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APPARATUS FOR DISTILLING SEA WATER

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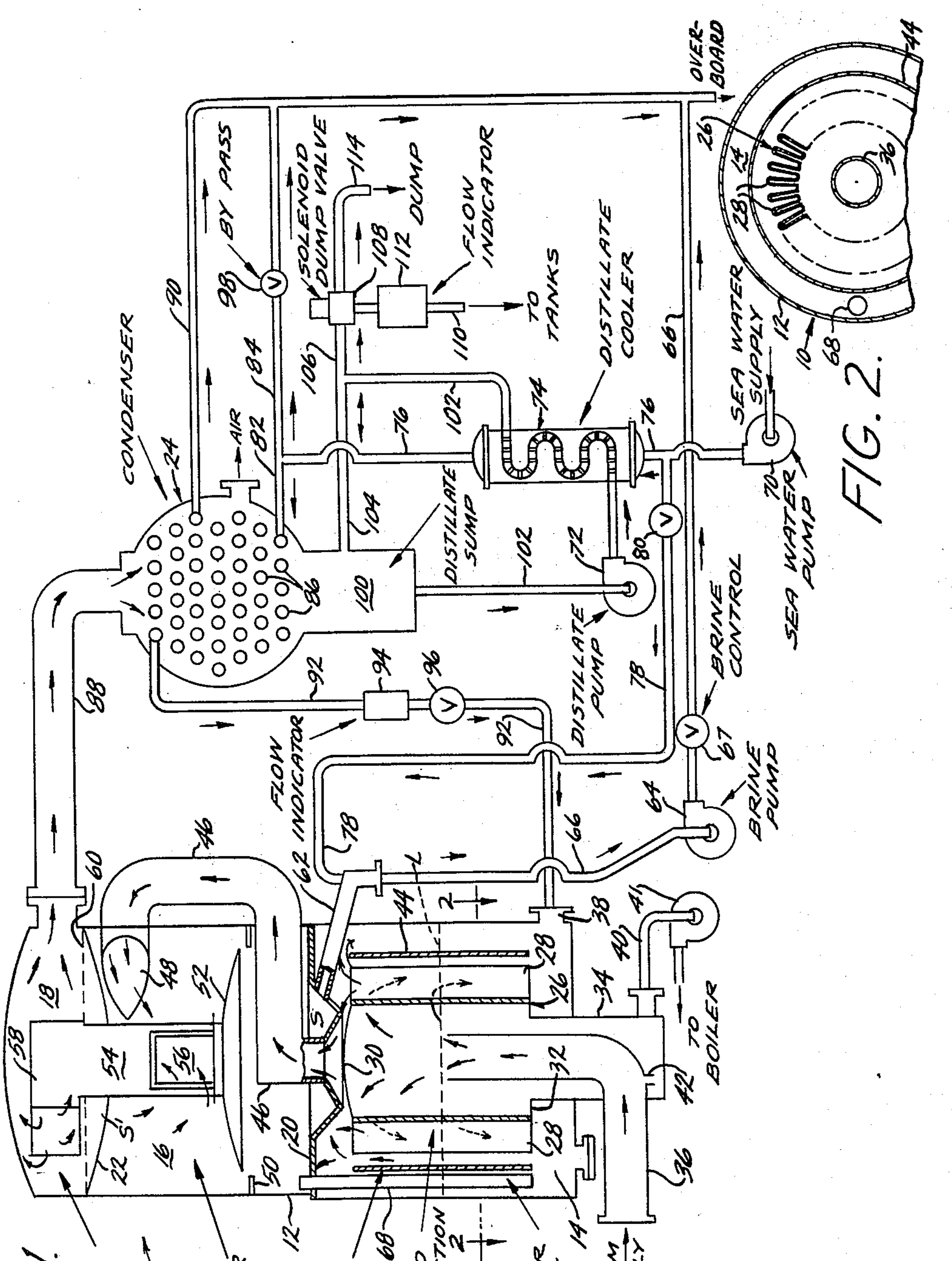

FIG. 1.

FIG. 2.

INVENTOR.
WILLIAM R. WILLIAMSON

Teller + McCormick
ATTORNEYS

2,960,449

APPARATUS FOR DISTILLING SEA WATER

William R. Williamson, Wethersfield, Conn., assignor, by mesne assignments, to American Machine & Foundry Company, Inc., New York, N.Y., a corporation of New Jersey

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5 Claims. (Cl. 202—163)

This invention relates to an improved method or system for evaporating sea water and for simplifying the operation of a sea water distillation plant, and the invention also encompasses an improved evaporator and associated apparatus for practising the aforesaid system of evaporation.

