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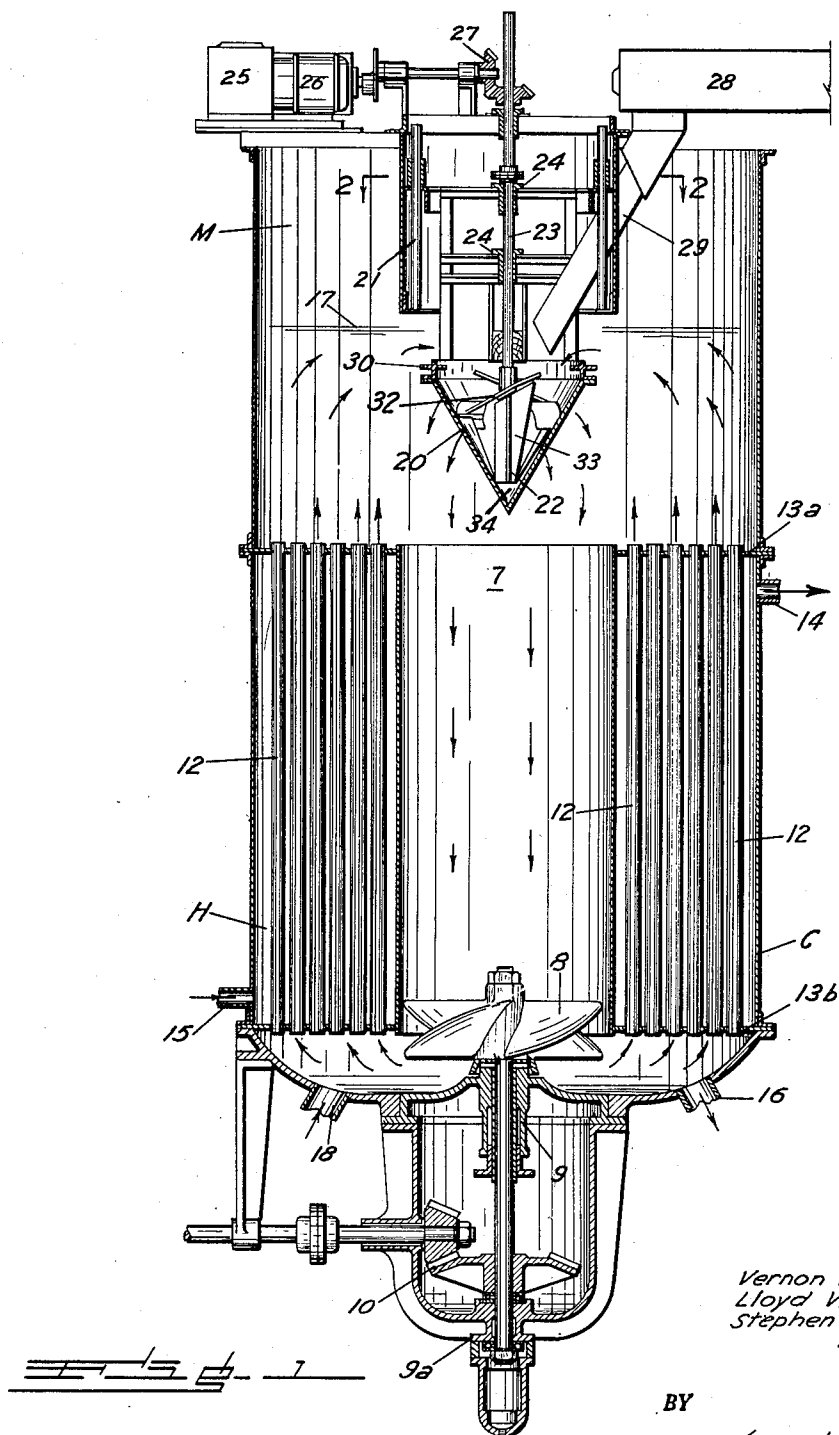
V. V. HARTMAN ET AL

