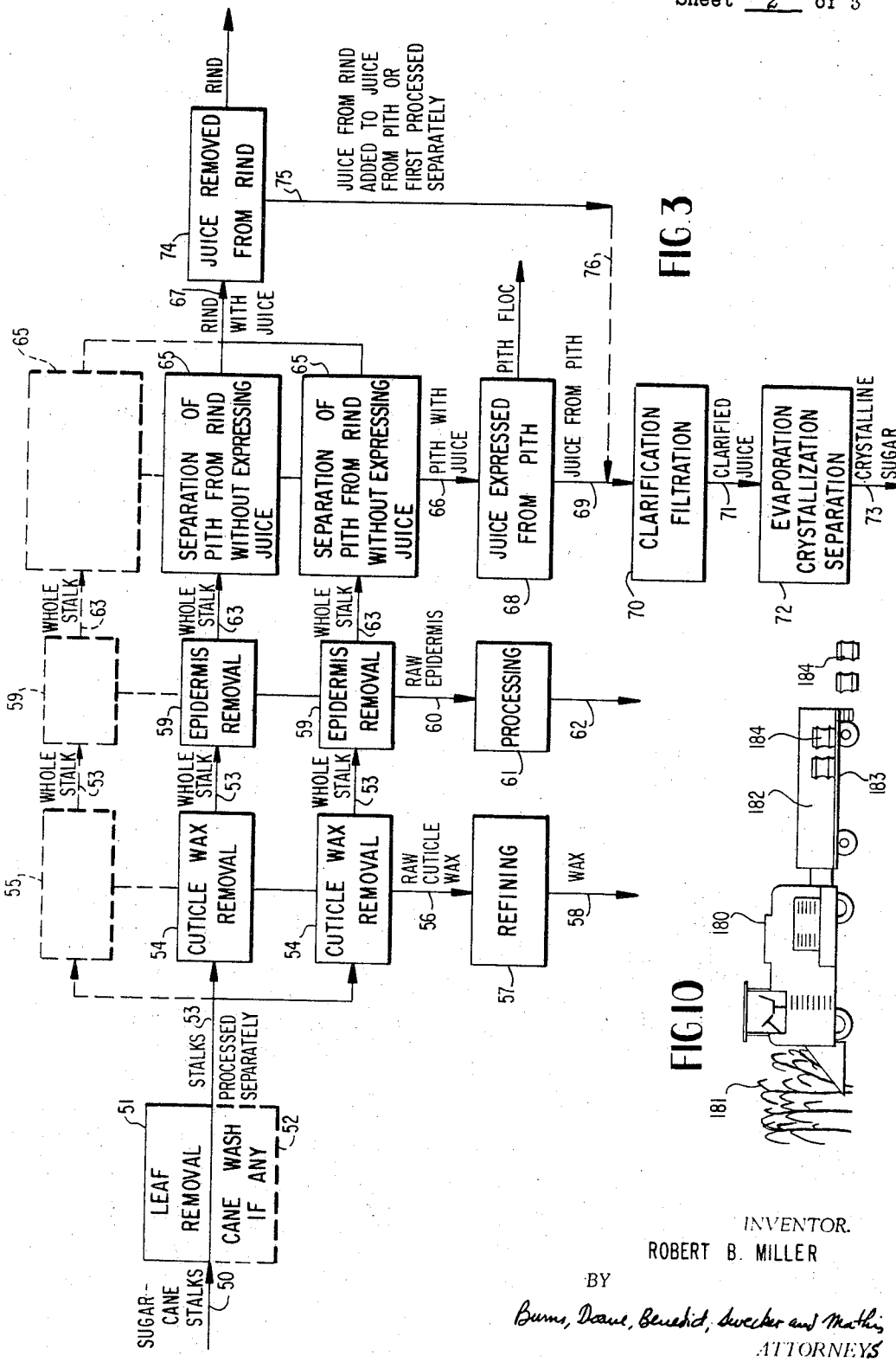


FIG 3

FIG 10

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SUGARCANE PROCESSING AND APPARATUS

