Sept. 11, 1945. J. S. HUGHES 2,384,747

CRYSTALLIZING EVAPORATORS

Filed May 13, 1942 2 Sheets-Sheet 1

Fig. 1.

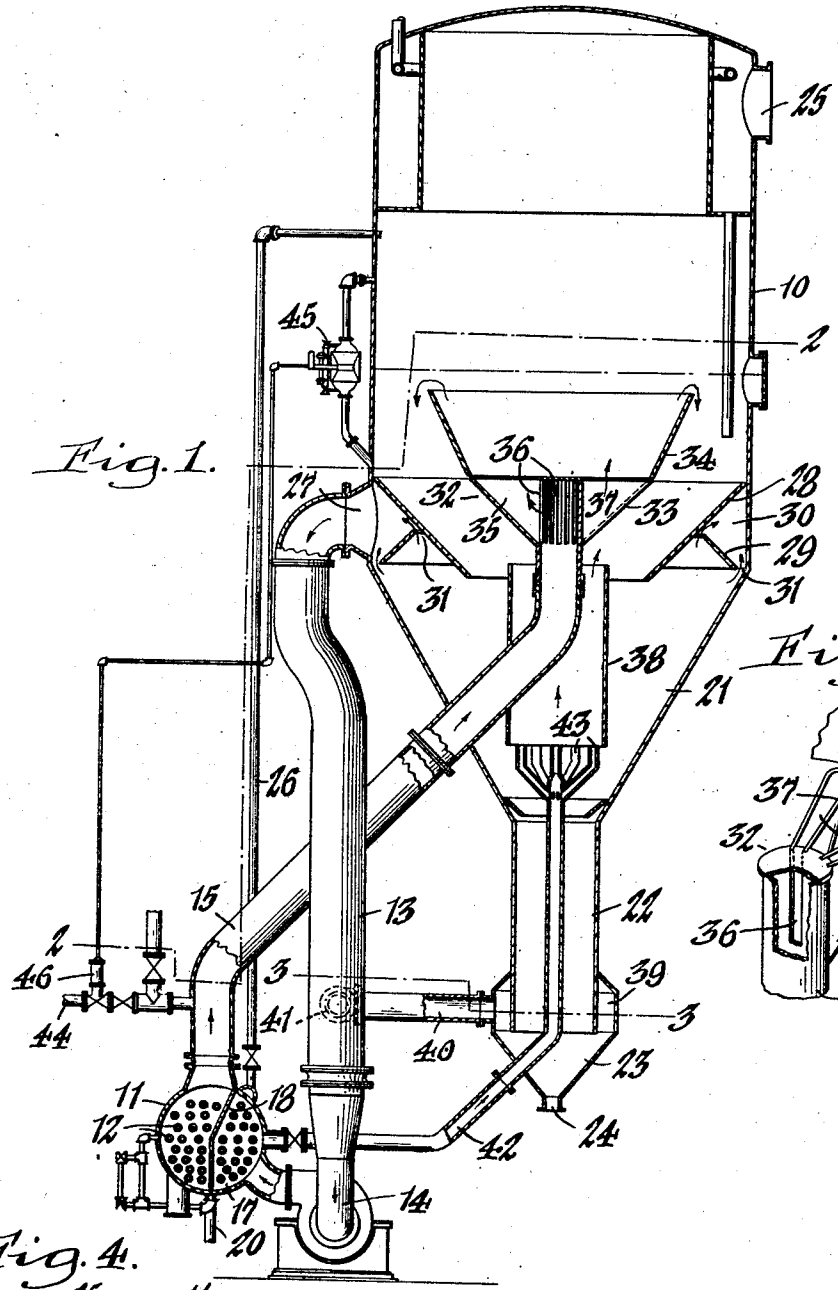
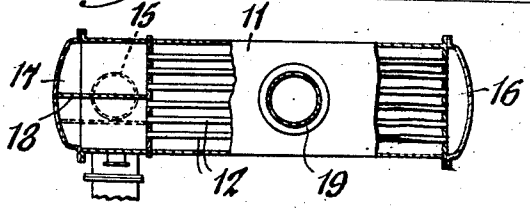


Fig. 5.

Fig. 4.



