Oct. 26, 1937. M. J. KERMER 2,096,748

EVAPORATOR

Filed March 30, 1936 4 Sheets-Sheet 1

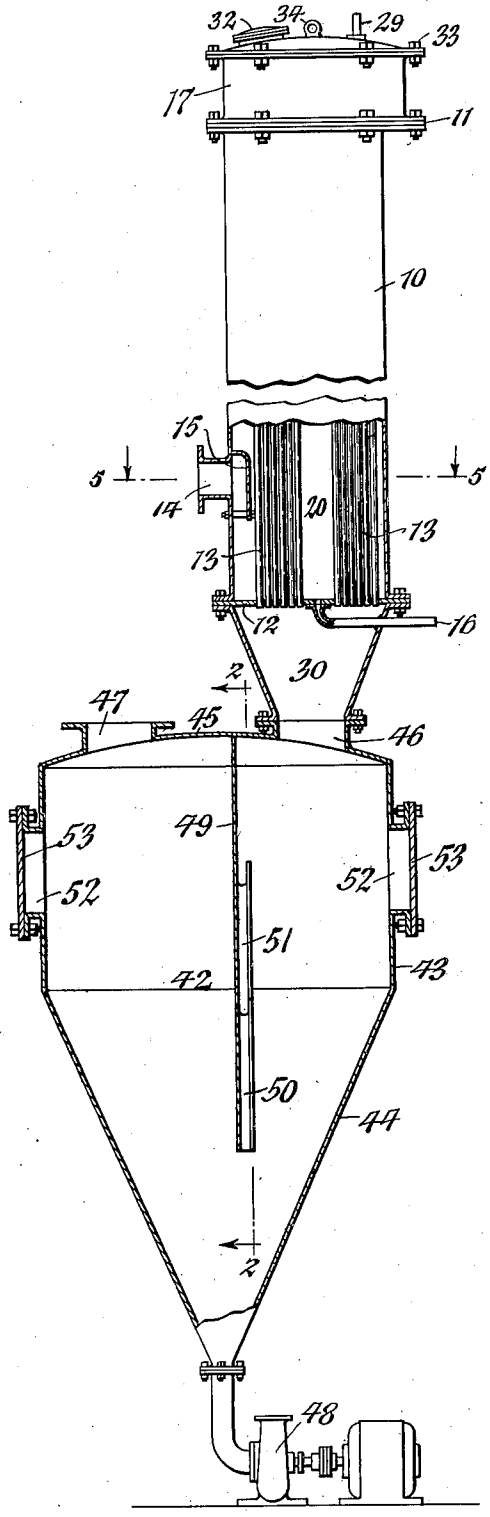
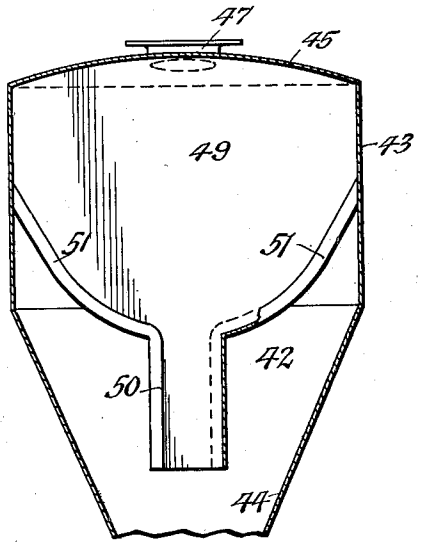


Fig. 1.

Fig. 2.



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Fig. 3.

