

May 15, 1928.

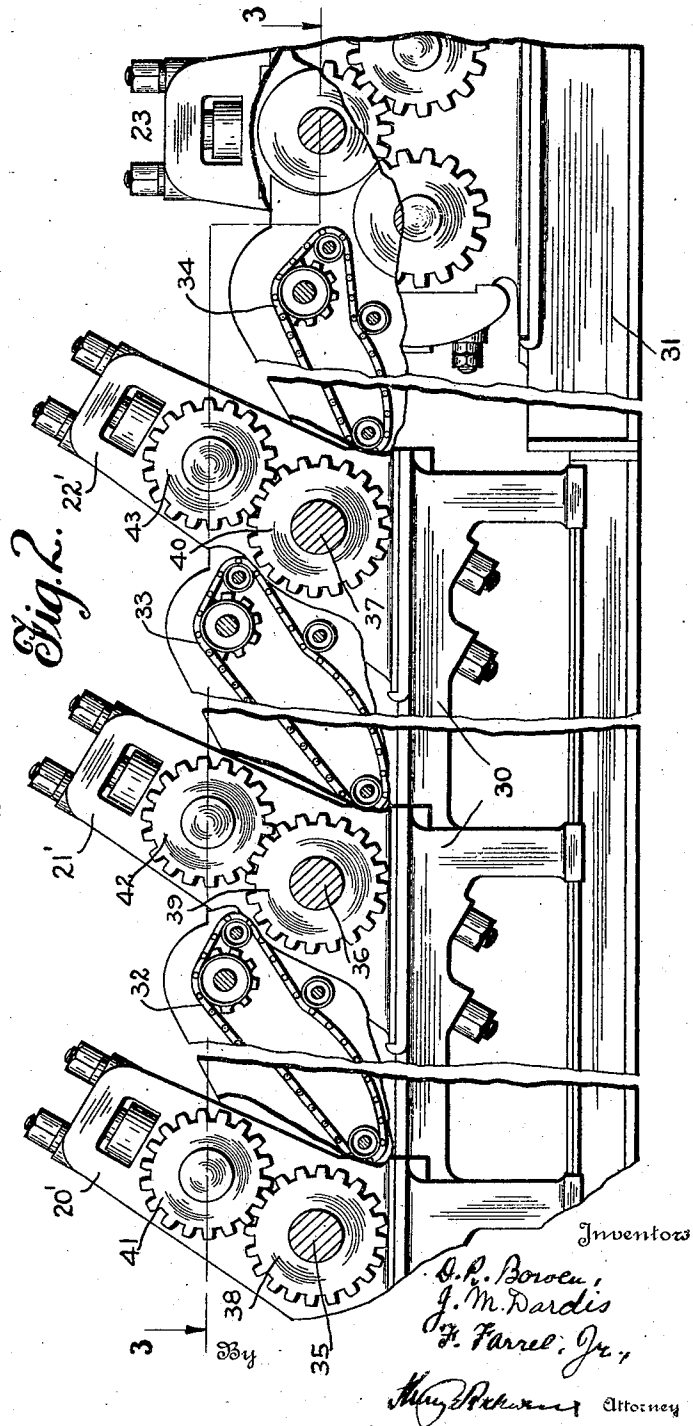
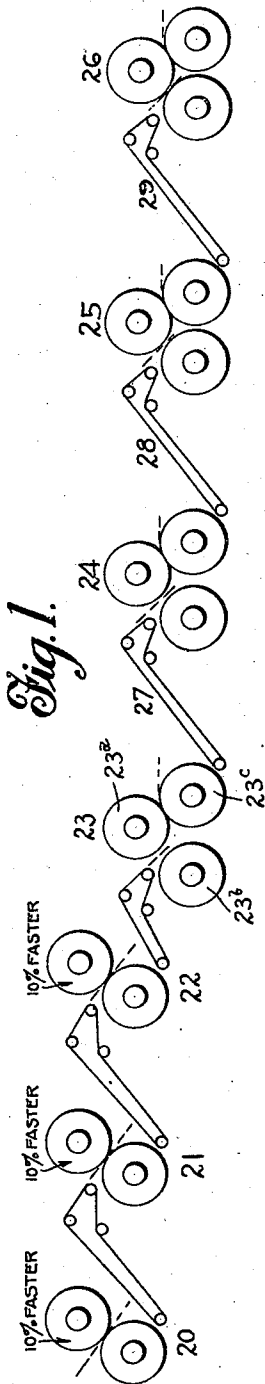
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CANE GRINDING MILL

Filed May 31, 1921

6 Sheets-Sheet 1



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CANE GRINDING MILL

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6 Sheets-Sheet 3

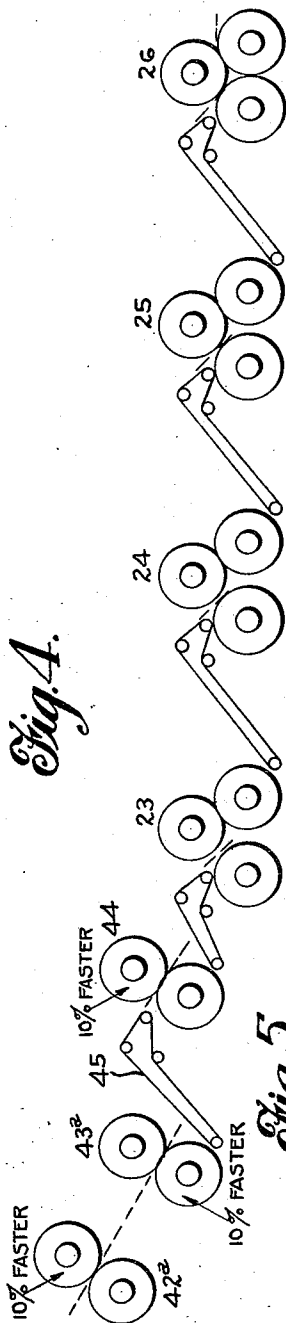


Fig. 5.

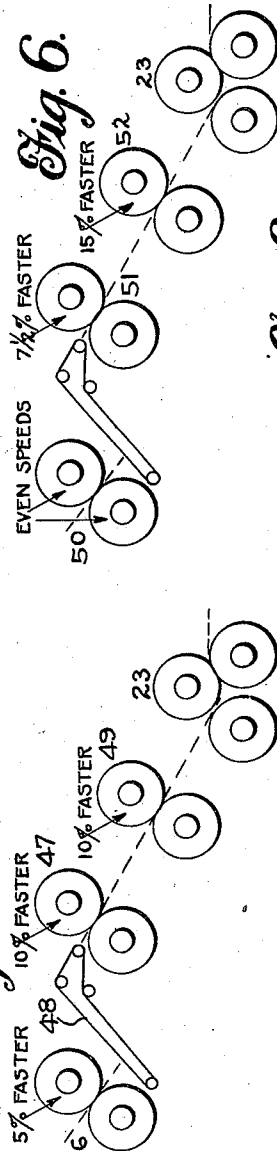


Fig. 6.