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Fig. 2.

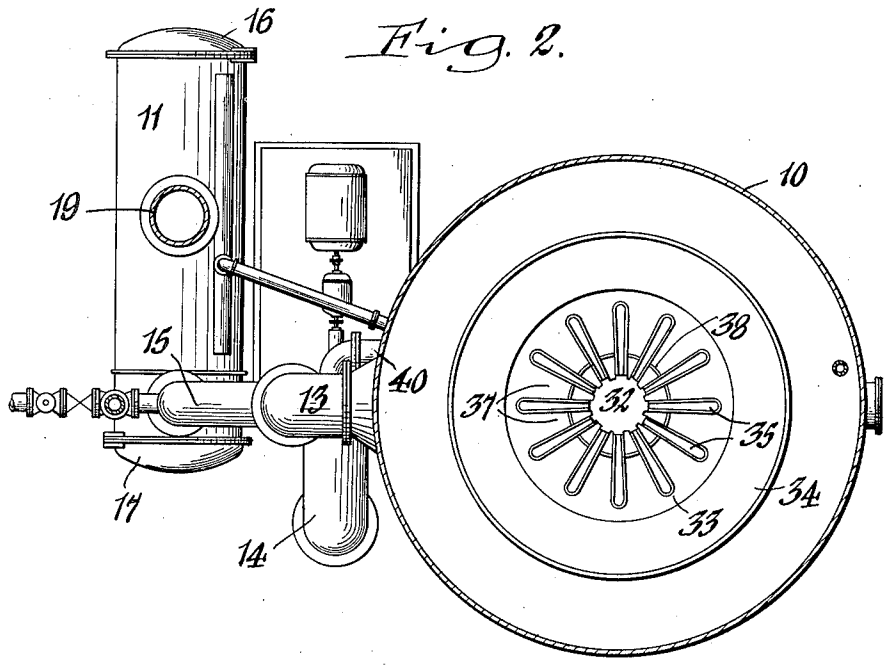
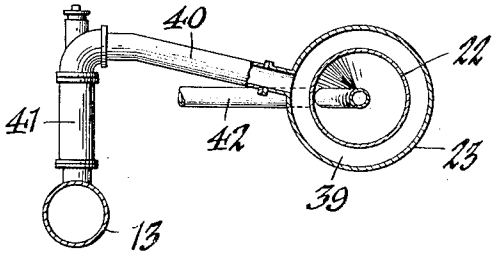


Fig. 3.



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UNITED STATES PATENT OFFICE

2,384,747

CRYSTALLIZING EVAPORATOR

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Application May 13, 1942, Serial No. 442,783

12 Claims. (Cl. 159—45)

This invention relates to certain new and useful improvements in evaporators for precipitating salts out of aqueous solutions or brines by removing part of the water by evaporation and thus concentrating the solution above saturation.

One of its objects is to provide a crystallizing evaporator which is designed to efficiently and economically produce very large crystals by effecting their repeated circulation through the boiling zone of the apparatus.

Another object of the invention is to provide an evaporator of this character having simple and effective means therein to maintain a continuous circulation of the solution therethrough at predetermined velocities to carry the smaller sized crystals repeatedly to the boiling zone to be built up to their required size and permit those crystals which have attained such size to gravitate out of solution and be discharged.

Other features of the invention reside in the construction and arrangement of parts hereinafter described and particularly pointed out in the appended claims.

In the accompanying drawings:

Figure 1 is a sectional elevation of the crystallizing evaporator embodying my invention. Figure 2 is a cross section taken substantially in the plane of line 2—2, Figure 1. Figure 3 is a cross section taken on line 3—3, Figure 1. Figure 4 is a sectional elevation of the steam-chest and connections thereto. Figure 5 is a sectional perspective view of the distributer head and associated parts.

Similar characters of reference indicate corresponding parts throughout the several views.

