

Dec. 4, 1945.

H. F. SILVER

2,390,131

CONTINUOUS DIFFUSION PROCESS

Filed Aug. 8, 1942

2 Sheets-Sheet 1

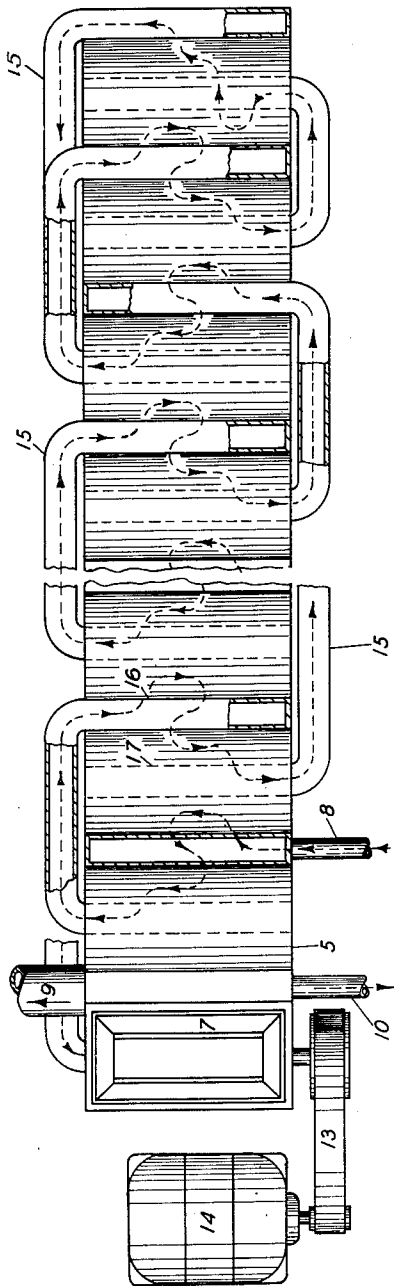


Fig. 1

LEGEND
SOLID FLOW = ———→
LIQUID FLOW = - - - - -→
LIQUID LEVEL = - - - - -

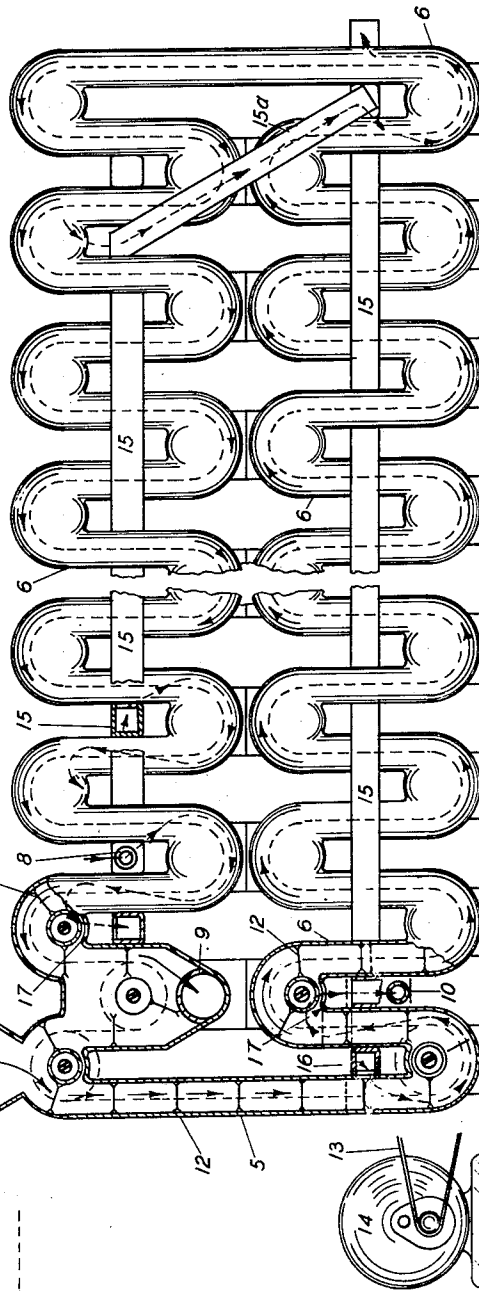


Fig. 2

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2 Sheets-Sheet 2

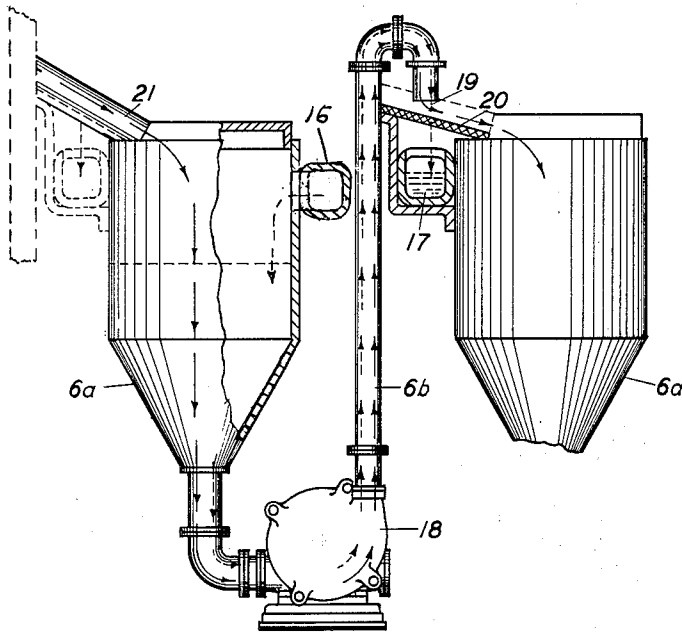


FIG. 3

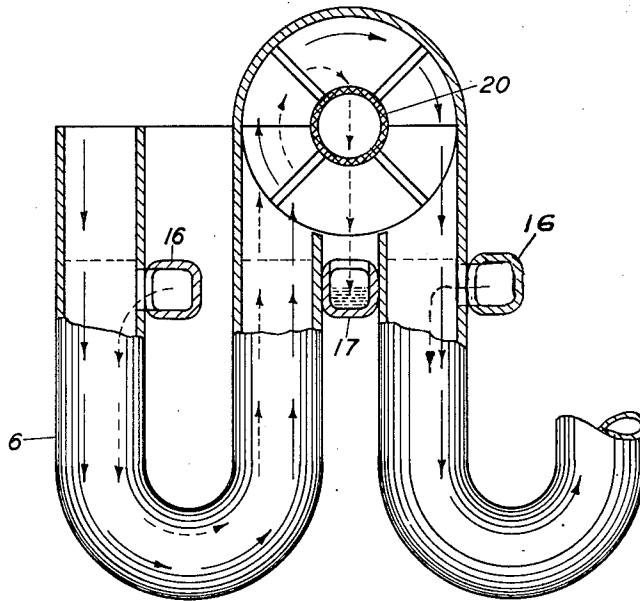


FIG. 4

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2,390,131

CONTINUOUS DIFFUSION PROCESS

Harold F. Silver, Denver, Colo.

Application August 8, 1942, Serial No. 454,098

16 Claims. (Cl. 127—45)

My invention relates to a continuous diffusion process and more particularly relates to a continuous diffusion process for use in the production of sugar from sugar beets.

While various methods have been developed in the sugar beet industry to permit the process of diffusion to be performed in continuous operation rather than by batch methods, such processes have not satisfied the requirements of the industry and therefore have not come into general use.

The batch method of treatment is subject to many objections. In particular, it requires a large amount of heavy manual labor with consequent high labor costs and is not very flexible in operation. However, it possesses an inherent reliability which accounts for its continued usage.

In general, the following requirements are specified by the industry for continuous diffusion:

1. Maximum cossette or slice area is required for high rate of diffusion.
2. The treatment should provide some means of maintaining cossette or slice area in relatively continuous contact with juice or solution.
3. The treatment should include a uniform cossette or slice fill in diffuser.
4. The treatment should include a proper density cossette fill and means to alter this density to suit beet conditions.
5. Mutilation of cossettes is undesirable.
6. Countercurrent flow of cossettes and juice is desired.
7. Means for increasing or decreasing rate of travel of cossettes and juice should be provided.
8. Means of varying and controlling temperatures in any part of diffuser is desirable.
9. Low draft is desired.
10. The treatment should provide for low heat consumption.
11. The treatment should insure high density and purity raw juice, commensurate with the beets handled.
12. The treatment should insure uniform and maximum exhaustion of cossettes or minimum sugar loss in pulp.
13. The operation should require low mechanical power.
14. Operating labor should not exceed one man per battery.

Other treatment standards may be prescribed in certain producing areas, but the foregoing specifications illustrate the complex problem involved in developing a continuous diffusion treatment acceptable to the industry.

