Nov. 13, 1928. 1,691,546

F. FARREL, JR

CANE MILL

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Fig. 1.

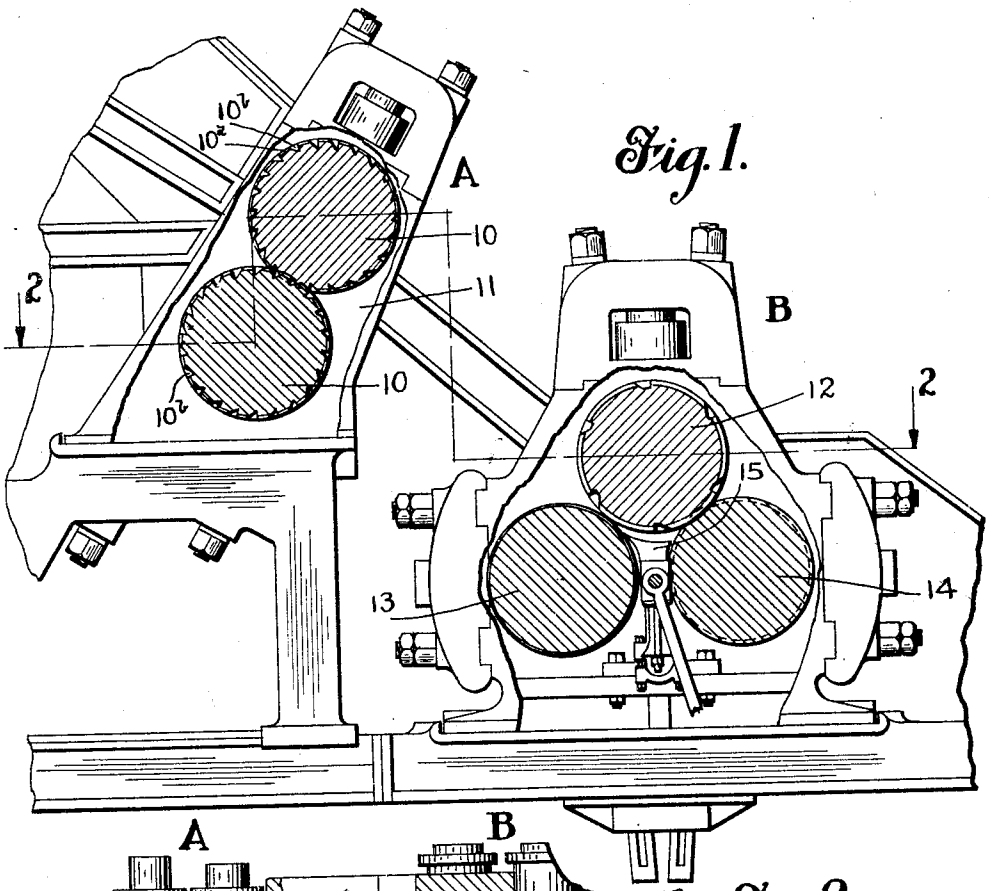
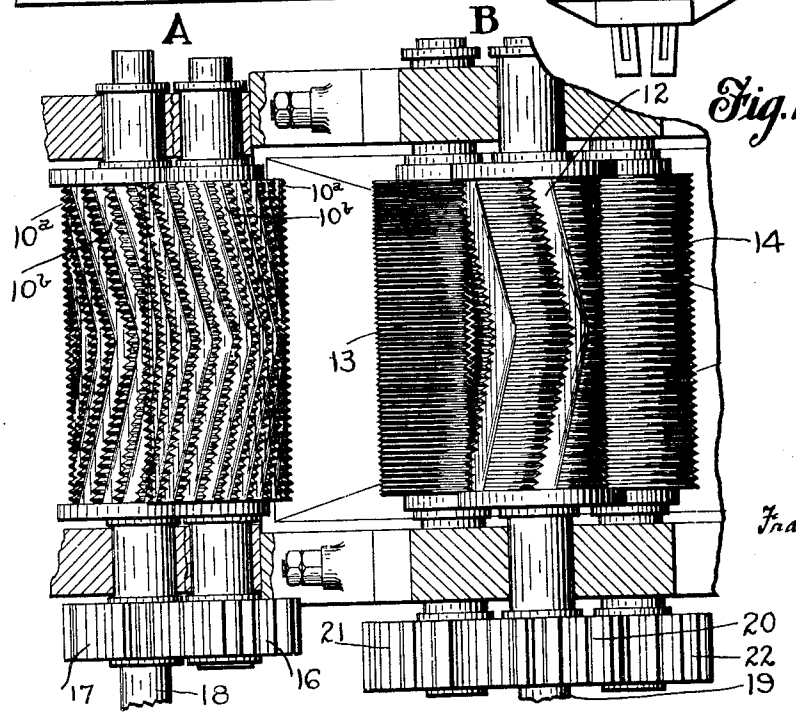


Fig. 2.



