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MULTIPLE-EFFECT VERTICAL-TUBE EVAPORATOR

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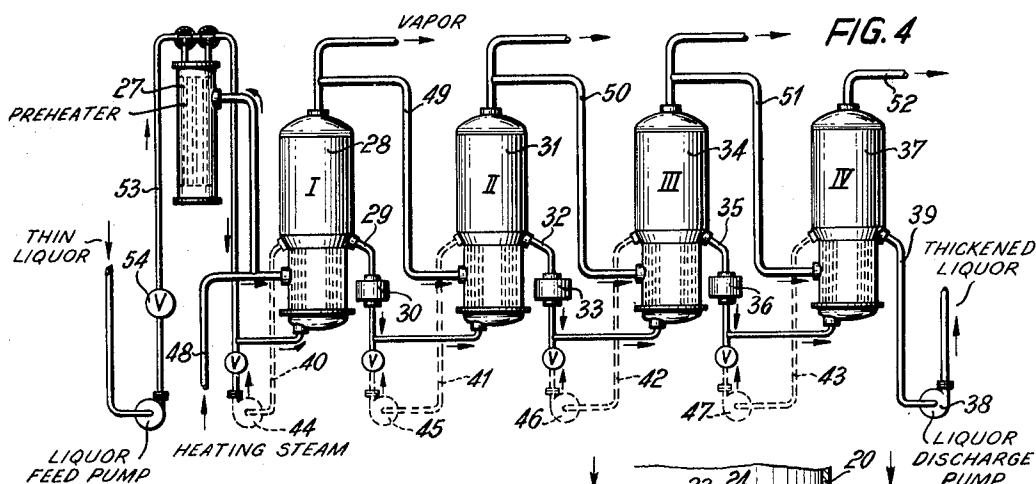


FIG. 1

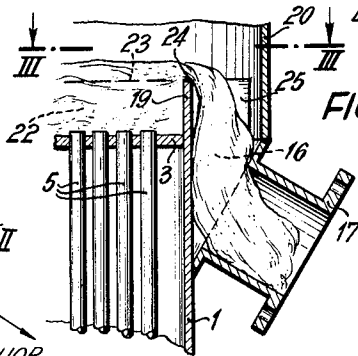
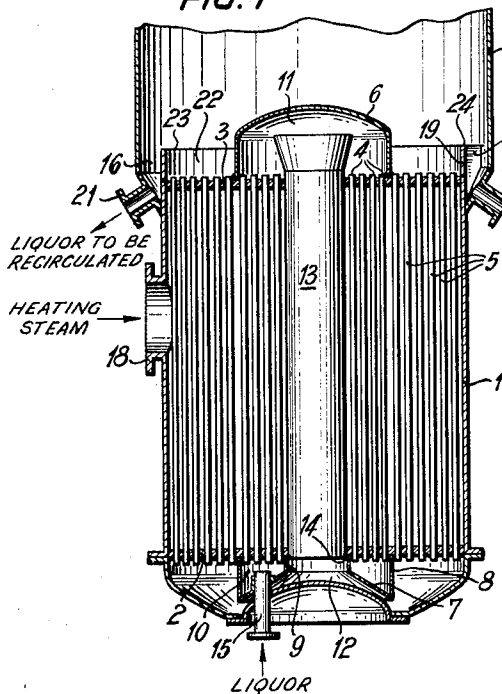
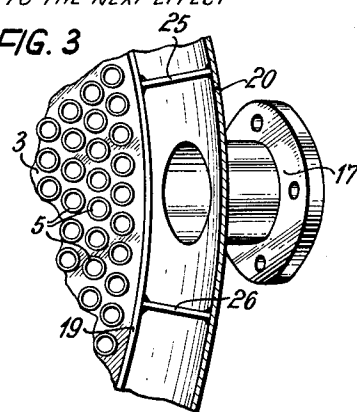


FIG. 3



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MULTIPLE-EFFECT VERTICAL-TUBE EVAPORATOR

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The present invention relates to evaporators which receive thin liquors and evaporate them so as to provide more concentrated thick liquors.