The principal objections to the continuous dif-

fusion processes so far developed are high initial cost of installations, high maintenance cost and insufficient improvement in results over present batch methods to justify adoption for commercial purposes.

Most of these operations utilize countercurrent principles with the cossette or solid material moving in one direction and the liquid or juice travelling countercurrent thereto.

Certain technical difficulties attend such operations. As the solid material progresses in its movement it softens and attains a mushy consistency and this resists the countercurrent flow of juice. The cumulative effect of this resistance through a continuous body of cossettes has been the principal reason why countercurrent diffusion systems have not been successful.

Furthermore, unless a relatively complete extraction is attained at low operating cost, continuous diffusion has nothing to offer over batch methods. Further, it is necessary in any such treatment to prevent any appreciable oxidizing action or other pronounced chemical change from occurring during the continuance of the treatment.

It is an object of the present invention to provide a relatively high extraction in a continuous diffusion process by utilizing an independent travel of liquid and solid in countercurrent relation, with intermittent mingling of the liquid and solid content in a succession of stages in a cyclic movement, during a portion of which, at least, the liquid and solids travel concurrently.

Another object of the invention is to provide a continuous diffusion process in which a relatively large volume of cossettes may be treated in a zone of relatively small superficial area and in which operation relatively high extraction is attained in a relatively short treatment interval.

A further object of my invention is to provide a continuous diffusion treatment in which little or no oxidizing action or other deleterious chemical reaction occurs.

Still another object of the invention is to provide a continuous diffusion treatment permitting selective variation of the respective movements of liquid and solids in the treatment and a close control of liquid-solids contact intervals at one or more stages of the treatment.

A still further object of the invention is to provide a simple, economical and efficient method of continuous diffusion that is particularly adapted for use in beet sugar refining operations.

Other objects reside in novel steps and treat-

ments all of which will be disclosed fully in the course of the following description.

The present invention utilizes an enclosed treatment zone, preferably sealed from the atmosphere, in which cossettes are caused to move progressively through a succession of treatment stages while the liquid of the treatment, preferably at low draft is caused to move progressively in a course that is generally countercurrent but which permits a controlled concurrent movement of the juice with the cossettes at the successive treatment stages.

The rate of travel of the cossettes through this zone is controlled at all times and may be varied at will to satisfy treatment requirements. Similarly, the rate of flow of the juice in its countercurrent course is subject to regulation, and in this way the liquid-solids contact interval at each stage may be varied to suit the requirements of a given treatment.

Preferably such control involves the movement of cossettes at a faster rate than the flow of juice and as a result, in the concurrent movement, the juice tends to drag on the solids with which it is in contact and thereby accelerates extraction.

The treatments hereinbefore and hereinafter described may be performed in a variety of apparatus. However, several arrangements of apparatus suited for the performance of the process have been shown in the accompanying drawings, and typical treatment methods will be described now with particular reference to such drawings.

In the drawings, in the several views of which like parts have been designated similarly,

Figure 1 is a top plan view of a substantially diagrammatic representation of one form of apparatus in which the process of the present invention may be performed;

Figure 2 is a side elevation of the apparatus of Figure 1, partially broken away to disclose essential features of the internal arrangement of parts;

Figure 3 is a fragmentary vertical central section through a modified form of apparatus in which the process of the present invention may be performed; and

Figure 4 is a fragmentary vertical central section through another modified form of apparatus in which the process of the present invention may be performed.

Referring first to the form of structure illustrated in Figures 1 and 2, the continuous diffusion treatment as applied to sugar beet processing will be described as performed therein. The apparatus comprises a treatment battery designated generally by the reference numeral 5, which is formed by a series of cells 6, interconnected with adjoining cells to provide a continuous treatment zone.

As shown in Figure 2, these cells 6 are disposed in vertical position in two tiers to conserve floor space and permit utilization of gravity flow in the circulation of the liquid of the treatment. While this is a preferred arrangement, it will be understood that the process also may be performed in cells disposed horizontally with a positive or gravity circulation of liquid employed.

The battery 5 is provided with a single feed inlet for cossettes in the form of a hopper 7, and a single solution supply conduit 8 delivers water or other treatment liquid to the battery. The final pulp discharged is provided at 9 adjacent hopper 7 while the separated juice flows from the battery through a discharge conduit 10. The

battery is otherwise sealed from the atmosphere due to the interconnection of the several cells 6.

