Aug. 1, 1961 W. R. WILLIAMSON ET AL 2,994,647

FLASH EVAPORATOR

Filed March 31, 1958

FIG. 3.

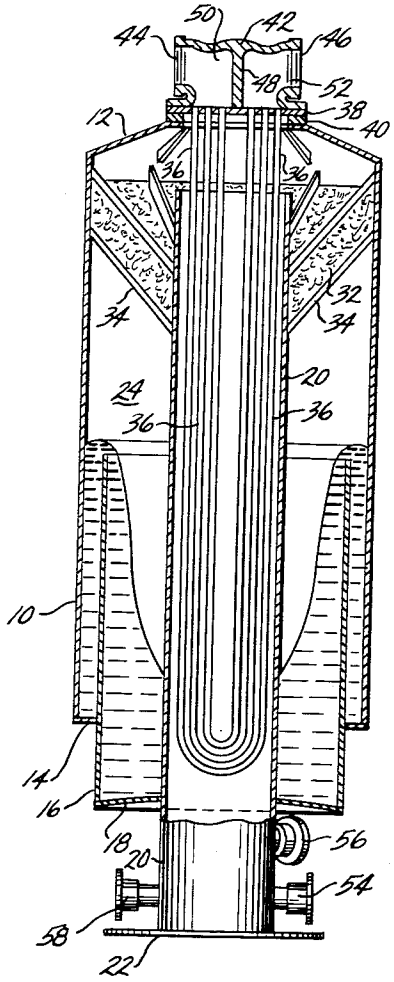


FIG. 1.

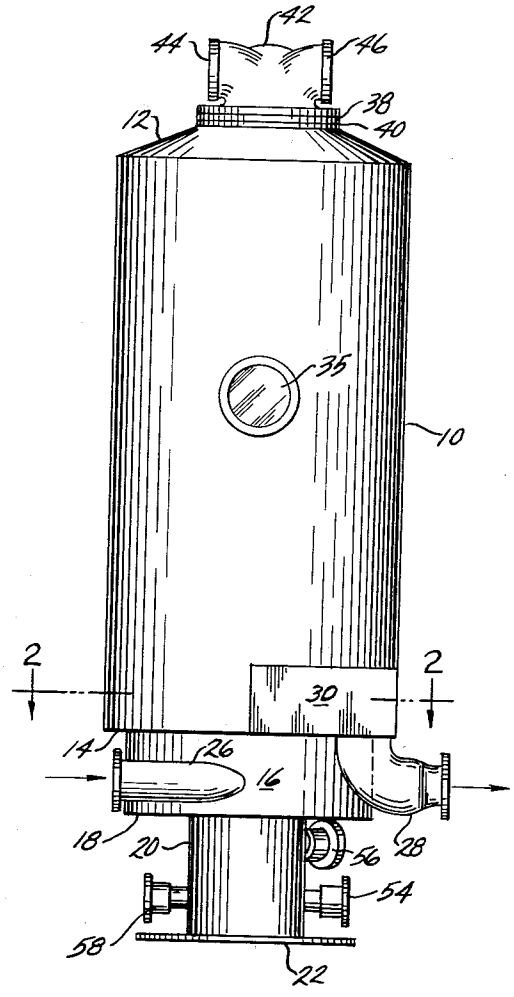
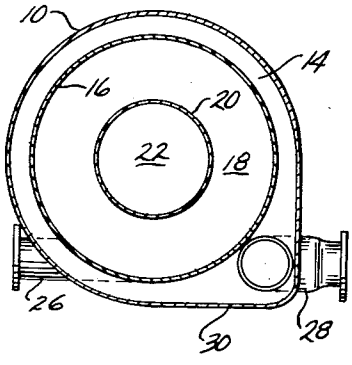


FIG. 2.



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FLASH EVAPORATOR

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This invention relates to improvements in sea water evaporation and, more specifically, to an improved flash evaporator.

It is the general object of the invention to provide a flash evaporator which can be used in sea water distillation with greater efficiency than other flash evaporators and to produce a more pure distillate at a higher capacity than flash evaporators of comparable size.