In particular the present invention relates to multiple-effect evaporators of the vertical-tube type.

As is well known, see U.S. Patent Number 2,800,955, such multiple-effect evaporators are used to thicken relatively thin liquors, such as sugar solutions, for example, which are delivered to the first of the plurality of effects and which pass from one effect to the next in which the liquor is heated so as to drive vapor therefrom. The vapors which are evolved from the heated liquor in one effect are delivered to the next following effect to heat the liquor in the latter. In the individual effects there are different temperatures and pressures of the vapors, and in each individual effect it is not possible to maintain the vapor at a constant temperature and pressure because of variations in the extent to which liquor is withdrawn from each effect. Moreover, these variations in the rate of withdrawal of liquor from each effect provide different periods of time during which the thickening takes place so that it is required to regulate the rate of passage of the liquor through the evaporator within certain limits. Moreover, it is necessary to maintain the level of the liquor in each effect substantially constant. The liquor level which is referred to here is the effective liquid level above the top wall of the heater which is to say within the lower portion of the vapor chamber in which the heated liquor flows, in contrast to the apparent liquor level which shows up as a column of liquid in the heating tubes and which does indeed depend upon the effective liquid level.

Regulation of the liquor level has heretofore been carried out by means of valves controlled either manually or by suitable floats, and it has heretofore been required that the liquor level be individually controlled for each effect.

The correct regulation of the liquor level in each effect is critical for the proper operation of the evaporator. If the apparent liquor level falls below the optimum elevation then the rate of heat transfer falls off very sharply because the amount of liquor which is present in the heater does not suffice to cover the inner surfaces of the heating tubes and thus the uppermost portions of the heating tubes are engaged only by the steam which is used as a heating medium. Furthermore, in such an event burning of the sugar solution because of localized complete removal of water from the solution can result, and of course an extremely undesirable deterioration of the heat transfer necessarily follows. On the other hand, even when the apparent liquor level increases upwardly beyond the optimum liquor level, there is a reduction in the rate of heat transfer because the liquid which flows beyond the heating tubes has its rate of flow sharply reduced because of the vigorous foaming which occurs under these conditions over the upper wall of the heating chamber.

As was mentioned above, it is known to control the liquor level individually for each effect by means of manual valves or float valves, but these constructions are extremely complicated, do not operate reliably, and

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require an undesirably large amount of attention from the personnel who operate the evaporator.

It is, accordingly, a primary object of the present invention to provide for a multiple-effect vertical-tube evaporator a construction which will very reliably regulate the liquor level in each of the effects without requiring the use of any of the complicated automatic or manually-operated structure heretofore considered essential for this purpose.

Another object of the invention is to provide a structure which has no moving parts but which is capable of reliably maintaining in each effect a predetermined level of the liquor.

Also, it is an object of the present invention to control the liquor derived from the multiple-effect evaporator by means of a single control which is applied to the thin liquor as it flows to the first effect of the evaporator so that regulation of individual controls at the several effects in order to determine the amount and Brix degree of the liquor discharged from the evaporator become unnecessary.

Furthermore, it is an object of the present invention to regulate with an exceedingly simple structure which has no moving parts the proportion of liquor which is recirculated in each effect with respect to the proportion thereof which is transferred to the next effect.