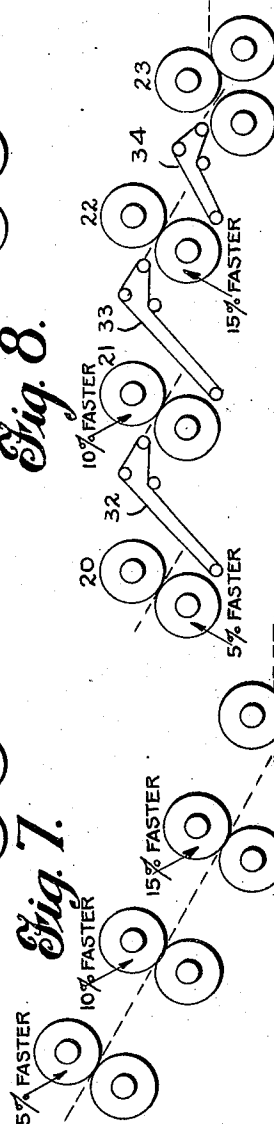


Fig. 7.

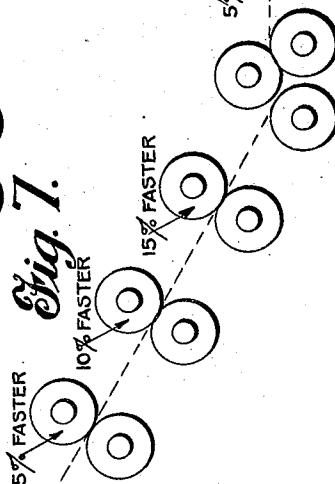
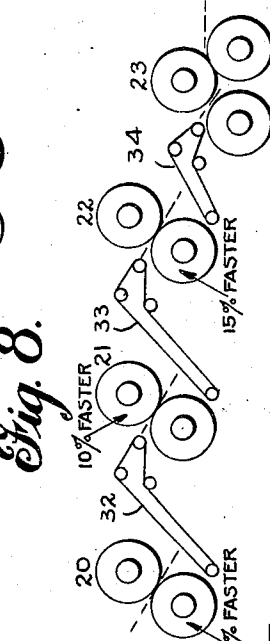


Fig. 8.



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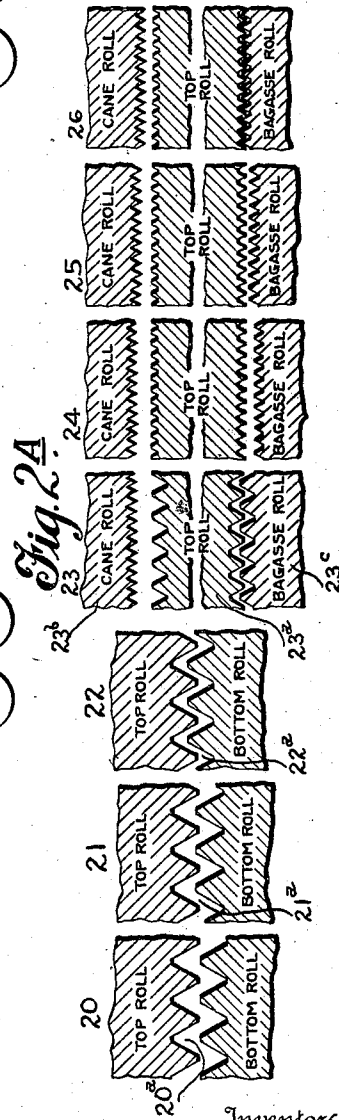
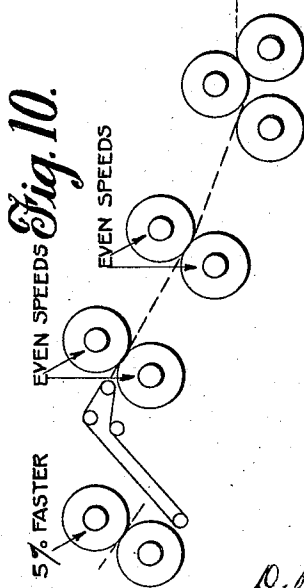
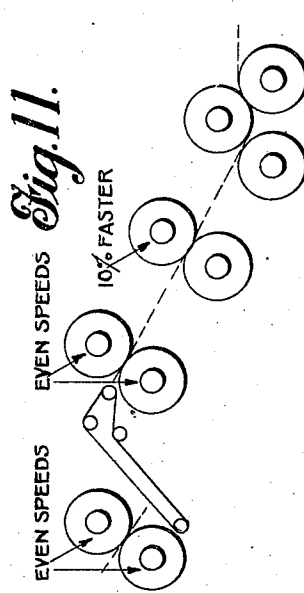
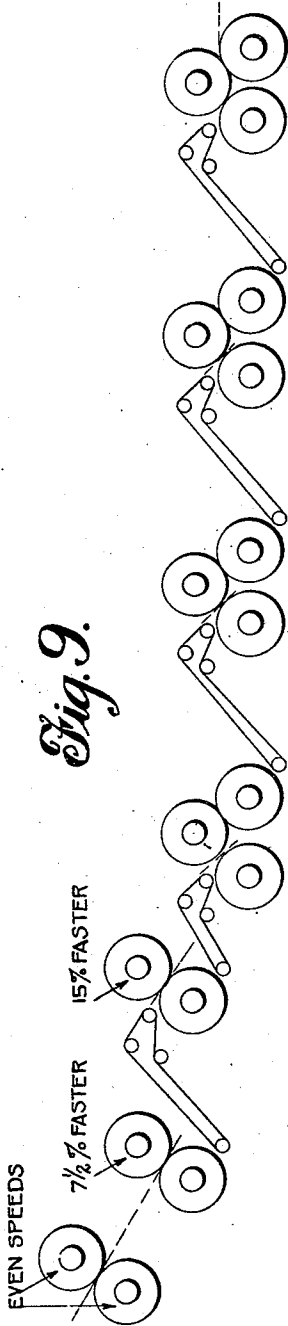
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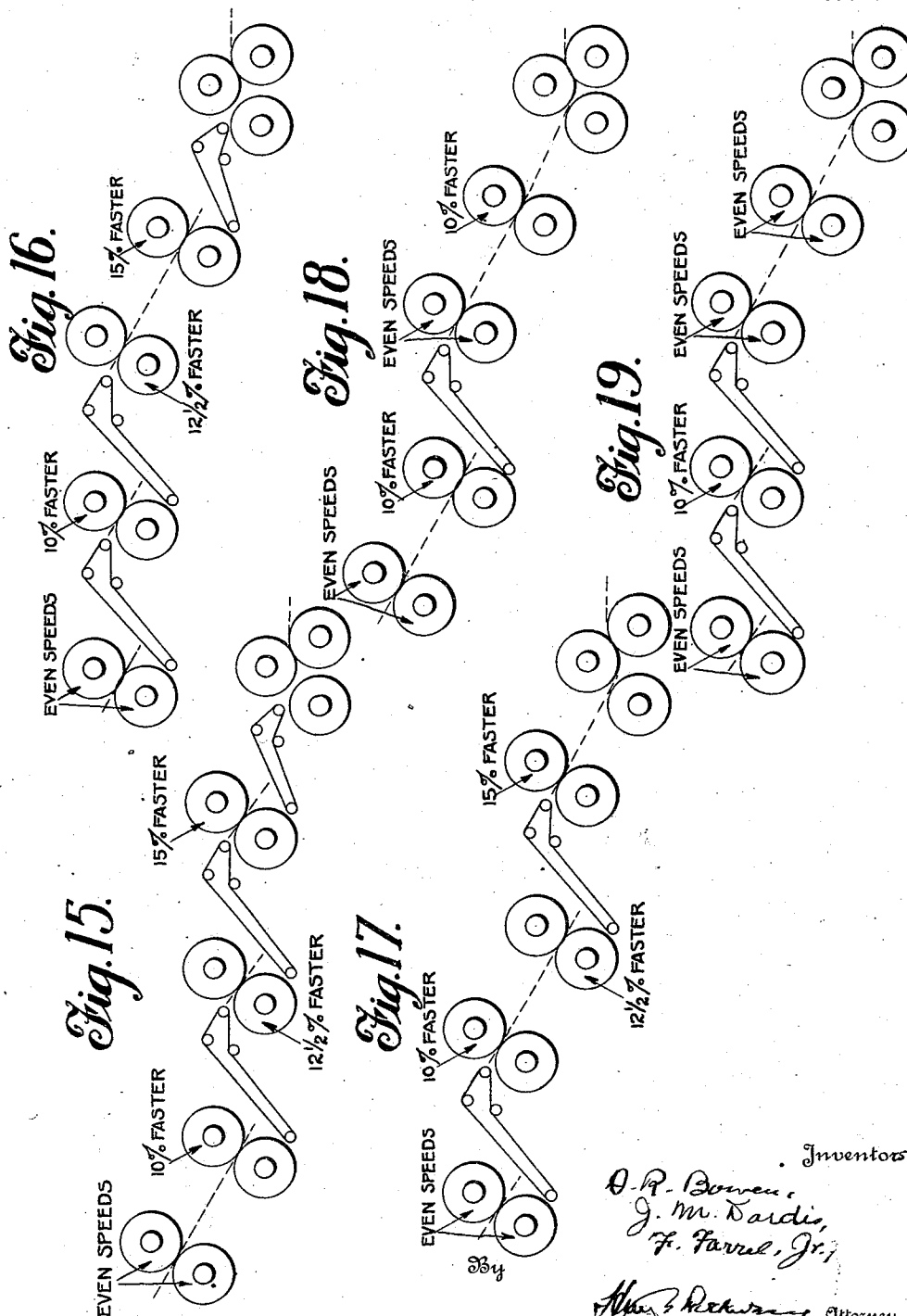
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Fig. 12.

