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2,257,531

EVAPORATING APPARATUS AND METHOD

Filed Aug. 8, 1938

2 Sheets-Sheet 1

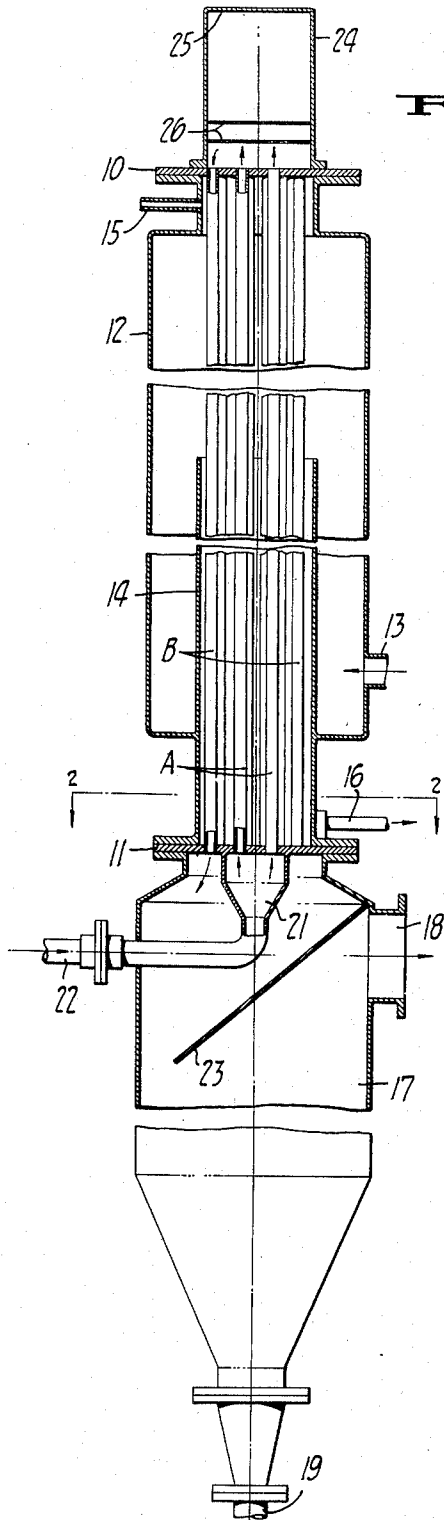


FIG. 1

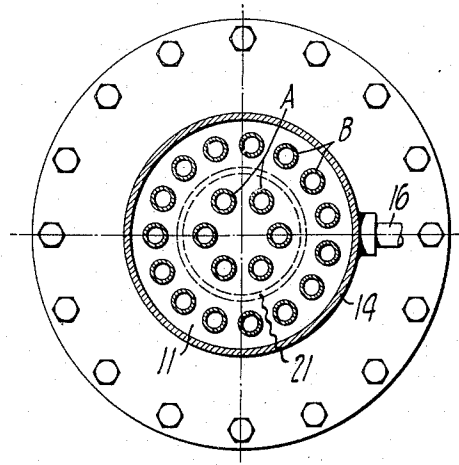
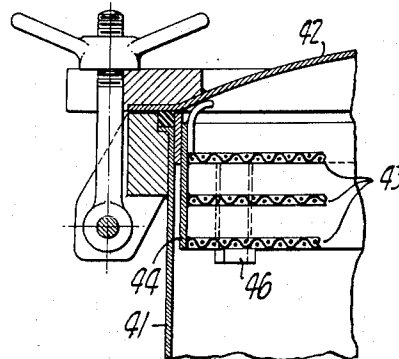