With these objects in view the invention includes, in a multiple-effect vertical-tube evaporator, a plurality of effects each of which includes a lower heating chamber and an upper vapor chamber. The lower heating chamber of each effect includes an outer wall enclosing a given space and upper and lower tube sheets extending across this space and fixed to the outer wall, the heater of each effect further including tubes which have opposed open ends and which extend between and are fixed to the upper and lower tube sheets of the heating chamber, so that the liquor which is to be evaporated can flow upwardly through the tubes of the heating chamber to be deposited upon the upper tube sheet thereof while being heated by a heating medium located within the heating chamber and engaging the exterior surfaces of the tubes. The vapor chamber of each effect extends upwardly from the upper tube sheet of the heating chamber to receive the vapors liberated from the liquor by the heating thereof, and each vapor chamber has an outer wall which at least in the region of the upper tube sheet of the heating chamber is of a larger diameter than the outer wall of the heating chamber and has a lower portion extending below the upper tube sheet of the heating chamber and fixed to the outer wall of the heating chamber to define with this outer wall a channel for receiving the liquor deposited upon the upper tube sheet of the heating chamber. In accordance with the invention the outer wall of the heating chamber of each effect extends upwardly beyond the upper tube sheet thereof to an extent which determines the level which the liquor must reach in each effect before flowing into the channel in which the liquor level is also lower than the level which the liquor must reach before flowing into the channel. A recirculating conduit means communicates with the channel of each effect for recirculating liquor there-through, and a transferring conduit means communicates with the channel of each effect for receiving liquor therefrom and transferring it to the next-following effect to be evaporated in the latter. In accordance with a further feature of the invention there is in each channel a pair of partitions located on opposite sides of the portion of the channel with which the transferring conduit means communicates and the fraction of the channel between the partitions which communicates with the transferring conduit means is substantially smaller than the remainder of the channel which communicates with the

recirculating conduit means so that as a result at each effect a considerably greater part of the liquor is recirculated than is transferred from one effect to the next-following effect.

The following features which are considered as characteristic for the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawings, in which:

FIG. 1 is a fragmentary longitudinal elevation showing the details of the structure of the heating chamber of an effect of a multiple-effect vertical-tube evaporator as well as showing the lower portion of the vapor chamber thereof and in particular how the vapor chamber is connected to the heating chamber in accordance with the invention;

FIG. 2 is a fragmentary sectional view at an enlarged scale of that part of the structure of FIG. 1 which is indicated by the arrow II;

FIG. 3 is a fragmentary plan view taken along line III—III of FIG. 2 in the direction of the arrows; and

FIG. 4 is a schematic illustration of a multiple-effect vertical-tube evaporator according to the invention which in the illustrated example has four effects.

Referring now to FIG. 1, there is shown therein a heating chamber of one of the effects of the multiple-effect vertical-tube evaporator, this heating chamber including an outer wall 1 which encloses a given space across which a lower tube sheet 2 and an upper tube sheet 3 extend, the lower and upper tube sheets 2 and 3 being respectively fixed to the outer wall 1 of the heating chamber. A plurality of tubes 4 and 5 extend between and are fixed to the upper tube sheet 3 and the lower tube sheet 2, these tubes 4 and 5 having opposed open ends and passing through the tube sheets 2 and 3 as well as being fixed thereto as, for example, by having their ends rolled down against the exterior surfaces of the tube sheets 2 and 3. The tubes 4 constitute an inner set of tubes providing the initial heating stage of the liquor in each effect while the tubes 5 are arranged outwardly of the inner set of tubes 4 and provide the main heating stage for the liquor in each effect. Thus, in each effect, the liquor will be preliminarily heated during flow in tubes 4 and then the main heating will be applied during passage of the liquor through the greater number of tubes 5. The upper tube sheet 3 fixedly carries a downwardly directed enclosure 6 which defines with the upper tube sheet 3 a chamber 11 which can receive only the liquor which discharges from the upper ends of the preliminary heating tubes 4. The connection between the element 6 and the tube sheet 3 is of course fluid-tight. An enclosure 7 of annular configuration is fluid-tightly fixed to the lower surface of the lower tube sheet 2 and has an outer wall 8 situated between the inner tubes 4 and the outer tubes 5, and the upwardly directed enclosure 7 defines with the lower tube sheet 2 a chamber 10 which communicates only with the inner set of tubes 4. The outer wall 8 of the enclosure 7 may be made separately from and fixed to the remainder of the closure 7, and the enclosure 7 may also have a separate inner member 9 which can take the form of a suitable sealing ring which provides a fluid-tight connection between the inner periphery of the upwardly directed enclosure 7 and the lower tube sheet 2 of the heating chamber. The enclosures 6 and 7 are concentric with the outer wall 1 which can have a cylindrical configuration. The heating chamber includes a larger central vertical tube 13 which also has opposed open ends and which extends between and is fixed to the tube sheets 2 and 3, and this tube 13 provides communication between the upper chamber 11 which receives the preliminarily heated liquor and the lower compartment 12 which is situated beneath the