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APPARATUS AND PROCESS FOR MIXING SOLIDS IN LIQUIDS

Filed Sept. 15, 1947

3 Sheets-Sheet 1



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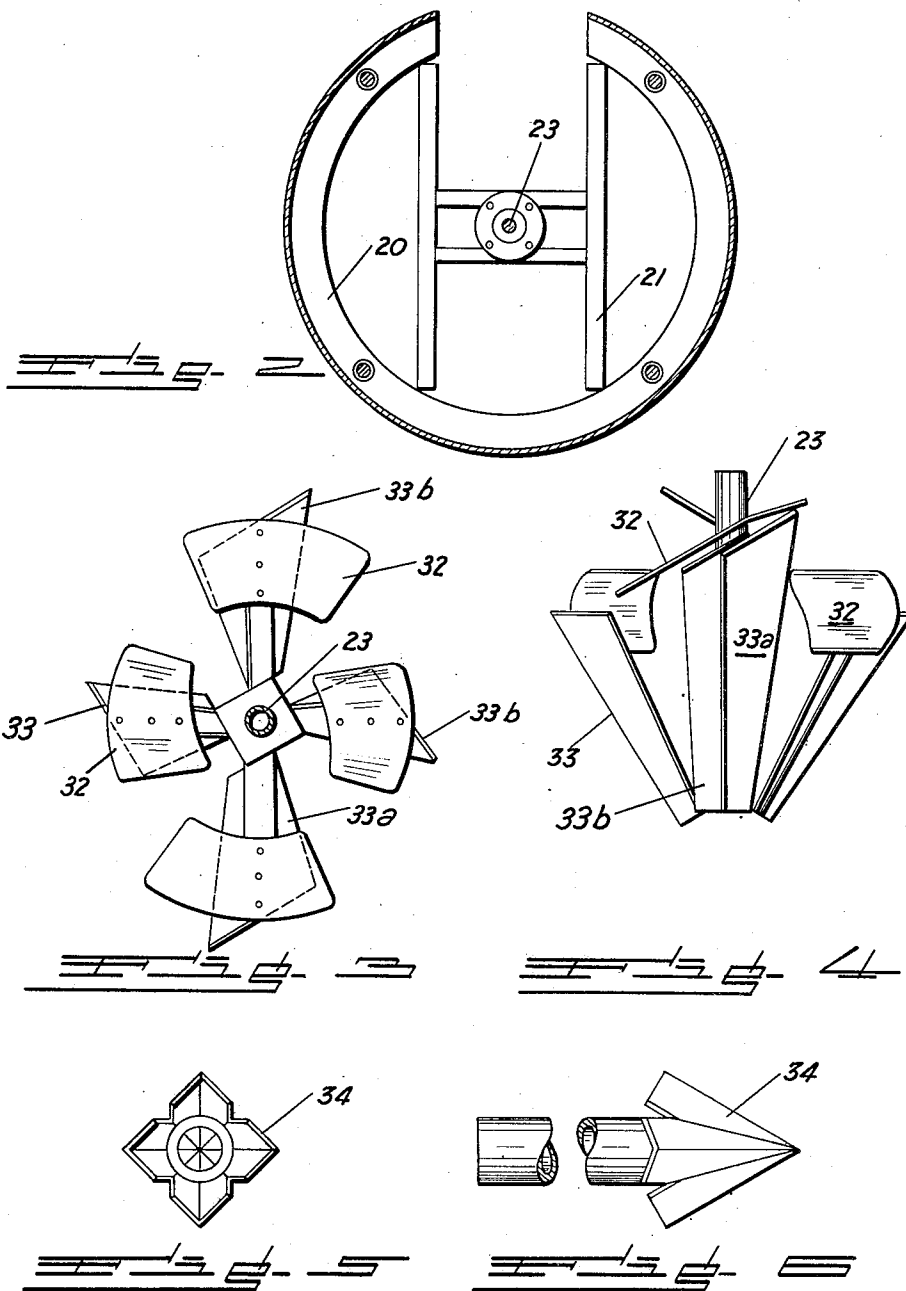
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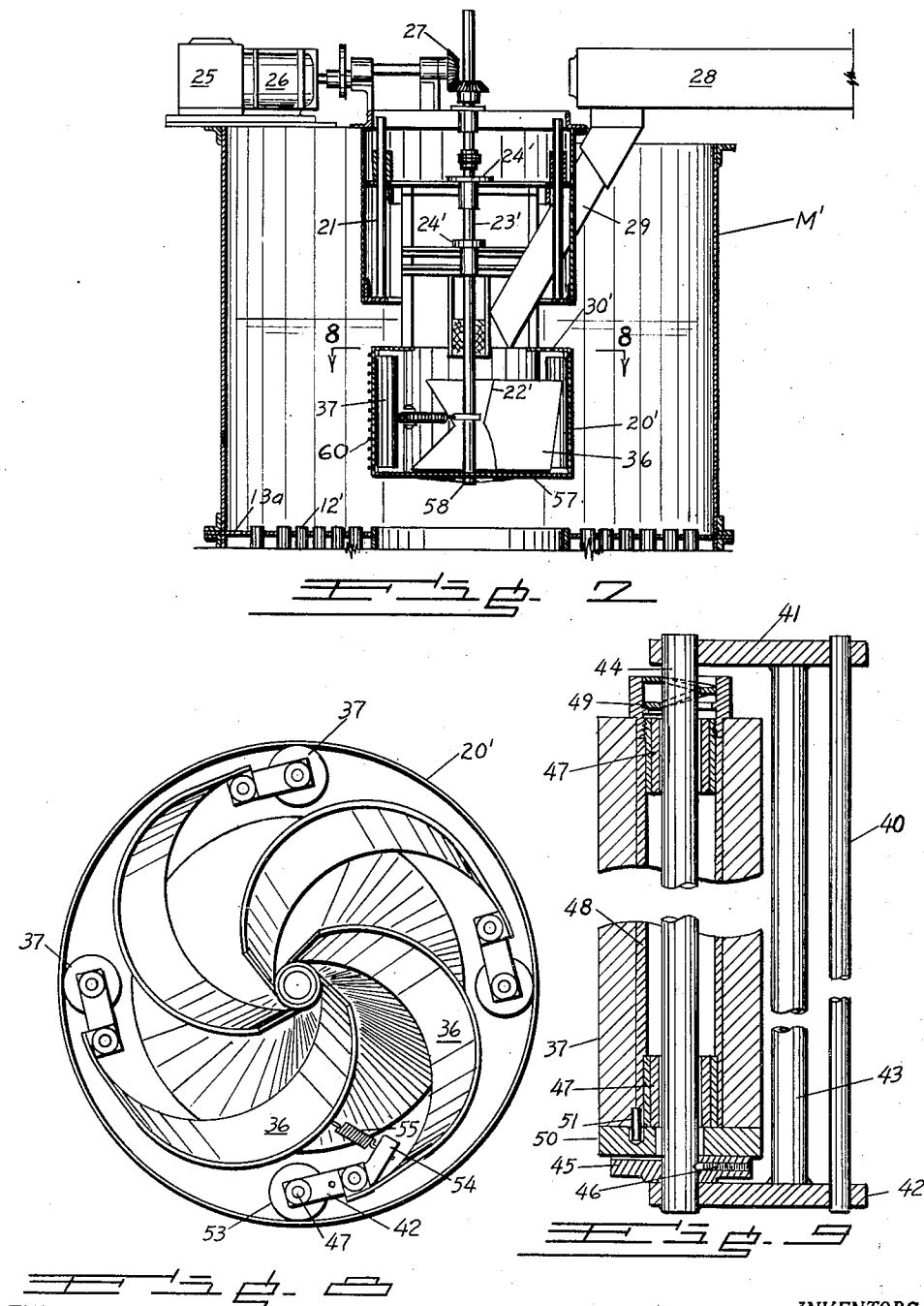
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UNITED STATES PATENT OFFICE

