May 30, 1972 C. R. STEELE 3,666,556

DIFFUSION APPARATUS WITH POSITIVE FLOW CONTROLS

Filed Jan. 21, 1970 2 Sheets-Sheet 1

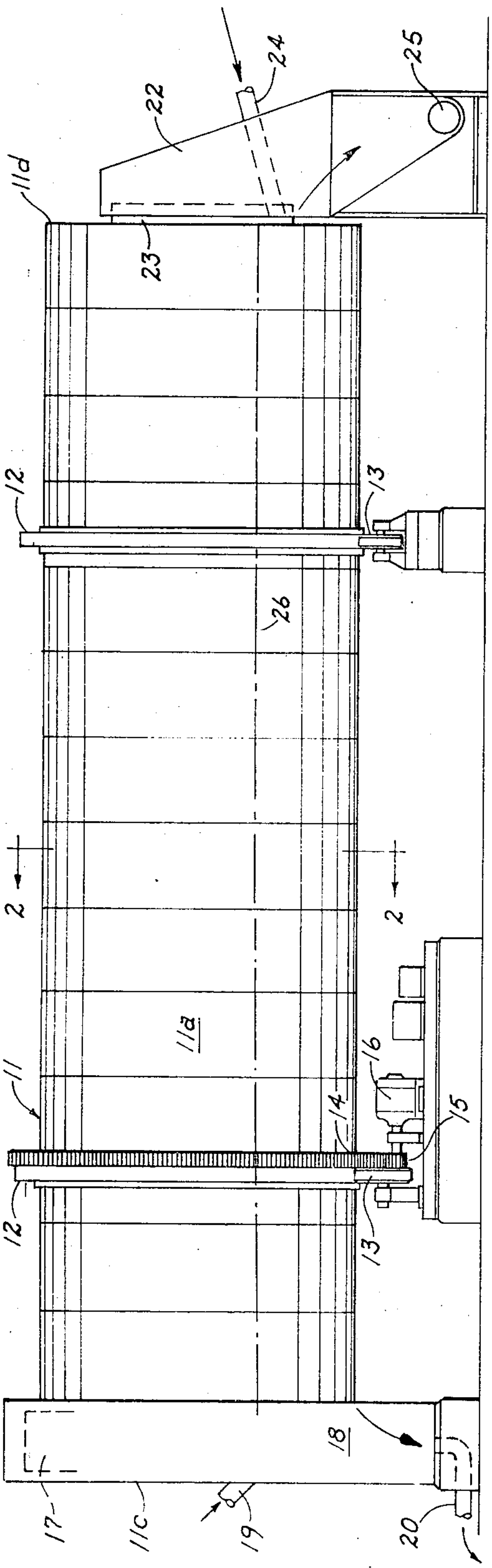

FIG. 1

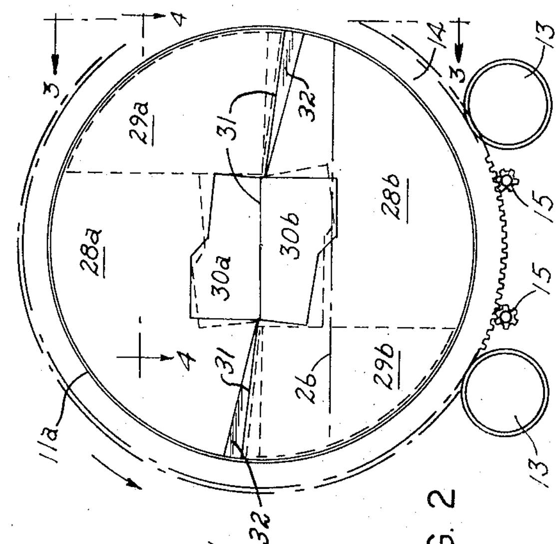

FIG. 2

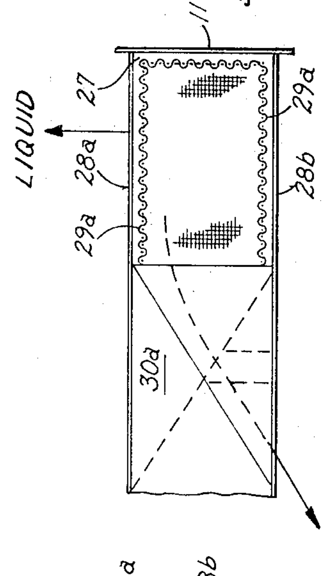