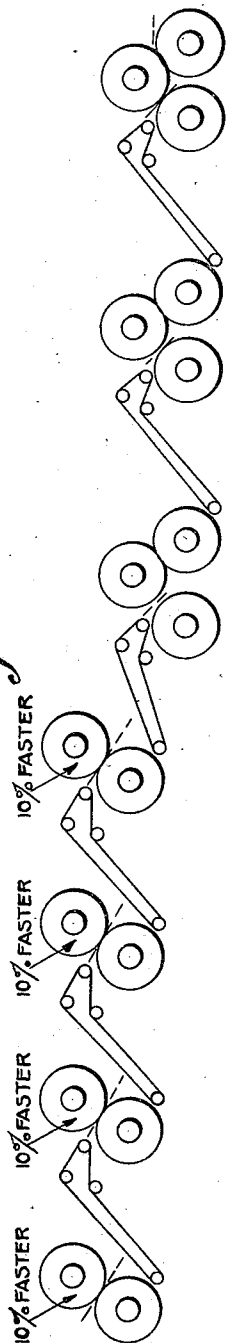


Fig. 13.

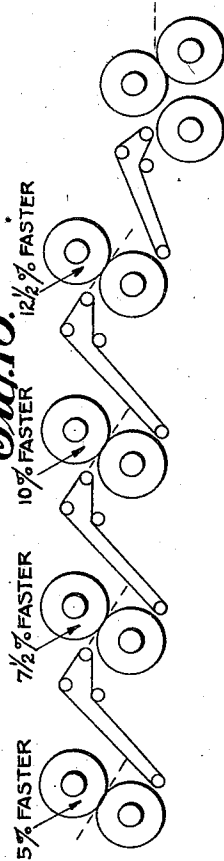
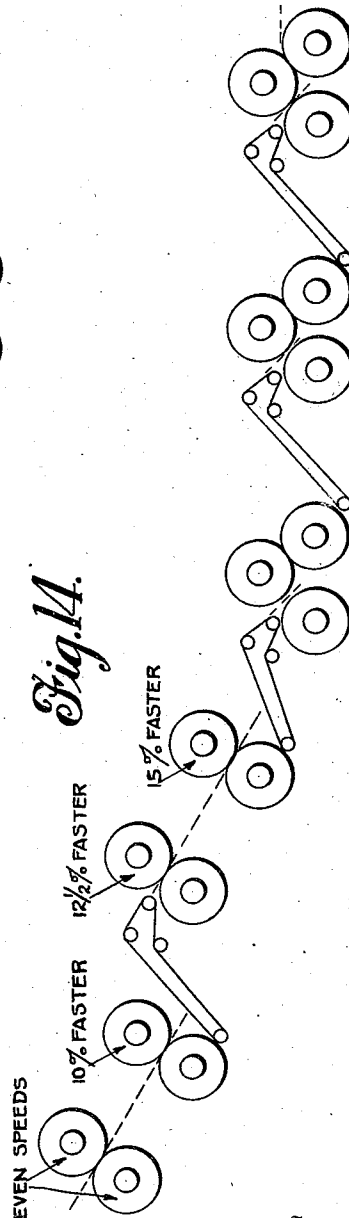


Fig. 14.