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APPARATUS AND PROCESS FOR MIXING
SOLIDS IN LIQUIDS

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16 Claims. (Cl. 127-14)

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This invention relates to apparatus for mixing solids in liquids and to certain methods for improving the well-known Steffen's process of the beet sugar refining art.

The Steffen's process is utilized in beet sugar refining to effect a final extraction of sugar content from the molasses discharge of the main refining operation. This molasses contains non-sugars in excess quantities that further recovery by retention in or recirculation through the main refining stages is uneconomical. However, by treating such molasses in a separate circuit employing an addition of powdered quicklime to the molasses, a further sugar extraction is obtained, due to the formation of a saccharate precipitate, which is filtered and may be taken as a final product, or may be and frequently is returned to the initial sugar-processing cycle of the main refinery operation as an additive of the raw sugar content of that operation.

While the aforesaid operation has been adequate to the extent that it is a standard procedure in many beet sugar factories, it has many deficiencies causing inefficient and uneconomical operation. One of the principal difficulties is the formation of slaked lime which will combine with the sugar of the molasses solution to only a limited degree.

Whenever there is an insufficient sugar content in contact with the lime, the lime tends to combine with the water of the solution forming the hydroxide, which assumes the consistency of a fine paste or almost colloidal dispersion in the solution. The hydroxide will combine with the sugar to only a limited extent, and consequently the presence of any substantial hydroxide formation reduces sugar recovery and impedes filtration. At the filtration stage, the hydration of unreacted lime causes a partial decomposition of the sugar content.