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Fig. 5.

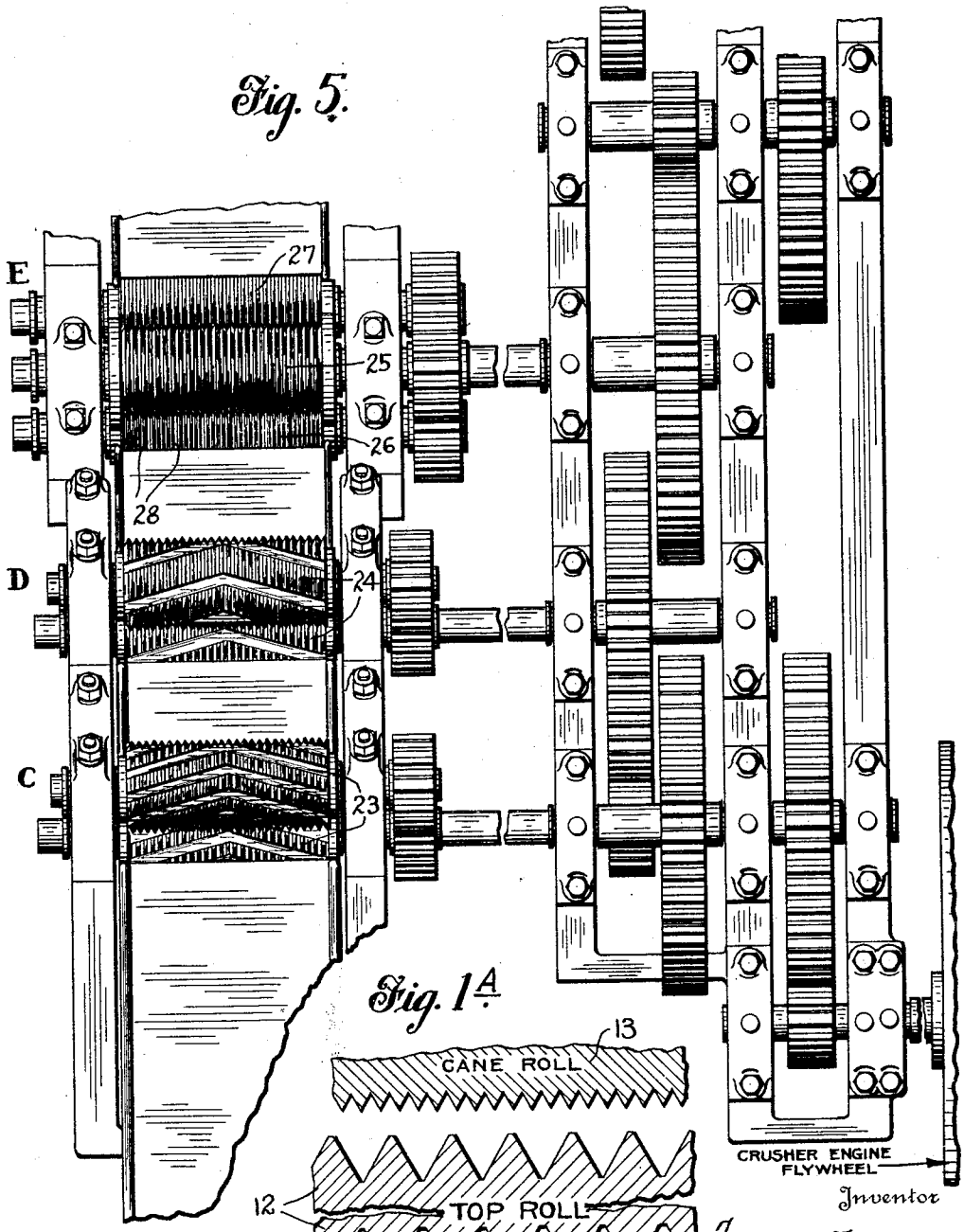


Fig. 1A.

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CANE MILL

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Fig. 3.