Filed July 22, 1964 Sheet 3 of 3

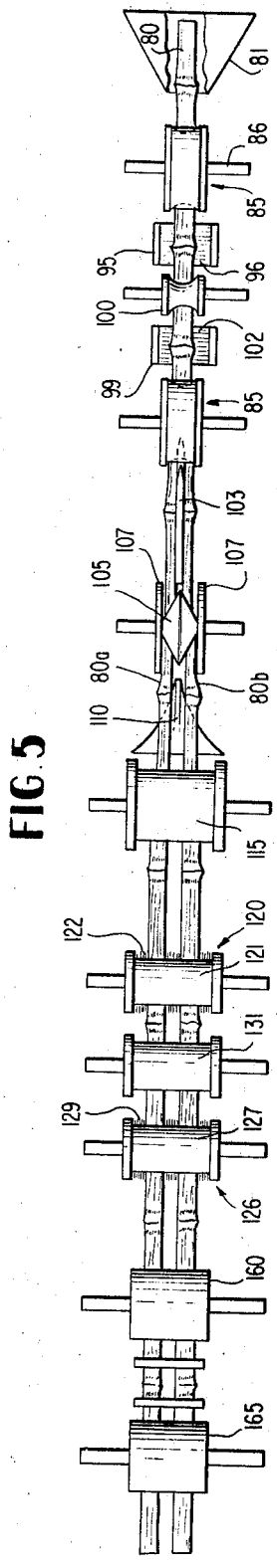


FIG. 5

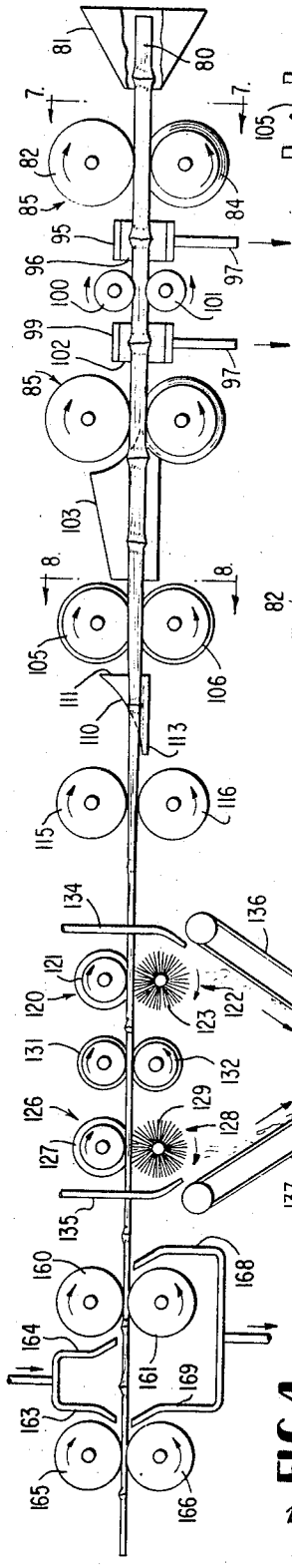


FIG. 4

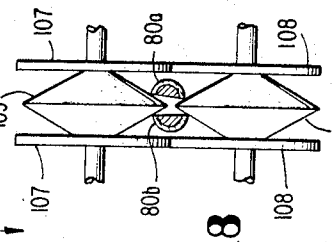


FIG. 8

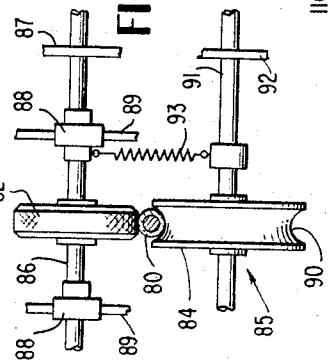


FIG. 7

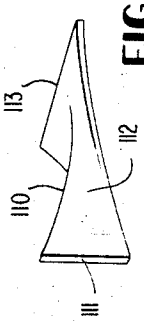


FIG. 9

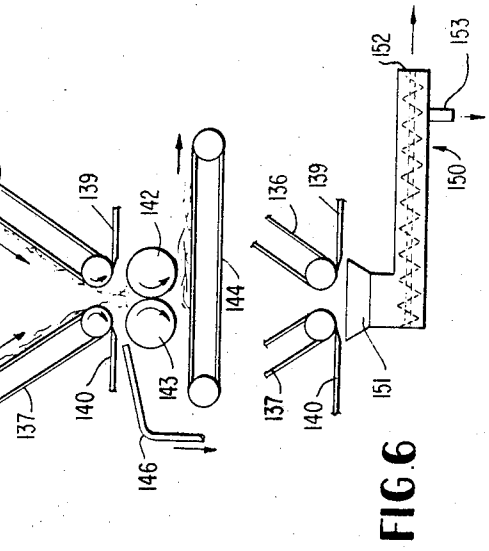


FIG. 6

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United States Patent Office 3,424,611
Patented Jan. 28, 1969

3,424,611

SUGARCANE PROCESSING AND APPARATUS

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Filed July 22, 1964, Ser. No. 384,410
U.S. Cl. 127—2 9 Claims
Int. Cl. C13d 1/06

ABSTRACT OF THE DISCLOSURE

Methods and apparatus for separating the pith and rind components of sugarcane involving the separation of stalk into longitudinal segments, followed by the removal of pith from the stalk segments.

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 commodities not heretofore obtainable. In addition, many undesirable drawbacks encountered in conventional processes and apparatus are eliminated. Not only does this invention enhance the processing of sugarcane and the removal of sugar juices from sugar cane, but the process avoids the production of certain waste materials considered, for the most part, heretofore to be undesirable.

Sugarcane is produced throughout the world generally in a belt extending from about 30 degrees north of the equator to about 30 degrees south of the equator. Reportedly, sugarcane is grown in some fifty countries where the cane is processed into crystalline sugar or lower grade sugar products. The primary commodity sought from the usual method of treating sugarcane, and in fact the only commodity normally derived from sugarcane, is the actual sugar itself with little or no regard given to the recovery of other products. A by-product of conventional sugarcane processing is bagasse—or megasse as it is called in some areas—which is the fibrous or woody portions of sugarcane. A major quantity of the bagasse produced of some sugarcane mills throughout the world is used as fuel for generating steam power for running the mills. Sometimes it is burned merely to get rid of it. Since considerably more bagasse is produced than can be used as fuel, disposal of the excess is a serious problem. Large sums have been spent on trying to find ways of readily disposing of the bagasse or developing it into a commercial product. Efforts in this direction have not been completely satisfactory.

Sugar from sugarcane is produced by a process which initially requires the violent destruction of the whole cane stalk by the use of massive machinery that cuts, crushes, shreds and breaks the whole cane stalk, and then, under enormous pressure, forcefully squeezes out the natural juices. This is referred to as milling; and while it has been used successfully in the extraction of the juices from the whole cane, it has created serious problems in the overall sugar refining process. This invention provides a new process and new apparatus which do not rely upon milling of the cane and which consequently avoid the problems created by it. Not only does this process enhance the quality of the natural juices taken from the sugarcane stalk, but it also produces new commodities from sugarcane stalk which have not been obtainable by conventional processes. Furthermore, the apparatus of my invention has many significant advantages over conventional equipment as will be explained.

One object of this invention is to provide a new process for treating sugarcane and a new apparatus for treating sugarcane, which process and apparatus are vast improvements over conventional processes and apparatus.

Another object of this invention is to eliminate in the handling of sugarcane the need for milling equipment heretofore believed to be essential for the treating of sugarcane, thereby simplifying the operation, reducing the power requirements for running the equipment, reducing the necessary initial costs of such equipment, and reducing the maintenance and repair costs as well.