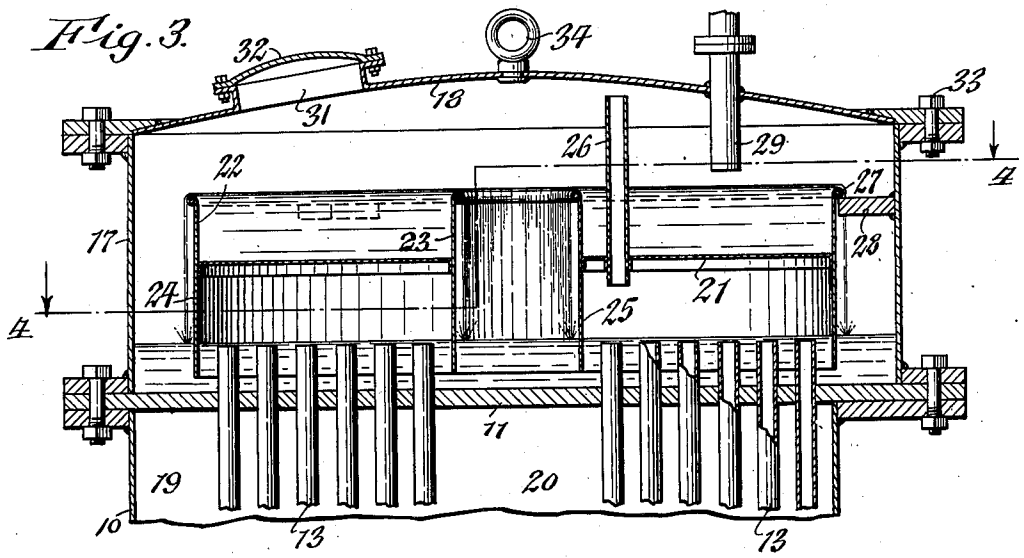
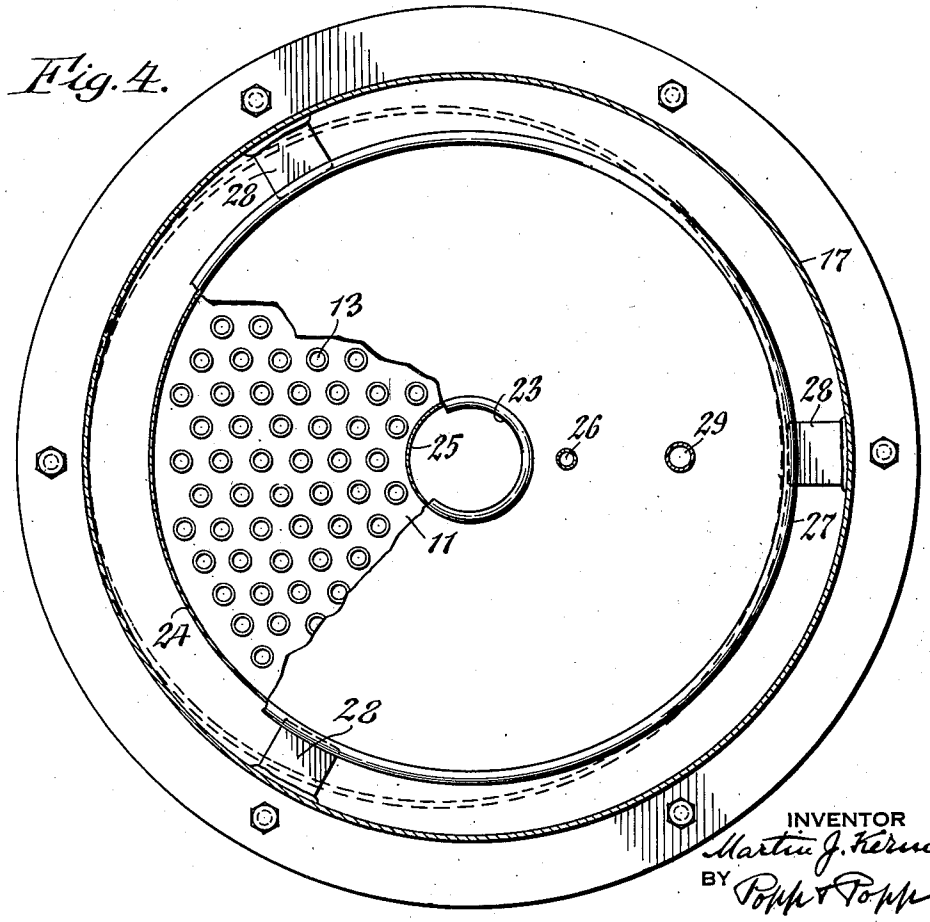


Fig. 4.



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Fig. 6.

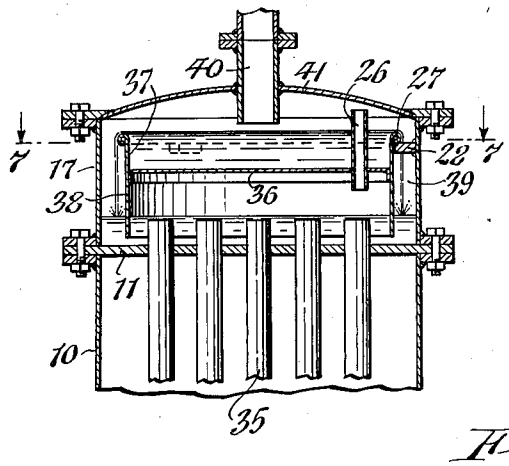


Fig. 7.