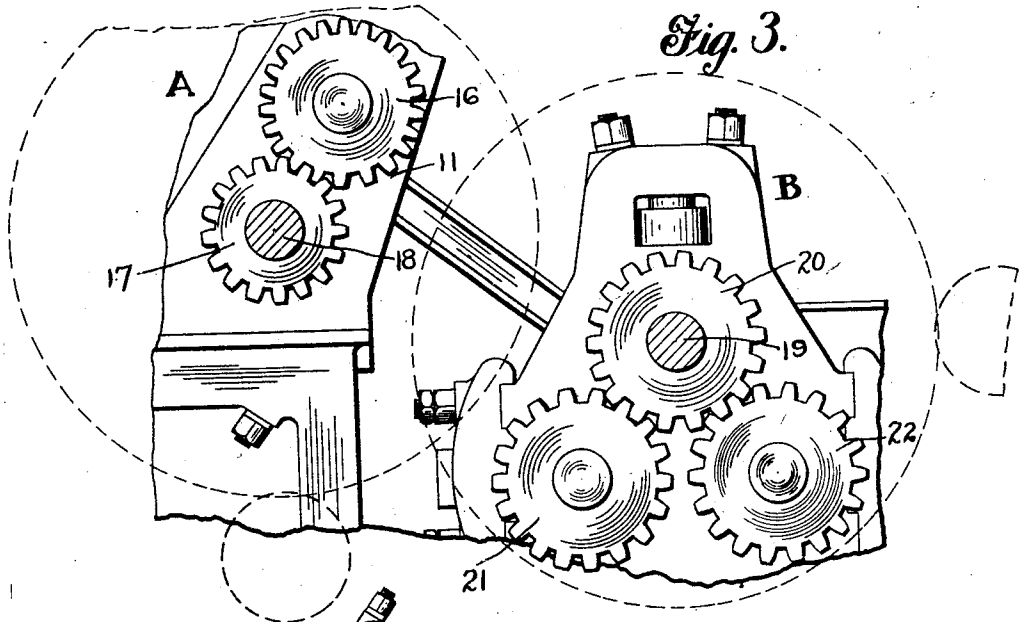
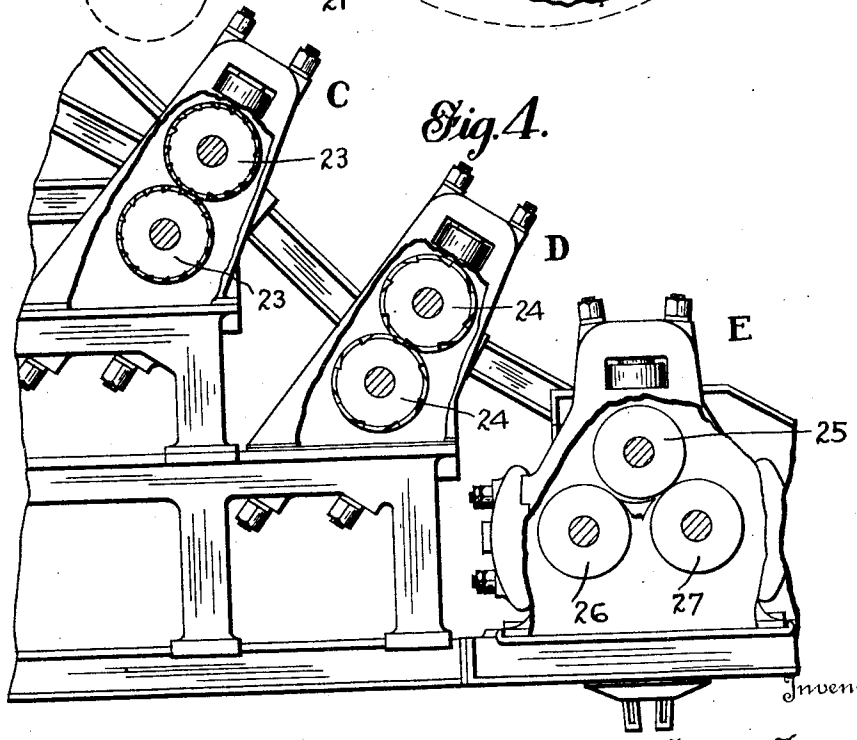


Fig. 4.