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

Another object of this invention is to provide a novel process and apparatus for handling sugarcane stalk and sugarcane products, beginning from the time the stalks are harvested, thereby resulting in more efficient transportation procedures, increasing the amount of available sucrose recovered, and otherwise improving sugarcane treating procedures.

Another object of this invention is to extract from sugarcane substantially all of the natural sugar juice, which juice is free from most of the contaminants and diluents normally found in juices extracted by ordinary processes.

Another object of this invention is to produce from sugarcane useful commodities such as wax, an epidermis-material, a pith floc, fiber products, and others, and to produce such commodities in an efficient and economical manner.

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

The cuticle wax is removed from the outer surface of each whole stalk together with dirt and other foreign matter. The raw cuticle wax is recovered and processed further. Next, the epidermis is removed and collected. Each whole stalk is then split longitudinally. The two stalk halves are separated, carefully rotated, and flattened, thereby exposing the pith which then is separate from the rind. The handling of the whole stalk and the stalk halves is done without any effective squeezing of the pith to express therefrom the juice or without materially damaging or disturbing the fibers of the rind. The pith, only after being separated from the rind, is pressed to extract therefrom the desirable sugar juices. The pith with the juice expressed therefrom may be processed further and the rind strips, after the pith has been separated, may be treated for the removal of the sugar juices. This is accomplished, for example, by wetting the rind and then squeezing or wringing the strips. This treatment of the rind is optional for reasons to be explained.

The apparatus of this invention includes a series of stations at which the cane is treated. Each stalk is handled separately and is propelled with continuous motion through the apparatus; that is, a whole stalk is introduced into the apparatus and as the apparatus runs continuously, the stalk is separated into various components. A shield or guide aids in aligning the stalk for introduction into the first station. Generally, the main stations are aligned longitudinally of the apparatus. A series of guide and drive roller assemblies are provided for propelling the stalk in such a manner as to forcefully advance the stalk longitudinally of the apparatus but so as not to significantly compress or squeeze the rind in a

transverse or radial direction. The guide and drive roller assemblies include one roller with a flexible circumferential surface cooperating with a second roller having a concave circumferential surface to receive therebetween the stalks.

A series of rotating brushes or scraping means at the first main station remove the cuticle wax from the stalk. These rotating brushes may have metal bristles or bristles made of other material which pass over the exterior of the cane to remove the soft and hard waxes without crushing the rind or squeezing the pith. Another group of brushes removes the epidermis from the exterior of the rind.

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

The two stalk halves slide off the stalk-turning member side-by-side and move to the next station comprising two rollers having vertically spaced apart cylindrically shaped surfaces for receiving therebetween the stalk halves. These two rollers, in effect, flatten out and lay open the rind of the stalk halves to expose the pith for the next station which includes a series of rotating brushes or scraping means located to one side of the path of the stalk halves. The bristles of the brushes are positioned to remove the pith from the rind without significantly compressing the pith. The bristles which engage the pith move into the path of the oncoming pith to separate the pith from the ring. The pith, thus separated from the ring, contains most of the natural sugar juices. Suitable transfer means carry the separated pith to a station where the raw sugar is removed from the pith. The raw sugar is collected and transmitted to the necessary equipment for beginning the refining processes. The pith also is collected for further processing. The rind strips, after the pith has been removed therefrom, are passed through dry rollers or may be passed through a wetting or soaking area whereafter at least one set of rollers receive the wetted rind strips to express the moisture and the rind juices. The rind strips are then collected for further handling. The apparatus can be located at or near the fields so that only the raw juice need be transported to the refining factories.

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

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

FIGURE 2 is a schematic diagram showing various steps of a conventional sugarcane process carried out heretofore which produces sugar and bagasse;

FIGURE 3 is a schematic diagram illustrating the novel process of this invention;

FIGURE 4 is a side elevation view showing diagrammatically the apparatus of this invention;

FIGURE 5 is a plan view, corresponding generally with FIGURE 4;

FIGURE 6 is a side elevation view showing diagrammatically an alternative device for expressing the juice from the pith;

FIGURE 7 is an enlarged view taken along line 7—7 of FIGURE 4;

FIGURE 8 is an enlarged view taken along line 8—8 of FIGURE 4;

FIGURE 9 is an enlarged perspective view of a stalk turning member of the apparatus of this invention; and

FIGURE 10 is a diagrammatic representation of a harvester with the apparatus of this invention transportably mounted therebehind.

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

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

FIGURE 2 represents diagrammatically certain of the steps currently practiced for the obtaining of crystalline sugar from sugarcane. According to this generally accepted method as it is practiced throughout the world, the sugarcane is harvested in the fields usually by cutting the stalks free from the soil with a knife or machete and then stripping off the adhering leaves and removing the topmost joints which contain little or no sugar. Mechanical harvesting and loading machines are being used more frequently. In some areas, the fields of sugarcane are burned to remove the leaves prior to mechanical harvesting. It is essential in the conventional method that the uppermost portion of the stalk just above the highest colored node be removed because it contains acids which are detrimental to the subsequent processing of sugarcane juice. The cut sugarcane stalks are carried to the factories, and it is the practice at some locations to wash the stalks at cleaning plants or laundries prior to the processing of the stalks; but because of the investment required for such laundries, it is not uncommon for the stalks not to be washed prior to processing. If the stalks are not washed thoroughly, they contain considerable field dirt, mold and other contaminants which find their way ultimately into the juices.

In FIGURE 2 the cane is represented at 30, the leaf removal operation at 31 and the washing of the cane at 32.

After the washing operation, if carried out, a preparatory operation is usually conducted to chop up the stalks by using a series of knives or rotating blades. The effect of this merely is to reduce the stalks to short lengths. In any event, in conventional methods, the stalks are handled in bulk and this has been accepted universally as the most efficient way of handling sugarcane in mass quantities.