In its general organization my improved crystallizing evaporator comprises an evaporator body 10, a heater or steam-chest 11 including a nest of tubes 12 through which the solution to be treated is circulated and heated, a suction pipe 13 connecting the evaporator body with the intake end of the steam-chest and having a circulating pump 14 interposed therein, a return pipe 15 connecting the discharge end of the heater with the evaporator body, and means within the latter for mixing the heated solution supplied by the pipe 15 with the solution contained in the evaporator body, and providing for free upward and downward circulation of the solution within the evaporator to and from its boiling zone, including a classifier operatively associated with the evaporator for returning to its boiling zone those crystals which are too small to be discharged but which have gravitated from and have not been returned to the boiling zone through normal circulation of the solution.

The heater 11 may be of any suitable type or construction, that shown in the drawings, by way of example, having compartments 16, 17 at its opposite ends with which the tubes 12 communicate, the compartment 17 having a partition 18 therein for dividing the heater-tubes into fore and aft circulating passages with the intake section thereof connected to the discharge end of the pump 14 and the other or discharge section connected to the pipe 15 for delivering the solution to the evaporator body. The heating of the solution circulated through the heater may be effected by steam or other heating medium and for this purpose an inlet 19 is provided in the heater for introducing the heating medium thereto. A drain pipe 20 is connected to the bottom of the heater for removing the condensate therefrom.

The evaporator body, which is adapted to contain a quantity of the aqueous solution to be treated and converted into unusually large crystals for producing such material as table salt and sodium nitrate, for example, is provided at its lower end with an inverted conical section or chamber 21 down which undersize crystals are adapted to gravitate to a recirculating zone, and which terminates in a cylindrical section 22 whose lower end is provided with an inverted conical chamber 23 containing a discharge 24 for the crystal product. The normal level of the solution in the evaporator body is shown in Figure 1 and the circulating suction pipe 13 communicates at its upper end therewith at a point adjacent the enlarged end of the conical section 21, where even very small crystals are adapted to settle out of solution. At its upper end the evaporator body 10 has an opening 25 for the release of steam, and if desired this opening may be connected with a condenser or with the succeeding body of a multiple effective evaporator. The steam-chest has a vent pipe 26 leading therefrom which is connected to the evaporator body, as shown in Figure 1.

Disposed in the lower portion of the evaporator body 10 adjacent the upper end of its inverted conical section 21 and substantially in the plane of its outlet 27 connected to the suction pipe 13 is an inverted conical partition 28 which is connected at its upper end to the inner wall of the evaporator while its remaining portion is spaced therefrom and extends at its lower end into open communication with the conical section 21. An oppositely-disposed conical partition 29 is dis-

posed between the conical partition 28 and the evaporator body to form a chamber 30 which is disposed in the zone of the solution outlet 27, as shown in Figure 1. The lower and upper edges of the conical partition 29 are spaced from the adjoining walls of the evaporator body and opposing partition 28, respectively, to provide annular passages 31 for the upward circulation of the solution from the conical section 21 into the chamber 30 and thence outwardly through the outlet 27 into the suction pipe 13.

A diffuser, indicated generally by the numeral 32, is disposed in the evaporator body below the normal level of the solution therein and in spaced relation thereto as well as to the conical partition 28 and is so designed as to effect the circulation of the heated solution introduced from the pipe 15 into the evaporator body with that contained in such body, as well as to separate the ascending current of solution inside the diffuser from the descending current exteriorly thereof. To this end the solution delivery pipe 15 extends through the side of the conical section 21 and terminates in an axially-disposed discharge portion 32 closed at its top and on which the diffuser is suitably mounted in operative circulating relation thereto. This diffuser preferably consists of a distributer head 33, of substantially inverted conical shape, and an annular extension or separator wall 34 rising therefrom in spaced relation to the surrounding wall of the evaporator body and terminating at its upper end below the level of the solution in such body. The distributer head includes hollow, radial arms or jets 35 whose inner edges are substantially upright and coextensive with the wall of the discharge portion 32 of the pipe 15 and which communicate with the latter through slots 36 formed therein, and whereby the heated solution is circulated upwardly from said pipe directly into the distributer and discharged in relatively thin sheets through the open upper ends of the hollow distributer arms into the adjoining chamber defined or enclosed by the partition wall 34, and which chamber constitutes the boiling zone of the evaporator. Between these distributer arms 35 are intervening spaces or ports 37 which provide for further upward circulation of the body of the solution surrounding the distributer and its separator wall 34. The heated solution, in passing from the pipe 15 through the distributer, is discharged at such a velocity through the ported distributer arms that part of its energy is imparted directly into the solution entrained within the chamber provided by the separator wall 34, thus causing upward circulation, through the distributer-ports 37, of the solution surrounding the lower portion of the diffuser and downward circulation of the solution surrounding said separator wall. That portion of the solution in the evaporator body which is not affected by the downward circulation induced by the entrance of the heated solution into the boiling zone, or that portion thereof adjoining the conical partition 28, is circulated downwardly into the upper portion of the conical evaporator section 21, then upwardly through the annular passages 31 into the chamber 30, and thence through the suction pipe 13 to the circulating pump 14. By mixing the heated solution with the much larger volume of unheated solution in the zone of the diffuser, the boiling is distributed over the entire area enclosed by the partition 34, thus giving a large steam disengaging surface and the ebullition is quiet. This condition is highly favorable to the building up of crystals to a large size, by recirculating them and bringing them repeatedly into the zone where the material is thrown out of solution by evaporation of water from the solution.