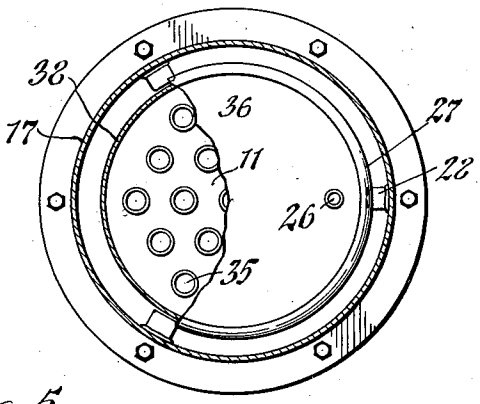
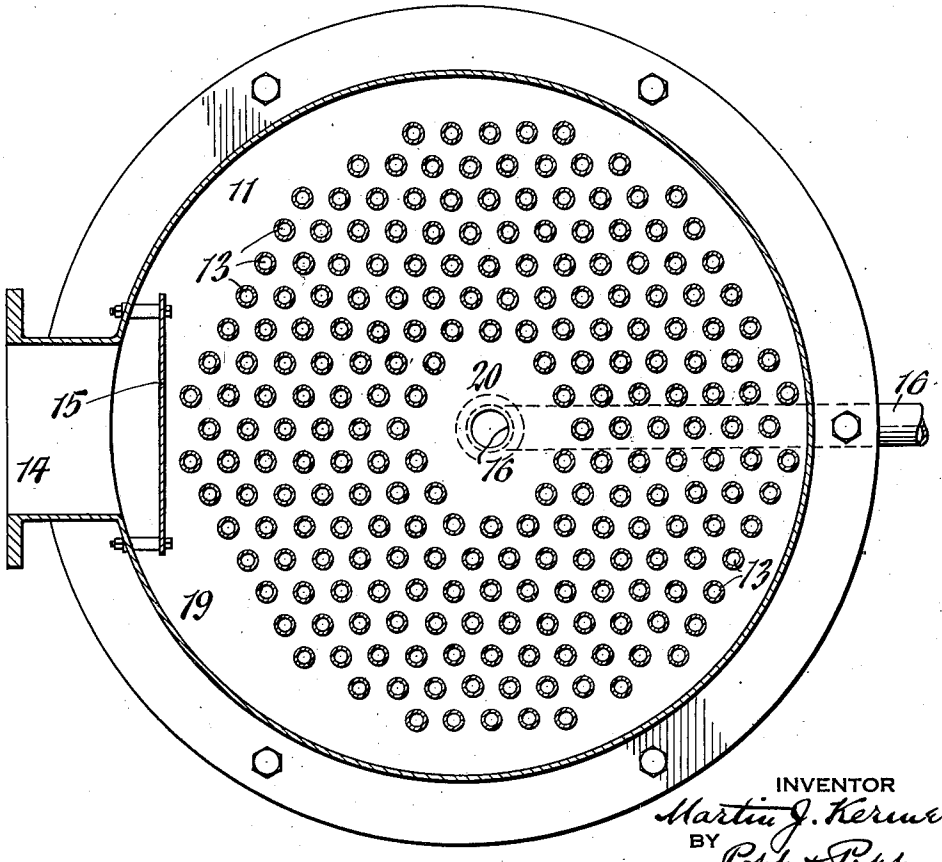


Fig. 5.