It is the general object of the invention to provide an evaporator and system of evaporation capable of extraordinarily efficient and high rate evaporation for the production of pure fresh water distillate in a sea water distillation plant, the said system and evaporator being particularly adapted to produce the distillate at a substantially constant rate with a minimum of manual control whereby the distillation plant can be operated by relatively unskilled persons.

Other, more specific objects as well as advantages of the invention will become apparent to those skilled in the art from the following specification taken with reference to the attached drawings which, by way of preferred example only, illustrate one embodiment of the invention. As indicated by the claims forming a part of the specification, the invention is of greater scope than may be apparent from the drawings and the description thereof.

In the drawings:

Fig. 1 is a schematic view of a sea water distillation plant which practices the evaporation and control system of this invention and which includes my improved evaporator; and

Fig. 2 is a horizontal cross-sectional view through the boiler chamber of the aforesaid evaporator, the section being taken as indicated by the line 2—2 of Fig. 1.

As will be more fully understood from the detailed description of the construction and operation of the distilling plant, it is a particular feature of the invention to provide a novel boiler for the evaporator wherein many advantages are realized in operation of the distillation plant. Among the advantages or benefits resulting from the boiler construction are (*a*) that sea water can be continuously introduced in non-critical supply as by a pump, (*b*) that excessive or unused brine may continuously be removed from the boiler with generated steam and then continously discharged from the system as by a pump, thus eliminating the need for brine handling and discharging means associated with the boiler, (*c*) that a desirable salt concentration can be maintained in the boiling sea water whereby to minimize scaling, (*d*) that a stable water level will maintain in the boiler in keeping with the sea water supply rate and the temperature, pressure, and rate of the steam supply for the heat exchanger, (*e*) that float valves, etc. need not be used to insure proper operation of the system, (*f*) that a high rate of sea water circulation over the heat exchange surfaces will maintain thus enhancing heat exchange efficiency, and (*g*) that the hydrostatic head in the boiler is minimized thus permitting a maximum temperature differential further to increase heat exchange efficiency.

With more specific reference to the drawing, it will be observed that the evaporator **10** comprises a generally cylindrical shell **12** which is disposed substantially vertically and which is divided into three compartments or chambers **14**, **16** and **18** in bottom-to-top order. The bottom chamber **14** constitutes a closed boiler chamber wherein sea water is boiled and evaporated, the said chamber being separated from the intermediate chamber **16** by a substantially horizontal or transverse partition **20**. The intermediate chamber **16** comprises a centrifugal separating chamber wherein water and foam are separated from the steam produced in boiling the sea water and the said separating chamber **16** is separated from the uppermost chamber **18** by a transverse partition **22**. The uppermost chamber **18** is also a separating chamber wherein a final separation of water from steam is effected before the steam or vapor produced by boiling the sea water is discharged from the evaporator **10** into a condenser **24** wherein the sea water vapor or steam is condensed to provide the fresh water distillate. That portion of the evaporator **10** identified as a separating chamber **16** is oftentimes referred to as the primary separating chamber and the chamber **18** is referred to as the secondary separating chamber. The present invention does not relate to the method or apparatus for separating the water and steam, and the primary and secondary separating chambers and the associated separating apparatus shown in the drawings are substantially the same as disclosed in the co-pending application of Roland B. Bourne, Serial No. 371,577, filed July 31, 1953, now U.S. Patent no. 2,759,558, and entitled "Steam and Water Separator for Sea Water Evaporators or the Like." Accordingly, the separating structure will be described only briefly hereinafter.

Referring now to the boiler chamber **14** as it is shown in Figs. 1 and 2, it will be observed that there is a heat exchanger indicated generally at **26** disposed within the said chamber. While certain other heat exchangers may be used if they are adapted to receive a fluid heating medium in out-of-contact heat exchange relationship with sea water in the boiler chamber, the heat exchanger **26** employed in the evaporator shown is much like the heat exchanger shown in the Williamson et al patent, No. 2,649,408 and comprises a deeply corrugated generally cylindrical sheet metal shell as described therein. The top of the corrugated shell **28** is closed by a plate or header **30** and the bottom of the shell is attached to a ring **32** which embraces and is secured to the top of a cylindrical chest **34** projecting vertically through the bottom or end header of the evaporator shell **12**. A steam inlet conduit **36** projects through the chest **34** and vertically upwardly into the corrugated heat exchanger **26**. The heat exchanger as thus far described is the same as the heat exchanger shown in the aforementioned Williamson et al. patent and such a heat exchanger has become known in the seat water evaporator art as a "basket type" heating section or heat exchanger.