The battery contains means for the progressive movement of cossettes through the succession of cells between hopper 7 and discharge outlet 9 here shown as an endless conveyor 12. This conveyor is driven through the intermediary of suitable transmission members 13 by a variable speed motor 14.

The battery also contains means for circulating liquid or juice between inlet 8 and outlet 10 in a direction generally countercurrent to the movement of cossettes. As illustrated, the circulating means comprises a series of launders 15.

Each of the launders 15 has a discharge outlet 16 constituting a juice inlet into the inlet or down side of its associated cell 6 and has its intake at juice outlet 17 in the second preceding cell with respect to the direction of movement of cossettes by conveyor 12. Consecutive launders are located alternately on opposite sides of battery 5 as illustrated in Figure 1 and in this way each cell is provided with a juice inlet and outlet.

By discharging into the inlet side of the cell 6, the juice is caused to travel concurrently with the cossettes until it reaches the inlet of the next launder in the series located in an elevated position in the up side of the cell.

The liquid-solids mixture travelling through a given cell 6 forms a substantially integral fluent mass which under the impelling influence of conveyor 12 acts like a piston in a cylinder to elevate excess liquid to a higher level than its level in the down side of such cell. This difference in level has been indicated by the dotted lines in Figure 2.

The last launder 15 in the upper tier of cells extends downwardly as indicated at 15a in Figure 2 and terminates at the inlet side of the end cell 6 of the lower tier. From the foregoing, it will be understood that the cossettes after being fed into hopper 7 descend to the lower tier of cells 6 and move progressively through the succession of cells to the end of the tier where they are elevated and then return through the succession of cells in the upper tier until they reach the discharge outlet 9 through which they pass from the battery 5.

The liquid entering through inlet 8 flows through the succession of cells 6 in the upper tier in the manner stated until it reaches the end cell from which it flows down launder 15a and assumes a return course through the cells of the lower tier until it reaches the final cell from which it is discharged through outlet 10.

Having thus described the structural arrangement, the operating procedure will be detailed now. Upon entering hopper 7, the cossettes descend into the first cell 6 of the lower tier and there mix with sugar juice of relatively high density entering through inlet 16 from the last launder 15 in the series.

This liquid-solids mixture is caused to travel through such cell 6 until it is ready to pass into the next cell of the series, when separation between liquid and solids is effected by suitable means, usually a screen, here indicated as a juice outlet 17.

As the cossettes progress through the series of cells between hopper 7 and outlet 9 they are progressively depleted in sugar content while the liquid entering through inlet 8 progressively increases in sugar concentration as it proceeds toward outlet 10.

In the concurrent movement through each cell 6 between inlet 16 and outlet 17, the cossettes preferably are caused to move at a faster rate than the juice and this accelerated movement causes the juice to drag against the solids mass giving greater surface contact and hence better sugar extraction.

By the time the cossettes reach discharge outlet 9, they contain such a minor proportion of sugar content that further working would be unprofitable. Similarly, by the time the juice has progressed from inlet 8 to outlet 10 it has attained such a high sugar content that it is almost unsuited for additional extraction.

It will be apparent from the foregoing description that in each cell there is a substantial superficial area that is not completely filled with liquid and the normal tendency under such conditions would be to expose the cossette surfaces to air for a considerable portion of their travel through each cell.

It has long been known in the sugar refining art that prolonged exposure of cossette surfaces to air at the diffusion stage results in substantial chemical change and consequent damage due principally to oxidation factors. To offset such deleterious conditions in the present treatment, the succession of cells is sealed from the atmosphere except at the inlets and outlets hereinbefore described.

It will be appreciated that substantially no air will be admitted through the discharges 9 and 10 and excluding small amounts of air which may be present by entrainment, no air will be admitted through inlet 8, or in the respective launders 15 returning juice to the cells. This leaves only the hopper 7 and discharge outlet 9 as possible sources of air introduction and the amount which could enter therethrough in comparison with the total treatment area is small.

The gases and vapors generated or released in the diffusion action are caused to fill the voids throughout the various treatment zones and thus provide a gas cushion or blanket preventing any tendency towards intake of atmospheric air which otherwise might occur.

In this connection, it will be understood that evolved gases containing oxygen such as carbon dioxide are largely absorbed by the treatment fluid in the progressive movement, leaving inert gases as the principal sealing medium by which atmospheric air is kept out of the treatment. Consequently corrosion is substantially reduced.