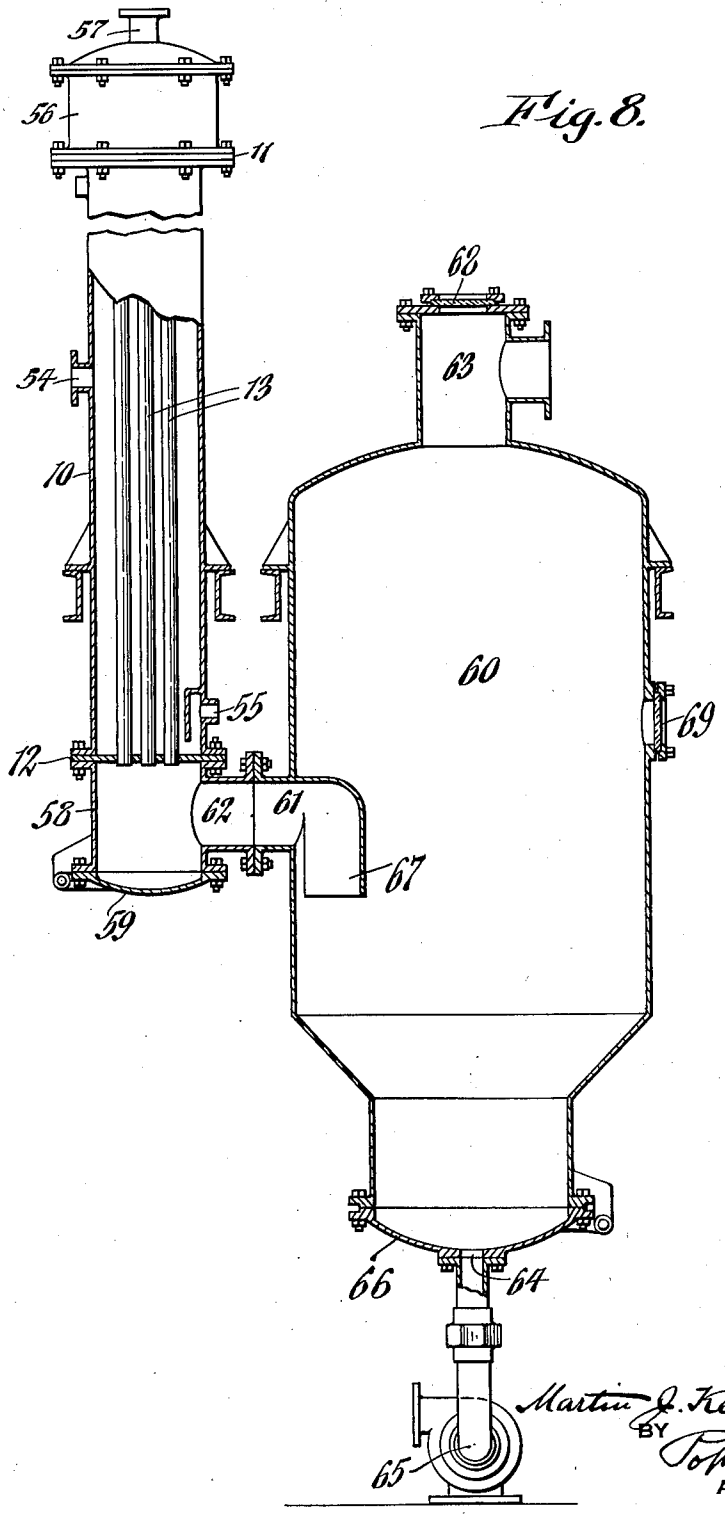
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Fig. 8.



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UNITED STATES PATENT OFFICE

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EVAPORATOR

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Application March 30, 1936, Serial No. 71,556

8 Claims. (Cl. 159—27)

This invention relates to an evaporator for concentrating liquors that do not crystallize or have solids in suspension, such as sulfate waste liquor, milk, fruit juices and so forth.

One of the objects of this invention is to provide an evaporator in which the heating of the liquor is effected while flowing downwardly, thereby causing the liquor to be propelled by gravity and also by the pressure of the vapor created during the evaporating operation.

Another object of this invention is to provide means for eliminating turbulence in the liquor after it enters the apparatus and cause the same to be supplied quietly and uniformly to the several heating tubes of the heater.

A further object of the invention is to provide improved means for separating the heated vapor and concentrated liquor and thus facilitate the concentration operation and effect a saving in cost of production.

Additional objects of this invention are to so organize the several parts that the same are readily accessible for cleaning, inspection and repairing.

In the accompanying drawings:—

Fig. 1 represents a side elevation of an approved form of my invention, but showing parts of the same in section.

Fig. 2 is a fragmentary, vertical section taken on line 2—2, Fig. 1.

Fig. 3 is a vertical section, on an enlarged scale, of the liquor distributor and the upper part of the liquor heater.

Fig. 4 is a horizontal section, taken on line 4—4, Fig. 3.

Fig. 5 is a horizontal section, on an enlarged scale, taken on line 5—5, Fig. 1.

Fig. 6 is a fragmentary vertical section of the liquor distributor and the upper part of a liquor heater embodying a modified form of this invention.

Fig. 7 is a horizontal section taken on the correspondingly numbered line in Fig. 6.

Fig. 8 is a vertical section showing another modification of this invention.

In its general organization this improved evaporator comprises a heater or steam chest whereby the liquor to be evaporated is heated for vaporizing and concentrating the same, a distributor whereby the liquor supplied is distributed over the heating area of the heater, and a separator which receives the heated liquor from the heater and separates the vapor from the concentrated liquor.

Although the heater may be varied in its detail construction the form shown in the drawings is satisfactory and comprises an upright cylindrical body or shell 10, upper and lower horizontal tube sheets or heads 11, 12 secured to the upper and lower ends of the body 10 and a plurality of upright heating tubes 13 arranged within the body and secured at their upper and lower ends to the upper and lower tube sheets. These tubes are heated by subjecting the exterior of the same to a heating medium such as steam whereby the liquor to be evaporated is heated by passing the liquor downwardly through the tubes. The steam is introduced into the body of the steam chest through an inlet collar 14 arranged on the lower part of the body and preferably deflected downwardly in the latter by a deflector or baffle 15 mounted on the inner side of the body and across the inner end of the collar and operating to direct the steam entering the body downwardly and thus insure heating the tubes throughout the entire length of the same. The water of condensation and non-condensible gases is preferably withdrawn from the lower part of the steam space of the heater by a discharge pipe 16 connected with the lower tube sheet 12 and opening through the latter in the central part of the steam space.