The next operation which is essential in present commercially operated sugarcane handling methods is to subject the bulk cane stalks to a crushing and grinding operation to remove as great a percentage of the juice present in the stalks as is economically possible. This step is commonly referred to as milling and normally is carried out by a series of three roller mills. In such mills, the entire cane stalk is shredded and crushed violently in order to break through the hard rind to rupture the pith cells and extract therefrom the juice containing the valuable sugar. Usually there are a series of the three roller mills, making up a train, the crushed stalks passing in series from mill to mill to make sure that the most efficient extraction of the juices has been obtained. To aid in the milling operation, the crushed stalks are steeped or wetted with water in the later stages of the crushing operation. This is called imbibition or maceration. Juices squeezed out by the last mills in the train are usually recycled and used to wet the stalks in the early stages of the crushing operation to obtain more effective use of the water which has been added. In FIGURE 2, the bulk handling of the sugarcane stalks is represented at 33. The milling and maceration of the cane and expression of the juice from the crushed cane is represented at 34. The extracted juices thus produced by the milling operation are screened and are sent to process, as represented at 35.

A soggy, pulp-like material containing intermingled fibrous portions of the rind and the pulpous pith, called bagasse, comes from the milling process. The bagasse will normally amount to about 30 percent by weight of the cane entering the operation. In most conventional processes, bagasse averages as high as 50 percent moisture as it leaves the mill.

At this point in the conventional process for handling sugarcane, there are two intermediary products; namely, the dilute sugar juices 35 containing the valuable sucrose and the wet bagasse 36. Neither one of these intermediary products, that is the juice of the bagasse, has commercial value without further processing. The dilute juices thus obtained by the milling and maceration of the cane contain a variety of contaminants. Theses contaminants include a considerable amount of fine fibers loosened from the rind and the pith, in addition to dirt which was not washed off the cane and which may be carried from the field through the milling process. The extended milling of the entire stalk presses the waxes, resins and other solids from the rind into the juice. Since cane stalk is subject to disease, any organic infestation and other micro-organisms, as well as insects, will be squeezed from the rind and washed into the juice. The many impurities in the raw juice as it comes through the milling process causes considerable difficulties in the subsequent refining processes. Such impurities may be removed by the clarifiers, filters, evaporators and crystallizers; and the failure to remove such impurities has a deleterious effect on the quality and quantity of the sugar thus obtained.

Previous methods for handling cane do not produce any type of juice other than a relatively impure raw sugarcane juice which can be manufactured into the desired sugar products. Accordingly, there has been developed through the years different types of equipment for handling such juices having a high amount of impurities. Not only does the milling step require extremely heavy equipment and considerable high power to tear the sugarcane apart in order to express the juice from the inner portions of the stalk, but out of necessity, as a result of the considerable number of impurities found in the dilute juice, extensive equipment is necessary to produce refined sugar.

The bagasse 36, which is the by-product or residue of conventional cane milling processes, historically has been a problem of great magnitude. When it comes from the milling process, it is wet, bulky and difficult to handle. A considerable quantity of the bagasse produced, amount to about one-fourth of all the cane ground in the world, supplies the fuel for generation of steam to run the sugarcane factories. There is, however, normally a vast excess of bagasse. Considerable money and effort have been spent seeking satisfactory ways of turning bagasse into a commercial product. It has been said that the research for commercial uses for bagasse has probably been more intense than for any other agricultural residue.

In some localities throughout the world, bagasse is disposed of by burning simply to get rid of it; but because it is quite wet when it leaves the mills, it must be burned in special furnaces or dried prior to being burned. This requires additional expense and equipment. Furthermore, the ash produced by burning bagasse is very offensive. In some localities in the British West Indies, for example, bagasse has been disposed of by pushing it into the ocean. Normally, wet bagasse does not dry in the atmosphere. It is subject to spontaneous combustion or to rot if stored in piles or bales. In FIGURE 2, the disposal of the wet bagasse by any means is represented at 37. The drying of the bagasse is represented at 38, and additional processing, for example separating the pith from the broken fibers for possible commercial use, is represented at 39.

The dilute juice 35 extracted from conventional milling operations is sent to process as represented at 40 in FIGURE 2. After weighing or measuring, the dilute juice is treated usually with a slurry of calcium hydroxide to raise the pH value to about 8 to 8.5. Following this operation, it is passed through heat exchangers where the temperature is raised to about 215 degrees F. The heated juice is passed to a continuous sedimentation unit where it is separated into two portions. The clarified or semi-clear juice continues in process while the muds, sometimes called cachaza, is sent to a rotary vacuum filter, for example, represented at 41. The filter cake 42 from this operation is discarded and the filter is recycled at 43 to the entering dilute juice stream. The filter cake waste 42 may be removed in a nearly dry form, and like the bagasse, presents a problem of disposal.

The mud from the sedimentation contains most of the waxes expressed into the dilute juice by the milling process. These muds contain about half the wax present in the cane, and attempts have been made in the past, as represented at 44, to separate this wax. With extensive processing, sometimes about two pounds of crude wax 45 can be recovered per ton of cane. This wax contains oils and resins from inner parts of rind in addition to the cuticle wax. The wax thus produced contains a considerable amount of oils which must be removed in order to obtain the more desirable hard wax. The wax and resins not removed by sedimentation continue through the process and must be removed in subsequent operations. The clarified juice 46 passes to the subsequent refining processes 47 including evaporation, crystallization and separation which produces the crystalline sugar 48. The refining processes are quite extensive, and as such, form no part of this invention except that the juice extracted from sugarcane according to the present invention is considerably less contaminated compared with juices extracted by ordinary milling procedures, as will be explained in detail. For this reason, juice from sugarcane extracted according to this invention is more readily refined into crystalline sugar leaving a smaller percentage of molasses and other low grade sugar products.

The process for treating sugarcane, as explained above, is practiced generally throughout the world and for many

years has supplied the world with usable sugar products. Recovery of sugar by a diffusion process has been attempted but with little success. These known processes, however, are directed primarily to the production of sugar only and do not take into consideration the efficient production of any other commercial product or commodity.