Another advantage of the present treatment resides in the quantitative and velocity controls of the liquid and solid bodies. Through this arrangement the system can be operated efficiently in conformity with the low draft specifications of a given plant, and even under such conditions the combined countercurrent and concurrent flow arrangement insures an adequate contact interval at each stage to insure adequate extraction by the time the cossettes have passed through the succession of stages.

The other forms of the invention illustrated in the drawings are cited merely to show the variety of arrangements in which the present invention may be embodied. In Figure 3, the cells 6 are U-shaped with the intake portion 6a thereof terminating in a conical bottom portion, while the other upright portion 6b of each cell employs a suitable pump element 18 for the elevation of the liquid-solids intermixture to an elevated point of discharge 19, preferably within a feed trough 21.

In this form, the cells 6 are not interconnected by the same type of conductive passage as the cells of Figure 2. However, the feed chute or trough 21 has a liquid-solids separating means such as a screen element 20 placed beneath the point of discharge 19 to receive the cascading mixture and carry the solids and entrained liquid into the receiving portion 6a of the next cell 6, while the free liquid or juice passes through member 20 in the bottom of trough 21 and thence into outlet 17 to enter the next associated launder 15.

The arrangement of the series of cells is similar to that shown in Figures 1 and 2, with one tier of cells forming a continuous passage for cossettes between the hopper 7 and discharge 9. The launder arrangement also is similar and provides a single inlet 8 and a single outlet 10 for the juice.

The movement of material in a given cell is obvious. Due to the volumetric differential between portions 6a and 6b, a substantial head is provided at the top of portion 6a which urges the liquid-solids intermixture into the pump in portion 6b.

Thereafter, the mechanical action serves to elevate substantial portions of the intermixture to the point of discharge 19, whereupon the liquid-solids separation is attained, with cossettes and entrained liquid passing into the next cell 6 in the series.

The liquid so separated by the screen 20 discharges through outlet 17 after which it flows countercurrent to the direction of cossette travel until it is delivered through the inlet 16 of a succeeding cell.

The form of cell structure illustrated in Figure 4 typifies an essentially all-gravity operation in which the weight of cossette feed to a given cell combined with the weight of the added treatment juice provides sufficient head to lift the liquid-solids intermixture into the zone of action of a rotary screen element 20 or other separator, by which it is conducted into the next cell 6 after removal of a substantial portion of its liquid content.

With such an arrangement, it will be preferable to incline the battery slightly from its feed end to its discharge end, and only a single tier of cells will be employed.

In all the foregoing arrangements, the system of launders or conduits preferably are slightly declined along each tier of cells in a direction countercurrent to the direction of travel of the cossettes.

In the forms of Figures 3 and 4, selective control of the movement of cossettes and juice is not provided except as it may be attained by varying the quantity of cossettes and juice fed into the treatment zones. However, since this arrangement provides general countercurrent movement of juice and cossettes, with an interval of concurrent movement at each treatment stage, this form of the invention will be adequate for certain treatment conditions.

In all the various structural forms illustrated and described, heating will be performed in accordance with present practice, but as this part of the operation only involves conventional practice, illustration of the same appears unnecessary.

Likewise, no venting means has been illustrated in the drawings. In preferred practice, all cells will be vented through a common vent.

In preferred practice, the treatment zone will be of substantially uniform section at any position throughout the range of travel of the cos-

setes. Because of this, it is unnecessary to provide a greater mass of solids at one stage than is present at another, and the quantity of liquid or juice delivered into a given cell will be the same as that delivered into the other cells of the battery.

Due to the character of the material under treatment, the liquid-solids intermixture forms a substantially integral fluent mass possessing lubricant-like qualities which promote its movement through the treatment under the mechanical or gravity influences or both.

While the launder arrangement illustrated in Figures 1 and 2 includes the use of conduits of substantially square shape, it will be understood that when desired these launders or conduits may be pipes or other forms of tubular bodies for the flow of juice or other treatment liquid through the battery. Likewise, while it is desired to employ gravity movement of the juice or liquid after its introduction into the battery except for the impelling influences of the cossette travel during the intermittent mingling, it will be appreciated that by using a sealed launder system the liquid may be subject to pumping or other pressure influences for its positive movement through the treatment.