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CANE-GRINDING MILL.

Application filed May 31, 1921. Serial No. 474,050.

This invention relates to cane grinding machinery of the type employed for the grinding of sugar cane.

In the past it has been common practice to
5 grind sugar cane in a mill or installation having a number of stands of juice expressing rolls arranged in groups of three, each stand or juice expressing mill having a top roll, a cane roll and a bagasse roll, all provided with annular grooves. Customarily
10 these three-roll stands or mills are preceded by a preliminary crushing instrumentality, consisting, for example, of one or two sets of toothed crushing rolls arranged in pairs instead of in sets of three, as is the case
15 with the juice expressing rolls.

The function of such preliminary crushing instrumentality has been to place the cane in condition for more efficient action of
20 the three-roll stands or mills which follow. The preliminary crushing rolls receive the cane when the latter is in a very thick, bulky mass, with the stalks arranged in various directions and overlapping each other; and as the stalks are of considerable size,
25 having a diameter say of two inches or more, the depth of the cane mass is considerable. The preliminary crushers reduce the thickness of the mass and at the same time have
30 a certain splitting and shredding action on the stalks, opening them up and separating the fibers thereof, and producing a thinner and fairly uniform mat of fiber which is in better condition for being subjected to the
35 squeezing action of the three-roll mills for the extraction of juice than would be the case if no preliminary crushing were effected.

Of course, it will be understood that in
40 crushing and shredding the cane stalks, the preliminary crusher or crushers express a certain amount of juice from the cane. This, however, has in the past been regarded primarily as an incident to the preliminary
45 crushing function rather than as a desirable end in itself. The common practice has been to place one or two pairs of preliminary crushing rolls in front of several three-roll mills. For example, in a
50 fairly large installation designed to grind somewhere from say twelve hundred to two thousand tons of cane in twenty-four hours,

there have been one or two pairs of preliminary crushing rolls followed by three or four three-roll juice expressing mills.

One object of the present invention is to increase the efficiency of machinery of the general type referred to in grinding sugar cane.

Another object is to provide an increase in the juice extraction.

More specifically, our object is to increase the efficiency of the mill as a whole by obtaining increased effectiveness of the preliminary crushing instrumentality so that it
65 does more and better work than in the past, splitting and shredding the cane stalks to a greater extent, producing therefrom a thinner, more uniform mat, and augmenting the extraction by the preliminary crushing rolls; the effect of all of which is to enlarge the
70 efficiency of the mill, reducing the number of the three-roll juice expressing mills following the crushers, which it is necessary to employ, and improving the mill in that respect also by virtue of the fact that coacting,
75 preliminary crushing rolls arranged in pairs are much easier and less expensive to set up, to adjust and to keep in repair than are the ordinary three-roll mills. By our
80 improvements also, the juice extraction with a given amount of roll surface may be increased.

More specifically, also, our invention has in view the feeding of the cane into the mill in
85 a more expeditious and uniform manner than heretofore; the more complete shredding and disintegration of the stalks by the preliminary crushing rolls, through the action of coacting rolls of certain pairs rotating at different surface speeds, in a mill
90 where two or more pairs of preliminary crushing rolls are employed, so that when the cane reaches the juice expressing mills it is in the best condition to be acted on thereby
95 in an effective manner; and another object is to improve the relation or coordination between the preliminary crushing instrumentality and the juice expressing instrumentality following the same.

To these and other ends the invention consists in the novel features and combinations of parts to be hereinafter described and
100 claimed.

In the accompanying drawings:

Fig. 1 is a diagrammatic side elevation of a cane grinding mill embodying our improvements;

Fig. 2 is a fragmentary enlarged side elevation of the mill shown in Fig. 1, illustrating the three stands of preliminary crushing rolls and the first three-roll mill;

Fig. 2^A is a diagram showing the annular grooves of the three-roll mill and crusher rolls;

Fig. 3 is a top plan view of the parts shown in Fig. 2, illustrating a portion of the gearing for driving the rolls; and

Figs. 4 to 19 inclusive, show different modifications, as hereinafter more particularly described, these views being in the nature of diagrammatic side elevations and showing more particularly the various rolls employed in grinding the cane.

In the installation shown in Fig. 1, three pairs, 20, 21 and 22, of preliminary crushing rolls are employed in front of four three-roll mills, 23, 24, 25 and 26, respectively. The three-roll mills may be of the type commonly employed, or any preferred type, but preferably each consists of a top roll, a cane roll and a bagasse roll. In the case of the first three-roll mill 23, the top roll, cane roll and bagasse roll are indicated at 23^a, 23^b, and 23^c, respectively. All of these rolls of the several three-roll mills are provided with annular grooves, in the preferred form, the grooves of succeeding mills being somewhat smaller than those of preceding mills, so that the division of the cane and the extraction of the juice are progressively continued as the cane is carried through the several sets of rolls. The grooving of the three-roll mills and the relative spacing of the three rolls of each mill may be as shown in Fig. 2^A.

The mills 23, 24, 25 and 26 may be spaced from each other at appropriate distances, as in ordinary practice, and conveyors 27, 28 and 29 may be interposed, as customary, these conveyors being of any suitable type for carrying the fibers from the bagasse roll of one mill into the bite between the top roll and cane roll of the following mill. Preferably also, the several three-roll mills will all be at the same level, as customary.

In the form shown in Fig. 1, the several pairs, 20, 21 and 22, of preliminary crushing rolls are provided with annular grooves, creating crushing ribs; and they are also provided with teeth for hooking into the cane, formed by cutting generally longitudinal grooves in the roll surface to intersect the transverse grooves. This kind of roll is described with greater particularity in an application of Franklin Farrel, Jr., Serial No. 445,527, and we shall, therefore, not refer herein to its detail features, except to say that the transverse V-shaped crushing ribs

of the rolls of the several pairs of preliminary crushing rolls are shown at 20^a, 21^a, and 22^a in Fig. 2^A and Fig. 3, and that the generally longitudinal, i. e., slightly oblique, grooves are shown at 20^b, 21^b, and 22^b, in Fig. 3. In the particular form now under discussion the ribs of the preliminary crushing rolls of all three pairs are of the same pitch, but this is not a matter of importance as they may be of successively smaller pitch if desired.

In the form shown in Figs. 1 to 3, the three pairs of preliminary crushing rolls are all located at the same, or substantially the same, elevation, which is somewhat higher than that of the following three-roll mills. In practice the housings 20', 21' and 22', of the respective pairs of crushing rolls may all be suitably secured on top of a raised framework 30, standing in front of the bed 31, on which the three-roll mills rest, and having its upper surface, or in other words a bed for the crushers, substantially above the bed for the three-roll mills. An endless conveyor belt 32, having its upper run somewhat upwardly and rearwardly inclined, is adapted to carry the cane mass discharged from the rolls of the pair 20 upwardly and rearwardly into the bite of the next pair 21 of preliminary crusher rolls. This conveyor 32 may be of any standard or preferred type. A similar conveyor 33 is interposed between the crushers 21 and 22, and a third similar conveyor 34 is interposed between the last crusher 22 and the first three-roll mill 23.