lower tube sheet 2 of the heater. Thus, it will be seen that liquor which flows from the chamber 10 upwardly through the tubes 4 will necessarily flow into the top end of the tube 13 and downwardly from the latter into the compartment 12 so as to reach in this way the lower open ends of the main heating tubes 5. The inner periphery of the enclosure 7 surrounds the lower end 14 of the tube 13 which is fluid-tightly fixed to the lower tube sheet 2 in a central opening thereof. The liquor is initially delivered to each effect by way of a tube 15 which passes through the compartment 12 and communicates only with the compartment 10 in the interior of the enclosure 7. The liquor will flow from the compartment 10 upwardly through the tubes 4 while being heated with a heating medium in the chamber engaging the exterior surfaces of the tubes 4, and this heating of the liquor will result in formation of steam bubbles in the liquor which in this condition flows downwardly through the tube 13 from the compartment 11 into the lower compartment 12 before passing up through the main heating tubes 5. The outer wall 8 of the enclosure 7 guarantees a uniform distribution of the liquor to the several tubes 5. The preliminarily heated liquor now will flow at high speed upwardly through the main heating tubes 5, and the liquor collects in thickened condition, as compared to the liquor delivered by the tube 15 into the compartment 10, on the upper tube sheet 3 of the heating chamber from where the liquor flows to a channel 16 which surrounds the outer wall 1 and extends to an elevation lower than the upper tube sheet 3 of the heating chamber, and a transfer conduit means, which includes the conduit 17, receives the thus-thickened liquor from one effect and transfers it to the next-following effect of the evaporator. The heating medium which is used to heat the liquor in the tubes 4 and 5 is steam and is delivered to the interior of the heating chamber by way of a conduit 18 which communicates with the inner space of the heating chamber defined by the outer wall 1 and the tube sheets 2 and 3.

In order to maintain on the upper tube sheet 3 of the heating chamber an accurately predetermined liquor level, the outer wall 1 of the heating chamber extends upwardly beyond the wall 3 to a predetermined extent so as to provide the ring 19 formed by the upper portion of the outer tube sheet 1 which extends upwardly beyond the upper tube sheet 3. The vapor chamber has its interior space defined by an outer wall 20, and this vapor chamber of each effect extends upwardly from the upper tube sheet 3 of a heating chamber so as to receive the vapors which are liberated from the liquor, and at least in the region of the upper tube sheet 3 the wall 20 has a diameter larger than the wall 1 and extends downwardly below the tube sheet 3 and is fixed to the wall 1 beneath the elevation of the tube sheet 3 so as to define with the wall 1 the endless, annular channel 16 into which the liquor flows after passing over the upper edge 24 of the wall 19. At the side of each effect which is opposite to that side thereof where the conduit 17 is located, the channel 16 communicates with a conduit 21 which forms part of a recirculating conduit means, and the liquor which is withdrawn from the channel 16 by the conduit 21 is pumped back to the same effect from which it is withdrawn, so that in this way the part of the liquor withdrawn through the outlet 21 is recirculated back to the same effect from which it is withdrawn.