In order to produce a more even distribution of the heating effect of the steam among the several heating tubes the latter are so arranged that the bundle of tubes as a whole form a group which is arranged eccentrically in the body of the steam chest and form a clearance space 19 between the outer periphery of the bundle of tubes and the steam chest, those tubes forming that part of the outer periphery of this group which is opposite the steam inlet 14 being spaced farthest from the body of the steam chest, while those tubes on the periphery of the group which are progressively more distant from said steam inlet being progressively closer to the body of the steam chest, thereby producing a steam space between the periphery of the group of tubes and the inner side of the steam chest body which is largest in area adjacent to the steam inlet and becomes progressively smaller in area away from this inlet, whereby the heat of the steam is supplied with greater uniformity to the several tubes in the bundle.

The means for receiving the liquor and distributing the same to the heating tubes shown in Figs. 3, 4 and 5 are constructed as follows:—

Above the steam chest or liquor heater is arranged a liquor inlet chamber the bottom of which is formed by the upper tube sheet 11 of the steam chest and which has an upright side wall 17 preferably of cylindrical form connected at its lower end with this tube sheet and an upper head

or cover 18 connected with the upper end of the side wall 17, as best shown in Fig. 3.

As shown in Fig. 3 the heating tubes have their upper ends projecting some distance above the tube sheet 11 which forms the bottom of the inlet chamber, and as shown in Figs. 3, 4 and 5 the bundle of tubes is arranged to form an annular group of tubes, the outer periphery of which group is spaced from the side wall of the steam chest by the outer clearance space 19 and an inner clearance space 20 being formed by the inner periphery of this group of tubes. Within this inlet chamber is arranged a liquor receiving and quieting pan which is adapted to receive the liquor to be evaporated from any source of supply and to aid in quieting the same and effect a uniform heating thereof.

This quieting pan in the construction shown in Figs. 3, 4 and 5 is of annular form and has a ring-shaped bottom 21 arranged above the upper ends of the heating tubes and having its outer periphery extending beyond the outer periphery of the annular bundle or group of heating tubes but spaced from the side wall of the inlet chamber while its inner periphery is arranged within the inner periphery of this bundle of tubes. From the outer periphery of the bottom 21 an outer wall 22 of annular form projects upwardly and from the inner periphery of this bottom an inner annular wall 23 projects upwardly, both of these walls being preferably of the same height and terminating at a distance from the top or cover of the liquor inlet chamber. At its outer periphery the quieting pan is provided with an annular baffle flange 24 which projects downwardly from the bottom of the pan into the annular space between the side wall of the inlet chamber and the outer periphery or circumference of the bundle of tubes and terminating between the bottom of this inlet chamber and the upper ends of the heating tubes. At its inner periphery or circumference the quieting pan is provided with an inner baffle flange 25 which projects downwardly from the bottom of the pan within the inner periphery of the annular bundle of heating tubes and terminates short of the bottom of the inlet chamber and preferably flush with the lower end of the outer baffle flange 24, as shown in Fig. 3. A vent or pressure balancing pipe 26 extends from the space on the underside of the pan bottom to the space in the upper part of the inlet chamber which pipe has its lower end secured to the pan bottom and its upper end terminating short of the top of the inlet chamber. This quieting pan and the parts mounted thereon are preferably removably supported within the inlet chamber by providing the upper end of the outer pan wall with an annular laterally projecting rim 27 which is adapted to rest with its underside on a plurality of lugs 28 projecting inwardly from the side wall of the inlet chamber, as shown in Figs. 3 and 4. The liquor to be evaporated may be delivered into the pan in any suitable manner from any suitable source, for example by a supply pipe 29 passing downwardly through the cover 18 of the inlet chamber and terminating over the pan.