The process and apparatus of this invention, in addition to the preparation of a sugar juice of considerable purity compared with the dilute juice obtained by the conventional milling process, produce four additional valuable products; namely, (1) wax readily capable of being refined for commercial use, (2) an epidermis material capable of being processed, (3) a rind product containing long plant fibers in relatively undisturbed condition highly suitable for further processing into a variety of commercial products or which is readily disposed of, and (4) a pith floc which has numerous uses. This process and apparatus eliminates the production of bagasse which, for the most part as explained before, is an undesirable residue of present sugarcane processes.

FIGURE 3 schematically illustrates certain significant steps of the novel process of this invention for treating sugarcane. 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 where any acids in the green leaf portion are expressed into the sugar juice. The acids present in the juice tend to hydrolize the desirable sucrose into glucose and fructose. In this novel process, 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. Field contaminants left on the cane stalks are not transmitted to the juice.

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 3, the stalks, represented at **50**, are harvested and the leaves are removed, as designated at **51**. The washing of the cane **52** may be carried out by conventional cleaning plants or cane laundries. At **53** in FIGURE 3, 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. 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. 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) is removed. This wax removal step is represented at **54**. Since several stalks can be handled simultaneously, a plurality of steps **54** are represented along with a box designated **55** 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 **56**, and can be refined **57** into commercial wax products **58**. After removal of the wax, the epidermis is removed **59** and the thin fibers which for the most part make up the epidermis are collected **60** for further processing **61** to recover the constituents **62** including silica and other substances.

Each whole stalk **53** 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 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 original stalk pieces. In FIGURE 3, the whole stalks leaving the epidermis removal step are represented at **63**. The pith separation step is represented at **65**. The pith collected from the handling of a plurality of sugarcane stalks is represented at **66** and the depithed rind is represented at **67**.

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 percent of the cane stalk and contains about 16–18 percent sugar dissolved in various forms in the juice portion. This pith is in a fluffy, loose form of cellular 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 **68**. 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 in to 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 should be compared 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 my process it is not necessary to add water in order to obtain a suitable extraction of the juice from the pith.

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 percent of sugar 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 of cane milled, this convention was adopted in the table.

TABLE I

Pressure (p.s.i.)	First expression sugar (Percent)	First wash		Second wash		Third wash	
		Sugar (Percent)	Water added (Percent)	Sugar (Percent)	Water added (Percent)	Sugar (Percent)	Water added (Percent)
100	7.1						
200	2.6	1.5	5	1.2	10	0.8	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				
1,000	1.1	0.3	5	0.1	10		
		0.2	10				
		0.1	20				
1,500	2.2	1.2	5	0.9	10		
		0.8	10	0.4	20		
		0.6	20				
2,000	2.4	1.4	5	1.0	15		
		1.0	10	0.5	20		
		0.7	20				
2,500	1.1	0.3	5	0.1	10		
		0.2	10				
		0.1	20				
4,000	2.2	1.2	5	0.9	10		
		0.8	10	0.4	20		
		0.6	20				
6,000	2.2	1.2	5	0.9	10		
		0.8	10	0.4	20		
		0.6	20				
8,000	2.2	1.2	5	0.9	10		
		0.8	10	0.4	20		
		0.6	20				
10,000	2.2	1.2	5	0.9	10		
		0.8	10	0.4	20		
		0.6	20				
12,000	2.1	1.1	5	0.8	10		
		0.7	10	0.4	20		
		0.4	20				
15,000	2.1	1.1	5	0.8	10		
		0.7	10	0.4	20		
		0.4	20				
25,000	1.1	0.3	5	0.1	10		
		0.2	10				
		0.1	20				

Table I reveals some of the advantageous results obtained by this process. It will be noticed that at pressures higher than 100 p.s.i., the sugar content of the resulting pith floc is in the range of 1.1 percent to 2.7 percent with one expression and no subsequent washing with water. This can be compared with various reported data concerning conventional processes. The sugar lost in the bagasse as it left the plants in Mauritius was on the average of 4.14 to 5.71 percent sucrose in the cane for the period of 1956 to 1961. During this time, the amount of imbibition water used was 209 to 231 percent fiber (J. M. Paturau, Proc. 11th Congress ISSCT, 1962, page 39. It has been reported that the bagasse as it leaves the mills on Taiwan contains approximately 3 percent sugar (Hsi-Shang Wu, Proc. 11th Congress ISSCT, 1962, page 1172. In the Ninth Edition (1963) Cane Sugar Handbook by George P. Meade, published by John Wiley and Sons, Inc., New York-London, the following statement is made on page 11: "The percentage of imbibition water varies with the country, the capacity of the mills, the character of the cane (especially its fiber content), and the relative costs of fuel and sugar. Modern mills and fuel economies have increased the amount of water permissible so that 25% to 30% is customary in larger factories where 10% to 15% was the rule 30 years ago. In Hawaii and Australia the range is from 25 to 40%."

The data in Table I show 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 present processes, virtually all of the sugar can be recovered from the pith produced by this 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 present 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 present 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 equipmetn 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 3, fur-

ther processing of the juice from the pith **69** is clarified and filtered **70**, whereafter the clarified juice **71** is subjected to evaporation, crystallization and separation **72** in order to produce crystalline sugar **73**.

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 percent 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 percent 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 allowing some of the juices to drain into the rind. The sugar in the rind may be readily recovered by various ways. For instance, the rind may be introduced into a pair of rollers directly after the pith is removed where pressure is applied to it and the sugar containing liquid is squeezed out, or the rind may be wetted or washed first with clear water and then subjected to suitable pressure. Alternatively, after the pith is separated from the rind, the rind may be washed by impinging upon it a jet of water under high pressure or by subjecting it to the action of a water bath that may or may not be heated. The water bath may be agitated or subjected to ultrasonic compression waves. These alternative steps of removing sugar from the rind avoid breaking the fibers and consequently introducing broken rind fragments into the juice. The sugar and moisture content of the rind may be lowered further by applying pressure to the rind after exposure to the water. 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 percent remaining sugar based on the weight of bagasse. The removal of the sugar from the rind is represented at **74** and the sugar juice at **75**. Juice extracted from the rind may be added **76** directly to the juice from the pith **69** or may be processed separately prior to being added to the juice **69**. In some commercial operations it may not be feasible to attempt to extract the juice from the rind.