A principal cause of the formation of hydroxide in such operations is the tendency of the finely powdered quicklime to form oversize agglomerated particles when it comes into contact with the molasses solution. These oversize particles break up very slowly even under violent mechanical agitation, and the quicklime contained within these particles fails to associate with the sugar of the molasses solution to effect the desired chemical reaction. As the particles eventually break up, the lime largely slakes to form hydroxide, with the disadvantage previously mentioned.

It is an object of the present invention to provide a simple, economical, and efficient method

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for improving the well-known Steffen's process in the beet sugar refining art.

Another object of the invention is to provide simple, durable, and efficient apparatus for mixing solids in liquids.

A further object of the invention is to provide fluid mixing apparatus that is well suited for installation in the coolers of the Steffen's process of beet sugar refining operations.

Still another object of the invention is to provide a process for mixing lime and molasses which produces a precipitate which can be filtered efficiently throughout a substantial temperature range.

Yet another object of the invention is to provide a continuous liming mixing operation for Steffen's coolers or the like.

Other objects reside in novel combinations and arrangements of parts and novel details of construction, all of which will be fully described in the course of the following description.

Briefly stated, the present process involves the mixing of the lime charge to the Steffen's cooler with a limited quantity of the solution circulating therein, while subjecting the mixture to intense agitation within a confined zone. After being mixed and agitated in this manner, the mixture is forced from the confined zone into the main circulating stream through a series of passages of such fineness that oversize particles of lime are prevented from entering the main stream. Also, in conjunction with the aforementioned agitation, the screening area is continuously wiped by suitable blades to keep the minute passages clean and to break up any oversize lumps of lime in the mixture.

The operating procedure and structural arrangements of the present invention will be best understood by reference to the accompanying drawings. In the drawings, in the several views of which like parts have been designated similarly,

Fig. 1 is a vertical central section through a Steffen's cooler in which the mixing apparatus of this invention has been installed;

Fig. 2 is a section taken along the line 2-2, Fig. 1;

Fig. 3 is a top plan view of the impeller member of the mixing apparatus shown in Fig. 1;

Fig. 4 is a side elevation of the impeller member shown in Fig. 3;

Fig. 5 is a top plan view of the foot piece of the impeller member shown in Fig. 1;

Fig. 6 is a fragmentary side elevation of the foot piece shown in Fig. 5;

Fig. 7 is a fragmentary vertical central section of a modified form of mixing unit, well suited for installation in a Steffen's cooler and which embodies novel features of the present invention;

Fig. 8 is a section taken along the line 8—8, Fig. 7 and drawn to an enlarged scale; and

Fig. 9 is an enlarged fragmentary sectional view of one of the roller assemblies shown in Figs. 7 and 8.

The structure illustrated in Figs. 1 through 6 represents one embodiment of the invention and comprises a conventional Steffen's cooler C in the form of a cylindrical tank divided into an upper mixing zone M and a lower heat exchange zone H. The latter zone includes a central well or tube portion 7 having a rotary impeller element or runner 8 in its lower end journaled for rotation in bearings 9 and 9a, and driven by suitable gearing 10 from a suitable prime mover (not shown).

Externally of well 7 the space of zone H is divided by a tube section comprising a series of upright tubes 12 supported in heads 13a and 13b, with an inlet 15 for introduction of heat-exchange fluid (usually water), and an outlet 14 therefor, by which the heat-exchange fluid is circulated about said tubes. Fluid is drawn by the impeller downwardly through well 7 and upwardly through the tubes 12 to return to the mixing zone M. Final discharge of the circulating solution from the heat exchange zone H is through an outlet 16, which may be valve-controlled, if desired, and serves to maintain a predetermined liquid level in the tank represented by the dot-dash line 17 in zone M. The molasses solution inlet is shown at 18, but may be at any convenient location.

The structure thus far described is a conventional Steffen's cooler. The novel arrangement of the present invention resides in the inclusion of a mixing unit in the mixing zone M. This unit comprises a conical partitioning member 20 supported from superstructure 21 and having a rotary agitator 22 mounted within the enclosure formed by partitioning member 20, on a shaft 23 journaled in bearings 24, and driven by a motor 25, speed reducer 26, and transmission 27. A feeding mechanism is located near the top of the tank and comprises a conveyor 28 and a chute 29, which deposits the lime into the circulating solution entering the conical member 20 by overflow.