During the operation of the evaporator while steam is supplied to the heater and liquor to be evaporated is supplied either continuously or in batches through the supply pipe 29, this liquor first runs into the pan until the latter is completely filled and then the liquor runs over the upper edges of the outer and inner walls of the pan and into outer and inner lower parts of the inlet chamber which act as a quieting zone. From the outer and inner parts of the inlet chamber the liquor flows quietly or without turbulence underneath the outer and inner baffle flanges 24 and 25 of the pan and into a space between these flanges into which the upper ends of the heating tubes project. In this last mentioned space the liquor rises and circulates freely around the tubes without excess friction until it reaches the upper ends of the heating tube and thereafter the liquor overflows into the upper ends of the heating tubes and downwardly through the latter and out from the lower ends of the same. Each heating tube acts as a weir and all of the tubes have the same hydrostatic head of liquor, thereby resulting in a uniform distribution of liquor into the several tubes under all circumstances. As the liquor passes through the heating tubes it is heated by the steam in contact with the outer sides of the tubes and produces concentrated liquor and vapor which issue from the lower ends of the tubes and are received by an outlet chamber 30 which communicates with the lower ends of the tubes and is connected with the lower part of the steam chest.

By first introducing the liquor into the pan it is permitted to become quiet or non-turbulent and therefore under better control so that the same can be distributed more uniformly into the several heating tubes for promoting uniform heating of the liquor and obtaining the maximum evaporating effect on the liquor. This quiescent delivery of the liquor and uniform distribution of the same to the several heating tubes is further promoted by the inner and outer baffle flanges and the extension of the upper ends of the heating tubes above the bottom of the inlet chamber and the lower edge of these flanges inasmuch as turbulence in the liquor is eliminated as it passes underneath the baffle flanges and rises to the upper ends of the several heating tubes before it can pass over into the latter preparatory to being heated.

By arranging the plurality of heating tubes in the form of an annular group or bundle and transferring the liquor from the outer and inner part of the pan to the outer and inner peripheries of the annular bundle of tubes the distance which the liquor must travel upon leaving the pan and until it enters the several tubes is substantially equalized, or at least is not excessive, whereby greater uniformity in the distribution of the liquor to the several tubes is obtained and a more uniform heating of the liquor results and the capacity of the evaporator is increased and the quality of the product is improved.

The vapors and concentrated liquor are discharged from the lower ends with considerable velocity which causes a difference between the pressures in the upper and lower ends of the heating tubes. The provision of the vent pipe 26 causes a balancing of pressure in the spaces below the pan and above the same and thus maintains a uniform level of the liquor in the quieting zone around the outer side of the pan and over the upper ends of the heating tubes.

The use of the vent pipe 26 also prevents air or vapors present in the space underneath the pan and between the inner and outer baffle flanges from being compressed by the rising of the liquor underneath the pan and interfering with the free passage of liquor underneath the baffle flanges and into the heating tubes.

Partial access to the inlet chamber for inspection or other purposes is possible through a man-

hole 31 in the cover 18 which is normally closed by a lid 32 but when a full access to the inlet chamber is required for cleaning or repairs and for the removal of the pan then the entire cover 18 is detached by removing the bolts 33 provided for this purpose. For convenience in raising and lowering the cover 18 the same is provided centrally with an eye 34 for the reception of the hook or other fastening of a hoisting or transporting apparatus.

The downflow of the liquor in this evaporator is caused not only by gravity but also by the pressure of the vapor created in the tubes while evaporation takes place.

The form of liquor distributor shown in Figs. 3, 4 and 5 is more particularly intended for evaporators of large size or capacity. For smaller sizes of evaporators the heater and liquor distributor may be constructed as shown in Figs. 6 and 7. In this modified form the heating tubes 35 may be spaced equal distances apart throughout the bundle instead of being arranged in the form of an annular group.

The liquor receiving and quieting pan in this case also has a continuous bottom 36, an upright wall 37 only at its outer edge and a single baffle flange 38 depending from the underside of the pan into the quieting zone between the wall of the inlet chamber 39 and the periphery of the group of heating tubes and between the bottom of this chamber and the upper ends of the heating tubes. The liquor supply pipe 40 in this instance is preferably arranged in the central part of the cover 41 so as to feed the liquor into the center of the pan. The operation of this form of evaporator is the same as that shown in Figs. 3, 4 and 5 so far as the corresponding parts are concerned, the same being of simpler construction and smaller capacity and also lower in cost.

From the outlet chamber of the heater the heated liquor is discharged to a separator which separates the vapor from the concentrated liquor and which in its preferred form is constructed as follows:—

The numeral 42 represents a separating chamber formed within an enclosing shell having a cylindrical upper part 43, and a conical lower part 44, and a top 45 closing the upper end of the separating chamber. On one side of its center the top of the shell of the separating chamber is provided with an inlet 46 which communicates with the outlet chamber of the heater for conducting vapor and concentrated liquor from the heater into the separating chamber. On the opposite side of its center this top of the separator shell is provided with an outlet 47 for vapor which is adapted to be connected with exhausting means of any suitable character for producing a vacuum in the separating chamber and the spaces connected therewith. At the lower small end of the conical part of the separator shell the same is connected with the inlet of a pump 48 of any suitable character whereby the concentrated liquor is withdrawn from the separator.