From the foregoing description, it will be apparent that the present invention attains the objects hereinbefore specified for continuous diffusion and more particularly satisfies the standards prescribed by the beet sugar industry. Furthermore, while a number of variations have been cited for performing the process of the present invention, it will be understood that these variations are intended as typical examples rather than as limiting the scope of the invention, and changes and modifications may be availed of within the spirit and scope of the invention as defined in the hereunto appended claims.

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

1. A diffusion process, which comprises the movement of cossettes or the like through a confined treatment zone having a succession of treatment stages, each said stage including alternate downward and upward courses of cossette travel, feeding cossettes into one end of said confined zone, flowing juice in a progressive movement through the succession of treatment stages in a separate course generally countercurrent to the cossette travel, moving said juice into the respective treatment stages at a point intermediate the ends of the downward course, directing the juice so intermixed with cossettes through a substantial extent of said treatment stage concurrent with the travel of the cossettes, withdrawing said juice from the succeeding upward course at a point near the top thereof to permit draining of the cossettes before they are again brought in contact with the juice at the intermediate position in the downward course of the next treatment stage, and discharging the juice and cossettes separately from the treatment.

2. A diffusion process, which comprises the movement of cossettes or the like through a confined treatment zone having a succession of treatment stages, each said stage including alternate downward and upward courses of cossette travel, feeding cossettes into one end of said confined zone, flowing juice in a progressive movement through the succession of treatment stages in a separate course generally countercurrent to the cossette travel, moving said juice into the respective treatment stages at a point intermediate the

ends of the downward course, directing the juice so intermixed with cossettes through a substantial extent of said treatment stage under the impelling action of the cossettes, withdrawing said juice from the succeeding upward course at a point near the top thereof to permit draining of the cossettes before they are again brought in contact with the juice at the intermediate position in the downward course of the next treatment stage, and discharging the juice and cossettes separately from the treatment.

3. A diffusion process, which comprises the movement of cossettes or the like at a substantially uniform rate throughout the entire extent of a confined treatment zone having a succession of treatment stages, each said stage including alternate downward and upward courses of cossette travel, feeding cossettes into one end of said confined zone, flowing juice in a progressive movement through the succession of treatment stages in a separate course generally countercurrent to the cossette travel, moving said juice into the respective treatment stages at a point intermediate the ends of the downward course, directing the juice so intermixed with cossettes through a substantial extent of said treatment stage concurrent with the travel of the cossettes, withdrawing said juice from the succeeding upward course at a point near the top thereof to permit draining of the cossettes before they are again brought in contact with the juice at the intermediate position in the downward course of the next treatment stage, and discharging the juice and cossettes separately from the treatment.

4. A diffusion process, which comprises the movement of cossettes or the like through a confined treatment zone having a succession of treatment stages at uniform intervals, each said stage including alternate downward and upward courses of cossette travel, feeding cossettes into one end of said confined zone, flowing juice in a progressive movement through the succession of treatment stages in a separate course generally countercurrent to the cossette travel, moving said juice into the respective treatment stages at a point intermediate the ends of the downward course, directing the juice so intermixed with cossettes through a substantial extent of said treatment stage concurrent with the travel of the cossettes, withdrawing said juice from the succeeding upward course at a point near the top thereof to permit draining of the cossettes before they are again brought in contact with the juice at the intermediate position in the downward course of the next treatment stage, and discharging the juice and cossettes separately from the treatment.

5. A diffusion process, which comprises the movement of cossettes or the like through a confined treatment zone sealed from the atmosphere and having a succession of treatment stages, each said stage including alternate downward and upward courses of cossette travel, feeding cossettes into one end of said confined zone, flowing juice in a progressive movement through the succession of treatment stages in a separate course generally countercurrent to the cossette travel, moving said juice into the respective treatment stages at a point intermediate the ends of the downward course, directing the juice so intermixed with cossettes through a substantial extent of said treatment stage concurrent with the travel of the cossettes, withdrawing said juice from the succeeding upward course at a point near the top thereof to permit draining of the cossettes before they are again brought in contact with the juice

at the intermediate position in the downward course of the next treatment stage, and discharging the juice and cossettes separately from the treatment.

6. A diffusion process, which comprises the movement of cossettes or the like through a confined treatment zone having a succession of treatment stages, each said stage including alternate downward and upward courses of cossette travel, feeding cossettes into one end of said confined zone, flowing juice in a progressive movement through the succession of treatment stages in a separate course generally countercurrent to the cossette travel, moving said juice into the respective treatment stages at a point intermediate the ends of the downward course, directing the juice so intermixed with cossettes through a substantial extent of said treatment stage concurrent with the travel of the cossettes but at a different rate, withdrawing said juice from the succeeding upward course at a point near the top thereof to permit draining of the cossettes before they are again brought in contact with the juice at the intermediate position in the downward course of the next treatment stage, and discharging the juice and cossettes separately from the treatment.