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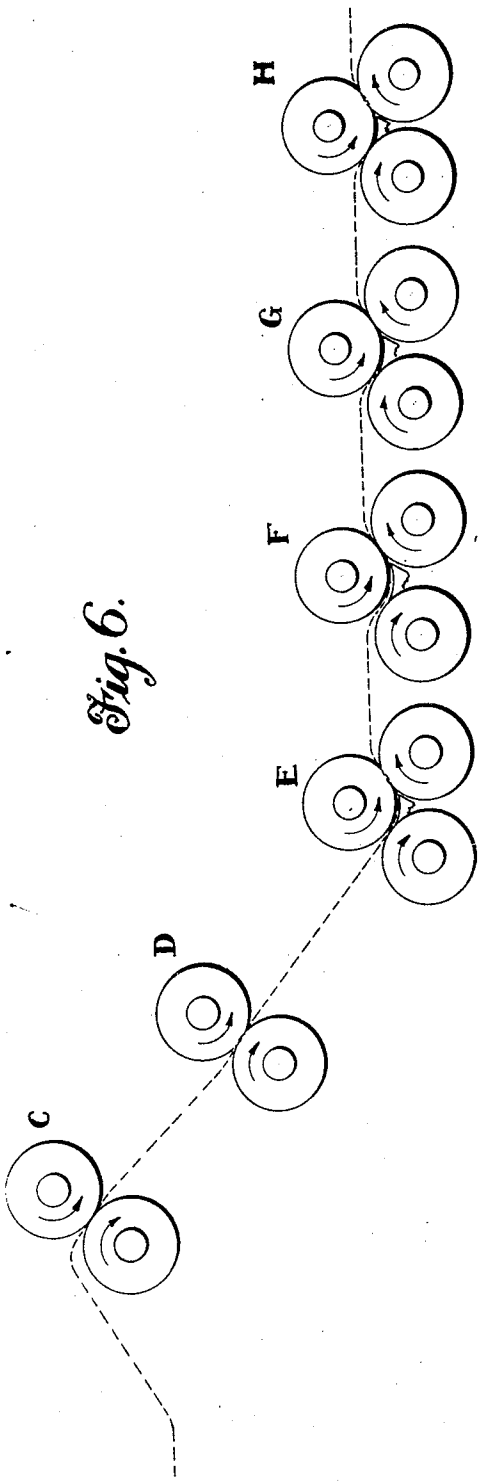


Fig. 6.

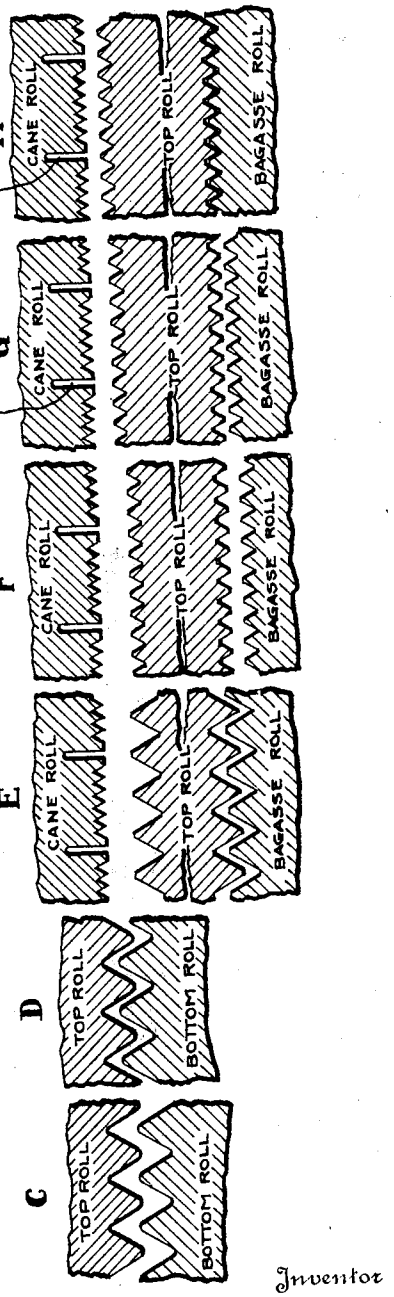


Fig. 7.

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Patented Nov. 13, 1928. 1,691,546

UNITED STATES PATENT OFFICE.

FRANKLIN FARREL, JR., OF NEW HAVEN, CONNECTICUT, ASSIGNOR, BY MESNE ASSIGNMENTS, TO FARREL BIRMINGHAM COMPANY, INCORPORATED, OF ANSONIA, CONNECTICUT, A CORPORATION OF CONNECTICUT.

CANE MILL.

Application filed February 16, 1921. Serial No. 445,527.

This invention relates to cane grinding machinery, such as employed for the grinding of sugar cane. In some of its aspects it is especially applicable to mills having one or more pairs of so-called preliminary crushing rolls which are arranged in front of one or more stands of juice expressing rolls. It is common practice for each juice expressing mill to have three rolls, viz, a top roll, a cane roll and a bagasse roll, all provided with annular grooves, the annular grooves of succeeding mills usually being smaller than those of preceding mills, so that the division of the cane and the extraction of juice are progressively continued as the cane is carried through the several sets of rolls. However, while my improvements are particularly designed for use in connection with an installation of this general character, the invention is not limited in all of its phases to use in such a combination. One of the primary objects of the invention is to increase the efficiency of the grinding.

Another object is an increase in the juice extraction.

More specifically I aim to provide a machine in which the cane is preliminarily crushed and shredded more effectively than in former practice, so that the stalks will be more thoroughly disintegrated and laid open and the fibres more thoroughly separated for the action of the following rolls which express the juice from the fibres.

By my invention a differential motion is produced between coacting cane crushing rolls or shredding rolls through the bite of which the cane passes, or between coacting rolls of a pair where such rolls have both a crushing and shredding action on the cane, for the purpose of shredding or disintegrating the stalks more thoroughly and expeditiously than in prior practice, which action is due in large part to the difference in the surface speed of the rolls acting on the cane at the respective sides of the stalk.