The upper portion 19 of the outer wall 1 of the heating chamber forms on the upper tube sheet 3 of the heating chamber a space 22 in which the liquor accumulates and in this space 22 the upper edge 24 of the wall 19 will determine the level 23 of the liquor. The liquor which flows upwardly from the main heating tubes 5 collects in the space 22 and flows over the edge 24 into the channel 16 which of course will in general have a lower liquor level than the level 23. The greatest part of the liquor which overflows into the channel 16 is removed

through the outlet 21 and returned again to the same effect by way of the conduit 15, while a relatively small portion of the liquor which overflows the edge 24 is removed by the conduit 17 which together with the remainder of the transferring conduit means described below transfers this portion of the liquor to the next effect of the multiple-effect generator.

As is apparent from FIGS. 1-3, a pair of partitions 25 and 26 are located in the channel 16 on opposite sides of the portion thereof which communicates with the transferring conduit means, of which the outlet 17 forms a part, and it will be seen that the fraction of the channel 16 which is situated between the partitions 25 and 26 communicates with the outlet 17 determines the portion of the liquor which will be transferred to the next-following effect, while the remainder of the channel 16, and of course by far the greater part thereof, will have the liquor therein flow through the outlet 21 to be recirculated back to the same effect from which it was withdrawn.

Referring now to FIG. 4, the thin liquor which comes from the processing plant passes through a conduit 53 into a preheater 27 which supplies the thin liquor to the first effect I. This first effect I includes the unit 28 made up of the lower heating chamber and the upper vapor chamber having the construction described above in connection with FIGS. 1-3, and, of course, the supply conduit leading from the preheater 27 delivers the liquor to the lower tube 15 of the unit 28 so as to flow in the manner described above first through the preheating tubes 4 and then through the main heating tubes 5 before liberating the vapors to the vapor chamber and overflowing into the channel 16. The transferring conduit means includes, in addition to the outlet 17 referred to above, a conduit 29 which leads from the outlet 17 to the inlet 15 of the next effect II which is made up of a unit 31 identical with the unit 28. In order to prevent vapor from flowing with the liquor from the unit 28 to the unit 31 the transferring conduit means 29 has a steam trap 30.

The liquor which reaches in this way the second effect of the evaporator is treated in the second effect precisely in the manner described above and then flows through the transferring conduit means 32 of the second effect to the third effect III which includes the unit 34 identical with the units 28 and 31, and the transferring conduit means 32 is also provided with a steam trap 33. In the same way the liquor from the third effect is transferred by a transferring conduit means 35 to the fourth and final effect IV which is made up of a unit 37 identical with the units 28, 31 and 34, and the transferring conduit means 39 takes the thickened liquor from the fourth effect and delivers it to a pump 38 which through a suitable conduit transfers the thickened liquor to a cooking station, as is well known in the art, and in accordance with the treatment of the liquor by the evaporator this liquor delivered by the pump 38 to the cooking station will have a predetermined Brix degree.

The unit 28 has a recirculating conduit means 40, which, of course, includes the outlet 21 referred to above as well as a pump 44 which recirculates liquor back to the unit 28, and the recirculated liquor is joined with fresh liquor derived from the preheater 27. The second effect is provided with the recirculating conduit means 41 which includes the pump 45 and the liquor recirculated in the second effect is of course joined with the liquor withdrawn from the first effect by way of the transferring conduit means 29. In the same way the liquor of the third effect is recirculated by a recirculating conduit means 42 which includes the pump 46 and which joins the recirculated liquor with liquor withdrawn from the second effect by the transferring conduit means 32, and, of course, the liquor of the fourth effect is recirculated by the recirculating conduit means 43 which includes pump

47 and which joins the recirculated liquor with the liquor withdrawn from the third effect III by way of the transferring conduit means 35 which, of course, includes the steam trap 36 as shown in FIG. 4.