Sea water is introduced to the boiler chamber **14** through an opening **38** located adjacent the lower end of the evaporator shell **12** and will reach a level L within the said chamber, the level L being subject to variation as will be described hereinafter. The sea water standing within the boiler chamber **14** will, of course, contact the external surfaces of the basket **26** between the corrugations or heat exchanging fins **28**, **28**. The sea water will be boiled within the chamber **14** by receiving heat from the steam supply introduced through the conduit **36** and circulated within the basket **26** on the interior of the corrugations or hollow heat exchanging fins **28**, **28**. In giving up heat to the surrounding sea water, the steam within the basket **26** will be condensed and drain from the said basket into the chest **34** from which it can be withdrawn through a conduit 40 and pumped as at 41, for return to the boiler where the supply steam was generated. Some of the steam may condense within the steam inlet conduit 36 and this condensate is drained at 42 into the chest 34 for removal with the other condensate.

In accordance with the present invention, an open end generally cylindrical shroud or skirt 44, of substantially the same vertical dimension as the heat exchanger or "basket" 26, is suitably secured within the boiler chamber 14 to surround the said basket. As shown in the drawing, the skirt 44 is positioned in spaced relationship to the outer edges of the corrugations of the basket. I prefer to make the radial distance between the outer end of the corrugations and the inside surface of the skirt approximately equal to the circumferential distance between the adjacent surfaces of the corrugations on the water side.

It is a purpose of the skirt 44 to define and maintain a column of boiling sea water, foam and steam in contact with the basket 26 over its entire vertical extent and to guide this column upwardly at high velocity, thus improving the transfer of heat from the basket to the sea water. It will be readily understood that the boiling column is considerably less dense than the solid water which is on the outside of the skirt 44 and consequently is forced upwardly. Furthermore, the boiling column, being less dense than a column of solid water of the same height, will boil at a lower temperature than would the solid water. This naturally increases the temperature gradient across the heat transfer surfaces and more heat is transferred from the steam inside the basket to the water outside thereof. In other words, the skirt 44 permits of a lower actual "head" on the water to be boiled, while, at the same time, keeping the entire surface of the corrugated basket bathed in water and foam.

Another factor contributing to the reduced density in the column defined between the basket 26 and the skirt 44 is the spacing between the said basket and skirt. That is, pressure resulting from generating steam causes water to be circulated or ejected laterally from between the the corrugations and at least some of this water will flow down the inside surface of the skirt. Thus, the density of the rising column within the skirt decreases with height. The decreased density will permit of a higher flow rate upwardly.

The vigorous boiling between the corrugations 28, 28 and the high velocity rise of the column within the skirt 44 will cause a substantial quantity of water and foam to be carried upwardly with the steam. As will be explained hereinafter, it is desirable to carry the foam and some of the water with the steam as it is discharged from the boiler chamber 14. However, it is not desirable to carry over all of the water emanating from within the skirt. It is a further feature of the evaporator boiler construction that the skirt 44 is spaced well within the shell 12 so that water can spill over the skirt and return to the sea water column standing in the boiler chamber 14 around the said skirt. To facilitate spill over, the partition 20 across the top of the boiler chamber 14 is provided with an annular V-shaped trough which defines an annular sump S within the separating chamber 16 and an annular baffle at the top of the boiler chamber. The baffle directs the excess solid water outwardly over the top of the skirt. Obviously, some steam and water separation takes place within the boiler chamber 14 before the steam is discharged therefrom and introduced to the separating chamber 16.

The steam and carry-over foam and water are discharged from the boiler chamber 14 through a conduit 46 having an inlet which is located centrally of the partition 20 within the annular trough defining the sump S. The conduit 46 projects substantially horizontally through the shell 12 at the bottom of the separating chamber 16 and then extends upwardly and then tangentially through the shell so as to provide a tangential inlet 48 in the upper portion of the said separating chamber.

The spacing between the bottom of the V-shaped annular sump and the top of the basket and skirt is arranged to reduce velocity of the steam at that point so as to prevent too much carry-over. The preferred spacing is obtained when the apex of the V-shaped annular baffle or sump and the top of the basket and skirt are separated by a distance which approximately equals one-quarter to one-half of the diameter of the steam conduit 46. If the distance is too great, the velocity will be undesirably low and too much water and foam will spill over to the outside of the skirt and the water level L in the boiler chamber 14 will rise to increase the hydrostatic head. If the spacing is too little, the velocity will be undesirably high and will carry over too much water to overburden the separators and reduce the water level in the boiler chamber. Furthermore, an increase in back pressure at this point would result in an increase in the boiling temperature with loss of heat transfer.