It will be observed that in the particular mill now under discussion, where the preliminary crushing rolls are located at the same level but somewhat higher than the following three-roll mills, the rolls of each pair of crusher rolls between which the cane passes have their shafts somewhat out of vertical alignment, the shaft of the upper roll being disposed above but somewhat to the rear of the shaft of the lower roll, whereby the cane passing through and discharged by the two coacting rolls takes a rearward and downward direction. In other words, by this offsetting of the roll centers, the passage of the cane between the rolls is assisted by gravity and the upper roll may, if desired, overhang to a certain extent the lower end of the adjacent conveyor so that the cane is discharged directly upon the lower portion of the upper run of the conveyor, which carries it into the bite of the next pair of rolls. While on this point it may be well to note the general similarity in relative location of the two rolls in a pair of crusher rolls to the arrangement of the top and cane rolls of a three-roll mill, although in the form shown in Fig. 2, the offsetting of the top roll in a rearward direction is somewhat greater than the offsetting of the top rolls of the crushers

This arrangement, however, facilitates the feed of the cane and at the same time makes the construction more compact. We have not shown any special arrangement for feeding or assisting the feed of cane between the crusher rolls of the first pair, but a suitable chute or any other appropriate device may be employed for this purpose, or, for example, an upwardly leading conveyor similar to those shown in the drawings. From the last crusher rolls 22, the cane passes onto the endless conveyor 34, which is partially overhanging by the top roll of pair 22, and which delivers the cane between the top roll and cane roll of the first mill. In all of the conveyors 32, 33 and 34, shown in Fig. 2, the upper run of the conveyor carries the material upwardly and rearwardly until it is above the level of the bite of the following two rolls, and thereafter it carries the material rearwardly into such bite and downwardly to a certain extent. Nevertheless, so far as the broad aspects of the present invention are concerned, the conveyor arrangement may be very considerably varied, or in some cases altogether omitted, as will be seen from the following description.

For the purpose of increasing the effectiveness of the crushing and shredding rolls, the rolls of one or more pairs are differentially driven as between the two rolls of a pair so as to produce a friction motion on the can and thereby cause the stalks to be split open and shredded. This occurs as a result of the different surface speeds of the rolls at the opposite sides of the stalk in the roll bite and by our invention this differential motion is produced in a crushing instrumentality having two or more pairs of crushing rolls; and by preference the upper rolls of some or all of the pairs of crushing rolls are driven at higher speeds than the corresponding lower rolls.

In the form shown in Figs. 1 to 3, the upper rolls of the pairs 20, 21 and 22 are all driven substantially faster than the corresponding lower rolls and in this particular instance about ten per cent faster than the corresponding lower rolls. In this particular form the upper roll of each pair is of substantially the same diameter as the lower roll and all of the rolls of the preliminary crushing instrumentality are of approximately the same diameter. Consequently in this case the upper rolls of the several pairs are driven approximately ten per cent faster than the corresponding lower rolls by gearing which is so designed as to accomplish that purpose. In attaining this end, as shown more particularly in Figs. 2 and 3, the lower rolls of the pairs 20, 21 and 22 are driven from a suitable prime mover by shafts 35, 36 and 37 respectively, on which said rolls are mounted, said shafts having keyed thereto gears 38, 39 and 40 respec-

tively, at one side of the machine. These gears mesh with gears 41, 42 and 43 respectively, on the shafts of the corresponding upper rolls. The gears 41, 42 and 43, however, have a smaller number of teeth than do the gears 38, 39 and 40, this number being so chosen as to bring about the drive of the upper rolls at a speed substantially ten per cent faster than the corresponding lower rolls, as previously stated.

It should be understood, however, that while the upper roll of pair 20 is driven substantially ten per cent faster than the lower roll of said pair, the upper roll of pair 21 will have a somewhat higher actual speed because in the form shown in Figs. 1 to 3, the surface speeds of the lower rolls of pairs 20, 21 and 22 will preferably be progressively increased to a certain extent, the lower roll of the first pair having, for example, a speed of thirty feet per minute, the lower roll of the intermediate pair having a surface speed of thirty-three feet per minute, for example, and the lower roll of the third pair having, for example, a surface speed of thirty-six feet per minute. This, however, is only one example of the relative surface speeds which may be employed. In this same mill the rolls of each three-roll stand will all have approximately the same speed, those of mill 23 being, in the case noted, say twenty-five feet per minute, those of mill 24 being say twenty-seven and one-half feet per minute, those of mill 25 being say thirty feet per minute, and those of mill 26 being say thirty-three feet per minute. In practice the rolls of the juice expressing stands will usually be somewhat larger than those of the pairs of crushers, but this is a feature which we have not deemed it necessary to illustrate. If, for example, all the rolls are seventy-eight inches long, the preliminary crusher rolls may be say thirty-two inches in diameter and the rolls of the succeeding three-roll mills may be say thirty-four inches in diameter. In such a mill the upper rolls of both the preliminary crushers and the three-roll mills may be equipped with the usual hydraulic pressure devices, which we have not deemed it necessary to illustrate. The pressure exerted by each pair of preliminary crusher rolls may be somewhere in the neighborhood of two hundred and fifty tons, for example, or the pressure may be successively increased to a certain extent in the crusher rolls as may be desired; and the four three-roll mills 23, 24, 25 and 26, may exert pressures of say three hundred and seventy-five, four hundred, four hundred and twenty-five, and four hundred and fifty tons, respectively.

While we have illustrated the crusher rolls as having teeth to hook into the cane to drag it along, such teeth being provided by the intersection of generally transverse and gen-

erally longitudinal grooves, respectively, we do not desire to limit ourselves to a construction in which rolls of this specific character are employed, as the roll surface may be considerably changed in character without departing from the scope of our invention or sacrificing the advantages thereof.

In operation the machine shown in Figs. 1 to 3, acts substantially as follows:

Cane is fed in any suitable manner between the rolls of the first pair 20, of preliminary crusher rolls, and the upper roll being rotated substantially ten percent faster than the lower roll, a friction motion upon the cane stalks is brought about, the surface at one side of the stalk being moved considerably faster than the surface at the opposite side so that while the stalks are being compressed and crushed between the ribs of the rolls, the rolls being subjected to high pressure, the different surface speeds tend to bring about a thorough tearing open and shredding of the cane. The mass of cane is considerably compacted and the individual stalks are torn apart, disintegrated and shredded so as to form a fairly uniform mat of fibers which is of considerably less depth than the body of cane passing to the rolls. This mat is discharged directly upon the conveyor 32, which carries it upward into the space between the rolls of the next pair, 21, which further reduce the cane and carry on the action hereinbefore described; and from these rolls the conveyor 33 carries the cane mat to the third pair of crusher rolls, from which it is carried by the conveyor 34 to the first mill.