7. A diffusion process, which comprises the movement of cossettes or the like through a confined treatment zone having a succession of treatment stages, each said stage including alternate downward and upward courses of cossette travel, feeding cossettes into one end of said confined zone, flowing juice in a progressive movement through the succession of treatment stages in a separate course generally countercurrent to the cossette travel, moving said juice into the respective treatment stages at a point intermediate the ends of the downward course, directing the juice so intermixed with cossettes through a substantial extent of said treatment stage concurrent with the travel of the cossettes but at a slower rate, withdrawing said juice from the succeeding upward course at a point near the top thereof to permit draining of the cossettes before they are again brought in contact with the juice at the intermediate position in the downward course of the next treatment stage, and discharging the juice and cossettes separately from the treatment.

8. A diffusion process, which comprises the movement of cossettes or the like in a cycle of operation through a confined treatment zone having a succession of treatment stages, each said stage including alternate downward and upward courses of cossette travel, feeding cossettes into one end of said confined zone, flowing juice in a progressive movement through the succession of treatment stages in a separate course generally countercurrent to the cossette travel, moving said juice into the respective treatment stages at a point intermediate the ends of the downward course, directing the juice so intermixed with cossettes through a substantial extent of said treatment stage concurrent with the travel of the cossettes, withdrawing said juice from the succeeding upward course at a point near the top thereof to permit draining of the cossettes before they are again brought in contact with the juice at the intermediate position in the downward course of the next treatment stage, varying the rate of cossette travel during different cycles of the process, and discharging the juice and cossettes separately from the treatment.

9. A diffusion process, which comprises the movement of cossettes or the like through a confined treatment zone sealed from the atmosphere

and having a succession of treatment stages, each said stage including alternate downward and upward courses of cossette travel, feeding cossettes into one end of said confined zone, flowing juice in a progressive movement through the succession of treatment stages in a separate course generally countercurrent to the cossette travel, moving said juice into the respective treatment stages at a point intermediate the ends of the downward course, directing the juice so intermixed with cossettes through a substantial extent of said treatment stage concurrent with the travel of the cossettes, withdrawing said juice from the succeeding upward course at a point near the top thereof to permit draining of the cossettes before they are again brought in contact with the juice at the intermediate position in the downward course of the next treatment stage, directing inert gases evolved in the operation into the portion of said upward course above the point of liquid withdrawal to prevent oxidation of cossette surfaces during their passage through said portion, and discharging the juice and cossettes separately from the treatment.

10. A diffusion process, which comprises the movement of cossettes or the like through a confined treatment zone having a succession of treatment stages, each said stage including alternate downward and upward courses of cossette travel, feeding cossettes into one end of said confined zone, flowing juice in a progressive movement through the succession of treatment stages in a separate course generally countercurrent to the cossette travel, moving said juice into the respective treatment stages at a point intermediate the ends of the downward course, directing the juice so intermixed with cossettes through a substantial extent of said treatment stage concurrent with the travel of the cossettes, dissolving evolved carbon dioxide gases in the juice during said concurrent flow, withdrawing said juice from the succeeding upward course at a point near the top thereof to permit draining of the cossettes before they are again brought in contact with the juice at the intermediate position in the downward course of the next treatment stage, and discharging the juice and cossettes separately from the treatment.

11. A diffusion process, which comprises the movement of cossettes or the like through a confined treatment zone having a succession of treatment stages, each said stage including alternate downward and upward courses of cossette travel, feeding cossettes into one end of said confined zone, flowing juice in a progressive movement through the succession of treatment stages in a separate course generally countercurrent to the cossette travel, moving said juice into the respective treatment stages at a point intermediate the ends of the downward course, directing the juice so intermixed with cossettes through a substantial extent of said treatment stage concurrent with the travel of the cossettes, withdrawing said juice from the succeeding upward course at a point near the top thereof to permit draining of the cossettes before they are again brought in contact with the juice at the intermediate position in the downward course of the next treatment stage, and separately discharging the cossette and juice at the ends of said countercurrent courses.