FIG. 2

FIG. 4



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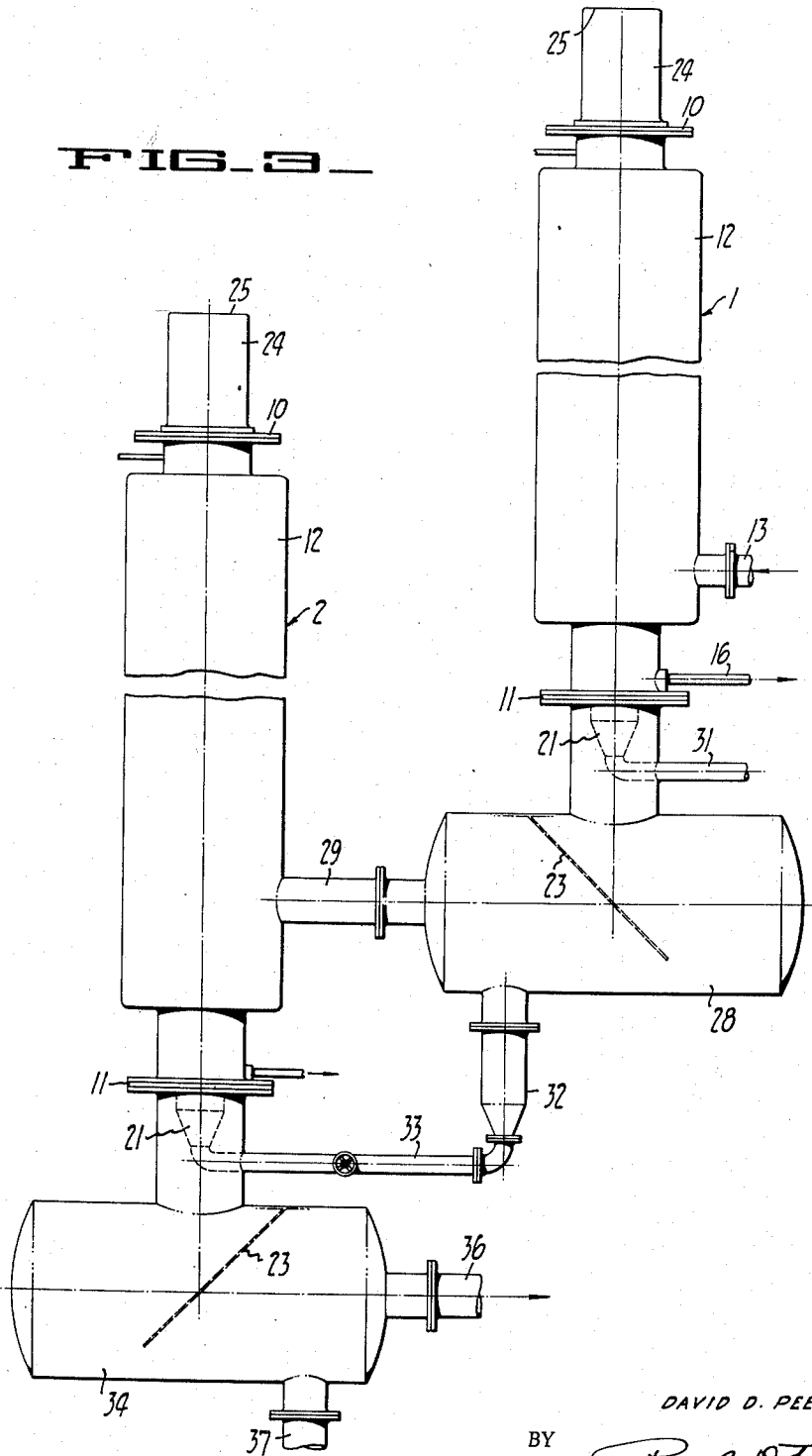
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FIG. 3



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## UNITED STATES PATENT OFFICE

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## EVAPORATING APPARATUS AND METHOD

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9 Claims. (Cl. 159—27)

This invention relates generally to apparatus and methods for the concentration of various liquid materials containing one or more vaporizable components.

In Peebles and Manning Patent No. 2,090,985, there is disclosed an evaporating apparatus and method of the vapor-mist type. The evaporating tubes in that instance are arranged so that their upper ends receive the material to be evaporated, and the evaporating cycle is such that evolved vapor together with dispersed liquid particles flow at high velocities through the evaporating tubes. Such an evaporator is particularly suited to the handling of organic materials sensitive to heat treatment, because it makes possible rapid concentration by evaporation, with a minimum volume of the material within the evaporating cycle at any one time, and with a minimum time period of heat treatment.

I have found that when certain organic pulps containing suspended solids of a fibrous nature, like tomato juice, are to be reduced to paste-like concentrates, the evaporator as specifically disclosed in said Patent No. 2,090,985, may not be entirely satisfactory, particularly for the higher concentrations. This is attributed to the viscosity of such materials, particularly when concentrated, which makes it difficult to distribute the material into the various evaporating tubes, and which tends to cause the material to plaster upon certain walls of the apparatus instead of continuing to progress through the evaporating cycle.