The action of the several pairs of crusher rolls as just described, causes a relatively considerable amount of juice to be expressed from the cane in the crusher instrumentality, this juice being collected in any customary manner; and the cane is very well conditioned for the subsequent action of the juice expressing mills 23, 24, 25 and 26, which in this case, due to the increased effectiveness of the crushers, may extract a smaller percentage of juice than would otherwise be the case. These three-roll mills act in the customary manner but the cane is in better condition for juice extraction by them when it reaches them and in certain cases it may be found that the crushing instrumentality, if constructed and operated along the lines described, is so effective that the three-roll mills can advantageously be reduced in number. It may be found, therefore, that in an installation having crushers of the kind shown in Fig. 1, the mill as a whole will be highly efficient with only three stands of juice expressing mills, or even a less number, instead of the four three-roll mills which we have illustrated in this particular case.

Referring now to the modified form of

machine shown diagrammatically in Fig. 4, it will be observed that the three-roll mills 23, 24, 25 and 26, are the same as in the case previously described, but the first pair 42^a, of preliminary crushing rolls is somewhat differently arranged, being located at a higher level than the second pair 43^a and being adapted to discharge the cane by gravity directly to the crusher rolls of the second pair without the use of a conveyor, although the cane in passing from the first pair to the second pair may slide over an inclined table or chute such as commonly used in the art and which we have not considered it necessary to illustrate. From the second pair 43^a, of crusher rolls, the cane passes to the third pair 44, over a conveyor 45, substantially in the manner previously described.

In this case also, the arrangement of the second pair of crusher rolls is somewhat different from that first described, in so far as the lower crusher roll of the pair 43^a is driven faster than the upper one; but in this case as well as the first case the difference between the surface speeds of the two rolls of the pair is substantially ten percent.

In the form shown in Fig. 5, the first pair 46 of crusher rolls, and the second pair 47, are arranged at the same elevation and a conveyor 48 carries the cane from the first pair to the second pair. These two pairs are located at a higher elevation than the third pair 49 and the material passes from the second pair 47 to the third pair 49 by gravity, and thereafter passes by gravity (over a suitable bed if desired) to the first three-roll mill 23.

In this case also, the relative speeds of the rolls of one pair are somewhat different than in the cases first described. In this particular instance the upper roll of the first pair is driven substantially five percent faster than the corresponding lower roll; but the rolls of the second and third pairs are driven at the same relative speeds as between the individual rolls of a pair, as in the case first mentioned.

In the form shown in Fig. 6, the relative locations of the different pairs of crusher rolls are the same as in the form shown in Fig. 5, but in this case the rolls of the first pair 50 are driven at the same speed, so that there is no differential motion in the first crusher, which acts to crush and compact the cane mass and to feed it to the second pair of rolls without a differential motion. Also in this case, the differential motion in the third crusher is increased relatively to that of the second crusher, so as to produce a relatively greater shredding action at a point where the cane mass is more compacted and more thoroughly disintegrated. In this case the top roll of the second pair 51 is driven seven and one-half percent faster than the bottom roll, whereas the top roll of the third

crusher 52 is driven fifteen percent faster than the corresponding bottom roll.

In the case shown in Fig. 7, there are no conveyors used in connection with the crusher rolls, of which there are, as previously described, three pairs. The first pair feeds by gravity to the second pair and similarly the second pair to the third pair and the third pair to the first three-roll mill. In this case the top rolls of the several crusher pairs have successively increasing differential motions, the top roll of the first pair being five percent faster than its mate, the top roll of the second pair being ten percent faster than its mate, and the top roll of the third pair being fifteen percent faster than its mate. In this form and others, wherein the friction motion is successively increased, as between two or more adjacent crusher pairs, the action of the preliminary crusher is especially efficient, as the differential motion becomes increasingly effective as the mat is condensed or compacted, and as it is more and more thoroughly separated into the individual fibers; and the action under discussion produces a fairly uniform, dense mat of separated fibers, upon which the following three-roll mills can act very effectively in extracting the remaining juice.

In the form shown in Fig. 8, there are likewise three pairs of preliminary crusher rolls. In this case the arrangement of the rolls is substantially the same as that shown in Fig. 1, with interposed conveyors 32, 33 and 34, like those previously described, but the bottom roll of the first pair is driven five percent faster than its mate and the bottom roll of the third pair is driven fifteen percent faster than its mate, while the top roll of the intermediate pair is driven ten percent faster than its mate.

It may be assumed for purposes of description that in the form shown in Figs. 5 to 8 inclusive, there are four three-roll mills following the crushers, as in the case first described, although we do not limit ourselves to such an arrangement.

In the form shown in Fig. 9, the rolls of the first pair of crushers are driven at even speeds and deliver the cane by gravity to a lower second pair of crushers, the upper roll of which is driven seven and one-half percent faster than the lower roll. The crusher rolls of the second pair deliver the cane to a conveyor similar to those previously described, which carries it to the third pair of crusher rolls, of which the upper roll is driven fifteen percent faster than the lower roll. From the third pair of crusher rolls the cane is carried through the mill in the manner previously described.

In the form shown in Fig. 10, the first crusher consists of a pair of rolls, of which the upper roll is driven five percent faster

than the lower roll, and these rolls deliver the cane to a conveyor which carries it to the second pair of crusher rolls, which are driven at even speeds; and the second pair of crusher rolls deliver the cane to the third pair, the individual rolls of which are driven at even speeds likewise; and from the third pair of crusher rolls the cane passes to the first three-roll mill by gravity.

In the form shown in Fig. 11, the first and second pairs of crusher rolls are driven at even speeds, there being an interposed conveyor. The second pair delivers the cane by gravity to the third pair, of which the upper roll is driven ten percent faster than the lower roll, and the cane is thereupon delivered by gravity to the first three-roll mill, as in the case illustrated in Fig. 10.

In the form shown in Fig. 12, there are four pairs of preliminary crusher rolls, which in this instance are all located at the same level, with interposed conveyors, substantially as shown in Fig. 1. In this case also the upper roll of each pair is driven ten percent faster than its mate. However, in this case a greater amount of work is done by the crushers than where three pairs of crusher rolls are employed, and consequently we have shown only three three-roll mills following the crushers in this case, and efficient results might be obtained by an even smaller number of three-roll mills.