Another object of the invention is to furnish an improved cane mill having a plurality of sets of preliminary crushing rolls constituting a multiple crusher, such multiple crusher having in addition to its crushing or shredding action a more effective juice expressing action than has been customary heretofore.

The invention also has in view the general improvement of machinery of the type to which I have referred above.

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

In the accompanying drawings:

Fig. 1 is a fragmentary side elevation, partly in section, of a cane mill embodying certain features of the invention;

Fig. 1[A] is a diagram showing the annular grooves of the rolls of the three-roll mill shown in Fig. 1, and the spacing of such rolls relatively to each other;

Fig. 2 is a top plan view of the parts shown in Fig. 1, partially illustrating the gearing for driving the rolls;

Fig. 3 is a side elevation showing the gears on the several rolls;

Fig. 4 is a partial side elevation, partly in section, of a modified form of mill;

Fig. 5 is a top plan view of Fig. 4, illustrating the gearing;

Fig. 6 is a diagram of the various rolls of a complete installation; and

Fig. 7 shows in detail the annular grooves of the rolls of the installation partially shown in Figs. 4 and 5, and fully shown in Fig. 6.

In the mill shown in Fig. 1, I have illustrated a preliminary crusher A, in front of a juice expressing mill B. The crusher comprises a pair of toothed rolls 10, mounted in a stand or housing 11. There may be two or more pairs of preliminary crushing rolls, if desired, but in the particular embodiment now under discussion it may be assumed for purposes of description that the raw cane as it comes from the field is delivered to the single pair of crushing rolls 10 by a suitable conveyor and chute (not shown). The cane is drawn in and crushed by the rolls 10 so as to split open the stalks and separate the fibres, and the stalks then pass directly to the mill B, consisting of the rolls 12, 13 and 14. The cane moves from the crusher to the mill over the ordinary inclined bed, which I have not deemed it necessary to illustrate, and enters between the rolls 12 and 13, which are termed the upper roll and the cane roll respectively. These rolls express a portion of the juice from the cane, which as it leaves them is deflected

upwardly in the customary manner by the well-known turn plate 15, so as to pass between the upper roll and the bagasse roll 14. It may be assumed for purposes of description also, that the installation is a large one, capable of handling many tons of cane daily, and that the mill B is followed by a plurality of similar juice expressing mills, there being suitable conveyors or carriers between the several juice expressing mills in accordance with the usual practice.

The crushing rolls 10 may be of any approved type, but preferably they will be provided with teeth for hooking or drawing in the cane, so that the latter will be fed into the machine uniformly and expeditiously. In the embodiment under discussion, the rolls 10 are provided with a plurality of annular grooves 10^a which are substantially V-shaped in cross section. The provision of the V-shaped grooves in the rolls creates correspondingly shaped ridges or ribs and the ribs of the upper crusher roll enter the grooves of the lower crusher roll with a certain amount of clearance, as is customary.

In order to provide teeth for hooking into the cane stalks and drawing them into the machine, the preferred practice is to cut a plurality of generally longitudinal grooves 10^b in each crusher roll, intersecting the transverse, i. e., annular V-shaped grooves. The cross-sectional shape of the longitudinal grooves 10^b in the preferred form, can be seen in Fig. 1. While, however, these grooves 10^b are longitudinal in a general sense, they are preferably not exactly in line with the axis of the roll; in fact it is considered the best practice to provide an obtuse angle in each lengthwise groove, as shown in Fig. 2, for example. In other words, a slightly inclined groove extending from one end of the roll to the center, or thereabouts, meets at the latter point a similar groove inclined in the opposite direction and extending to the other end of the roll. These grooves may be inclined at an angle of say 10° to the roll axis, as such an arrangement has given very good results in practice.

With the purpose of increasing the crushing effect of the rolls and particularly of the preliminary crushing rolls, and of augmenting the capacity of the machine, a differential motion of one roll relatively to its mate or coacting roll is provided. For obtaining these advantages one roll rotates at a materially greater surface speed than the roll on the opposite side of the cane stalk, between which two rolls the can passes, and by which rolls the cane is fed. The result is that the cane stalks are torn apart more thoroughly and more effectively shredded and opened up, so as to separate or permit the separation of the individual juice carrying fibres; and by shredding the cane in this manner the fibres are put in a condition in which they will readily give up their juice when they are subjected to the squeezing action of the following rolls. The provision of the different surface speeds in the respective rolls of a pair of cane grinding rolls, and particularly crushing rolls, is considered of special advantage in the case where the crushing rolls are provided with teeth, such for example as the crushing rolls 10 shown in Figs. 1 and 2; but if desired, this feature may be used also in connection with juice expressing rolls, or in other words, the ordinary three-roll mills that follow the preliminary crushing rolls, or it may be useful in connection with a mill in which one or more rolls have a hooking or drawing-in action on the cane and a considerable juice expressing action in addition.