For heating purposes fresh steam is delivered by a conduit 48 to the preheater 27 as well as to the heating chamber of the first unit 28 through the inlet 18 of this heating chamber. The steam vapors which are received in the vapor chamber of the first effect are delivered by way of a conduit 49 to the heating chamber of the second effect to heat the liquor therein, and the conduits 50 and 51 serve respectively to deliver the steam vapors from the vapor chambers of the second and third effects to the heating chambers of the third and fourth effects, respectively, as indicated in FIG. 4. The conduits shown at the uppermost part of FIG. 4 and associated with arrows which are directed to the right, as viewed in FIG. 4, deliver excess steam vapors to a location where these vapors are used in a known way, and this conduit 52 for the fourth unit 37 delivers the vapors directly from the fourth unit to the same location as the excess vapors from the first three units.

The Brix degree of the thickened liquor withdrawn from the fourth unit is checked from time to time, and in the event that this final liquor obtained from the multiple-effect evaporator does not have the desired degree of Brix, it is necessary to make a suitable adjustment in the supply conduit 53 for the thin liquor, this adjustment being made only at the single valve 54 in the conduit 53. With the adjustment of the single valve 54 it is possible to regulate the amount of liquor which flows over the edge 24 of the ring 19 into the channel 16 in each effect.

It is thus possible by adjustment of the valve 54 to maintain in the individual effects the required level of the liquor in an extremely accurate manner, so that the apparent liquor level also will remain during normal operations within the permissible limits and thus the best possible evaporations of the liquor is achieved and at the same time adjustment of the individual liquor levels of the individual effects is no longer required.

The difficulties with conventional apparatus in regulating the liquor level occurs for the most part with multiple-effect evaporators where adjustments are required at each of the effects and where there is a recirculation of a part of the liquor at each of the effects. With evaporators of this type the recirculated liquor and the liquor which is transferred to the next-following effect are withdrawn from the same channel, and it is therefore essential that the heating tubes deliver a greater amount of liquor than is recirculated at each effect.

Inasmuch as the identical process is repeated at each of the effects, with the structure of the invention it becomes unnecessary for the operator to make adjustments of the liquor level at each effect and instead it is only required to determine whether there is obtained from the last effect a sufficient amount of thickened liquor with the required degree of Brix. In the event that this is not the case, then it is only necessary to adjust the valve 54 by closing it to a greater degree or opening it to a greater degree.

The steam traps 30, 33 and 36 referred to above of course avoid the carry-over of vapors from one effect to the next in the transferred liquor, and instead of steam traps it is also possible to use adjustable siphons having suitable valves in their conduits.

Furthermore, with the structure of the invention the positions of the partitions 25 and 26 determine the proportion of liquor which is transferred to the next effect and the proportion thereof which is recirculated. The location of the partitions 25 and 26 must be such that during normal operations a sufficient amount of liquor will be recirculated in each effect. For this purpose the larger portion of each channel 16 which communicates with the recirculating conduit means must remain filled with liquor during operation of the evaporator and thus have a prede-

terminated relation to the liquor level above the upper wall of the heating chamber, while on the other hand the level of the liquor between the partitions 25 and 26 which communicates with the transferring conduit means at each effect can during normal operations have a somewhat lower level in the channel 16. In this way, by maintaining a relatively high liquor level in the part of the channel 16 which communicates with the recirculating conduit means of each effect there is a guarantee of sufficient liquor for recirculating purposes because the heating tubes deliver to the upper tube sheet 3 of each heating chamber more liquor than is recirculated at each effect. The excess liquor which is not recirculated is of course transferred to the next-following effect. The transferring conduit means between the several effects include automatic controls such as suitable automatic valves or the like which maintain the liquor level in the portion of the channel 16 which communicates with the transferring conduit means between a maximum and a minimum value. The length of the channel 16 included between the partitions 25 and 26 and communicating with the outlet 17 at each effect, as shown most clearly in FIG. 3, is chosen so that there will be transferred from one effect to the next only as much liquor as is required to pass through the entire evaporator when considered as a single unit.

It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of evaporators differing from the types described above.