A further object of the invention is to provide a flash evaporator having a built-in vapor condenser so as to provide a complete distillation plant in one compact space saving unit which is of sturdy construction and adapted for easy connection to one or more additional evaporator units of similar or different construction and form.

The drawing shows a preferred embodiment of the invention and such embodiment will be described, but it will be understood that various changes may be made from the construction disclosed, and that the drawing and description are not to be construed as defining or limiting the scope of the invention, the claims forming a part of this specification being relied upon for that purpose.

Of the drawing:

FIG. 1 is an elevational view of a flash evaporator incorporating the features of the present invention;

FIG. 2 is a horizontal, cross-sectional view of the evaporator taken as indicated by the line **2—2** of FIG. 1; and

FIG. 3 is a vertical cross-sectional view of the evaporator shown in FIG. 1.

As will be described in greater detail hereinafter, the sea water which is to be flashed into steam or vapor is introduced tangentially at the lower end of a substantially vertical and preferably cylindrical shell. The sea water is introduced in sufficient volume and at a rate which will cause a substantial body of sea water to be established within the shell above the said tangential inlet. Due to the swirling movement of the body of sea water, its surface is paraboloidal in form with the crest of the surface at the wall of the vertical shell. The parabolic surface of revolution is formed about a vertical axis which coincides or substantially coincides with the vertical center line of the shell.

It has been found that the vapor or steam flashing from the body of sea water above the sea water inlet entrains less sea water and is accordingly more salt-free than the vapor flashing from the conventional flash evaporators wherein the flashing takes place near the sea water inlet. In the past, efforts have been made to suppress flashing immediately adjacent the sea water inlets by using orifice plates and nozzles. However, the need for such devices is eliminated in accordance with this invention which provides for a submerged inlet. The static head over the inlet provided by the body of water at the lowest point on its surface is sufficient to prevent premature flashing and there is no need to resort to the aforementioned orifice plates and nozzles. Moreover, the static head increases gradually from the lowest surface point to the highest surface point to provide for a more gradual or controlled release of vapor than is provided with the use of orifices and nozzles. In addition, the total amount of vapor released in the evaporator of this invention is greater than in a conventional flash evaporator of comparable size, because of the increase in water surface area provided by the paraboloidal form thereof.

As will also be described in further detail, a vapor condenser is disposed substantially centrally and co-axially within the evaporator shell so as to provide a complete distillation unit of compact size. An additional advantage of providing for a built-in condenser is that pressure drops encountered and associated with externally located condensers are avoided.

Referring now to the drawing in greater detail for an explanation of the aforesaid features, it will be observed that the flash evaporator comprises a substantially vertical and preferably cylindrical shell **10** of substantial diameter which is closed at the top by a dished header **12**, the convex side of which faces outwardly and upwardly. The bottom of the shell **10** is closed by a ring or an annulus **14** which is secured at its inner periphery to an inner cylindrical shell **16** extending well into the outer shell **10** from the bottom thereof for a purpose to be described hereinafter. The bottom of the inner shell **16** is closed by a dished ring or annular header **18** having its concave side facing downwardly and which at its inner periphery is secured to a preferably cylindrical vertically disposed tube housing **20** which may also be referred to hereinafter as a condenser housing or shell. The tube housing extends upwardly within the inner shell **16** and the outer shell **10** for purposes to be described, and the said shells and tube housing are preferably coaxially or concentrically arranged. Thus, as will be observed from FIGS. 1 and 3, the inner shell **16** extends below the outer shell **10** and the tube or condenser housing **20** extends below the said inner shell. The evaporator as described can be supported in a vertical position on suitable frame members extending from the floor to either or both of the shells **10** and **16**, or the evaporator can be supported as shown on the tube housing or condenser housing **20** which rests upon a suitable floor base **22**.

In the flash evaporation of sea water, it has been a common pratice to introduce sea water at an elevated temperature to a flash chamber defined within an evaporator shell wherein a partial vacuum has been established, the sea water temperature being in excess of the boiling temperature for the vacuum condition present. The vacuum is generally established by connecting the chamber to a vapor condenser, and the sea water is generally introduced in the prior evaporators to the flash chamber from an elevated inlet so that much of the flashing occurs at or adjacent to the inlet opening or nozzle. Frequently, the sea water has been introduced in a spray through suitable nozzle means to assist the flashing, but some of the flashing will occur at the surface of a body of sea water established within the evaporator shell. After being exposed to the partial vacuum within the evaporator shell, the sea water is withdrawn from the evaporator through suitable conduit means.