As will be more fully described, the provision of the skirt to obtain spill-over and carry-over is important to attaining substantially automatic control of the distilling plant and to obtaining full advantage of the invention.

The steam and water mixture entering the primary separating chamber 16 tangentially thereof is whirled at a high velocity within the said chamber and a substantial portion of the foam and water is separated by centrifugal force. That is, water will collect along the inner surface of the shell 12 and drain downwardly in the chamber 16 and spill over a ring 50 disposed within the said chamber above the horizontal portion of the conduit 46. The said ring 50 prevents collected water from splashing or being drawn upwardly in the separating chamber 16 and a plate 52 is secured on the bottom end of a centrally disposed vertical conduit 54 for the same purpose. That is, the plate 52 is spaced slightly above the ring 50 and over the opening therein to prevent water from splashing or being drawn upwardly into the whirling steam. The plate 52 will also drain any moisture that may collect on its top surface outwardly into the stream draining onto and over the said ring.

A side opening or window 56 is defined in the vertical conduit 54 adjacent and above the plate 52 and the relatively dry stream within the primary separating chamber 16 is discharged from the said separator through the conduit 54. The conduit 54 extends through the partition 22 into the secondary separating chamber 18 where it communicates with a volute conduit 58 which admits the relatively dry steam to the secondary separating chamber in a whirling stream. Water which is not removed in the primary separator is separated from the steam within the secondary separating chamber 18 by centrifugal force and drains through a perforate anti-splash plate 60 into a sump S' which is defined on the top concave surface of the partition 22. Water collected within the sump S' can be drained as by a pipe or tube (not shown) extending through the conduit 54 into the lower region of the primary separating chamber 16.

The water drained from the secondary separating chamber into the primary separating chamber and the water collected in the primary separating chamber 16 will collect in the annular sump S formed in the partition 20 around the vertical portion of the boiler discharge conduit 46. As previously mentioned, the bottom surface of the annular trough defining the sump S will deflect some of the upwardly ejected mixture from within the skirt 44 radially outward and will conduct the remainder of the mixture, including the steam content thereof, into the entrance to the steam conduit 46. The apex of the annular "cone" so formed is preferably positioned just inside the inner extent of the radial fins 28, 28 of the basket substantially as shown. Thus, the under side of the partition 20 serves as a pre-separator, whereby active re-circulation is provided and whereby the desired carry-over takes place.

The water collected within the sump S has a high concentration of salt and the other impurities found in sea water. This concentrated sea water or brine is immediately pumped from the sump S through one or more radially extending conduits **62** by means of a brine pump **64** connected therewith by a pipe **66**. A valve **67** is disposed in the conduit **66** to reduce any irregularities or surges in the flow of brine being discharged from the system by the pump **64**.

As thus far described, the evaporator **10** is only generally similar to the evaporator shown in Patent No. 2,649,408, differing therefrom in several important aspects, as for example, in providing the annular sump S, the skirt or shroud **44**, and in providing the sea water inlet **38** adjacent the lower end of the boiler chamber **14**. The evaporator shown and described in the the aforesaid patent admitted sea water to the boiler chamber from a sea water reservoir located above the boiler chamber and in the lower region of the primary separating chamber, the said sea water being admitted through a standpipe extending between the boiler chamber and the primary separating chamber. In the primary separating chamber associated with the present invention, there is no significant amount of standing sea water or brine, the brine pump **64** being provided to immediately remove or discharge the brine collected in the sump S, as previously described. There is, however, at least one vertically extending standpipe **68**, of relatively small diameter, provided to extend through the partition **20** between the boiler chamber **14** and the primary separating chamber **16**, not as a boiler filling pipe extending between the two chambers, but as an equalizing pipe or tube between the two chambers. The tube **68** is of sufficient length to extend from the lower portion of the boiler chamber **14**, through the partition **20** and, preferably, a short distance thereabove to minimize the amount of brine which may re-enter the boiler chamber from the separator chamber above. The lower end of the pipe **68** is submerged in the water in the chamber **14**. The purpose of the equalizer tube is to provide means for quickly removing more water from the boiler chamber **14** than is provided by carry-over, should transient operating conditions, particularly when starting up the plant, cause a sudden relatively high pressure to exist in the boiler. Under this condition, water will flow upwardly through the pipe **68** into the chamber above and be removed by the pump **64**. Under normal conditions, there is no flow through the pipe **68**. A sudden increase in steam entering the inside of the basket, particularly when the water level in the boiler chamber **14** is high may cause this flow to take place until the water level is sufficiently reduced. Normally the carry-over through the conduit **46** is sufficient to maintain a proper water level in the boiler. The operation of the evaporator to provide automatic regulation and stabilization will be described hereinafter.