It is an object of the present invention to provide an improved evaporating apparatus and method, which can be successfully employed for the concentration of materials like tomato pulps, and which will afford relatively high efficiency, and high capacity, with a minimum amount of impairment of heat sensitive properties, and with equipment of simple construction. While the apparatus and method has been devised in connection with the evaporation of materials like tomato pulp, it can be used successfully upon a wide variety of materials including substances such as "black liquor."

Further objects of the invention will appear from the following description in which the preferred embodiments of the invention have been set forth in detail in conjunction with the accompanying drawings.

Referring to the drawings:

Fig. 1 is a side elevational view, in cross-section,

illustrating evaporating apparatus incorporating the present invention.

Fig. 2 is a cross-sectional detail, on an enlarged scale, taken along the line 2—2 of Fig. 1.

Fig. 3 is a side elevational view, showing a multiple effect evaporating apparatus, making use of two units of the type shown in Fig. 1.

Fig. 4 is a cross-sectional detail showing a suitable construction for the distributing or plenum chamber.

Referring first to that embodiment illustrated in Figs. 1 and 2, it consists of two groups of upright evaporating tubes A and B. The upper ends of these tubes are attached to tube sheet 10, and the lower ends to the tube sheet 11. Surrounding the evaporating tubes A and B, there is a heater jacket 12, into which steam can be introduced through the pipe connection 13. Pipe 15 serves to remove non-condensable gases from the upper portion of the jacket.

Extending upwardly within the steam jacket 12, there is a conduit or shroud 14 which surrounds the two groups of evaporating tubes. Steam introduced through pipe 13 flows upwardly within the conduit 14 and the outer walls of the jacket 12, before contacting the evaporating tubes, after which the steam flows downwardly about the evaporating tubes to a point near the lower end of these tubes, where condensate is drained away through pipe 16. Below the tube sheet 11 there is a separating chamber 17, which serves to receive material discharged from the lower end of the evaporating tubes B. Pipe 18 is a vapor outlet from chamber 17, and a pipe 19 at the lower end of chamber 17, is for the purpose of draining away concentrate. Chamber 21 is suitably secured to the lower side of tube sheet 11 and communicates with the inner group of evaporating tubes A. The liquid to be concentrated is introduced into chamber 21, through pipe 22. A baffle wall 23 extends within the chamber 17, and facilitates separation of liquor from vapor.

Above the tube sheet 10 and communicating with the upper ends of all of the evaporating tubes, there is a chamber 24, which can be termed a plenum chamber. The purpose of this chamber is to transfer and distribute material discharged from the upflow evaporating tubes A, to the downflow tubes B. This chamber 24 is of substantial height whereby the top wall 25 is considerably elevated above the upper ends of the evaporating tubes. The purpose of this proportioning is to prevent plastering of the upper wall 25 with material discharged from tubes A,

since it has been found that such plastering, if it is permitted to occur, prevents proper operation of the evaporator, particularly in that it makes for uneven distribution of the liquid material into the downflow tubes B, and because the accumulation of such material upon the walls of chamber 24 serves in effect to unduly prolong heat treatment on a part of the material.

In addition to providing a chamber 24 of substantial height, it is desirable to make use of one or more spaced diffusion screens 26. These diffusion screens extend across the lower portion of the chamber 24, and are in the path of material discharged from the upper ends of the tubes A. They can be of relatively coarse mesh wire, such as a screen of  $\frac{1}{4}$  inch mesh. These screens act in effect as a break to check discharged material, and in addition they insure uniform distribution of droplets of liquid to the downflow tubes B.

The equipment described above can be operated as a single unit at atmospheric pressures, or under vacuum. Assuming atmospheric pressure, pipe 13 is connected to a suitable source of steam, and pipe connection 18 is permitted to discharge vapor at atmospheric pressure. The concentrate pipe 19 is connected to some suitable means for removing the concentrate, as for example a suitable form of pump which will remove the liquid material substantially as fast as collected in chamber 17. The material to be concentrated, such as tomato pulp, is preheated and then supplied to pipe 22 by a suitable pump. When operating under vacuum the temperature to which the liquid material is supplied to chamber 21 can be such that at the pressure existing in chamber 21, there is some immediate expansion, with evolution of vapor, although such operation is not essential. As the liquid material, together with any vapor evolved in chamber 21, passes into the lower ends of pipes A, evolution of vapor occurs due to heat absorption through the walls of the evaporating tubes, and as a result vapor together with dispersed liquid material flows upwardly at high velocities through tubes A, to be discharged into the lower part of chamber 24.