While the main or outer shell **10** of the evaporator provided in accordance with the present invention does define a flash chamber or vaporizing chamber **24**, the sea water is not introduced directly thereto by an elevated inlet or nozzle. In the evaporator of our invention, the sea water is introduced through a conduit **26** which opens tangentially into the inner shell **16** adjacent its bottom header **18** and well below the bottom of the main or outer shell **10**. As will be noted in FIG. 3, the inner shell **16** is spaced inwardly from the outer shell **10** and extends a substantial distance upwardly therein from the bottom end of the said outer shell. It will also be observed that the cylindrical inner shell **16** is open at the top. Thus, it will be seen that before the sea water can

reach the outer shell **10**, a body of the water must be built up within the cup-shaped inner shell **16** and spill over the top edge thereof. Accordingly, the inner shell may be referred to as a cylindrical dam or weir or as a cylindrical spill-over baffle. Since the sea water is introduced to the bottom of the cup-shaped inner shell tangentially and at a high flow rate, the body of water formed therein and spilling over its top edge will have a generally parabolic surface.

The parabolic surface of revolution increases the flash area or interface area of the body of water whereby to increase the amount of flashing or volume of vapor derived from this evaporator when compared to a more conventional evaporator of equal shell size. Moreover, the vapor flashing from the surface of the body of water entrains less sea water and is consequently more salt-free. It is believed that reduced salinity content of the vapor results from the fact that the vapor is released from a surface well above the sea water inlet so that little turbulence is encountered. It is further believed that turbulence adjacent the sea water inlet or nozzle in a conventional flash evaporator causes much of the sea water entrainment in the vapor derived therein.

In addition, a greater amount of flashing occurs because of the passage of the body of water over the top edge of the inner shell **16**. In spilling over the top edge, a great amount of vapor is released from the water at the said edge. That is, the greatest possible flashing area is provided at the top edge of inner shell **16**, and at said top edge the static head, or distance from the edge to the water surface, is at a minimum or its lowest value. Therefore, for a given rate of flow, the liquid temperature of the spill over or rejected brine more closely approaches the vapor temperature. This, of course, results in high efficiency.

The sea water or brine spilling over the edge of the cylindrical inner shell or dam flows downwardly in the outer shell into the annular space surrounding the said inner shell. The concentrated sea water or brine is then removed from the outer shell **10** through a discharge conduit **28** which is connected at the bottom of the outer shell in an angular or corner extension **30** thereof as best shown in FIGS. 1 and 2. That is, a box-like corner extension **30** is provided at the bottom of the shell **10** to define a discharge chamber and to accommodate the discharge conduit **28**.

At this point the advantages of connecting the sea water inlet to the inner shell **16** below the outer shell **10** should be observed. That is, by connecting the inlet conduit **26** to the inner shell **16** below the outer shell **10** it is possible to avoid construction difficulty that would be encountered in extending the said conduit through the outer shell for connection to the inner shell. In addition, the conduit **26** is not disposed in the path of whirling brine in the outer shell **10**, and the smooth flow of the brine to the discharge area is not in any way disrupted.

The vapor flashing from the body of sea water rises in the flash or vapor chamber **24** within the shell **10** and passes through a mist separating pack **32** which is supported within the outer shell adjacent its upper end. The pack **32** may be made of any suitable material, but a preferred pack is made up of wire in knitted layers, and the pack is made in conico-annular form to extend from the tube or condenser housing **20** to the outer shell **10**, and to slope upwardly from the tube to the shell. Preferably, the pack **32** is supported on suitable frame elements **34, 34** which may be welded to the tube housing and to the outer shell. Substantially the entire amount of any sea water which may be entrained with the vapor and carried thereby is separated in the pack **32** and by capillary action flows along the pack to the surface of the tube housing **20** or to the surface of the outer shell **10** and then flows downwardly. A sight port **35** (FIG. 1) is provided in shell **10** for observation of the interior of the shell whereby the flow of water along the shell can be seen.