For the purpose of effecting further recirculation of the solution into the boiling zone defined by the separator wall 34, and thereby produce crystals of very large and uniform size, as, for example, in producing such materials as table salt and sodium nitrate, means are provided to intercept and carry the small crystals which gravitate down the conical section 21 of the evaporation back to the distributer head. This means preferably consists of a large pipe or tube 38 disposed axially of such conical section in spaced relation thereto to provide inner and outer chambers for the upward and downward circulation of the solution, respectively, therein. This tube terminates at its upper end adjacent the lower end of the distributer head 33 in open communication with its ports 37 and in spaced surrounding relation to the discharge portion 32 of the solution delivery pipe 15, and terminates at its lower end in spaced relation to the smaller end of the conical section 21 to permit circulation of the solution therein into the lower end of said tube.

Located below the conical section 21 of the evaporator body 10 is the classifier which functions to return to the boiling zone those crystals which gravitate down such section but which have not been recirculated or returned by the tube 38. This classifier is composed of the tubular extension 22 depending from the conical section 21 and the communicating inverted conical chamber 23 whose upper portion is in concentric spaced relation to the lower end of such extension to provide an annular chamber 39 adapted for communication with the suction pipe 13 through the medium of a by-pass connection or pipe 40 and a variable speed, low head pump 41 interposed therein.

Upward flow of solution into the tube 38 is not only induced by that circulated by the pump 14 into the distributer head 33, but also by solution taken from that compartment 17 of the steam-chest 11 in direct communication with such pump, and for this purpose a pipe 42 is provided which extends upwardly and centrally through the classifier tube 22 depending from the cone section 21 and terminates at its upper end in a distributer preferably including a plurality of jet pipes 43 which open at their upper ends into the lower end of the tube 38. The circulating pump operates under a normal head of from 11 to 13 feet and there is sufficient power available in the small quantity of solution delivered by it through the pipe 42 to induce a rapid upward flow in the tube 38 and carry any small crystals gravitating down the conical section 21 upwardly through such tube into the distributer head and the boiling zone.

In the operation of the apparatus, the solution to be treated is continuously supplied to the evaporator 10 at the rate required to maintain the desired level therein, the pump 14 being operated continuously to draw the solution through the suction pipe 13 and force it through the heater-tubes 12, return pipes 15, 42, and distributer head 33 into the entrained body of liquid or boiling zone defined by the separator wall 34. The low head pump 41 also operates continuously to circulate the solution upwardly through the classifier 22, 23. The conical wall

above the distributer head separates the ascending current of solution within the boiling zone from the descending current between such wall and the evaporator body. By reason of the continual circulation, crystals thrown out of solution are repeatedly carried upwardly through the boiling zone until they attain a size that causes them to settle into the conical section 21 of the evaporator body. Those smaller crystals which gravitate down this concial section, instead of gravitating to the crystal outlet 24, are caused to be recirculated or carried back to the distributer head and into the boiling zone, being directed into the bottom of the tube 38 and thence upwardly into the distributor head by the induced circulation created by forcing part of the solution from the steam-chest by the pump 14 into the pipe 42. In like manner, those crystals which are still too small to be discharged but which have not been directed into the tube 38 for recirculation and building up in the boiling zone, are intercepted at the classifier or lower cone 23 and returned to such zone. Upward flow of the solution and smaller crystals in this classifier is induced by the low head pump 41 operating at from 2 to 4 feet total head. The velocity in this lower cone is necessarily slightly higher than that in the upper cone or section 21, and the other flow areas in the evaporator are of predetermined size in order to maintain the velocity required to return the smaller crystals into the boiling zone for building up purposes and to permit those crystals which have attained the required size to gravitate to the bottom of the lower cone 23 where they are discharged at 24 and delivered to suitable filtering equipment (not shown).