FIG. 4

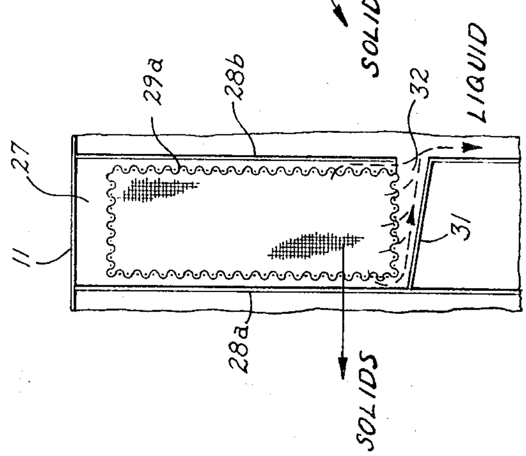

FIG. 3

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DIFFUSION APPARATUS WITH POSITIVE FLOW CONTROLS

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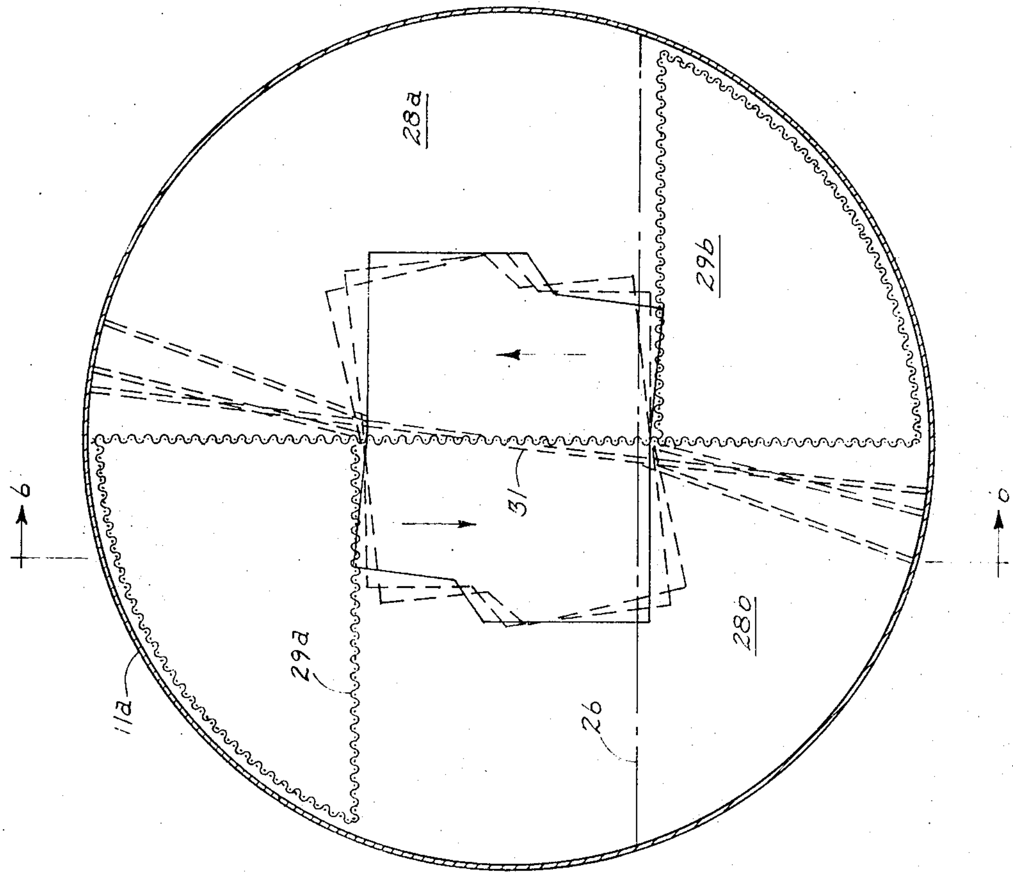