The vapor passing through the pack flows radially inwardly at the top of the outer shell and enters the centrally disposed tube housing or condenser housing **20**. It will be observed that the top end of condenser housing **20** is located above the pack **32** and that it is open. The open end of the cylindrical housing **20** receives a tube bundle comprising a plurality of elongated condenser tubes **36, 36** which are U-shaped and which extend into the housing **20** from the top thereof to a point adjacent the bottom of the inner shell **16** wherein the said tubes are bent through 180° and extend out of the top of the tube. The open ends of the tubes **36, 36** are secured within and supported by a plate **38** which at its marginal portion rests upon a support ring **40** surrounding a central opening in the top header **12** of the evaporator shell **10**. A dome **42** is secured over the tube plate **38** and has a water inlet **44** and a water outlet **46**. The dome also has a substantially vertical partition **48** which separates the interior of the said dome into an inlet chamber **50** and an outlet chamber **52**. Cold water introduced to the chamber **50** through the inlet **44** flows into the inlet ends of the U-shaped condensing tubes **36, 36** and downwardly within the said tubes and then upwardly through the tubes into the chamber **52** and the discharge opening **46**. It will be understood that condensers of specifically different form may be used, such as floating tube condensers which eliminate the necessity for bent tubes.

In passing through the condenser tubes **36, 36**, the water therein absorbs heat from the sea water vapors causing condensation thereof within the tube housing or condenser **20**. That is, the water introduced to the condenser tubes **36, 36** is at a temperature substantially lower than the vapor temperature so as to cause condensation thereof. The condensation of the vapor within the condenser housing **20** creates the vacuum for the evaporator and establishes a body of fresh water distillate to the bottom of the said housing below the condenser tubes **36, 36**. The distillate is withdrawn from the bottom end of the condenser housing, which may be referred to as a distillate sump, through a discharge conduit **54**. Air and other non-condensibles which may accumulate in the distillate sump are discharged through a conduit **56** by suitable pumping means (not shown) such as an ejector.

The aforedescribed flash evaporator is particularly well adapted or suited for connection with a plurality of similar or different evaporators so as to provide one stage of evaporation in a multi-unit or multi-stage plant. When the evaporator is connected to one or more similar flash evaporators, it is desirable to connect the cold water inlet **44** at the dome **42** with the cold water outlet **46** of the dome of an adjacent evaporator, the connection being effected by a suitable conduit. Also, in effecting a multi-stage connection, it is desirable to have the distillate from one unit flow through the distillate sump of an adjacent unit. To facilitate such connection, each flash evaporator is preferably provided with an inlet conduit **58** at its distillate sump for connection with the discharge conduit **54** of an adjacent similar unit. In addition, the sea water or brine outlet **28** of one evaporator can be connected with the sea water inlet **26** of an adjacent evaporator.

Obviously, the location of the various conduits can be altered within the scope of the invention to suit the needs of any specific installation. It should also be obvious that other and perhaps more substantial changes in construction can be effected within the scope of the following claims.

The invention claimed is:

1. A flash evaporator comprising a closed outer shell, means for establishing a partial vacuum within said outer shell, a substantially vertical inner shell which is closed at the bottom and open at the top and which extends upwardly into said outer shell in spaced relationship to the

sides thereof to define therewith an unobstructed annular chamber to accommodate a swirling body of liquid, means for introducing a liquid to be evaporated to the inner shell so as to establish a body of the liquid therein which spills over the open top of the inner shell, the said surface being defined above the liquid introducing means, and means for discharging from the outer shell liquid which spills over the said inner shell.

2. A flash evaporator comprising a closed outer shell, means for establishing a partial vacuum within said outer shell, a substantially vertical cylindrical inner shell which is closed at the bottom and open at the top and which extends into said outer shell from the bottom in spaced relationship to the sides thereof to define therewith an unobstructed annular chamber to accommodate a swirling body of liquid, means for introducing a liquid to be evaporated to the inner shell so as to establish a revolving body of the liquid therein which spills over the open top of the inner shell and which defines a surface of generally paraboloidal form about a substantially vertical axis, the said surface being defined above the liquid introducing means, and means for discharging from the outer shell liquid which spills over the said inner shell.