In addition to the evaporator **10**, the condenser **24** and the brine pump **64**, the distillation plant shown in Fig. 1 includes a sea water pump **70**, a distillate pump **72**, a distillate cooler or heat exchanger **74** and a plurality of conduits, valves and flow gages. The sea water pump **70** is disposed in a sea water conduit **76** which extends through the distillate cooler or heat exchanger **74** for the purpose of preheating the sea water and cooling the distillate. There is no valve or other flow limiting means in the sea water line **76** and the sea water pump **70** is of sufficient capacity to continuously introduce sea water to the distillation plant in quantities well in excess of the amount needed to supply the evaporator **10** under any anticipated operating condition. Part of the sea water delivered by the pump **70** flows through the pipe **78**, which is connected to the pipe **76**, and is fed into the brine discharge conduit **62** leading from the evaporator **10**. A flow control valve **80** is positioned in the conduit **78** to control the sea water flow therein which is used to cool, by direct mixing, the hot brine being discharged from the sump S of the evaporator. The brine is cooled to a temperature low enough to prevent flashing at the inlet to the brine discharge pump **64**.

The preheated sea water in the conduit **76** which has passed through the distillate cooler **74** flows into two conduits **82** and **84**. The conduit **82** is connected with a plurality of tubes **86**, **86** in the condenser **24**, the sea water flowing in the said tubes providing the cooling medium for condensing the steam discharged from the evaporator **10** through the conduit **88**. Most of the sea water flowing in the tubes **86**, **86** (wherein the sea water is further heated) is discharged overboard from the condenser **24** through a conduit **90**, preferably at an intermediate point in the condenser **24**. The remaining portion of the sea water passing through the condenser tubes **86**, **86** is, of course, heated to a still higher temperature and flows from the said condenser through a conduit **92** to the sea water inlet **38** in the evaporator boiler chamber **14**. Thus, the sea water, as it enters the boiler chamber has been brought to within a few degrees of its boiling temperature. It is desirable to provide a flow gage or indicator **94** in the line **92** to determine the flow therein and it is also desirable to provide a flow control valve **96** for controlling the flow of sea water in the line **92** to the evaporator **10**. In addition to that portion of the sea water which is discharged from the distillation plant through the conduit **90**, a portion of the sea water is discharged from the plant through the conduit **84**, the flow in the conduit **84** being regulated by a by-pass valve **98**. The flow in the conduit **84** is the excess sea water from the distillate cooler **74** not required for the condenser **24** and the evaporator boiler.

It will be readily understood that the amount of sea water flow to the evaporator **10** can effectively be controlled by the valves **96** and **98**. In fact, the valve **96** is not essential to sea water flow control. That is, the by-pass valve **98** may be used without the valve **96** to control flow to the condenser **24** and to the evaporator sea water inlet conduit **92**. However, it is desirable to provide both valves so as to more precisely regulate flow to the evaporator, and the valve **96** is used in starting the plant into operation as will be described.

The condenser **24** which receives sea water vapor or steam from the evaporator **10** through the conduit **88** condenses the same to provide the fresh water distillate, said condenser **24** being provided with a distillate sump **100** from which the distillate is pumped by the distillate pump **72** through a conduit **102** to the distillate cooler **74**. A portion, approximately 20%, of the cooled distillate or condensate flowing from the distillate cooler **74** through the line **102** is returned to the distillate sump **100** through a restricted branch conduit **104** to prevent flashing at the suction of the distillate pump **72**. The remaining portion of condensate flowing in the line **102** flows through a branch conduit **106** to a solenoid operated valve **108** which will normally discharge the distillate or condensate through a conduit **110** to the fresh water tanks. In the line **110** is disposed the flow indicator **112**. Should the purity of the fresh water be degraded to a predetermined value, from any cause, the solenoid dump valve **108**, which is controlled by suitable instrumentation, will close off the flow to the fresh water tanks and will simultaneously permit the distillate to be dumped overboard through the conduit **114**, thus avoiding contamination of the fresh water in the tanks.