In the machine shown in Figs. 1 to 3 inclusive, the crusher rolls 10 of crusher A, are differentially driven, but in this particular case the rolls of the three-roll mill B are all driven at substantially the same speed. While the differential drive which produces a friction motion on the cane is shown in connection with crusher rolls having teeth, it is to be understood, however, that this feature may be utilized in certain cases where the rolls have no teeth, and in some cases where the rolls have no grooves, and in fact where the character of the roll surface is entirely different from that herein particularly described. I believe it desirable, however, that the rolls have a somewhat roughened surface, because otherwise they cannot grip the cane stalk which is especially slippery as a result of the fact that the cane becomes covered with the slippery juice as soon as it enters the machine. The teeth of the preliminary crusher are especially desirable for the prevention of the slippage of the roll surface on the wet and slippery mass of cane, inasmuch as they provide a means for penetrating the stalks or at any rate of gripping them so effectively that the feed of the cane into the machine will not be arrested, which might otherwise be the case.

In the embodiment shown in Figs. 1 to 3 inclusive, the top roll 12 is provided with lengthwise grooves similar in character to those of the preliminary crushing rolls. These grooves of roll 12 are for the purpose of improving the feed of the cane into the mill B, and in this case the toothing of the roll has advantages similar to those pointed out above. It will be understood, of course, that the action of the rolls 12 and 13, that is to say, the action produced by their coordination, is the feeding of the cane into the three-roll mill, which is improved materially by the lengthwise grooving of the top roll. The greatest crushing effect occurs between the top roll and the bagasse roll. The annular ribs of these two rolls are usually in staggered relation and so arranged that the annular rib of one roll extends within a

groove of the other, although a suitable clearance is always provided, such clearance being determined with respect to the squeezing or pressure which it is desired to exert. It will be understood that where the top roll 12 is provided with the longitudinal grooves its squeezing surface is somewhat diminished, but in the case under discussion the number of lengthwise grooves in roll 12 is considerably less than that of the lengthwise grooves in the preliminary crusher, so that while the available cooperating squeezing surfaces of the top roll 12 and bagasse roll 14 are not materially decreased, the feeding action of rolls 12 and 13 on the other hand is quite noticeably increased and improved.

Referring now to the difference in the surface speed of the coacting cane grinding rolls, and more especially the different surface speed of the preliminary crushing rolls 10, above described, it may be said that in the machine shown in Figs. 1 to 3, the top crusher roll 10 is driven at a speed approximately 13% slower than the coacting upper roll. This arrangement, while preferred, is merely illustrative, however, as the upper roll may be the faster one. The differential motion may be readily obtained by proper toothing of the driving gears, and in this connection it may be explained that in the machine now under discussion, the gear 16, by which the upper roll 10 is driven, has a somewhat larger number of teeth than its coacting gear 17. The lower roll 10 is of the same diameter as the upper roll and is driven in the ordinary manner by a shaft 18, on which gear 17 is mounted, the gear 16 on the shaft of the upper roll meshing with said gear 17, as in ordinary practice; but the arrangement under discussion differs from ordinary practice in providing for a different surface speed of the rolls through the dissimilar number of teeth on the driving gears, which in this particular case causes one roll to be driven at least 13% faster than the other under all conditions, although I do not limit myself to any specific difference in the surface speed of the coacting rolls.

The mill B is driven from a shaft 19, connected with or carrying the roll 12, and a gear 20 on said shaft meshes with a gear 21 on the shaft of cane roll 13, and with a gear 22 on the shaft of bagasse roll 14. If it be desired to produce a differential action, as between any two of the rolls of the three-roll mill B (all of which rolls are in this case of substantially the same diameter), the intermeshing gears will have a dissimilar number of teeth, as above described, in connection with the preliminary crushing rolls.

The longitudinal grooving of the top roll of mill B has been found very advantageous in actual practice in cases where such mill, or its equivalent, is followed by a plurality of similar three-roll mills, all of the mills being arranged in tandem in the well-known manner. In such a case the first mill, or more particularly the top roll thereof, has to a certain extent the function of a crusher, owing to the crushing or shredding action that is produced by the provision of teeth on the roll; so that in many cases a single pair of preliminary crushing rolls will suffice in an installation of this character; although at the same time the first three-roll mill retains its character as a means for exerting high pressure on the cane passed through it, as above described, so as to force out a large quantity of juice, which runs off in the roll grooves and is then disposed of in the usual way.