3. A flash evaporator comprising a closed outer shell, means for establishing a partial vacuum within said outer shell, a substantially vertical cylindrical inner shell which is closed at the bottom and open at the top and which extends into said outer shell from the bottom thereof in spaced relationship to the sides thereof to define therewith an unobstructed annular chamber to accommodate a swirling body of liquid, the bottom of the inner shell being disposed below the outer shell, a tangential inlet conduit opening into the inner shell adjacent the bottom thereof for introducing the liquid to be evaporated and to establish a revolving body of the liquid which spills over in the inner shell at the open top and which defines a surface of generally paraboloidal form about a substantially vertical axis, the said surface being defined above the said inlet, and means for discharging from the outer shell liquid which spills over the said inner shell.

4. A flash evaporator comprising a closed outer shell, means for establishing a partial vacuum within said outer shell, a substantially vertical cylindrical inner shell which is closed at the bottom and open at the top and which extends into said outer shell from the bottom thereof in spaced relationship to the sides thereof to define therewith an unobstructed annular chamber to accommodate a swirling body of liquid, the bottom of the inner shell being disposed below the outer shell, a tangential inlet conduit opening into the inner shell adjacent the bottom thereof for introducing the liquid to be evaporated and to establish a revolving body of the liquid which spills over in the inner shell at the open top and which defines a surface of generally paraboloidal form about a substantially vertical axis, the said surface being defined above the said inlet, and means for discharging from the outer shell liquid which spills over the said inner shell comprising a box-like corner extension on the outer shell at the bottom thereof having a bottom opening therein.

5. A flash evaporator comprising a closed outer shell, a substantially vertical inner shell which is closed at the bottom and open at the top and which extends upwardly in said outer shell in spaced relationship to the sides thereof to define therewith an unobstructed annular chamber adapted to accommodate a swirling body of liquid, a substantially vertical condenser having a housing which is spaced inwardly from said inner shell and which is closed at the bottom and open at the top to receive vapors from the outer shell and which extends above said inner shell, means for introducing a liquid to be evaporated to the inner shell so as to establish a body of the liquid therein which spills over the top of the inner shell while flashing vapors, means for discharging from the outer shell liquid which spills over the said inner shell, and means for discharging condensate from said condenser housing.

6. A flash evaporator comprising a closed outer shell, a substantially vertical cylindrical inner shell which is closed at the bottom and open at the top and which extends into said outer shell from the bottom in spaced relationship to the sides thereof to define therewith an unobstructed annular chamber to accommodate a swirling body of liquid, a substantially vertical condenser having a housing which is spaced inwardly from said inner shell and which is closed at the bottom and open at the top to receive vapors from the outer shell and which extends upwardly in said inner shell from the bottom thereof, means for introducing a liquid to be evaporated to the inner shell so as to establish a revolving body of the liquid around said condenser housing and which spills over the top of the inner shell while flashing vapors and which defines a surface of generally paraboloidal form about a substantially vertical axis, the said surface being defined above the liquid introducing means, means for discharging from the outer shell liquid which spills over the said inner shell, and means for discharging condensate from said condenser housing.

7. A flash evaporator comprising a closed outer shell, a substantially cylindrical inner shell which is closed at the bottom and open at the top and which extends into said outer shell from the bottom thereof in spaced relationship to the sides thereof to define therewith an unobstructed annular chamber to accommodate a swirling body of liquid, the bottom of the inner shell being disposed below the outer shell, a substantially vertical condenser having a cylindrical housing which is spaced inwardly from said inner shell and which is closed at the bottom and open at the top to receive vapors from the outer shell and which extends upwardly in said inner shell from the bottom thereof, a tangential inlet conduit for the inner shell adjacent the bottom thereof for introducing a liquid to be evaporated and to establish a revolving body of the liquid around said condenser housing and which spills over the top of the inner shell while flashing vapors and which defines a surface of generally paraboloidal form about a substantially vertical axis, means for discharging from the outer shell liquid which spills over the said inner shell, and means for discharging condensate from said condenser housing.