In the form shown in Fig. 13, there are four pairs of preliminary crusher rolls, the upper roll of the first pair being driven five percent faster than its mate, the upper roll of the second pair being driven seven and one-half percent faster than its mate, the upper roll of the third pair being driven ten percent faster than its mate, and the upper roll of the fourth pair being driven twelve and one-half percent faster than its mate. It will be seen, therefore, that in a crusher having at least four pairs of crusher rolls the differential motion is progressively increased throughout the series.

In the form shown in Fig. 14, there are four pairs of preliminary crusher rolls and the rolls of the first pair are driven at even speeds but in the remaining crusher rolls the differential motion is progressively increased, the top roll of the second pair being driven ten percent faster than its mate, the top roll of the third pair being driven twelve and one-half percent faster than its mate, and the top roll of the fourth pair being driven fifteen percent faster than its mate. In this case the cane passes by gravity from the first pair to the second pair, then to a conveyor, and then by gravity from the third pair to the fourth pair, and by a conveyor to the first three-roll mill, of which in this case there are three.

In the form shown in Fig. 15, there are four pairs of crusher rolls, the first pair be-

ing driven at even speeds. The first crusher rolls deliver the cane by gravity to the second pair, of which the top roll is driven ten percent faster than its mate. The cane then
 5 discharges onto a conveyor which carries it to the third pair of crusher rolls, of which the bottom roll is driven twelve and one-half percent faster than its mate. The cane is then discharged upon a second conveyor
 10 which carries it to the fourth pair of crusher rolls, of which the top roll is driven fifteen percent faster than its mate.

In the form shown in Fig. 16, there are likewise four pairs of preliminary crusher
 15 rolls. The rolls of the first pair are driven at even speeds. The cane discharges from them onto a conveyor which carries it to the rolls of the second pair, the upper roll of the second pair being driven at a surface
 20 speed ten percent faster than its mate. From the rolls of the second pair the cane discharges onto a second conveyor which carries it to the rolls of the third pair, all of the first three pairs of rolls being arranged
 25 at the same elevation. From the third pair of rolls the cane discharges by gravity into the bite of the rolls of the fourth pair. In this case the lower roll of the third crusher is driven twelve and one-half percent faster
 30 than its mate and the top roll of the fourth crusher is driven fifteen percent faster than its mate.

In the form shown in Fig. 17, there are two pairs of preliminary crusher rolls arranged at the same elevation, with an interposed conveyor and two pairs of following
 35 crusher rolls arranged at the same elevation, which is lower than the elevation of the first two pairs, there being a gravity feed from the second pair to the third pair and a conveyor feed from the third pair to the
 40 fourth pair. In this case the rolls of the first pair are driven at even speeds. The upper roll of the second pair is driven ten percent faster than its mate. The lower roll of the third pair is driven twelve and one-half percent faster than its mate. The upper roll of the fourth pair is driven fifteen percent faster than its mate.

In the form shown in Fig. 18, the first and the third pairs of crusher rolls are driven at even speeds and in the second and fourth pairs the top roll is driven ten percent faster. There is a gravity feed between
 50 the first and second pairs and between the third and fourth pairs, and also between the fourth pair and the first three-roll mill; but there is a conveyor feed between the second pair of crusher rolls and the third pair.

In Fig. 19, there are three pairs of preliminary crushing rolls arranged at the same level, a fourth pair arranged at a lower level, and a first three-roll mill at a still lower level. Between the first and second
 60 pairs a conveyor is arranged, as also be-

tween the second pair and the third pair; but the feed between the third pair and the fourth pair is by gravity, as is also the feed from the fourth pair to the first three-roll mill. In this case the rolls of the first pair
 70 and those of the third pair are driven at even speeds, likewise those of the fourth pair, but the rolls of the second pair have a differential motion, the upper roll of the said pair being driven ten percent faster
 75 than its mate.

It will be understood that in all of these forms relative speeds are given merely by way of example, and that various other arrangements may be adopted without departing from the scope of the invention as set forth in the claims.

It will be observed that in the mill shown in Fig. 3, the crusher rolls of the second pair have a less number of longitudinal grooves
 85 than do the rolls of the first pair, and similarly the rolls of the third pair have a less number of longitudinal grooves than do the rolls of the second pair. We consider this arrangement of advantage, owing to the
 90 fact that the longitudinal grooving provides teeth which are more necessary when the cane is first acted upon than when it has been somewhat reduced and compacted. As the cane comes from the field, a considerable
 95 number of teeth are necessary to hook into it and to carry it along from the first pair of crusher rolls to the second pair, but the second pair of crusher rolls does not need such a large number of teeth, and similarly in the
 100 third pair the number can be further reduced. It will be understood also that the longitudinal grooves interrupt the rolls circumferentially and reduce the crushing action as distinguished from the hooking action.
 105 By providing the successive pairs of crusher rolls with successively fewer circumferential interruptions it will be seen that the crusher surface available for forcibly squeezing the cane in the valleys of the
 110 transverse or annular grooves and on the summits of the annular ribs is successively increased, which is a feature of considerable advantage. While it is meritorious, however, it is not essential in all cases and it
 115 may be assumed that in the other forms shown and described the hooking surface of successive crusher rolls may or may not be successively decreased in proportion as the rib squeezing surface is successively in-
 120 creased.

Various changes in these and other respects will occur to those skilled in the art as being within the scope of our inventive
 125 conception as expressed in the following claims.

It will be understood, for example, that in a preliminary crusher having the relative speeds referred to in connection with Fig. 14, the several pairs of crusher rolls may all
 130

be located at the same elevation, as shown in Fig. 12, with interposed conveyors. So, also, crusher rolls having the same or approximately the same relative speeds referred to in connection with Fig. 6, may all be located at the same level, with interposed conveyors, as shown in Fig. 2. Obviously, also, many other combinations may be made, the forms shown being merely by way of example.

We desire to have it clearly understood, furthermore, that in certain aspects of our invention we do not limit ourselves to an installation having more than two pairs of preliminary crusher rolls. One of these aspects concerns particularly the feature of having the relative speeds of the crusher rolls of one pair different from the relative speeds of the individual rolls of another pair, as where, for example, the rolls of one pair have the same surface speed, whereas the rolls of another pair have different speeds relatively to each other; or where two different pairs of crusher rolls produce a friction action on the cane, the difference in surface speed in one pair being different from that in another pair. While we have not shown these and related features embodied in a mill having only two pairs of crusher rolls, nor have we shown a mill with only two pairs of crushers designed to produce a certain friction motion in the first pair and an increased friction motion in the second pair, it will be obvious to those skilled in the art that such features are applicable to preliminary crushers having more than one pair of rolls, and are not confined to installations wherein there are more than two pairs of preliminary crusher rolls. In Fig. 7, for example, the first pair of crusher rolls might be omitted; and in Fig. 6, for example, the third pair of crusher rolls might be omitted and provision might be made for carrying the shredded cane directly from the second pair to the first three-roll mill.