Within the central upper part of the separating chamber is arranged an upright baffle 49 having the form of a plate which extends diametrically across the interior of the separating chamber and projects downwardly from the top thereof between the vapor and concentrated liquor inlet 46 and the vapor outlet 47 of the same and terminating at its lower end short of the lower end of the separating chamber.

On the central part of the lower edge of the baffle 49 the same is provided with a downwardly projecting spout 50 and on opposite sides of this spout the lower edge portions of this baffle converge downwardly and are provided on that side of the baffle facing the inlet 46 with two upwardly opening and downwardly converging gutters or channels 51 which open into opposite sides of the spout.

During the operation of the apparatus the heated mixture of vapor and concentrated liquor passes from the inlet of the separating chamber downwardly in the latter and after the same reaches the lower edge of the baffle the liquor continues its downward movement to the bottom of the separating chamber while the vapor passes around the lower edge of the baffle 49 and upwardly in the separating chamber on the back side of the baffle and then escapes through the vapor outlet 47. Any vapors which condense on the walls of the separating chamber flow downwardly thereon to the lower end of this chamber and any liquor which is entrained in vapor engaging the front side of the baffle 49 is separated therefrom by the latter and runs down the front side thereof into the channels 51. From these channels the separated liquor is conducted to the central spout 50 which latter discharges this liquor to the bottom of the separating chamber where the same is below the stream of outgoing vapor and therefore not liable to become entrained in the stream of vapor and carried out of the apparatus.

This apparatus is capable of use as a single unit for evaporating liquors with a single effect and a plurality of such apparatus may be coupled to evaporate with a multiple effect as is customary.

The operation of evaporation may also be conducted continuously or the liquor may be evaporated in batches to suit varying conditions or the character of the liquor in hand.

For convenience in cleaning, repairing and inspecting the interior of the separator the upper part of its enclosing shell or body is provided on opposite sides of the baffle 49 with manholes 52 which are normally closed by removable covers 53.

The modified form of this invention shown in Fig. 8 is constructed as follows:—

The heater or steam chest in this modified form is substantially like that shown in Figs. 1, 3 and 6, and comprises a steam chamber formed within an upright shell or body 10 and upper and lower tube sheets 11 and 12, upright heating tubes 13 arranged within the steam chamber and secured to the upper and lower tube sheets, a steam inlet 54 for the steam chamber, and a condensation outlet 55 for the steam chamber.

The upper ends of the heating tubes open into a liquor receiving chamber 56 into which the liquor to be evaporated is fed by a supply pipe 57 or other suitable means and which contains distributing and quieting means similar to those shown in Figs. 3–7 for eliminating turbulence in the liquor and effecting a uniform distribution of the same into the several tubes of the heater.

The liquor after being heated in its passage downwardly through the tubes by the steam surrounding the latter emerges from the lower ends of the tubes into an outlet chamber 58 which is preferably provided with a movable bottom or head 59 which upon being opened affords ready access to the tubes at the lower ends thereof for cleaning them when this is required. This bottom 59 may be connected with the body of the outlet chamber 58 either by hinges, as shown, or otherwise movably connected with this body.

Alongside of the lower part of the heater is arranged a separator for separating the vapors from the liquor. This separator comprises a chamber 60 which is formed within a shell and in which the liquor is separated from the vapors contained therein, a vapor and liquor inlet 61 in the side of the separating chamber which is connected by a conduit 62 with the side of the outlet chamber 58, a vapor outlet 63 on the upper part of the separating chamber which is adapted to be connected with a pump, condenser or other means for withdrawing the vapors from the separating chamber and a liquor outlet 64 on the lower part of the separating chamber, and a pump 65 which communicates with the outlet of the separating chamber and is adapted to withdraw the liquor therefrom and return the same to the inlet chamber 56 for recirculating the liquor or the latter may be delivered to the inlet of the next evaporating effect.

The heated liquor and vapors are conducted by the conduit 62 from the outlet chamber 58 into the separating chamber 60 where the liquor goes to the bottom and is carried away by the pump 65 and the vapors go to the top and are carried away through the vapor outlet 63 in a manner well known in this type of apparatus. As the liquor and vapors enter the separating chamber they are preferably deflected downwardly therein by a deflection 67 which extends across the inner side of the inlet 61. The liquor outlet 64 of the separating chamber is preferably formed in a bottom head 66 which closes the lower end of the separator and is movably connected therewith by hinges or otherwise to permit of conveniently opening the separating chamber and render the interior thereof accessible for cleaning and inspection.