In order to control the circulation of material in member 20, we preferably locate an annular shield 30 near the top of the partitioning member and extending inwardly from its periphery to narrow the entrance and providing overhanging surfaces which prevents any backward surge of the contents which might result from occasional excessive chemical reaction.

The conical portion of partitioning member 20 preferably is formed of fine mesh screen which allows a continuous outflow of liquid, but retains any lumps or particles of lime. To insure the rapid reaction of the lime and juice, agitator 22 preferably includes two sets of wiping blades which contact the inner surface of the screen and break up any solids lodged against the screen. The position and inclination of the upper set of blades designated 32, draws solution downward into the interior of member 20, while retaining any upward surge of material from said interior. Blades 33 serve two functions. The lead edges 33a of the blades are inclined at a 30° angle from the screen to guide the solution movement toward the screen and wipers 33b which are at-

tached to the opposite edge of said blade and contact the inner surface of the screen throughout.

The pointed end member 34 is provided as a seat for the blades and gives stability to the assembly.

In the operation of the apparatus hereinbefore described, juice flows into cooler C through inlet 18 and discharges from outlet 16, filling the interior to a predetermined level represented by the dot-dash line 17. While in the cooler it is subjected to the circulatory influence of impeller 8 at the bottom of well 7 and then upwardly through the tubes 12. Some of this juice is drawn through the interior of the partitioning member, while the remaining solution recirculates through well 7 and back through tubes 12.

The portion of juice overflowing the conical partitioning member 20 mixes with lime introduced therein by conveyor 28 and chute 29, and any oversize particles of the mixture are drawn to the screen surface by the outflow of liquid therefrom where it is acted on by the agitator 22 and particularly the blades 32 and 33 until it disintegrates and passes into the main body of the molasses solution in a finely dispersed condition.

The annular baffle or shield 30 prevents any backward surge which might result from the violent mechanical agitation, and thus the contents of the conical chamber 20 discharge only through the passages of the screen. The outflowing solution mixes with the main body of circulating molasses juice, and in the recirculation, has ample time to produce the desired chemical reaction.

After the solution has recirculated sufficiently to produce the required chemical reaction, the valve controlling the discharge through outlet 16 is opened and the mixture passes to a filtration stage (not shown) usually comprising rotary drum type filters, and the saccharate content is recovered as a cake, while the spent liquor is discharged as a waste product. As previously mentioned, the cake discharge may be conveyed to and mixed with the raw sugar feed at the head of the main refinery operation.

The form of the invention shown in Figs. 7, 8 and 9 represents a mixer unit installation which possesses some advantages over the form hereinbefore described. In this form, the partitioning member or enclosure 20' is cylindrical rather than conical and is supported from superstructure 21 with a rotary agitator 22' mounted interiorly of the enclosure on a shaft 23' journaled in bearings 24' and driven by a motor 25, speed reducer 26 and transmission 27. Lime is fed to the unit by the conveyor 28 and chute 29.

The cylindrical side wall of enclosure 20' preferably comprises fine mesh screen, or may be other foraminous structure, permitting continuous outflow of liquid while retaining any particles of lumps of lime. If desired, a spiral wire enclosure 60 may be provided for the screen to prevent undue deformation. To provide the desired mixing action, agitator 22' includes a plurality of spirally directed blades 36 which provide the impelling movement for the material fed to the mixer, while a series of rollers 37 are arranged for continuous wiping contact with the screen during rotation of shaft 23'.

Usually the centrifugal action will be sufficient to keep the rollers in contact with the screen throughout the cycle of rotation, particularly when the screen is of true cylindrical shape, but

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if this action is not adequate, a spring action may be provided to insure proper contact. This arrangement will be best understood by reference to Figs. 8 and 9.

As shown in Fig. 9, a pivot pin 40 is supported in top and bottom arm members 41 and 42 respectively, which are maintained in uniformly spaced relation by a rod 43 suitably attached, as by welding, to said arms. A shaft 44 is journaled for rotation in these arms and a disc 45 is keyed on shaft 44 as shown at 46 in a position to contact arm 42. Adjacent its ends, shaft 44 has rubber bearings 47 held by a sleeve 48 threadedly connected with an impeller 49 at its top which in turn is connected with the shaft. A hard rubber disc 50 is replaceably held at the lower end of sleeve 48 by dowels 51.