FIGURES 4 and 5 illustrate diagrammatically apparatus for handling sugarcane according to this invention. Whole cane stalks, such as the stalk **80**, 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 **81** may be employed to guide the stalk. The cane stalk **80** immediately is gripped between a pair of power-driven rollers **82** and **84** which are part of a drive and guide roller assembly **85** shown in FIGURE 7. The assembly **85** serves to hold the stalk **80** in properly aligned position and to advance the stalk through the apparatus. The roller **82** has a flexible circumferential surface like a balloon tire and is mounted on a rotatable shaft **86** power driven by a gear or sheave **87**. The shaft **86** may be supported by suitable brackets **88** slidable up and down on brackets **89**. The roller **84** has a concave circumferential surface **90** spaced from the roller **82** far enough to receive therebetween the stalk **80**. The roller **84** is mounted on a rotatable shaft **91** power driven by a gear or sheave **92**. The roller **82** can move toward or away from the roller **84** to accommodate stalks and node and internode portions of different diameter. Gravity or suitable light, spring means **93** are employed to keep the rollers **82** and **84** close enough together so that the surface of the roller **82** may grip and propel the stalk **80** while guided and held in alignment by the concave surface **90**. The flexible surface of the roller **82** assures that the stalk **80** will not be squeezed hard enough to rupture the cells of the pith in the stalk. The rollers **82** and **84** may be reversed, that is the roller **82** could be on the bottom with the roller **84** on top.

The whole stalk **80** is propelled by the assembly **85** to the first of a series of treating stations comprising a rotating brush **95** in the shape of an iris with the stalk **80** passing therethrough. The rotating brush has wire bristles **96** or bristles formed of another suitably stiff material, for example nylon or the like. The bristles **96** extend radially from the longitudinal axis of the cane and rotate in a plane normal to the path of the stalk. As the bristles **96** rotate around and scrape over the outside surface of the stalk **80**, they remove the cuticle wax as the moving stalk passes. As the bristles **96** pick up the wax, which is in the form of dust or powder, suction in a line **97** withdraws the wax from the bristle area and carries the wax off for recovery and processing. The bristles **96** may also remove extraneous matter such as field dirt which may not have been washed off. The bristles **87** are of such length and of a pliable nature so that the wax portion will be removed but the rind will not be penetrated. 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, as well as the bristles **96**.

A second rotating brush **99** similar in construction to the brush **95** is spaced therefrom and receives the stalk **80** after it passes through a pair of idler guide rollers **100** and **101**. The brush **99** has bristles **102** which are slightly longer and slightly less flexible compared with the bristle **96**. The bristles **102** 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 fibers are not broken.

The whole stalk **80** then is engaged by another assembly **85** which forces the stalk **80** into a stalk severing station in the form of a stationary knife or blade **103** positioned in the path of the stalk. Other stalk severing devices may be used instead of the particular stationary blade **103**, for example a moving saw may be used as well. Whatever form of stalk severing member is used, the pith within the stalk should not be subjected to sufficient pressure to express a material amount of the juice. It is desirable that as much of the juice remain in the pith at this point of the operation for extraction at a subsequent station.

After the stalk, which now is in two pieces, leaves the stalk severing station, it is propelled to the next station where it is spread apart and advanced by a pair of power-driven spreader wheels **105** and **106**, illustrated in FIGURE 8. The two halves of the stalk **80** are spread apart by back-to-back frusto-conical shaped surfaces of the wheels **105** and **106**, and held in proper position by discs **107** and **108**. The two halves of the stalk **80** are shown in cross section in FIGURE 8 and designated **80***a* and **80***b*. The frusto-conical shaped surfaces on corresponding sides of the spreader wheels **105** and **106** 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, consequentlly, juice is not squeezed out. A single wheel such as either wheel **105** or **106** may be used with a cylindrically shaped wheel to handle the stalk halves.

The stalk halves **80***a* and **80***b* leave the spreader wheels **105** and **106** and are forced to the next station comprising a stalk turning or aligning member **110** which serves the two stalk halves **80***a* and **80***b* about one-quarter turn so that the pith or inner portion faces downward and the outer curved rind portions face upwardly. The aligning member **110** has a vertically extending thin plate portion **111** curving at **112** into a horizontally extending plate portion **113**. The stalk halves engage and slide along the vertical portion **111** and by the time they reach the horizontal portion **113**, they are properly positioned.

The next station comprises a pair of flattening wheels **115** and **116** which guide the stalk halves and prepare them for the succeeding station. Wheel **115** may have a flat, cylindrical surface for engaging the rind while wheel **116** may be a flexible surface, 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 **115** and **116** additionally serve to propel the stalk halves **80***a* and **80***b* 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 **82** and **84**, 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 completely expose the pith and to get the pith and rind oriented with respect to one another for separation of the pith and the rind. This handling of the stalk is accomplished without expressing a significant amount of juice from the pith.

At the next station, the stalk halves engage an assembly **120** for separating the pith from the rind. This assembly **120** comprises a top roller **121** 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 **122**. The bristles **123** of the brush roller **122** rotate into the path of the moving stalk halves. Rotation of the bristles **123** may be either clockwise or counterclockwise with respect to FIGURE 3; however, it has been found that a clockwise rotation is most effective. The bristles **123** may be of wire of other suitable material and of suitable length to gently scrape the pith from the inside of the rind. The pith, in effect, is engaged head-on by by the bristles **123** 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 **120** 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 **126** is spaced from the first assembly **120** for separating the pith from the rind and includes a control roller **127** and a lower brush type roller **128** similar to the brush roller **122**, but which may have bristles **129** slightly stiffer and slightly shorter than the bristles **123** 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 **120** and **126** may be employed as necessary to remove adhering pith. A pair of idler rollers **131** and **132** are positioned between the assemblies **120** and **126** for guiding the stalk halves.