Observation of the condition of the material within the separating chamber may be observed from the exterior thereof while evaporation is in progress by means of sight glasses, one 68 of which may be arranged on top of the vapor outlet conduit and another 69 may be arranged at the side of the evaporator body, as shown in Fig. 8.

I claim as my invention:

1. An evaporator comprising a liquor inlet chamber, a group of liquor heating tubes projecting into said chamber and having their upper ends arranged above the bottom of said chamber, a liquor quieting pan having an imperforate bottom and arranged within said chamber and extending with its periphery laterally beyond the group of tubes, and means for supplying liquor to said pan.

2. An evaporator comprising a liquor inlet chamber, a group of liquor heating tubes projecting into said chamber and having their upper ends arranged above the bottom of said chamber, a liquor quieting pan arranged within said chamber and extending with its periphery laterally beyond the group of tubes, means for supplying liquor to said pan and a baffle flange projecting downwardly from said pan and terminating between the bottom of said inlet chamber and the upper ends of said tubes and extending around the group of tubes.

3. An evaporator comprising a liquor inlet chamber, a group of liquor heating tubes projecting into said chamber and having their upper ends arranged above the bottom of said chamber, a liquor quieting pan arranged within said chamber and extending with its periphery laterally beyond the group of tubes, means for supplying liquor to said pan, a baffle flange projecting downwardly from said pan and terminating between the bottom of said inlet chamber and the upper ends of said tubes and extending around the group of tubes, and a vent tube extending from the space below the pan to the space above the same.

4. An evaporator comprising a liquor inlet chamber, an annular group of liquor heating tubes projecting into said chamber and having their upper ends arranged above the bottom of the chamber, a liquor quieting pan arranged within said distributing chamber and having a ring shaped bottom arranged above the upper ends of said tubes and having its outer periphery spaced from the side wall of said chamber and extending beyond the area of said annular group of tubes and having its inner periphery arranged within the area of said annular group of tubes, an outer wall projecting upwardly from the outer periphery of said pan bottom, an inner wall projecting upwardly from the inner periphery of said pan bottom, and means for supplying liquor to said pan.

5. An evaporator comprising a liquor inlet chamber, an annular group of liquor heating tubes projecting into said chamber and having their upper ends arranged above the bottom of the chamber, a liquor quieting pan arranged within said distributing chamber and having a ring shaped bottom arranged above the upper ends of said tubes and having its outer periphery spaced from the side wall of said chamber and extending beyond the area of said annular group of tubes and having its inner periphery arranged within the area of said annular group of tubes, an outer wall projecting upwardly from the outer periphery of said pan bottom, an inner wall projecting upwardly from the inner periphery of said pan bottom, means for supplying liquor to said pan, an inner baffle flange projecting downwardly from the outer periphery of said pan into the space between the side of said chamber and outermost tubes of said group and terminating between the bottom of the distributing chamber and the upper ends of said tubes, and an inner flange projecting downwardly from the inner periphery of said pan into the space within the innermost tubes of said group and terminating between the bottom of said chamber and the upper ends of said tubes.

6. An evaporator comprising a liquor inlet chamber, an annular group of liquor heating tubes projecting into said chamber and having their upper ends arranged above the bottom of the chamber, a liquor quieting pan arranged within said distributing chamber and having a ring shaped bottom arranged above the upper ends of said tubes and having its outer periphery spaced from the side wall of said chamber and extending beyond the area of said annular group of tubes and having its inner periphery arranged within the area of said annular group of tubes, an outer wall projecting upwardly from the outer periphery of said pan bottom, an inner wall projecting upwardly from the inner periphery of said pan bottom, means for supplying liquor to said pan, an inner baffle flange projecting downwardly from the outer periphery of said pan into the space between the side of said chamber and outermost tubes of said group and terminating between the bottom of the distributing chamber and the upper ends of said tubes, an inner flange projecting downwardly from the inner periphery of said pan into the space within the innermost

tubes of said group and terminating between the bottom of said chamber and the upper ends of said tubes, and a vent tube extending from the space below said pan to the space above the same.

7. An evaporator comprising a liquor inlet chamber, a group of liquor heating tubes projecting into said chamber and having their upper ends terminating above the bottom of said chamber, an imperforate liquor quieting pan arranged within said chamber above said tubes, means for supplying liquor to said pan, and means for removably supporting said pan within said chamber.

8. An evaporator comprising a liquor inlet chamber, a group of liquor heating tubes projecting into said chamber and having their upper ends terminating above the bottom of said chamber, a liquor quieting pan arranged within said chamber above said tubes, means for supplying liquor to said pan, means for removably supporting said pan within said chamber including an external rim arranged on said pan, and a plurality of lugs which project inwardly from the side of said chamber and upon which said rim is adapted to rest.

MARTIN J. KERMER.