FIG. 5

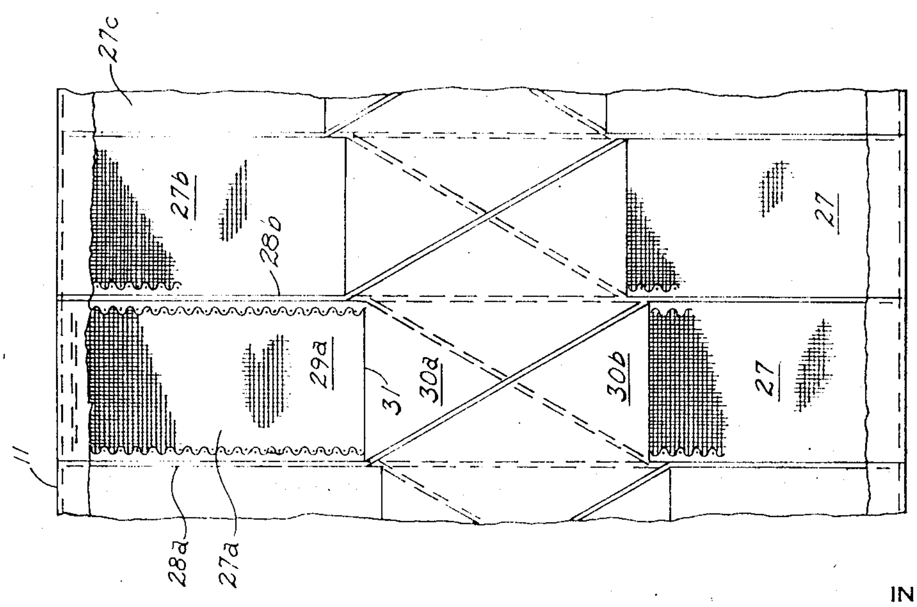

FIG. 6

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DIFFUSION APPARATUS WITH POSITIVE FLOW CONTROLS

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Int. Cl. C13d *1/12*
U.S. Cl. 127—7 8 Claims

ABSTRACT OF THE DISCLOSURE

Drum type, liquid-confining tank mounted for rotation about a substantially horizontal axis of rotation and having a solution inlet and a pulp discharge outlet at one end and a pulp inlet and a juice outlet at its opposite end maintaining approximately a one-third fill of pulp in said tank. Partitioning means extend through the tank interior in spiral pattern inclusive of a pair of segmental division plates defining each cell, the latter having an opening formed in one plate to provide the segmental shaping and maintain a juice flow path for discharge from the cell. Means for rotating tank and cells. A screening member in each segment is closed on three sides and one end with its other end open for delivering pulp to a chute member directing it to the succeeding cell. Juice passing the screen is directed in the opposite direction to a succeeding cell.

This invention relates to continuous diffusion apparatus particularly suited for the treatment of cossettes or beet sugar pulp and sugar cane.

Continuous diffusion treatments have had widespread acceptance by the beet sugar industry and a lesser degree of acceptance by the cane sugar industry due to processing complications in the handling of sugar cane. In general, these treatments involve the movement of cossettes through a succession of treatment stages with the solution or juice of the treatment moving generally countercurrent to the cossettes through the succession of stages. In recent years, the sugar factories have been designed for increased capacity and some of the earlier designs which were quite satisfactory in smaller capacity operations do not lend themselves to the larger capacity performance requirements.