The pith removed from the inside face of the rind contains most of the sugar content of the cane stalk. To assist in the removal of the pith from the brushes **122** and **129**, a fluid, such as air, may be forced through conduits **134** and **135** and adjusted to blow the pith off of the brushes and onto conveyors **136** and **137** for removal of the pith for further processing. The conveyors **136** and **137** extend downwardly from the brushes **122** and **129** and converge to a point where a pair of scrapers **139** and **140** remove the pith from the conveyor so that the pith may fall onto two elongated rollers **142** and **143**. The rollers **142** and **143** are held together and each is rotatably driven so as to squeeze therebetween the pith after it leaves the conveyors **136** and **137**. The squeezing action applied by the rollers **142** and **143** expresses the juice from the pith as it passes between the rollers and falls onto a conveyor **144** which carries the pith floc away for further processing. The juice remains on top of the rotating rollers in the V-shaped trough formed by adjacent top surfaces of the rollers, and by suitable conduits such as the conduit **146** is removed from on top of the rollers to be accumulated for further processing.

While two rollers **142** and **143** are illustrated in FIGURE 4 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 **150** illustrated diagrammatically in FIGURE 6 may be used wherein the pith drops from the conveyors **136** and **137** into a hopper **151**. The pith floc is removed at **152** and the juice is removed at **153**. 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 my invention. The differences between the massive milling equipment employed in present 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, in explosive 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 this process and apparatus, on the other hand, is relatively free of contaminants.

The juice obtained by this process is of significantly higher purity than the dilute juice obtained by ordinary milling procedures. In terms of degrees Brix, the juice normally extracted from conventional processes is about 16 degrees Brix, whereas juice obtained according to this invention is as high as 22 degrees Brix. Those familiar with the problems relating to the recovery of juices from sugarcane will immediately recognize this tremendous advantage afforded by this process and apparatus. Considerable time, effort and money have been spent in the past in order to develop processes and apparatus for increasing the degrees Brix of the obtainable juices only a point or two. In addition to the high degrees Brix obtained by this invention, the purity of the juice is significantly increased since impurities from the rind are not introduced into the juice. Whereas conventional milling equipment squeezes the rind and the pith together under tremendous pressures to obtain the juice, this step which adds to the juice any number of contaminants and diluents is avoided. Trash, rind particles, wax, dirt, gums, mold and microorganisms normally found in dilute juices are vastly reduced or completely eliminated from the juice obtained by this invention. Deteriation caused by holding over cane during mill repair shutdown can be reduced or eliminated because of the exclusion of deleterious constituents from the juice. Because little or no imbibition water is used such as is used in the normal maceration processes, there is less water to remove from the juice and, accordingly, less liquid to be handled by the clarifiers and evaporators. The decrease in non-sugar bodies found in the juice results in less filtration; and, accordingly, the processing of juice into crystalline sugar is greatly enchanced.

The juice is removed from the rind portions of the depithed stalk halves **80***a* and **80***b* by passing the rind strips through a wringer or pair of rotating pressure rollers **160** and **161**. 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 **160** and **161**, means for wetting the rind is provided, for example spray nozzles **163** and **164**. A second wringer or pair of rotating pressure rollers **165** and **166** 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 **168** and **169**, 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 that the juice from the pith, or it may be added directly to the pith juice collected by conduit **146**.

The stalk halves **80***a* and **80***b* 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 dry 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 present 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 fibers, this process and apparatus produce pith and relatively undisturbed fibers 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.

Normally the sugarcane stalks are taken from the fields and delivered to the factories in railroad cars, or other vehicles. The handling of the cane stalks in this manner represents a considerable disproportionate ratio in the transportation of commercial product and non-commercial product since normally the sugar obtained from cane stalk averages only about ten percent by by weight of the cane. Also, the bulkiness of piled cane stalks creates an undesirable high volume requirement compared with the weight of the stalks which can be transported. The handling of large quantities of stalks at the field and at the factories requires considerable expensive equipment. For the most efficient recovery of sugar, sugarcane should be processed as soon after it is cut to lessen the loss of moisture and the inversion of the sucrose. In ordinary processing of sugarcane juice, inversion begins when the cane is cut and continues during transportation to the factory and through the milling and maceration and until the juices are maintained at or slightly above pH 7 which usually does not occur until clarification. Actually, the hot imbibition water customarily used speeds inversion. Sometimes sugarcane must be stored in the field or at the factory before it is processed and this results in a considerable loss of sucrose. Present processes are not suitable for the rapid treatment of the juice to check inversion of the sucrose.

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 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 taken 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 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.

Moreover, 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 10 wherein a conventional harvester **180** cuts the growing cane **181** which then is fed immediately to the apparatus **182** of this invention mounted upon a suitable transportable platform **183**. 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 **183**. The dry products can be bagged or baled and the raw pith or the juice can be put into suitable containers **184** and then left 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 the 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 manufacturing process is greatly enhanced. As pointed out previously, the sugarcane stalk is processed into five primary components; namely, wax, epidermis, rind fibers, pith floc and juice. Bagasse is not produced, and this in itself can be considered an extremely valuable improvement over existing processes.

Although various embodiments of this invention have been disclosed, modifications may become apparent to others skilled in the art. Consequently, it is intended that the foregoing description be considered as exemplary only and that the scope of the invention be determined from the following claims.

I claim:

1. Apparatus for the recovering of wax, epidermis, rind, pith and juice from sugarcane comprising means for propelling a single stalk of sugarcane in a path longitudinally with respect thereto, means for removing wax from the exterior of the stalk, means for removing the epidermis from the stalk, means for cutting the stalk longitudinally into elongated parts, means for spreading open the stalk parts, means for separating the juice laden pith from the rind of the stalk parts, and means for separating the juice in the pith from the pith.