Through the above arrangement, periodic replacement of worn contact surfaces can be effected easily and quickly. If contact is not maintained adequately by centrifugal action alone, the aforementioned spring action may be provided to assist in holding the rollers 37 in contact with the screen, as shown at 53 in Fig. 8. With such an arrangement, a projection 54 on arm 42 carries a spring 55 which in turn is connected with one of the surfaces of the adjoining spiral blade 36 maintaining sufficient pull on the end of arm 42 in which shaft 47 is mounted to keep the roller in contact with screen 20'.

From the foregoing description, it will be apparent that the spiral arrangement of the blades serves to keep the material under treatment directed outwardly against the screen in the centrifugal action and by having the rollers 37 in constant contact with the screen during this action, any lumps or particles tending to collect on the screen are reduced by the contact with the roller and brought into more intimate contact with the solution. In addition, the impeller 49 at the top of each roller forces liquid down through the bearings mounted on shaft 47 to enter the space 56 above disc 45 and thus lubricates the hard rubber disc 50 to prevent excessive wear.

While the roller design just described represents a preferred embodiment of the invention, it will be understood that any arrangement of impeller members which provides a wiping contact along all interior surfaces of the screen and which also provides means for directing material into the tank against said screen, will satisfy the purposes of the present invention. The structure illustrated is highly satisfactory, in that it does not deteriorate appreciably through chemical action and possesses sufficient stability and wear-resistant properties to provide long life without undue adjustment or replacement.

Another feature of the arrangement shown in Fig. 7 is the spacing of the impeller blades from the bottom surface of enclosure 20' as shown at 57 in Fig. 7, permitting grit and the like to work underneath the impeller assembly and pass out through the coupling 58 which preferably is maintained open to provide a continuous clean-out.

Thus, it will be seen that in all forms of the invention hereinbefore described, provision is made for continuous mixing of lime and juice, even though the overall operation of the Steffen's cooler is a batch operation. By having the mixing continue throughout the operating cycle of the cooler, a more uniform distribution of the lime with the molasses solution is obtained and this prelimed solution in turn is more uniformly

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distributed through the main body of circulating solution. As a consequence, hydroxide formation is kept to a bare minimum with consequent improvement in sugar recovery and filtration.

No temperature control is required in the mixing action of the present process, although under former practice it was necessary to discharge the mixture from the cooler at about 10° C. and then raise the temperature of the composition to about 20° C. to get proper filtration. In this process, the mixture has been filtered while at a temperature of 9° C. with just as good results as when maintained at 11° C. or higher.

The aforesaid treatment has a number of beneficial results. In the first place, the quantity of lime required in the mixing stage is substantially less than that required in the former treatment. Also, the decomposition occasioning the former sugar loss at the filters is substantially avoided, and in addition, it is possible to form a substantially thicker cake which is of dryer consistency and thus provides improvement in the mechanical action of filtration. Higher purity saccharate is obtained probably due to the substantial reduction in calcium hydroxide formation and an apparent physical change producing a more granular precipitate. Thus, it is apparent that the change in operating procedure attains the various objects of the invention set out hereinbefore.

The apparatus features of the present invention have been described particularly with reference to improving the Steffen's process. However, it should be understood that the apparatus is well suited for use in other treatments wherever the desideratum is the mixing of solids in liquids, particularly of the type occasioning chemical reaction reducing the solids content to liquid state. Therefore, the apparatus as shown and described herein is intended merely to teach the practice of the present invention, but not to limit the scope of same except as set forth in the hereunto appended claims.

What we claim and desire to secure by Letters Patent is:

1. Apparatus for mixing solids in liquids, comprising a tank having its interior divided into upper and lower mixing and heat exchange compartments and having an inlet and outlet for juice, means for circulating a stream of juice from the heat-exchange compartment into the mixing compartment and back into the heat-exchange compartment, a foraminous mixing chamber in the mixing compartment submerged in the circulating stream in a position to receive some of the circulating juice, means for feeding lime into the foraminous chamber out of contact with the stream of circulating juice, and agitating means in the mixing chamber for reducing solids of the feed while mixing with the juice so as to finely disperse substantially all solids content in the solution and arranged to force said solution through the foraminous member into the circulatory stream of juice in contact with said member.

2. Apparatus for mixing solids in liquids, comprising a tank having its interior divided into upper and lower mixing and heat-exchange compartments and having an inlet and outlet for juice, means for circulating a stream of juice from the heat-exchange compartment into the mixing compartment and back into the heat-exchange compartment, a foraminous mixing chamber in the mixing compartment submerged in the circulating stream in a position to receive

some of the circulating juice, means for feeding lime into the foraminous chamber out of contact with the stream of circulating juice, agitating means in the mixing chamber for reducing solids of the feed while mixing with the juice so as to finely disperse substantially all solids content in the solution and arranged to force said solution through the foraminous member into the circulatory stream of juice in contact with said member, and a baffle in the upper portion of said mixing chamber arranged to prevent outflow from said portion.