The diffusion treatment utilizes a displacement effect in which a solution of lesser sugar concentration is brought into contact with cossettes having sugar cells containing sugar solution of somewhat higher concentration. Thus, in the countercurrent flow arrangement, the new cossette feed is introduced at one end of the diffusion apparatus and the solution, initially fresh water, is introduced at the opposite end to flow in countercurrent relation through the apparatus. Thus, solution of highest sugar concentration is being discharged from the end of the apparatus in which the new cossettes are introduced and such concentration is somewhat less than the concentration of the sugar solution within the sugar cells of the cossettes. These cells have a membrane encasing the interior and solution of higher concentration will penetrate the cell exterior and displace solution of still higher concentration therein. Thus, in the final contact of the enriched solution with the entering cossettes, additional extraction is obtained and at the opposite end of the operation where water is brought in contact with the spent cossettes, the displacement within the cell structure is so complete that little, if any, further extraction occurs, but the water application provides a wash to obtain final removal of sugar which may be present on the solids surfaces even if not confined within the cells.

It will be apparent that the sugar extraction must proceed on an orderly basis to attain proper efficiency and where the treatment is performed in a succession of stages, the treatment time in the respective stages must be substantially uniform and the amount of extraction also should be approximately uniform so as to provide a concentration differential in the solids material introduced in each separate stage of the treatment.

The practice of my invention includes several innovations in the arrangement of continuous diffusion apparatus. The treatment tank is a cylindrical drum-like structure having exterior portions seated on rollers and driven by exteriorly applied forces to rotate continuously during the treatment. The interior of the cylindrical structure is divided into a series or progression of treatment cells of novel structural arrangement and in spiral arrangement. The cossettes delivered into a given cell from a preceding cell are deposited into a hollow screening structure anad while so defined are moved through a zone of immersion in the treatment solution and then are directed to a discharge movement from a given cell into a succeeding cell. In the same cycle of revoluton, the solution, after concurrent contact with the cossettes in the immersion zone, is directed in a flow counter to the direction of cossette travel so that cossettes travel progressively from one end of the apparatus to the other and the juice flow also is progressive and counter to the direction of cossette travel. This direction of counter flows assures that the advancing pulp enters into juice of different concentration at each succeeding cell for brief concurrent movement therewith and thus the diffusion action is maintained at high efficiency throughout the entire course of treatment.

The tank of the present invention is operated at approximately a one-third fill and the partitioning means defining the cell arrangement include segmental portions defining passages through which liquid and solids can be introduced and discharged. Each cell has two such segments spaced throughout a portion of their length adjoining the periphery of the segment and this arrangement provides slightly less than 180° of surface which is imperforate so that it is only when the opening or gap between segments moves into the zone of submergence that liquid and associated cossettes can move through the gap to advance the cossettes from one cell to another. The screen shaping and arrangement distributes the cossettes in essentially loose condition within the interior of confining screen structure and the screen prevents any misdirected movement of the cossettes while permitting passage of the liquid to establish substantial liquid contact with all cossette surfaces during the retention interval in the submerging zone.

Accordingly, it is an object of my invention to provide a large capacity diffusion treatment for cossettes and sugar cane which provides a control of material circulation and retention time in each treatment stage so as to obtain an efficient sugar extraction at each stage and a complete or substantially complete extraction by the time the material has been moved through the succession of stages.

Another object of my invention is to provide a control of cossette movement into and out of contact with solution of the treatment so as to maintain a different concentration in the solution at each stage where pulp is introduced into solution.

A further object of my invention is to provide a large capacity diffusion apparatus which can be installed and operated at relatively low cost and which is capable of efficient continuous operation over protracted periods with a minimum of service and maintenance requirement.

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

The practice of my invention will be best understood by reference to the accompanying drawings illustrating an apparatus arrangement well suited to perform the treatment of the present invention. In the drawings, in the several views of which like parts bear similar reference numerals,

FIG. 1 is a side elevation of an embodiment of the apparatus of my invention showing feed and discharge arrangements and the support and drive arrangement for rotation of the cylindrical tank structure;

FIG. 2 is a section taken along the line **2—2**, FIG. 1, and drawn to an enlarged scale;

FIG. 3 is a fragmentary sectional view of the upper portion of one cell shown with the shell removed and extending to a point near the pulp level of the tank;

FIG. 4 is another fragmentary sectional view of one cell taken along the line **4—4** of FIG. 2;

FIG. 5 is a fragmentary vertical section through a tank of the type shown in FIG. 1 drawn to an enlarged scale and showing details of the structural arrangement for directing solution and solids components oppositely from one treatment stage to a next succeeding stage; and

FIG. 6 is a fragmentary section taken along the line **6—6**, FIG. 5.