The solution is maintained at the desired level in the evaporator body by continuously supplying solution to replace that evaporated or removed as crystals, and for this purpose a solution inlet pipe 44 is provided which is connected to the pipe 15, while a liquid level control 45 of any suitable construction is provided for automatically controlling such flow through a control valve 46 disposed in the inlet pipe.

I claim as my invention:

1. A crystallizing evaporator, comprising a container for the soltion to be crystallized, means disposed in superposed relation below the solution-level and spaced from the container wall for defining substantially concentric circulating zones including companion inner chambers for the upward circulation of the solution and companion outer chambers for the downward circulation of the solution, the respective chambers being in communicating relation, pipes for conveying solution to the lower ends and substantially centrally of said inner chambers, respectively, means surrounding and interposed between the discharge ends of said conveying pipes and the opposing ends of said inner chambers for controlling the flow of solution thereto and for inducing circulation upwardly in the inner chambers and downwardly in the outer chambers, a crystal-receiving section depending from the bottom of the container in communication with the lower circulating zone thereof and into which the crystals resulting from the treated solution are adapted to gravitate, and means for inducing a circulation of the solution upwardly through said section for returning small-sized crystals to the lower circulating zone for recirculation.

2. A crystallizing evaporator, comprising a container for liquid to be crystallized having a concentrically arranged, partition-like wall in the upper portion thereof and below the level of the liquid therein and defining an inner chamber for the upward circulation of the liquid and an outer chamber for the downward circulation of the liquid, means for supplying heated liquid under pressure to the lower end of the inner chamber defined by said partition-like wall, means interposed between the discharge end of said liquid-supplying means and the lower end of said inner chamber for introducing the liquid in stream-like fashion into such chamber and for establishing induced down circulation of the liquid from the outer chamber into the inner chamber, means disposed in the lower portion of said container for dividing the same into upward and downward circulating zones and communicating at their upper ends with the companion inner and outer chambers defined by said partition wall, and a crystal-receiving section depending from the lower end of the container and into which large-sized crystals gravitate for discharge and through which small-sized crystals are circulated upwardly into said circulating zones.

3. A crystallizing evaporator, comprising a container for liquid to be crystallized having a concentrically arranged, partition-like wall in the upper portion thereof and below the level of the liquid therein and defining an inner chamber for the upward circulation of the liquid and an outer chamber for the downward circulation of the liquid, means for supplying heated liquid under pressure to the lower end of the inner chamber defined by said partition-like wall, means interposed between the discharge end of said liquid-supplying means and the lower end of said inner chamber for introducing the liquid in stream-like fashion into such chamber and for establishing induced down circulation of the liquid from the outer chamber into the inner chamber, means disposed in the lower portion of said container for dividing the same into upward and downward circulating zones and communicating at their upper ends with the companion inner and outer chambers defined by said partition wall, means disposed adjacent the lower end of said zone-dividing means for supplying liquid under pressure to the upward circulating zone defined thereby and for establishing induced down circulation of the liquid from the down-circulating zone into the upward circulating zone, and a classifier depending from the bottom of the container and having means connected thereto for causing an upward flow of the liquid therein to return small-sized crystals to said circulating zones.