3. Apparatus for mixing solids in liquids, comprising a tank having its interior divided into upper and lower mixing and heat-exchange compartments and having an inlet and outlet for juice, means for circulating a stream of juice from the heat-exchange compartment into the mixing compartment and back into the heat-exchange compartment, a conical foraminous mixing chamber in the mixing compartment submerged in the circulating stream in a position to receive some of the circulating juice, means for feeding lime into the foraminous chamber out of contact with the stream of circulating juice, and agitating means in the mixing chamber arranged to contact the conical interior of the mixing chamber for reducing solids of the feed while mixing with the juice so as to finely disperse substantially all solids content in the solution and arranged to force said solution through the foraminous member into the circulatory stream of juice in contact with said member.

4. Apparatus for mixing solids in liquids, comprising a tank having its interior divided into upper and lower mixing and heat exchange compartments and having an inlet and outlet for juice, means for circulating a stream of juice from the heat-exchange compartment into the mixing compartment and back into the heat-exchange compartment, a foraminous mixing chamber in the mixing compartment submerged in the circulating stream in a position to receive some of the circulating juice, means for feeding lime into the foraminous chamber out of contact with the stream of circulating juice, and agitating means in the mixing chamber for reducing solids of the feed while mixing with the juice so as to finely disperse substantially all solids content in the solution and arranged to force said solution through the foraminous member into the circulatory stream of juice in contact with said member, said agitating means including two sets of blades, the uppermost of which has substantially horizontally disposed portions contacting the foraminous member, and the lowermost of which is substantially vertically disposed and contacts the foraminous member throughout the major portion of their vertical extent.

5. In apparatus for mixing solids in liquids, a conical foraminous member adapted to be mounted in a circulating solution, a rotary agitator in the foraminous member comprising upper and lower sets of unitary blades, the blades of said upper set extending in a substantially horizontal direction with their ends in material-deflecting relation to the foraminous member and the lower set of blades extending in a substantially vertical direction with their sides in yieldable wiping contact with the foraminous member, and means for rotating said agitator.

6. Apparatus for mixing solids in liquids, comprising a tank having its interior divided into upper and lower mixing and heat-exchange com-

partments and having an inlet and outlet for juice, means for circulating a stream of juice from the heat-exchange compartment into the mixing compartment and back into the heat-exchange compartment, a foraminous mixing chamber in the mixing compartment submerged in the circulating stream in a position to receive some of the circulating juice, means for feeding lime into the foraminous chamber out of contact with the stream of circulating juice, and agitating means in the mixing chamber arranged to contact the interior of the mixing chamber for reducing solids of the feed while mixing with the juice so as to finely disperse substantially all solids content in the solution and arranged to force said solution through the foraminous member into the circulatory stream of juice in contact with said member.

7. In apparatus for mixing solids in liquids, a foraminous member adapted to be submerged in a stream of circulating solution and having an upper intake opening for material under treatment, and a rotary agitator in the foraminous member, including at least one unitary blade member arranged to exert a deflecting action against the foraminous member and at least one unitary blade member arranged to travel with an edge portion in yieldable wiping contact with the foraminous surface, so as to reduce the solids of the material under treatment to sizes permitting their passage through the foraminous member.

8. In apparatus for mixing solids in liquids, a foraminous member adapted to be submerged in a stream of circulating solution and having an upper intake opening for material under treatment, and a rotary agitator in the foraminous member, including at least one member extending substantially across the intake opening and arranged to exert a downward deflecting action against the foraminous member and at least one unitary blade member arranged to travel in wiping contact with the foraminous surface so as to reduce the solids of the material under treatment to sizes permitting their passage through the foraminous member, said foraminous member having a restricted bottom opening, and the agitator being arranged with its lower edges in spaced relation to said bottom opening so as to permit the outflow of gritty particles through said opening.

9. The improvement in the Steffen's process for beet sugar refining in which lime is mixed with a molasses solution in a zone of circulatory cooling, which comprises flowing a small portion of the circulating solution into a mixing zone submerged in and physically separated from the main circulatory stream, feeding dry lime in finely divided condition directly into said mixing zone, agitating the mixture in the mixing zone in an action in which the solids are reduced and go into solution, directing the solution mixture from the mixing zone through a plurality of small orifices and into the portion of the main circulatory stream encompassing said zone while restraining the outflow of solids in flocs or lumps from said mixing zone, and mixing said solutions in the circulatory movement through said cooling zone.