In the mill shown in Figs. 4 to 7, there are two pairs of preliminary crushing rolls. The first pair, consisting of toothed rolls 23, has a housing C, and the second pair, consisting of the rolls 24, has a housing D. These pairs of crushing rolls, which are arranged at different elevations in the ordinary way, and to which the cane is supplied in the customary manner, feed the cane over the customary inclined runways (not shown) to a juice expressing mill E, following which are a plurality of similar three-roll mills F, G, and H, as shown more particularly in Fig. 6. The lengthwise grooving of the preliminary crushers is shown in Figs. 4 and 5, and the annular grooving of the various rolls and the relative spacing of the coacting rolls of the complete mill, are shown in Fig. 7. Where I refer here to the relative spacing of the coacting rolls, I means the spacing of each roll relatively to its mate or coacting roll to form the bite through which the cane passes, and do not mean to refer to the distance between the several mills which, in practice, will be greater than that indicated in Fig. 6, which is merely a diagram. It will be understood also that suitable conveyors will be interposed between the mills for carrying the cane from the preceding to the following one.

In this last mentioned mill the toothing of the first pair of crushing rolls 23 is similar to that of the preliminary crushing rolls 10 previously described. The toothing of the rolls 24 is also of a similar character, but in this case there are a less number of teeth; although the pitch of the annular ribs is about the same. In other words, the rolls 24 have a materially smaller number of longitudinal corrugations. This is so because there is less necessity for hooking into the cane to draw or drag it along than there is in the case of the first crusher; and with a less number of longitudinal corrugations, i. e., where there are fewer gaps or interruptions in the circumference of the roll, there is provided a greater amount of squeezing surface. In the particular case now under discussion there are twice as many longitudinal grooves in the first crushing rolls as in the second

crushing rolls and hence the juice expressing function of the second rolls is considerably greater. I do not wish to limit myself, however, to any specific number of corrugations in any of the pairs of preliminary crushing rolls, or to any specific ratio between the number of teeth of one pair and the number of teeth of another pair, for various changes may be made in this regard while retaining all of the advantages of the principle involved.

The gearing for driving the installation is partially shown in Fig. 5, from which it will be noted that in this case preliminary crushers are driven from one and the same engine, whereas the three-roll mills are separately driven. It may be assumed for purposes of description that this installation has a capacity of say somewhere between 1,800 and 2,000 tons of cane per day, the preliminary crusher rolls being say 32″ in diameter and 78″ long, and the rolls of the various three-roll mills being say approximately 34″ in diameter and 78″ long. In such a mill the pressure exerted by each pair of preliminary crushers will be somewhere in the neighborhood of 250 tons, for example, and the four mills E, F, G and H, may have pressures of 375, 400, 425, and 450 tons respectively.

In the various three-roll mills of this installation, the deep grooves 28 of the cane rolls shown in Fig. 7 are for the purpose of carrying off the juice caught in the space between the bite of the top and cane rolls and the uppermost portion of the cane roll. This, however, is a matter of ordinary practice, to which I make no claim.

It is assumed that in the mill now being described the crusher rolls 23, and also the crusher rolls 24 are differentially driven to produce a friction motion on the cane, as previously described, in connection with the crushing rolls 10, and that in this case also the top roll is driven more slowly than the bottom roll. It will be obvious, however, that if desired the upper rolls could be driven faster than the lower rolls, or the upper roll of one crusher might be driven faster than the lower roll, while the upper roll of the other crusher might be driven slower than the lower roll; and various other arrangements might be made without departing from the scope of the invention. It is obvious, of course, that if desired the preliminary crushers shown in Figs. 4 and 5, could be used in front of a three-roll mill having one or more toothed juice expressing rolls similar to the top roll of mill B, or in other words, that one or more of the rolls of mill E could be provided with longitudinal grooves. In the form shown in Figs. 4 to 7, it is assumed that the rolls of mills E, F, G and H, are not provided with longitudinal grooves, but one or more of them might have one or more longitudinally grooved rolls, if desired. In the installation shown in Fig. 1, it is assumed that the first three-roll mill has a longitudinally grooved top roll, but that the following three-roll mills (not shown) have the annular grooves only.

The arrangement of the longitudinal grooves in the rolls of the crushers A, C and D, also increases to a large extent the efficiency of a cane mill of the illustrated type. With reference to Figs. 2 and 5, it will be noted that the longitudinal grooves 10^b in Fig. 2 and the similar grooves of Fig. 5, while forming with the annular ribs teeth to assist in drawing the cane in between the rolls, are so arranged upon each roll that there is no determined cooperation between the teeth formed upon one roll and the teeth formed upon the other roll, but the action of each is more or less independent of the other, and that the various pieces of cane being crushed between the rolls when the same are operating, are acted upon differently at various points along the longitudinal axis of the rolls. Inasmuch as more than one annular rib acts upon the same piece of cane, the teeth above mentioned will, due to the above mentioned action, more effectively open up the fibres of the cane preparatory to pressing the juice therefrom.