Within the chamber 24 the material jetted or blown from the upper ends of tubes A is checked by screens 26, so that there is no plastering of the top wall 25, or of the adjacent side walls of the chamber 24. In fact the liquid material discharged from tubes A remains in more or less dispersed state, or in the form of droplets, and immediately after discharge into chamber 24, both the vapor and liquid components are delivered downwardly into the tubes B. If any material is caught upon the side walls above the screens it is immediately picked up by the vapor and re-distributed into the down flow tubes. Within tubes B the liquid material is again subjected to evaporation to be finally discharged as a concentrate into the separator 17.

The size of the evaporating equipment described above can vary in accordance with the capacities required, and the type of material to be concentrated. In the evaporation of tomato pulp I have employed evaporating tubes about  $1\frac{1}{4}$  inch inside diameter, and about 20 feet in length. For such an evaporator the chamber 24 can vary in height from say 12 to 24 inches. For any particular material to be handled one should make the chamber 24 sufficiently high to avoid plastering the top wall 25 with the liquid material.

It will be noted from Fig. 2 that a large number of downflow tubes B are employed, in proportion to the number of upflow tubes A. While the precise ratio employed can vary in practice, it is desirable that the cross sectional flow area for the downflow tubes B be at least twice that afforded by the upflow tubes, because of the large amount of evolved vapor which must pass downwardly through the tubes B.

In the multiple effect evaporator of Fig. 3, separate units similar to the equipment described with reference to Fig. 1, are connected together to form a double effect vacuum evaporator. Thus the downflow tubes B of the unit 1 discharge into a separator 28, similar to the separator 17 of Fig. 1. Vapor or steam from a suitable source is supplied to the jacket of unit 1, through pipe 13, while the jacket of unit 2 is supplied with vapor through the pipe connection 29, from separator 28. The liquid material to be concentrated is supplied to the unit 1 through pipe 31, and the liquid material collected in separator 28 is drained into the outlet 32, and delivered by pipe 33 to the pipes A of unit 2. The separator 34 which receives concentrate from unit 2, has a vapor pipe connection 36 leading to a suitable condenser, while the liquid connection 37 can be connected to a suitable pump, for removing the liquid concentrate.

The multiple effect evaporator of Fig. 3 operates substantially the same as the single effect evaporator of Figs. 1 and 2. The vacuum to be maintained upon the two units is dependent upon the vacuum applied to the connection 36, and is somewhat dependent upon the type of material being treated. The chamber 24 for the two units 1 and 2 may vary somewhat in dimensions, but in any event they are dimensioned in such a manner as to prevent plastering of the top wall 25.

In order to facilitate cleaning the top chamber 24 structural details can be employed as shown in Fig. 4. In this instance the chamber is formed by a cylindrical shell 41 having a removable cover 42. The wire screens 43 are secured to a ring 44, whereby the screen assembly can be readily removed after removing the cover 42. Ring 44 may rest upon lugs 46 which may be positioned at a desired elevation.

I claim:

1. In evaporating apparatus, two sets of generally upright evaporating tubes, means for introducing liquid material to be evaporated into the lower end of one set of tubes, means for receiving evaporated material and evolved vapor from the lower end of the second set of tubes, and a chamber serving to transfer evolved vapor and dispersed liquid from the upper end of the first set of tubes to the upper end of the second set of tubes, and a diffusion screen through which vapor and liquid is caused to pass within said chamber, said screen being disposed above the upper open ends of both said sets of tubes.

2. In evaporating apparatus, two sets of generally upright evaporating tubes, a common heating jacket for said tubes, a chamber communicating with the upper end of all of said tubes, means for introducing liquid material to be evaporated into the lower end of the first set of tubes, whereby evolved vapor and dispersed liquid flowing upwardly through the first set of tubes is discharged into said chamber and whereby all of the liquid and evolved vapor discharged into said chamber is immediately thereafter caused to enter the upper ends of the second set

of tubes, and a diffusion screen extending across said chamber above the upper ends of said tubes, said screen serving to check the discharge of material from the upper ends of the first set of tubes, and aiding the distribution of vapor and liquid into the second set of tubes.