10. The improvement in the Steffen's process for beet sugar refining in which lime is mixed with a molasses solution in a zone of circulatory cooling, which comprises flowing a small portion of the circulating solution into a mixing zone submerged in and physically separated from the

main circulatory stream, feeding quicklime directly into said mixing zone, agitating the mixture in the mixing zone in an action in which the solids are reduced and go into solution, directing the solution mixture from the mixing zone through a plurality of small orifices and into the portion of the main circulatory stream encompassing said zone while restraining the outflow of solids in flocs or lumps from said mixing zone, and mixing said solutions in the circulatory movement through said cooling zone.

11. The improvement in the Steffen's process in beet sugar refining, in which lime is mixed with a molasses solution in a zone of circulatory cooling, which comprises flowing a small portion of the circulating solution into a mixing zone submerged in and physically separated from the main circulatory stream, feeding dry lime in finely divided condition directly into said mixing zone, agitating the mixture in the mixing zone in an action in which the solids are reduced and go into solution, directing the solution mixture from the mixing zone through a screening stage and into the portion of the main circulatory stream encompassing said zone while restraining the outflow of solids in flocs or lumps from said mixing zone, and mixing said solutions in the circulatory movement through said cooling zone.

12. The improvement in the Steffen's process in beet sugar refining, in which lime is mixed with a molasses solution in a zone of circulatory cooling, which comprises flowing a small portion of the circulating solution into a mixing zone submerged in and physically separated from the main circulatory stream, feeding dry lime in finely divided condition directly into said mixing zone, agitating the mixture in the mixing zone in an action in which the solids are reduced and go into solution, directing the solution mixture from the mixing zone through a screening stage and into the portion of the main circulatory stream encompassing said zone while restraining the outflow of solids in flocs or lumps from said mixing zone, the outlet passages of said screening stage being of such restricted size as to permit outflow of liquid but substantially no solids.

13. The improvement in the Steffen's process in beet sugar refining, in which lime is mixed with a molasses solution in a zone of circulatory cooling, which comprises flowing a small portion of the circulating solution into a mixing zone submerged in and physically separated from the main circulatory stream, feeding dry lime in finely divided condition directly into said mixing zone, agitating the mixture in the mixing zone in an action in which the solids are reduced and go into solution, directing the solution mixture from the mixing zone through a screening stage and into the portion of the main circulatory stream encompassing said zone while restraining the outflow of solids in flocs or lumps from said mixing zone, and subjecting the circulating mixture to a heat-exchange action.

14. The improvement in the Steffen's process in beet sugar refining, in which lime is mixed with a molasses solution in a zone of circulatory

cooling, which comprises flowing a small portion of the circulating solution into a mixing zone submerged in and physically separated from the main circulatory stream, feeding dry lime in finely divided condition directly into said mixing zone, agitating the mixture in the mixing zone in an action in which the solids are reduced and go into solution, directing the solution mixture from the mixing zone through a screening stage and into the portion of the main circulatory stream encompassing said zone while restraining the outflow of solids in flocs or lumps from said mixing zone, and subjecting the circulating mixture to a cooling action to counteract the heat input of the reaction of the lime with the juice.

15. In apparatus for mixing solids in liquids, a conical foraminous mixing chamber having its apex at its lower end and an agitator mounted for movement about a vertical axis in said chamber and comprising a stabilizing member at the apex of said chamber, an upper set of generally horizontal blades arranged for exerting a deflecting action downwardly towards the walls of the chamber and a lower set of generally vertical blades, the outer edges of said lower set of blades being disposed substantially in contact with the inner face of the foraminous chamber throughout a major portion of their vertical extent, whereby aggregates of solids are dispersed and forced through the foraminous member by the action of said sets of blades.

16. In apparatus for mixing solids and liquids, a conical foraminous member adapted to be submerged in a circulating solution, a rotary agitator in the foraminous member comprising upper and lower sets of blades, one set of blades being positioned to exert a deflecting action downwardly towards the walls of the foraminous member and the other set of blades having upwardly extending outer edges arranged for movement substantially in contact with the walls of the foraminous member and a baffle extending inwardly from the top interior surface of the foraminous member above the first-mentioned set of blades and defining a restricted inlet for restraining overflow from said member.

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