2. A process for treating a whole sugarcane stalk comprising: moving the stalk continuously through a series of steps until the stalk is separated into components; the first step comprising removing the outer wax from the whole stalk; the second step comprising separating the rind and the pith; the third step comprising separating the juice from the pith; and, subsequent to said removing of said outer wax. removing the epidermis from the whole stalk.

3. A process for treating sugarcane to extract juice therefrom comprising: cutting the outer, rind portion of the sugarcane stalk longitudinally without expressing a significant amount of juice from the inner, pith portion; spreading the cut rind portion to expose the pith without expressing a significant amount of juice from the pith; separating the pith from the rind portion without expressing a significant amount of juice from the pith; removing the juice from the pith; removing the juice from the rind portion after the pith has been separated from the rind portion by subjecting the rind portion to pressure; and, prior to the cutting of the rind portion, removing the wax end epidermis from the exterior of the rine portion.

4. A process for treating sugarcane stalks which includes as components, a pith core laden with sugar juice, and rind encircling the pith, said process comprising: longitudinally opening sugarcane stalk without expressing a significant amount of juice from the pith core; separating said opened sugarcane stalk into a plurality of separate sugarcane stalk portions, with each sugarcane stalk portion including rind and sugar juice laden pith; exposing a pith bearing side of each sugarcane stalk portion; separating the pith from the rind of said sugarcane stalk portions while substantially retaining said sugar juice in said pith and while maintaining the fibers of the rind of said sugarcane stalk portions substantially undisturbed; collecting said separated pith; and removing said retained sugar juice from said collected and separated pith.

5. A process for treating sugarcane stalks which includes as components, a pith core laden with sugar juice, and rind encircling the pith, said process comprising: longitudinally opening sugarcane stalk without expressing a significant amount of juice from the pith core; separating said opened sugarcane stalk into a plurality of separate sugarcane stalk portions, with each sugarcane stalk portion including rind and sugar juice laden pith; exposing a pith bearing side of each sugarcane stalk portion; separating the pith from the rind of said sugarcane stalk portions while substantially retaining said sugar juice in said pith and while maintaining the fibers of the rind of said sugarcane stalk portions substantially undisturbed; collecting said separated pith; and removing said retained sugar juice from said collected and separated pith; said removing of said sugar juice being effected, at least in part, by subjecting said collected and separated pith to pressure.

6. A process for treating sugarcane stalks which includes as components, a pith core laden wih sugar juice, and rind encircling the pith, said process comprising: longitudinally opening sugarcane stalk without expressing a significant amount of juice from the pith core; separating said opened sugarcane stalk into a plurality of separate sugarcane stalk portions, with each sugarcane stalk portion including rind and sugar juice laden pith; exposing a pith bearing side of each sugarcane stalk portion; separating the pith from the rind of said sugarcane stalk portions while substantially retaining said sugar juice in said pith and while maintaining the fibers of the rind of said sugarcane stalk portions substantially undisturbed; collecting said separated pith; and removing said retained sugar juice from said collected and separated pith; said removing of said sugar juice being effected, at least in part, by subjecting said collected and separated pith to diffusion.

7. A process for treating sugarcane stalks which includes as components, a pith core laden with sugar juice, rind encircling the pith, and outer epidermis and wax on the exterior of said rind, said process comprising: longitudinally opening sugarcane stalk without expressing a significant amount of juice from the pith core; separating said opened sugarcane stalk into a plurality of separate sugarcane stalk portions, with each sugarcane stalk portion including rind and sugar juice laden pith; exposing a pith bearing side of each sugarcane stalk portion; separating the pith from the rind of said sugarcane stalk portions while substantially retaining said sugar juice in said pith and while maintaining the fibers of the rind of said sugarcane stalk portions substantially undisturbed; collecting said separated pith; removing said retained sugar juice from said collected and separated pith; and removing sugar juice from said rind after said pith has been separated from said rind.

8. A process for treating sugarcane stalks which includes as components, a pith core laden with sugar juice, rind encircling the pith, and outer epidermis and wax on the exterior of said rind, said process comprising: longitudinally opening sugarcane stalk without expressing a significant amount of juice from the pith core; separating said opened sugarcane stalk into a plurality of separate sugarcane stalk portions, with each sugarcane stalk portion including rind and sugar juice laden pith; exposing a pith bearing side of each sugarcane stalk portion; separating the pith from the rind of said sugarcane stalk por-

tions while substantially retaining said sugar juice in said pith and while maintaining the fibers of the rind of said sugarcane portions substantially undisturbed; collecting said separated pith; removing said retained sugar juice from said collected and separated pith; prior to said removing of said sugar juice, removing wax and outer epidermis from the exterior of said rind; and collecting said removed wax and outer epidermis.

9. A process for treating sugarcane stalks which includes as components, a pith core laden with sugar juice, rind encircling the pith, and outer epidermis and wax on the exterior of said rind, said process comprising: longitudinally opening sugarcane stalk without expressing a significant amount of juice from the pith core; separating said opened sugarcane stalk into a plurality of separate sugarcane stalk portions, with each sugarcane stalk portion including rind and sugar juice laden pith; exposing a pith bearing side of each sugarcane stalk portion; separating the pith from the rind of said sugarcane stalk portions while substantially retaining said sugar juice in said pith and while maintaining the fibers of the rind of said sugarcane stalk portions substantially undisturbed; collecting said separated pith; removing said retained sugar juice from said collected and separated pith; prior to said removing of said sugar juice from said pith, removing wax and outer epidermis from the exterior of said rind; collecting said removed wax and outer epidermis and treating said collected and removed wax and outer epidermis separate from said collected and separated pith; collecting said rind from which said wax, outer epidermis, and pith have been separated; and treating said collected rind separate from said pith, wax and outer epidermis.

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U.S. Cl. X.R.

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