While in all of the cases illustrated, the so-called friction motion on the cane in the bite of a pair of rolls is produced by using on the roll shafts gears having a dissimilar number of teeth, the rolls being of substantially the same diameter, it will of course be readily understood that the difference in the surface speed of the two rolls may be obtained in other ways; and it is obvious also that where the two coacting rolls are of different diameters the revolutions per minute of the respective roll shafts may or may not be the same, although for producing the friction motion there will be in all cases an appreciable difference of surface speed.

According to our invention the speed difference should, if practicable, amount to at least five per cent, while according to the practice which we regard as the best, it will

approximate ten per cent, as in the forms of our invention herein illustrated and described. In the practice of our invention, a substantial speed difference is produced intentionally and by preference through the use of dissimilar gear toothing in connection with cooperating rolls of the same diameter so as to bring about a marked increase in the shredding action, the cooperating rolls, furthermore, being preferably circumferentially grooved and provided with interruptions in the ribs between the grooves so as to create teeth as described. It will be understood, however, that in some cases the speed difference may be obtained by difference of diameter of the crusher rolls, and that various other modifications may be made without departure from the scope of the appended claims.

What we claim is:

1. In a cane grinding mill, a preliminary crusher having more than two pairs of coacting ribbed crushing rolls arranged so that the cane passes successively through the bites of the several pairs, at least two of said pairs having the individual rolls driven at different speeds, the difference between the surface speeds of the rolls of one pair being greater than the difference between the surface speeds of another pair of differentially driven rolls.

2. In a cane grinding mill, a preliminary crusher having more than two pairs of coacting ribbed crushing rolls arranged so that the cane passes successively between the bites of the several pairs, the individual rolls of at least one pair having different surface speeds to produce a friction action on the cane and thereby increase the shredding thereof, and the individual rolls of at least two other pairs likewise having different surface speeds to produce a friction motion on the cane by those pairs of rolls, the difference in the surface speeds of the individual rolls of one pair being greater than the difference between the surface speeds of the individual rolls of another pair.

3. In a cane grinding mill, a preliminary crusher having more than two pairs of coacting ribbed crushing rolls arranged so that the cane passes successively between the bites of the several pairs, the individual rolls of at least one pair having different surface speeds to produce a friction action on the cane and thereby increase the shredding thereof, and the individual rolls of at least two other pairs likewise having different surface speeds to produce a friction motion on the cane by those pairs of rolls, the difference in the surface speeds of the individual rolls of one pair being greater than the difference between the surface speeds of the individual rolls of a preceding pair.

4. A preliminary crusher for cane grind-

ing mills having a plurality of grooved crusher rolls arranged in pairs and means for driving said rolls so as to produce a progressively increasing friction action on the cane as it passes through the series.

5 5. A preliminary crusher for cane grinding mills having more than one pair of grooved cane crushing rolls, said pairs arranged in tandem and the relation between
10 the surface speeds of the individual rolls of one pair being different from the relation between the surface speeds of the individual rolls of another pair and the rolls of a succeeding pair having a greater surface speed
15 than the corresponding rolls of a preceding pair.

6. A preliminary crusher for cane mills having more than one pair of crusher rolls, said pairs arranged in tandem, and the rolls
20 of a following pair having a greater difference of surface speed as between themselves than in the case of a preceding pair and having a greater actual surface speed than the corresponding rolls of a preceding pair.

25 7. A preliminary crusher for cane mills having more than one pair of crusher rolls, said pairs arranged in tandem, and the rolls of a following pair having a difference of surface speed as between themselves, the
30 individual rolls of a preceding pair having approximately the same surface speeds.

8. A preliminary crusher for cane grinding mills having more than three pairs of toothed crusher rolls arranged in tandem,
35 certain of said rolls having such relative surface speeds as to produce a progressively increasing friction motion on the cane as the latter passes through the machine.

9. A preliminary crusher for cane grinding mills having more than three pairs of toothed crusher rolls arranged in tandem,
40 certain of said rolls having such relative surface speeds as to produce a progressively increasing friction motion on the cane as the latter passes through the machine, the
45 rolls of the first pair having substantially the same surface speeds and having finer teeth than those of a succeeding pair.

10. In a cane grinding mill, a preliminary
50 crusher having at least two pairs of crusher rolls arranged in tandem, the rolls of one pair of crusher rolls having different relative speeds from the rolls of another pair and having greater crushing surfaces than
55 the rolls of said other pair.

11. In a cane grinding mill, at least three pairs of preliminary crushing rolls arranged in tandem, the individual rolls of at least two pairs being driven at different surface

speeds, and the difference of surface speed
60 being different in the two pairs.

12. A cane grinding mill comprising a preliminary crusher having more than one pair of longitudinally and circumferentially
65 grooved crusher rolls, the rolls of a following pair of crusher rolls having a greater difference of surface speed as between themselves than in the case of a preceding pair.

13. A cane grinding mill comprising a preliminary crusher having more than one
70 pair of longitudinally and transversely grooved crusher rolls, the rolls of a following pair of crusher rolls having a greater difference of surface speed as between themselves than in the case of a preceding pair,
75 the longitudinal grooves of the rolls of said pairs being decreased in number toward the discharge end of the crusher.

14. A cane grinding mill comprising a preliminary crusher, having more than two
80 pairs of crusher rolls arranged in tandem and constructed and arranged to produce an increasing friction action on the cane due to different roll speeds in the individual rolls of the several pairs as the cane passes
85 through the machine.

15. A preliminary crusher for cane grinding mills having more than one pair of grooved cane crusher rolls, said pairs being
90 arranged in tandem and the relation between the surface speeds of the individual rolls of one pair being different from the relation between the surface speeds of the individual rolls of another pair.

16. A preliminary crusher for cane grinding mills having two pairs of cane crushing
95 rolls, said pairs being arranged in tandem, and means for driving said rolls, the relation between the surface speeds of the individual rolls of one pair being different
100 from the relation between the surface speeds of the individual rolls of another pair, there being a greater difference between the surface speeds of two of the corresponding rolls of said pairs than between the other
105 rolls of said pairs.

17. A cane grinding mill having more than two sets of circumferentially grooved crusher rolls in tandem constructed and arranged to produce an increasing friction
110 action on the cane due to different roll speeds in the individual rolls of the several sets as the cane passes through the mill.

In witness whereof, we have hereunto set our hands.

DAVID R. BOWEN.
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