The operation of the distilling plant shown in Fig. 1 will now be described. Assuming that the said plant is installed aboard a ship, it will be readily understood that the ship's boilers can provide a low pressure steam supply for the evaporator **10**. It is, of course, desirable to provide some means (not shown) for regulating the steam pressure and temperature in the steam supply conduit **36** to avoid undesirably wide excursions thereof.

In starting the plant into operation, the sea water pump **70** is energized and the sea water flow control valve **96** is opened to introduce sea water to the boiler chamber **14** of the evaporator **10** through the conduit **92**. The valve **96** is opened so that the sea water within the boiler chamber will reach a substantial level such as indicated at L. The steam introduced to the heat exchanger basket **26** will start to boil the sea water within the skirt **44**. If there is any substantial delay before boiling starts, which may be due to the initial temperature of the sea water, the valve **96** should be closed to prevent flooding of the boiler chamber and to maintain the sea water level therein. After boiling commences, the valve **96** is opened to provide a continuous supply of sea water to the evaporator.

The steam generated in the boiler chamber will be discharged therefrom through the conduit **46** and will carry with it foam and some sea water as described. The foam and water in the steam is separated therefrom in the primary and secondary separators, the dry steam being discharged from the evaporator **10** through the conduit **88** into the condenser **24**. The salt-concentrated water or brine separated from the steam-water mixture within the evaporator will drain into the annular sump S and be removed by the brine pump **64** which will discharge the brine overboard.

The generated steam flowing to the condenser **24** is condensed to produce distillate and the generated steam in the condenser and the distillate in the distillate cooler or heat exchanger **74** will preheat the sea water flowing to the evaporator. When evaporation has reached a high rate so as to produce distillate at a desired rate as will be indicated by the distillate flow indicator **112**, the sea water by-pass valve **98** is adjusted to more precisely regulate sea water flow through the condenser **24** whereby to regulate the temperature of the sea water which is introduced to the boiler chamber of the evaporator **10**. That is, by regulating the amount or rate of sea water flow through the condenser **24**, the temperature of the sea water introduced to the evaporator may effectively be maintained at a convenient value, generally about 10° F. below the boiling temperature. The operator will then adjust the valve **96** to regulate the volume or rate of flow of sea water, the said rate being indicated in the flow indicator **94**. The preferred rate of sea water flow to the boiler chamber is approximately three times the rate of distillate production indicated in the flow indicator **112**. The reason for selecting a sea water flow rate at approximately three times the rate of distillate production is that a desired salinity concentration is maintained in the boiling sea water and in the carry-over. More specifically, if three parts of sea water is introduced to the boiler chamber and one part thereof is evaporated to produce the distillate, the remaining two parts which make up the carry-over and the spill-over to the boiler chamber have a salt concentration increase of 50%. It has been found that an increase of approximately 50% in the salt concentration in boiling sea water minimizes the deposit of scale in the boiler chamber and in the evaporator, thus making it most desirable to maintain a 3 to 1 proportion or relationship between the sea water and distillate flow rate.

When the operator has completed his adjustment of the by-pass valve **98** to regulate the sea water temperature and the adjustment of the valve **96** to regulate the sea water flow rate, no further regulation or adjustment is necessary during operation of the plant. That is, it is an important feature of the present invention that substantially automatic control or regulation will take place so as to maintain a substantially constant rate of evaporation and distillation and so as to accommodate variations or changes which may occur in the sea water flow rate without affecting the rate of distillate production.

The feature of providing for a substantially constant rate of distillate production without adjustment of sea water flow to correct for variations which may occur therein may be epitomized by saying that the provision of the heat exchanger skirt and the V-shaped annular baffle adapts the evaporator boiler to produce distillate at a rate which can be affected to any material extent only by a variation in the steam supply to the boiler heat exchanger. The skirt and baffle arrangement also adapts the boiler to maintain a substantially constant level of sea water in the boiler chamber for a given rate of sea water supply. That is, the evaporator is adapted to regulate to a change in the sea water supply rate by establishing a sea water level in the boiler chamber which is in keeping with the new rate of sea water supply without changing the rate of distillate production.

More specifically, and as has been previously explained, the heat exchanger skirt reduces the density of the column within the skirt and causes relatively high velocity rise of the boiling column within the skirt to continuously wet or bathe the heat exchanging surfaces of the heat exchanger. Regardless of the water level outside the skirt, the heat exchanging surfaces are bathed. Therefore, the only way in which the rate of steam generation and distillate production can be materially changed is by changing or varying the steam supply to the heat exchanger. Variations in the steam supply will affect the water level outside of the skirt and will affect to a limited extent the amount of carry-over as will be described.