4. A crystallizing evaporator, comprising a container for the solution to be crystallized, means disposed in superposed relation below the solution level and spaced from the container wall for defining upper and lower circulating zones including companion inner chambers for the upward circulation of the solution and companion concentrically-arranged outer chambers for the downward circulation of the solution, the respective chambers being in communicating relation, a heater for heating the solution, pump means interposed between the container and the heater including downwardly and upwardly circulating pipes for conducting the solution from the outer chamber of the upper circulating zone to the lower ends and substantially centrally of the respective inner chambers of said upper and

lower circulating zones, distributer heads at the discharge ends of said solution-returning pipes for directing the solution into the lower portions of the inner chambers of said circulating zones and for establishing induced circulation of the solution from the outer chambers of such zones into the inner chambers thereof, and a classifier depending from the bottom of the container and having means connected thereto for causing an upward flow of the liquid therein to return small-sized crystals to said circulating zones.

5. A crystallizing evaporator, comprising a container for the solution to be crystallized having upper and lower separator walls therein below the solution-level and defining concentric interior and exterior circulating zones for the upward and downward flow, respectively, of the solution about such walls, distributer heads disposed in operative communication with the lower ends of the zones defined by said separator walls, a heater for heating the solution, pump means interposed between the container and the heater including a pipe for withdrawing the solution from the upper circulating zone of the container through the heater and pipes leading from the heater to said distributer heads for delivering the solution through the lower ends of the latter into the respective interior circulating zones defined by said separator walls, and means connecting said first-named pipe with said container at a point below the lower separator wall and its distributer head for delivering a portion of the withdrawn solution under pressure to the companion circulating zone for causing an upward flow of the liquid and any small-sized crystals contained therein to said circulating zones.

6. A crystallizing evaporator, comprising a container for the solution to be crystallized having upper and lower circulating zones therein and a communicating discharge section for the crystallized product depending from such lower circulating zone, means in said zones defining concentrically-arranged interior and exterior chambers for the upward and downward flow of the solution therein, a heater for heating the solution, pump means interposed between the container and the heater including a pipe for withdrawing the solution from the upper circulating zone through the heater and pipes leading from the heater to the lower ends of the respective interior chambers for delivering the solution thereto, distributor means disposed adjacent the lower ends of said zone-defining means and in operative communication with the discharge ends of said last-named pipes for establishing induced circulation of the solution in the respective zones downwardly through their exterior chambers and upwardly into their interior chambers, and means connecting said solution withdrawal pipe in advance of its pump means with said product-discharge section including a pump for inducing the circulation of some of the withdrawn solution upwardly through said discharge section to return any small-sized crystals contained therein into the lower circulating zone.

7. A crystallizing evaporator, comprising a container for the solution to be crystallized including means therein and below the solution-level thereof for dividing it into inner and outer chambers for the upward and downward circulation of the solution a heater for heating the solution, a pipe for conveying heated solution from the heater to said container at a point adjacent the lower end of said inner chamber, a distributer disposed between the discharge end of said pipe and said chamber-forming means for directing the flow of heated solution upwardly into said inner chamber and for establishing induced circulation of the solution from the outer into the inner chamber thereof, pump means for withdrawing the solution from the outer circulating chamber of the container to the heater and thence to said pipe for returning the heated solution to said distributer, and a classifier depending from and in circulating communication with said container for returning the smaller crystals in the solution to the induced circulating zone of the container, said classifier having a pipe at its lower end connected with said solution-withdrawing means and including a second pump for circulating a portion of the withdrawn solution upwardly through the classifier to return any small-sized crystals contained therein to the distributer.

8. An evaporator of the character described, comprising a container for the solution to be treated including an upper section and an intermediate section defining intercommunicating upper and lower circulating zones, respectively, for the building up of crystals from the solution and a lower communicating classifier section into which the larger crystals are adapted to gravitate and from which they are discharged, means in the upper and intermediate sections for dividing them into substantially concentrically-disposed inner and outer circulating chambers for the upward and downward circulation of the solution therethrough, a heater through which the solution is circulated and heated, a suction pipe connecting the upper section of the container with the intake of the heater and including a circulating pump interposed therein, a return pipe connecting the discharge end of the heater with the lower end of the inner chamber of said upper circulating zone at a point substantially centrally thereof, a second return pipe connecting the intake end of the heater with the lower end of the inner chamber of said lower circulating zone at a point substantially centrally thereof, means in said circulating zones and in operative relation with the respective return pipes thereof for effecting upward and downward circulation of the solution within the container to and from the boiling zone in the upper section thereof, and means establishing communication between the lower end of said classifier section and said suction pipe including a pump for circulating a portion of the withdrawn solution from the container upwardly through said classifier section to return any of the smaller crystals gravitating therein to the aforesaid circulating zones.