While the invention has been illustrated and described as embodied in multiple-effective evaporators, it is not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can be applying current knowledge readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be secured by Letters Patent is:

1. In a multiple-effect vertical-tube evaporator, in combination, a plurality of effects each of which includes a lower heating chamber and an upper vapor chamber, said lower heating chamber of each effect including an outer wall, upper and lower tube sheets extending across the interior of the space enclosed by said outer wall and fixed to the latter, and vertical tubes having opposed open ends and extending between and fixed to said upper and lower tube sheets so that the liquor which is to be evaporated can flow upwardly through said tubes to be deposited on said upper tube sheet while being heated by a heating medium in said heating chamber engaging the outer surfaces of said tubes, said vapor chamber upwardly from said upper tube sheet to receive the vapors liberated from the liquor by the heating thereof and said vapor chamber having an outer wall which at least in the region of said upper tube sheet is of a larger diameter than the outer wall of said heating chamber and which has a lower portion fixed to said outer wall of said heating chamber at an elevation lower than said upper tube sheet thereof to define with said outer wall of said heating chamber a channel into which the liquor will flow from said upper tube sheet; recirculating conduit means communicating with said channel of each effect for recirculating liquor therethrough; transferring conduit means communicating with the channel of each effect for receiving liquor therefrom and transferring it to the next-following effect of the evaporator; and a pair of partitions located in each channel and defining between themselves a channel portion

with which said transferring conduit means communicates, said channel portion between said partitions being substantially smaller than the remainder of the channel with which said recirculating conduit means communicates so that at each effect there is recirculated a larger amount of liquor than is transferred to the next effect.

2. In a multiple-effect vertical-tube evaporator, in combination, a plurality of effects each of which includes a lower heating chamber and an upper vapor chamber, said lower heating chamber of each effect including an outer wall, upper and lower tube sheets extending across the interior of the space enclosed by said outer wall and fixed to the latter, and vertical tubes having opposed open ends and extending between and fixed to said upper and lower tube sheets so that the liquor which is to be evaporated can flow upwardly through said tubes to be deposited on said upper tube sheet while being heated by a heating medium in said heating chamber engaging the outer surfaces of said tubes, said vapor chamber extending upwardly from said upper tube sheet to receive the vapors liberated from the liquor by the heating thereof and said vapor chamber having an outer wall which at least in the region of said upper tube sheet is of a larger diameter than the outer wall of said heating chamber and which has a lower portion fixed to said outer wall of said heating chamber at an elevation lower than said upper tube sheet thereof to define with said outer wall of said heating chamber a channel into which the liquor will flow from said upper tube sheet; recirculating conduit means communicating with said channel of each effect for recirculating liquor therethrough; transferring conduit means communicating with the channel of each effect for receiving liquor therefrom and transferring it to the next-following effect of the evaporator; and a pair of partitions located in each channel and defining between themselves a channel portion with which said transferring conduit means communicates, said channel portion between said partitions being substantially smaller than the remainder of the channel with which said recirculating conduit means communicates so that at each effect there is recirculated a larger amount of liquor than is transferred to the next effect, said outer wall of said heating chamber extending upwardly from said tube sheet thereof to an extent which determines the level which must be reached by the liquor deposited on said upper tube sheet before flowing into said channel and which maintains in the tubes a liquor level preventing damage to the tubes and deterioration of the liquor passed therethrough.