8. A flash evaporator comprising a closed outer shell, a substantially vertical cylindrical inner shell which is closed at the bottom and open at the top and which extends upwardly in said outer shell from the bottom thereof in spaced relationship to the sides thereof to define therewith an unobstructed annular chamber to accommodate a swirling body of liquid, the bottom of the inner shell being disposed below the outer shell, a substantially vertical condenser having a cylindrical housing which is spaced inwardly from said inner shell and which is closed at the bottom and open at the top to receive vapors from the outer shell and which extends upwardly in said inner shell with its bottom disposed below the bottom of the said inner shell, a tangential inlet for said inner shell adjacent the bottom thereof for introducing a liquid to be evaporated and to establish a revolving body of the liquid around said condenser housing and which spills over the top of the inner shell while flashing vapors and which defines a surface of generally paraboloidal form about a substantially vertical axis, means for discharging from the outer shell liquid which spills over the said inner shell, and a discharge conduit opening into said condenser housing below said inner shell to withdraw condensate therefrom.

9. A flash evaporator comprising a closed outer shell, a substantially vertical inner shell which is closed at the bottom and open at the top and which extends upwardly in said outer shell in spaced relationship to the sides thereof to define therewith an unobstructed annular chamber to accommodate a swirling body of liquid, a substan-

tially vertical condenser housing which is spaced inwardly from said inner shell and which is closed at the bottom and open at the top to receive vapors from the outer shell and which extends above said inner shell, means for introducing a liquid to be evaporated to the inner shell to establish a body of the liquid around said condenser housing and which spills over the top of the inner shell while flashing vapors, means for discharging from the outer shell liquid when spills over the said inner shell, a plurality of condenser tubes disposed within said condenser housing for circulating a vapor condensing medium therein, and means for discharging condensate from said condenser housing.

10. A flash evaporator comprising a closed outer shell, a substantially vertical cylindrical inner shell which is closed at the bottom and open at the top and which extends upwardly in said outer shell from the bottom thereof in spaced relationship to the sides thereof to define therewith an unobstructed annular chamber to accommodate a swirling body of liquid, a substantially vertical condenser housing which is spaced inwardly from said inner shell and which is closed at the bottom and open at the top to receive vapors from the outer shell and which extends above the said inner shell from the bottom thereof, a plurality of condenser tubes extending vertically into said housing from the top of the said outer shell to circulate a vapor condensing medium within said housing, means for introducing a liquid to be evaporated to the inner shell so as to establish a revolving body of the liquid around said condenser housing and which spills over the top of the inner shell while flashing vapors, means for discharging from the outer shell liquid which spills over the said inner shell, and means for discharging condensate from said condenser housing.

11. A flash evaporator comprising a closed outer shell, a substantially vertical inner shell which is closed at the bottom and open at the top and which extends upwardly in said outer shell in spaced relationship to the sides thereof to define therewith an unobstructed annular chamber to accommodate a swirling body of liquid, a substantially vertical condenser having a housing which is spaced inwardly from said inner shell and which is closed at the bottom and open at the top to receive vapors from the outer shell and which extends above said inner shell, means for introducing a liquid to be evaporated to the inner shell so as to establish a body of liquid therein which spills over the top of the inner shell while flashing vapors, means for discharging from the outer shell liquid which spills over the said inner shell, a generally annular pack of liquid and vapor separating material disposed between said condenser housing and said outer shell above said inner shell, and means for discharging condensate from said condenser housing.

12. A flash evaporator comprising a closed outer shell, a substantially vertical cylindrical inner shell which is closed at the bottom and open at the top and which extends upwardly in said outer shell from the bottom thereof in spaced relationship to the sides thereof to define therewith an unobstructed annular chamber to accommodate a swirling body of liquid, a substantially vertical condenser housing which is spaced inwardly from said inner shell and which is closed at the bottom and open at the top to receive vapors from the outer shell and which extends above the said inner shell from the bottom thereof, a plurality of condenser tubes extending vertically into said housing to circulate a vapor condensing medium within said housing, means for introducing a liquid to be evaporated to the inner shell so as to establish a revolving body of the liquid around said condenser housing and which spills over the top of the inner shell while flashing vapors, means for discharging from the outer shell liquid which spills over the said inner shell, a generally annular pack of vapor and liquid separating material extending from said condenser housing to said outer shell above said inner shell, and means for discharging condensate from said condenser housing.

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