12. A process of treating divided solids material with a liquid, which comprises moving such divided material through a confined treatment zone having a succession of treatment stages,

each said stage including alternate downward and upward courses of material travel; feeding said divided material into one end of said confined zone; flowing said liquid in a progressive movement through the succession of treatment stages in a separate course generally counter-current to the material travel; moving said liquid by gravity into the respective treatment stages at a point intermediate the ends of the downward course; directing the liquid so intermixed with divided material through a substantial extent of said treatment stage concurrent with the travel of the material; withdrawing liquid from the succeeding upward course at a point near the top thereof to reduce the amount of liquid associated with the material before the material is again brought in contact with liquid in the downward course of the next treatment stage; and discharging the divided material and liquid separately from the treatment.

13. A process of treating divided solids material with a liquid, which comprises moving such divided material through a confined treatment zone having a succession of treatment stages, each said stage including alternate downward and upward courses of material travel; feeding said divided material into one end of said confined zone; flowing said liquid in a progressive movement through the succession of treatment stages in a separate course generally countercurrent to the material travel; moving said liquid into the respective treatment stages at a point intermediate the ends of the downward course; directing the liquid so intermixed with divided material through a substantial extent of said treatment stage concurrent with the travel of the material; withdrawing liquid from the succeeding upward course at a point near the top thereof to reduce the amount of liquid associated with the material before the material is again brought in contact with liquid in the downward course of the next treatment stage, said liquid being withdrawn from the upward course of each stage at a different level than liquid is introduced into said stage on the downward course; and discharging the divided material and liquid separately from the treatment.

14. A process of treating divided solids material with a liquid, which comprises moving such divided material through a confined treatment zone having a succession of treatment stages, each said stage including alternate downward and upward courses of material travel; feeding divided material into one end of said confined zone; flowing said liquid in a progressive movement through the succession of treatment stages in a separate course generally countercurrent to the material travel; moving said liquid by gravity into the respective treatment stages at a point intermediate the ends of the downward course; directing the liquid so intermixed with divided material through a substantial extent of said treatment stage concurrent with the travel of the material; withdrawing liquid from the succeeding upward course at a point near the top thereof to reduce the amount of liquid associated with the material before the material is again brought in contact with liquid at the intermediate position in the downward course of the next treatment stage, said liquid being withdrawn from the upward

course of each stage at a higher level than liquid is introduced into said stage on the downward course, the movement of material through said stage maintaining a higher level of liquid in said upward course; and discharging the divided material and liquid separately from the treatment.

15. A process of treating divided solids material with a liquid, which comprises moving such divided material through a confined treatment zone having a succession of treatment stages disposed in upper and lower tiers, each said stage including alternate downward and upward courses of material travel; feeding divided material into one end of said lower tier of treatment stages; moving said material along the lower tier of stages away from the entrance end, then upwardly to the upper tier of stages, and then through the upper tier of stages in the opposite direction; flowing said liquid in a progressive movement through the succession of treatment stages in a separate course generally countercurrent to the material travel; introducing said liquid into one end of the upper tier of stages and passing said liquid downwardly by gravity from the upper to the lower tier of stages at the opposite end of said tiers; moving said liquid into the respective treatment stages at a point intermediate the ends of the downward course; directing the liquid so intermixed with divided material through a substantial extent of said treatment stage concurrent with the travel of the material; withdrawing liquid from the succeeding upward course at a point near the top thereof to reduce the amount of liquid associated with the material before the material is again brought in contact with liquid at the intermediate position in the downward course of the next treatment stage; discharging said divided material from the end of the upper tier of stages at which said liquid is introduced; and discharging said liquid at the end of said lower tier of stages at which said divided material is introduced.

16. A process of treating divided solids material with a liquid, which comprises moving such divided material through a confined treatment zone having a succession of treatment stages, each said stage including alternate downward and upward courses of material travel; feeding divided material into one end of said confined zone; flowing said liquid in a progressive movement through the succession of treatment stages in a separate course generally countercurrent to the material travel; moving said liquid into the respective treatment stages at a point intermediate the ends of the downward course; moving the liquid so intermixed with divided material through a substantial extent of said treatment stage concurrent with the travel of the material by an impelling force applied to said intermixture adjacent the lower end of said downward course; withdrawing liquid from the succeeding upward course at a point near the top thereof to reduce the amount of liquid associated with the material before the material is again brought in contact with liquid at the intermediate position in the downward course of the next treatment stage; and discharging the divided material and liquid separately from the treatment.

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