3. In evaporating apparatus, two sets of generally upright evaporating tubes, a common heating jacket for said tubes, a chamber communicating with the upper end of all of said tubes, means for introducing liquid material to be evaporated into the lower end of the first set of tubes, whereby evolved vapor and dispersed liquid flowing upwardly through the first set of tubes is discharged into said chamber and whereby all of the liquid and evolved vapor discharged into said chamber is immediately thereafter caused to enter the upper ends of the second set of tubes, and a diffusion screen extending across said chamber above the upper ends of said tubes, said screen serving to check the discharge of material from the upper ends of the first set of tubes, and aiding the distribution of vapor and liquid into the second set of tubes, the second set of tubes in comparison with the first set having at least substantially twice the effective cross-sectional flow area.

4. In an evaporating method for the concentration of pulp-like liquid materials containing suspended solids, wherein the material to be evaporated is passed at high velocities through two sets of upright heated evaporating tubes, with one set of tubes having its upper end connected to a plenum chamber which also connects with the upper ends of the second set of tubes and with the top wall of the plenum chamber overlying the upper ends of both sets of tubes; the improvement comprising causing liquid material interspersed with evolved vapor to pass rapidly upwardly through the one set of evaporating tubes whereby a mixture of vapor and liquid material jets from the upper end of the first set of tubes, causing the liquid material in the jetting mixture to lose its upward velocity before contact of the same with the top wall of the chamber, and then immediately transferring a mixture of evolved vapor and liquid material from the chamber into the upper end of the second set of tubes.

5. In an evaporating method for the concentration of liquid materials to form paste-like concentrates wherein the liquid material to be evaporated is passed at high velocities through two sets of upright heated evaporating tubes, with the one set of tubes having its upper end connected to a plenum chamber which also connects with the upper end of the second set of tubes and with the top wall of the plenum chamber extending over the upper ends of both sets of tubes; the improvement comprising causing liquid material interspersed with evolved vapor to pass rapidly upwardly through the one set of evaporating tubes and to jet from the upper end

of the tubes, checking and diffusing the jetting mixture thereby preventing liquid material of the same from being propelled into contact with the top wall of the chamber, and then causing evolved vapor together with particles of the liquid material diffused through the same to pass downwardly through the second set of tubes.

6. In evaporating apparatus, two sets of generally upright evaporating tubes, means for introducing liquid material to be evaporated into the lower end of one set of tubes, means for receiving evaporated material and evolved vapor from the lower end of the second set of tubes, a chamber serving to transfer evolved vapor and dispersed liquid from the upper end of the first set of tubes to the upper end of the second set of tubes, and means in said chamber disposed above the upper open end of the first set of tubes for diffusing and checking the flow of material discharging therefrom.

7. In evaporating apparatus, two sets of generally upright evaporating tubes, means for introducing liquid material to be evaporated into the lower end of one set of tubes, means for receiving evaporated material and evolved vapor from the other end of the second set of tubes, a chamber serving to transfer evolved vapor and dispersed liquid from the upper end of the first set of tubes to the upper end of the second set of tubes, and means within the chamber disposed above the upper open ends of both sets of tubes for diffusing liquid material being transferred through said chamber and for checking material discharged from the upper end of the first set of tubes.

8. In evaporating apparatus, two sets of generally upright evaporating tubes, means for introducing liquid material to be evaporated into the lower end of one set of tubes, means for receiving evaporated material and evolved vapor from the lower end of the second set of tubes, a chamber serving to transfer evolved vapor and dispersed liquid from the upper end of the first set of tubes to the upper end of the second set of tubes, and a diffusion screen through which vapor and liquid is caused to pass within said chamber, said screen being disposed above the upper open end of said first set of tubes.

9. In evaporating apparatus, two sets of generally upright evaporating tubes, means for introducing liquid material to be evaporated into the lower end of one set of tubes, means for receiving evaporated material and evolved vapor from the lower end of the second set of tubes, a chamber serving to transfer evolved vapor and dispersed liquid from the upper end of the first set of tubes to the upper end of the second set of tubes, and a diffusion screen through which vapor and liquid is caused to pass within said chamber, said screen being disposed above the upper open end of said second set of tubes.

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