One form of roll structure which will cause the above mentioned action and a more efficient operation between the crusher rolls, is shown in Figs. 2 and 5. The top roll of each crusher shown in these figures is provided with longitudinal grooves diverging forwardly from a point substantially intermediate the ends of the rolls, and form, as stated above, an obtuse angle. The bottom roll is likewise shown provided with similar groovse, which also diverge in the same direction, in this instance, forwardly, and form obtuse angles which are substantially the same as those of the upper roll. Because of this structure and arrangement, the longitudinal grooves and the ribs formed thereby of the upper and lower rolls, can never mesh, and during the operation of the rolls cooperating portions of the same act differently upon the cane at intervals along the entire longitudinal axis of the rolls. For instance, at an intermediate point between the ends of the rolls, the rib portion formed by the longitudinal grooves of one roll may be co-acting against and with a longitudinally grooved portion of the other roll, while at another point in the length of the roll a short distance from the first point, the reverse action may be taking place; in between this point at another point along the longitudinal axis of the rolls, the annular ribs of one roll may be in mesh with certain of the annular ribs of the other roll, due to portions of the longitudinal ribs of both rolls co-acting at this point.

While the above advantages are obtained by the use of the specific structure shown in Figs. 2 and 5, described above as being pref-

erable, it will be understood that the longitudinal grooves might be arranged to diverge rearwardly in both rolls, or the grooves might diverge in the same direction in both rolls while the obtuse angles formed thereby in each roll might be unequal, or any other arrangement of grooving might be made which would have the same result. This result is, in general, the use of generally longitudinally disposed grooves extending across the coacting rolls in such a manner, that at the portions of the rolls along the longitudinal axis thereof that co-act to crush the cane, the respective grooves upon the rolls will intersect or cross each other during the rotation thereof and not be in alignment with or parallel to each other.

Various changes may be made in the details of the machine, as herein particularly described, without digressing from my inventive concept, as expressed in the claims.

I am aware that in prior sugar cane mills there have been slight differences of surface speed between intermeshing grooved rolls, caused by the uneven wearing of the roll surfaces or by slight inaccuracies in manufacture, but in such cases the surface speed difference has not amounted to say more than one or two per cent, which is insufficient to produce a substantial increase in the shredding effect such as achieved by my invention, according to which the speed difference should, if practicable, amount to at least five per cent, while according to the practice which I regard as the best, it will approximate ten per cent, as in the forms of my invention herein illustrated and described. In the practice of my 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.

I do not claim herein specifically the application of the differential surface speed feature to a three-roll mill, as claimed in my application Serial No. 465,958; nor do I claim herein a cane grinding installation comprising a plurality of pairs of toothed pre-crushing rolls, with the rolls of the succeeding pair having a less number of teeth than the rolls of the preceding pair, or other features claimed in my application Serial No. 509,257.

What I claim is:

1. In a cane mill, two coacting cane crushing and juice expressing rolls, each having circumferential grooves forming ribs, the ribs of one roll adapted to mesh with those of the other roll, and each roll having generally longitudinally disposed grooves extending between the ends of said rolls and interrupting the ribs thereon to form teeth to hook into and draw in the cane, the longitudinal grooves in the upper roll having portions diverging from a point intermediate the ends of said roll in such a manner that the teeth formed at the ends of said grooves will attack the cane passing between said rolls before the teeth formed at the apex of the grooves, the longituidnal grooves in the lower roll having portions diverging from a point intermediate the ends of said rolls in such a manner that the teeth formed at the apex of said grooves will attack the cane passing between said rolls before the teeth formed at the ends of said grooves, and means to drive said rolls, said means including means to drive one of said rolls at a greater surface speed than the other.

2. In a cane mill, two coacting cane crushing and juice expressing rolls, each having circumferential grooves forming ribs, the ribs of one roll adapted to mesh with those of the other roll and each roll having generally longitudinally disposed grooves extending between the ends of said rolls and interrupting the ribs thereon to form teeth to hook into and draw in the cane, the longitudinal grooves in one of said rolls having portions diverging from a point intermediate the ends of said roll in such a manner that the teeth formed at the ends of said grooves will attack the cane passing between said rolls before the teeth formed at the apex of the grooves, the longitudinal grooves in the other of said rolls having portions diverging from a point intermediate the ends of said rolls in such a manner that the teeth formed at the apex of said grooves will attack the cane passing between said rolls before the teeth formed at the ends of said grooves, and means to drive said rolls, said means including means to drive one of said rolls at a greater surface speed than the other.

In witness whereof, I have hereunto set my hand on the 11th day of February, 1921.

FRANKLIN FARREL, JR.