The way in which the skirt and annular baffle control or stabilize the sea water level within the boiler chamber for a given sea water supply rate can best be explained by considering what will happen with changes in the sea water supply rate while the heat exchanger steam supply rate is held constant. Assume that at a constant steam supply rate and sea water supply rate, the sea water level in the boiler chamber will be stabilized. That is, at a given rate of sea water supply, and at a constant rate of steam supply which will maintain a constant rate of evaporation, water will be carried over with the steam at a constant rate and the rate of spill-over will be constant to maintain a substantially constant sea water level in the boiler chamber. If the rate of sea water supply is increased, the water level will rise and there will be more solid water at the top of the skirt. This results in an increase in carry-over. The water level will continue to rise until the increase in carry-over equals the increase in the sea water supply rate whereby the water level is stabilized at the higher elevation. The steam generated remains substantially unchanged.

If the sea water supply rate is decreased, the sea water level in the boiler chamber will fall and there will be less solid water at the top of the skirt. There being less solid water at the top of the skirt, the carry-over will decrease and there will be an increase in the amount of spill-over water which is being circulated. The water level in the boiler chamber will continue to fall until the reduction in carry-over equals the reduction in the sea water supply. The steam generated remains substantially unchanged.

If the sea water supply rate is constant and there is a reduction in the steam supply to the heat exchanger, there will be less vigorous boiling at first and there will be a decrease in carry-over. The water level will rise to increase the solid water content at the top of the skirt thereby increasing the carry-over. The water level will continue to rise until the increased carry-over causes water level stabilization to be effected. The stabilization in this instance is similar to that occurring under constant steam supply conditions when there is an increase in sea water supply, but the rate of distillate production will be decreased to a new constant level.

If the sea water supply rate is constant and the steam supply rate is increased, more vigorous boiling will take place at first and will cause an increase in carry-over. The increased carry-over will reduce the sea water level thus reducing the solid water content at the top of the skirt to decrease carry-over. The decrease in carry-over will stabilize the water level similarly to the stabilization when the steam supply rate is constant and the water supply rate is reduced, but the rate of distillate production is increased to a new substantially constant level.

It will thus be seen that the skirt and annular baffle are important elements of the evaporator construction. While it is possible to provide an operable evaporator without the skirt and baffle, efficiency is greatly reduced in such an evaporator. More specifically, there is no substantially automatic control, the capacity of the plant is considerably reduced, orderly circulation of sea water within the boiler chamber is impaired, the amount of carry-over is greatly increased, and the separators are overburdened to separate the carry-over from the steam.

While the improved evaporator of this invention has been described as incorporated in a single effect distillation plant, it should be understood that a plurality of such evaporators can be connected in series to provide a multiple effect plant, the feature of automatic control being advantageous in such low pressure multiple effect plants or systems.

It should also be understood that while the evaporator has been described and claimed in connection with a sea water distillation plant, it can be used to advantage in other installations wherein it will operate to separate contaminants from liquids others than sea water.

Obviously, there can be changes made in the construction described and there can be other uses of the invention which will fall within the scope of the following claims.

The invention claimed is:

1. An evaporator for a sea water distillation plant and comprising a substantially vertical shell having a plurality of transverse partitions defining a boiler chamber having a sea water inlet and having an outlet defined in its upper partition, a generally cylindrical substantially vertical heat exchanger disposed below said outlet and having generally radially extending heat exchange corrugations which heat exchanger is adapted to receive a heating medium in out-of-contact heat exchange relationship with sea water in the boiler chamber, a substantially vertically disposed generally cylindrical skirt spaced within said shell and surrounding said heat exchanger in spaced relationship to define a rising column of steam and boiling sea water between and around said corrugations, the said skirt being arranged so that a portion of the water in said column will spill over the skirt into the boiler chamber while the remainder will be carried by the steam through said outlet, the said upper partition of the boiler chamber being formed to provide an annular V-shaped baffle surrounding the boiler chamber outlet and projecting into the boiler chamber radially inwardly of the said skirt which baffle cooperates with the skirt to separate the spill-over portion of the water from said rising column and to direct the steam and carry-over portion of the water into said outlet, and steam and water separating means connected with said outlet.