9. A crystallizing evaporator, comprising a container for the solution to be treated, means disposed in superposed relation below the solution level and spaced from the container wall for defining upper and lower circulating zones including companion inner chambers for the upward circulation of the solution and companion concentrically arranged outer chambers for the downward circulation of the solution, the respective chambers being in communicating relation, a heater for heating the solution, a downwardly-circulating solution-conducting pipe connecting the container with the heater and including a circulating pump interposed therein for withdrawing the solution from the outer zone-defined chambers to the heater, upwardly circulating solution-return pipes connecting the heater with the inner chambers of the respective upper and lower circulating zones, said return pipes discharging into

the container adjacent the lower ends of said inner chambers, and distributor heads at the discharge ends of said upwardly-circulating return pipes for directing the solution into the lower portions of the inner chambers and for establishing induced circulation of the solution from the outer chambers of such upper and lower circulating zones into the inner chambers thereof.

10. A crystallizing evaporator, comprising a container for the solution to be treated, means disposed in superposed relation below the solution level and spaced from the container wall for defining upper and lower circulating zones including companion inner chambers for the upward circulation of the solution and companion concentrically arranged outer chambers for the downward circulation of the solution, the respective chambers being in communicating relation, a heater for heating the solution, a downwardly-circulating solution-conducting pipe connecting the container with the heater and including a circulating pump interposed therein for withdrawing the solution from the outer zone-defined chambers to the heater, upwardly circulating solution-return pipes connecting the heater with the inner chambers of the respective upper and lower circulating zones said return pipes discharging into the container adjacent the lower ends of said inner chambers, distributor heads at the discharge ends of said upwardly-circulating return pipes for directing the solution into the lower portions of the inner chambers and for establishing induced circulation of the solution from the outer chambers of such upper and lower circulating zones into the inner chambers thereof, and means depending from and in communicating relation with the lower end of the container for receiving and subsequently returning any smaller gravitating crystals in the solution to the lower circulating zone, said means having a by-pass connection to said downwardly-circulating pipe and including a pump interposed therein for circulating a portion of the solution together with such smaller crystals withdrawn from the upward circulating zone of the container upwardly through such means to the lower circulating zone.

11. A crystallizing evaporator of the character described, comprising a container for the solution to be treated, a heater through which the solution is circulated and heated, a suction pipe connecting the upper portion of the container below the solution level thereof with the intake end of the heater and including a circulating pump interposed therein, a return pipe connecting the discharge end of the heater with said container, a second return pipe connecting the intake end of the heater with said container at a point below that of said first-named return pipe, said return pipes discharging in the container at points substantially axially and at different elevations thereof, and partition-like means disposed in superposed relation below the solution level and spaced from the container wall for defining upper and lower circulating zones including companion inner chambers for the upward circulation of the solution and companion outer chambers for the downward circulation thereof, the lower ends of said inner chambers communicating, respectively, with the discharge ends of the first and second-named return pipes for establishing induced circulation of the solution from the outer chambers of such zones into the inner chambers thereof for effecting upward and downward circulation of the solution within the container and to and from the level of the solution therein.

12. A crystallizing evaporator, comprising a container for the solution to be treated including a cylindrical upper section, an intermediate inverted conical section and a lower cylindrical section, means in the upper and conical sections for dividing them into substantially concentrically-disposed inner and outer circulating chambers for the upward and downward circulation of the solution in predetermined zones, a heater for heating the solution, a pump interposed between the container and the heater and including a suction pipe for circulating the solution from the upper section of the container through the heater and pipes for returning the heated solution under pressure from the heater to the container and having their discharge ends in communication with the lower ends of said inner circulating chambers, respectively, means correlated with the discharge ends of said return pipes for causing the entrainment of the returned solution with that in the container to effect the induced circulation of the solution upwardly through said inner chambers and downwardly through said outer chambers, and a by-pass connection between said suction pipe and the lower container section and including a pump for inducing the upward flow of solution through such section.

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