3. In a multiple-effect vertical-tube evaporator, in combination, a plurality of effects each of which includes a lower heating chamber and an upper vapor chamber, said lower heating chamber of each effect including an outer wall, upper and lower tube sheets extending across the interior of the space enclosed by said outer wall and fixed to the latter; and vertical tubes having opposed open ends and extending between and fixed to said upper and lower tube sheets so that the liquor which is to be evaporated can flow upwardly through said tubes to be deposited on said upper tube sheet while being heated by a heating medium in said heating chamber engaging the outer surfaces of said tubes, said vapor chamber extending upwardly from said upper tube sheet to receive the vapors liberated from the liquor by the heating thereof and said vapor chamber having an outer wall which at least in the region of said upper tube sheet is of a larger diameter than the outer wall of said heating chamber and which has a lower portion fixed to said outer wall of said heating chamber at an elevation lower than said upper tube sheet thereof to define with said outer wall of said heating chamber a channel into which the liquor will flow from said upper wall of said heating chamber; recirculating conduit means communicating with said channel of each effect for recirculating liquor therethrough; transferring conduit means communicating with the channel of each effect for receiving liquor therefrom and trans-

ferring it to the next-following effect of the evaporator; and a pair of partitions located in each channel and defining between themselves a channel portion with which said transferring conduit means communicates, said channel portion between said partitions being substantially smaller than the remainder of the channel with which said recirculating conduit means communicates so that at each effect there is recirculated a larger amount of liquor than is transferred to the next effect, said outer wall of said heating chamber extending at least between said partitions upwardly from said upper tube sheet to an extent which determines the elevation which the liquor must reach before flowing into the channel portion situated between said partitions to be withdrawn from one effect by the transferring conduit means and delivered thereby to the next-following effect and which maintains in the tubes a liquor level preventing damage to the tubes and deterioration of the liquor passed therethrough.

4. In a multiple-effect vertical-tube evaporator, in combination, a plurality of effects each including a lower heating chamber and an upper vapor chamber, said lower heating chamber of each effect including an outer wall enclosing a given space, upper and lower tube sheets extending across said space and fixed to said outer wall, and a plurality of tubes having opposed open ends and extending between and fixed to said upper and lower tube sheets so that liquor which is to be evaporated will flow upwardly through said tubes to be deposited on said upper tube sheet and heated during upward flow through said tubes by a heating medium in each heating chamber engaging the exterior surfaces of said tubes, said vapor chamber of each evaporator having an outer wall which at least in the region of said upper tube sheet is of a larger diameter than said outer wall of said heating chamber and which has a lower portion fixed to said outer wall of said heating chamber at an elevation lower than said upper tube sheet thereof to define with said outer wall of said heating chamber an endless channel for receiving the liquor which is deposited on said upper wall; recirculating conduit means communicating with the channel of each effect for recirculating liquid therethrough; transferring conduit means communicating with the channel of each effect and with the next-following effect for withdrawing liquor from one effect and transferring it to the next-following effect to be further evaporated in the latter, the transferring conduit means of the last effect transferring the liquor withdrawn therefrom to a given station for further processing; supply conduit means communicating only with the first of the plurality of effects for delivering to the latter liquor to be successively evaporated in the successive effects; and control means carried only

by said supply conduit means for controlling the rate of flow of liquor from one effect to the next and thus the rate of flow of liquor in the transferring conduit means which communicates with the last of the plurality of effects, the outer wall of the heating chamber of each effect extending to a predetermined extent upwardly from said upper tube sheet thereof to determine the elevation which must be reached by the liquor in each effect before flowing into the channel thereof and to maintain in said tubes a liquor level preventing damage to the tubes and deterioration of the liquor passed therethrough.

5. An evaporator as recited in claim 4 and wherein a pair of partitions are located in the channel of each effect on opposite sides of the portion thereof with which said transferring conduit means communicates, the fraction of the channel between said partitions which communicates with said transferring conduit means being substantially smaller than the remainder thereof which communicates with said recirculating conduit means so that at each effect the amount of liquor which is recirculated is substantially greater than the amount which is transferred to the next effect.

6. In an evaporator as recited in claim 4, means carried by each of said transferring conduit means except that which communicates with the last of the plurality of effects for preventing vapors from being transferred with the liquor from one effect to the next effect.

7. In an evaporator as recited in claim 5, means carried by the transferring conduit means of each effect except the last of the plurality of effects for preventing vapors from being transferred with the liquor from one effect to the next effect.

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