2. In a sea water distillation plant which includes means for continuously introducing sea water, an improved evaporator comprising a substantially vertical shell having a plurality of transverse partitions defining in bottom-to-top order a boiler chamber and a separating chamber, the said boiler chamber having a sea water inlet and also having an outlet defined in its upper partition, the said separating chamber having an inlet and also having an outlet, conduit means interconnecting the boiler chamber outlet and the separating chamber inlet, a generally cylindrical substantially vertical heat exchanger disposed below said boiler chamber outlet and having generally radially extending heat exchange corrugations which heat exchanger is adapted to receive a heating medium in out-of-contact heat exchange relationship with sea water in the boiler chamber, a substantially vertically disposed generally cylindrical skirt spaced within the said shell and surrounding said heat exchanger in spaced relationship to define a rising column of steam and boiling sea water between and around said corrugations, the said skirt being arranged so that a portion of the water in said column will spill over the skirt into the boiler chamber while the remainder will be carried by the steam through said outlet, the said upper partition of the boiler chamber being formed to provide an annular V-shaped baffle surrounding the boiler chamber outlet and projecting into the boiler chamber radially inwardly of the said skirt which annular baffle defines a sump in said separating chamber and also cooperates with the skirt to separate the spill-over portion of the water from said rising column and to direct the steam and the carry-over portion of the water into the boiler chamber outlet, and means connected with said sump for continuously removing separated water therefrom.

3. In a sea water distillation plant which includes means for continuously introducing sea water, an improved evaporator comprising a substantially vertical shell having a plurality of transverse partitions defining in bottom-to-top order a boiler chamber and a separating chamber, the said boiler chamber having a sea water inlet and also having a centrally disposed outlet in its upper partition for steam and sea water carried thereby, the said separating chamber having a sump surrounding the said outlet for receiving water separated from steam and having an inlet and also having an outlet, conduit means interconnecting the boiler chamber outlet and the separating chamber inlet, a heat exchanger disposed in said boiler chamber below its outlet and adapted to receive a heating medium in out-of-contact heat exchange relationship with sea water in the boiler chamber, a substantially vertically disposed skirt spaced within said shell and surrounding said heat exchanger to define a rising column of the boiling sea water and steam therearound, the said skirt being arranged so that a portion of the water in said column will spill over the skirt into the boiler chamber while the remainder will be carried by the steam through said outlet, baffle means disposed within the said boiler chamber over said skirt to assist in separating the spill-over portion of the water in said column from the remainder thereof, and means connected with said sump for continuously removing all of the brine from the plant without return to the boiler chamber.

4. An evaporator for a sea water distillation plant which includes means for continuously introducing sea water, the said evaporator comprising a substantially vertically disposed shell and a plurality of vertically spaced transverse partitions defining in bottom-to-top order a boiler chamber and a separating chamber, the said boiler chamber having a sea water inlet directly connected with the means for introducing sea water and also having an outlet defined in its upper partition which upper partition is formed to provide a generally V-shaped annular trough around said outlet whereby to define a sump in said separating chamber, the said separating chamber having an inlet for steam and sea water carried thereby and a steam outlet, conduit means interconnecting the boiler chamber outlet and the inlet to the separating chamber, heat exchange means disposed in said boiler chamber below and in spaced relationship to said trough to produce a mixture of boiling water and steam from sea water in said boiler chamber below and around the said trough, means cooperating with said heat exchanger to define a rising column of steam and boiling sea water adjacent said heat exchanger, the said annular trough providing baffle means for separating some of the sea water in said column while the remainder is carried by the steam through the boiler chamber outlet, and means directly connected with said sump for continuously removing all

of the brine from the plant without return to the boiler chamber.

5. An evaporator for a sea water distillation plant which includes means for continuously introducing sea water, the said evaporator comprising a substantially vertical shell and a plurality of vertically spaced transverse partitions defining in bottom-to-top order a boiler chamber and a separating chamber, the said boiler chamber having a sea water inlet and also having an outlet defined in its upper partition which upper partition is formed to provide a trough around said outlet and projecting into the boiler chamber which trough defines a sump in said separating chamber, the said separating chamber having an inlet for steam and sea water carried thereby and a steam outlet, conduit means interconnecting the boiler chamber outlet and the inlet to the separating chamber, heat exchange means disposed in said boiler chamber below and in spaced relationship to said trough to produced a mixture of boiling sea water and steam, skirt means associated with said heat exchanger to define a rising column of steam and boiling sea water adjacent said heat exchanger, and the said trough providing baffle means for separating some of the sea water from said column while additional sea water in the column is carried by the steam through the boiler chamber outlet.

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