As shown in FIG. 1, a cylindrical tank **11** is supported by external metallic tire members **12** seated on rollers **13** at intervals along its length and an external gear **14** is mounted on the shell **11**_a_ of the tank and is driven by a pinion **15** and associated motor **16**. The end **11**_c_ of the tank terminates in an enlarged screen member **17** within a stationary housing **18** and an inlet **19** directs the pulp feed into screen **17** while a conduit **20** delivers enriched solution or juice to a tank (not shown). Pulp discharges into a stationary hopper **22** at end **11**_d_ from a trunnion outlet **23** and a conduit **24** delivers water or other solution into and through outlet **23** for juice makeup within the tank. A pulp discharge screw **25** removes spent pulp from the hopper.

FIGS. 2, 3 and 4 show details of the cell arrangement within tank **11** with the juice level **26** shown at the same depth as in FIG. 1. The tank interior is divided throughout its length by suitable partitioning structure into a series of treatment cells **27** which are formed by division plates in spiral arrangement having a horizontal partitioning surface **31** dividing segmental portions **28**_a_ and **28**_b_ as shown in FIG. 2. The interior of cells **27** includes segmental screen members **29**_a_ and **29**_b_ and associated chutes **30**_a_ and **30**_b_. The segmental plate members **28**_a_ and **28**_b_ are spaced as shown in FIGS. 2 and 3 to provide gaps **32** through which screened juice passes from cell to cell.

As previously mentioned, the treatment performed in the apparatus shown in the drawings utilizes countercurrent flow in which solids, such as cossettes in liquid, constitute the pulp and are passed progressively from cell to cell from the pulp inlet end to the pulp discharge end of the tank. Fresh water is introduced through an inlet **24** at the pulp discharge end of the tank and washes the spent cossettes in the first pulping stage of its progressive movement through the tank. As the water takes up sugar to form an aqueous solution, the sugar displacement effect within the cell structure previously described takes effect at each stage and the retention time of the solution and contact of cossettes and solution is sufficient so that there is a substantial change in concentration by the time the solution is passed from a given cell to the succeeding cell in the series. Also in the progressive treatment, the sugar concentration in the cells of the cossettes changes at each treatment stage so that being brought into contact with solution of changed concentration results in efficient extraction because the solution concentration within the respective cells is changed at each stage of the treatment.

The arrangement for directing the flow of solids countercurrent to the solution travel provides a short interval in each treatment stage in which solids and solution move concurrently followed by directed movement of the solids to a succeeding treatment stage and a directed flow of separated solution to a succeeding stage in the opposite direction. FIGS. 5 and 6 illustrate the structure by which such flows are conducted. FIG. 5 is a view generally similar to FIG. 2, but drawn to an enlarged scale and positioned about 90° to FIG. 2.

As shown in FIG. 5, the segmental screen members are open at their forward ends and in each cycle of rotation such open end is moved progressively into, through and out of the pulp body, and until the forward end emerges from the solution, the entrained liquid and solids of the pulp travel concurrently as directed by the rotation of tank **11**. When the emergence progresses beyond liquid level **26**, the solution will drain and flow out of screen **29**_a_, for example, as shown in FIG. 3 and then penetrates the gap **32** to pass into a succeeding treatment stage. Cossettes or other solids confined by the screen surfaces remain in the chute **30**_a_ until elevated sufficiently to flow by gravity into the succeeding cell.

For convenience in reference, three cells are shown in FIG. 6 arranged in the successive order of the solids flow through tank **11**. Cell **27**_a_ is the first complete cell in the progression, cell **27**_b_ is next, and a fragment of cell **27**_c_ is shown for the succession. Cell **27**_c_ would be the first in sequence of solution flow, cell **27**_c_ next in succession and **27**_a_ would be last in this progression of solution flow.

The provision of the gravity screening separation providing resumption of the progressive solution flow countercurrent to the progressive solids movement and the rate of tank rotation determine the time interval in which solids and solution travel concurrently at each treatment stage. Once the solids and solution are separated at a given stage, they are barred physically from further mixing and the solids are advanced for introduction to new solution in the succeeding stage while the separated solution passes in an opposite direction for mixing with new solids at its next successive treatment stage.

While not shown in the drawings, a diffusion battery as shown and described may and preferably will have an associated temperature regulating system for the contents. Also, material input and discharge will be controlled and balanced preferably by automatic instrumentation. Since such devices and circuitry form no part of the present invention, they have not been illustrated and described.

I claim:

1. In diffusion apparatus, a horizontally disposed liquid-confining tank having a liquid inlet and a pulp discharge outlet at one end and a pulp inlet and a juice outlet at its opposite end maintaining approximately a one-third fill of pulp in said tank, partitioning means interiorly of the tank arranged to define a sequence of treatment cells lengthwise of the tank and defining two confining courses for separated pulp travel through the succession of cells, means for rotating said tank, inclusive of said cells and confining courses, one said course being disposed at 180° from the other course in the rotation of said cells, each cell having a flow-directing assembly inclusive of two adjoining segmental screening members with one located in each course, and a chute disposed beyond each screening member with the chute of one segmental portion facing in an opposite direction to the other chute whereby in each revolution pulp from a preceding cell is collected and advanced across the screening surface of its course of travel and passed into the next succeeding cell of said course of travel and juice from the next preceding cell flows concurrently with the pulp unitl it passes said screening surface and then is passed into the next succeeding cell in the course of juice flow so as to maintain a progressive counterflow of pulp and juice through the succession of cells, with introduction of advancing pulp into juice of

different concentration as it enters each successive cell along its course of travel.

2. Apparatus as defined in claim **1**, in which said screening members are at least partially submerged in the circulating pulp in each revolution.

3. Apparatus as defined in claim **1**, in which one chute member has an intake opening at approximately 180° to the intake opening of said other chute member.

4. Apparatus as defined in claim **1**, in which said flow-directing assembly during each revolution advances pulp in each course after draining directly from a given cell to the next succeeding cell in the series.

5. Apparatus as defined in claim **1**, in which the respective chute members direct pulp from a given cell to the next succeeding cell in the same direction at 180° rotational intervals.

6. In diffusion apparatus, a horizontally disposed liquid-confining tank having a liquid inlet and a pulp discharge outlet at one end and a pulp inlet and a juice outlet at its opposite end maintaining approximately a one-third fill of pulp in said tank, partitioning means interiorly of the tank including a pair of associated segmental division plates arranged to define a sequence of treatment cells lengthwise of the tank with a division plate wall in each cell having two openings formed therein so as to provide the segmental shaping and said partitioning means defining two confining courses for separated pulp travel through the succession of cells with a single course directed through only one said opening, means for rotating said tank, inclusive of said cells and confining courses, one said course being disposed at 180° from the other course in the rotation of said cells, each cell having a flow-directing assembly for collecting pulp from a preceding cell and advancing it along its course of travel and passing it into the next succeeding cell of said course of travel in each revolution, and a screening member in each segment closed on three sides and at one end and with its other end open for delivering collected pulp to a chute member whereby in each revolution pulp deposited into the screen is drained and then discharged onto a chute by which it is directed into the next succeeding cell while the juice passing said screen is directed by other surfaces of the screening member to pass counter to the pulp flow into the next succeeding cell in the direction of juice flow.

7. Diffusion apparatus as defined in claim **6**, in which the chute member has an opening at each end, one said opening being an intake opening movable by tank rotation to a completely submerged position in each cycle of revolution.

8. Diffusion apparatus as defined in claim **6**, in which said partitioning means, inclusive of said division plates, define two continuous helical passages comprising the confining courses extending between the pulp inlet and pulp discharge outlet.

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U.S. Cl. X.R.

23—269, 270; 127—5