July 13, 1965 K. B. RIS ETAL 3,194,747

EVAPORATOR CONSTRUCTION

Filed Nov. 8, 1961 2 Sheets-Sheet 1

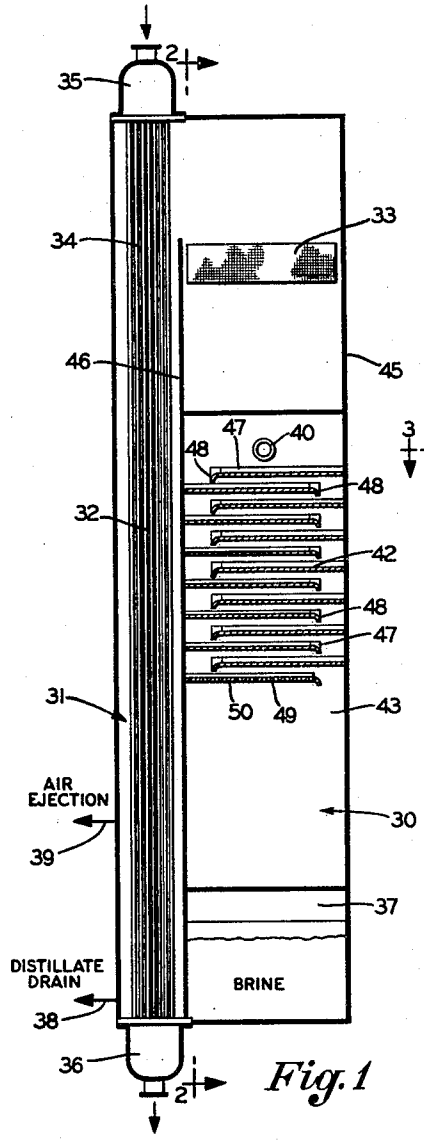


Fig. 1

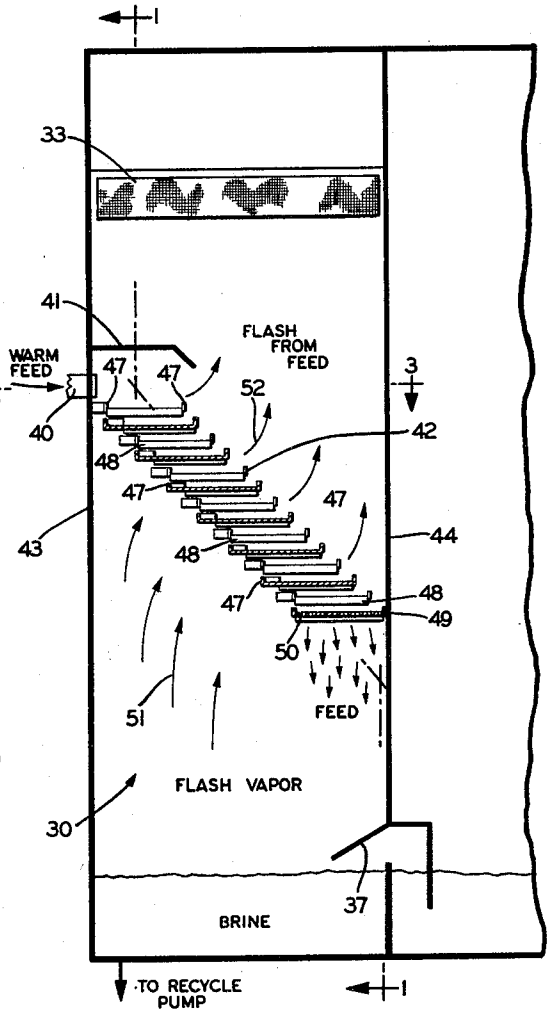


Fig. 2

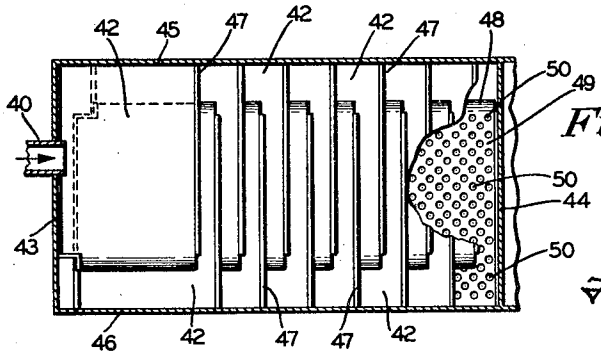


Fig. 3

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EVAPORATOR CONSTRUCTION

Filed Nov. 8, 1961 2 Sheets-Sheet 2

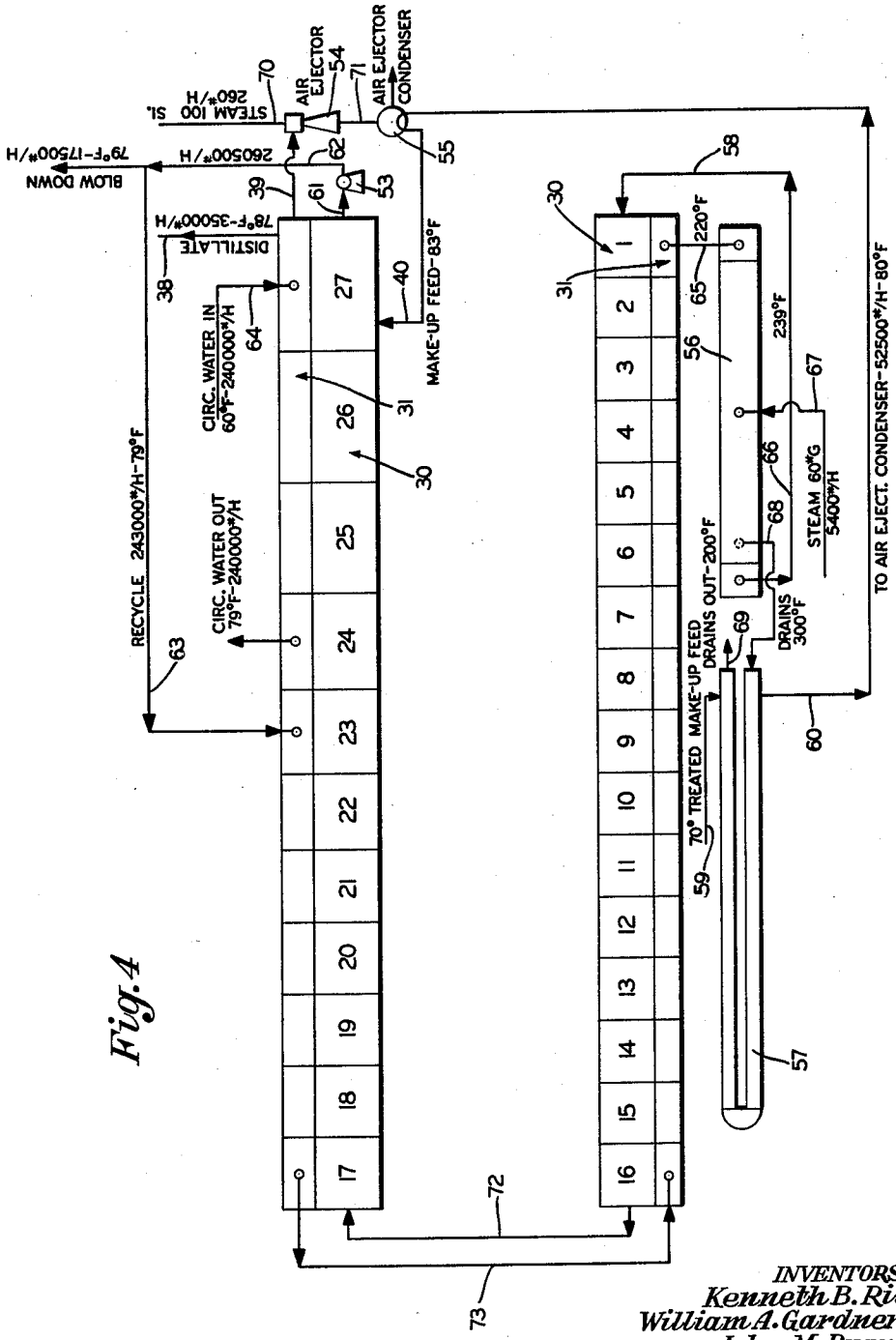


Fig. 4

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EVAPORATOR CONSTRUCTION

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Our invention relates to improvements in evaporator construction and more specifically to the recirculation type of flash evaporators for distilling sea water and the like. Even more specifically, our invention concerns the deaeration of make-up feedwater in a recirculation flash evaporator, and also concerns the manner of injection of the feedwater to be recirculated back into the evaporator system of a multi-stage evaporator plant.

It has been common practice in the construction of evaporator plants and particularly in all but the last few lower temperature stages of multi-stage flash evaporator plants to form parts of the various chambers, and particularly the condenser tubes, tube sheets and various water boxes, of highly corrosion resistant materials such as copper-nickel alloys or cast bronze, due to the corrosive nature of the water and water vapors particularly at the higher temperatures. The cost of these necessary corrosion resistant materials is relatively high and this has added greatly to the cost of providing such evaporator units.

It has been found and is well established that disssolved oxygen in the water is a leading contributor to the corrosion of the various elements and tubing of the evaporator system, and that thoroughly deaerated water has very little corrosive effect, even on elements and tubing merely formed of the usual relatively low cost steels. Thus, if all of the water used in an evaporator system can be thoroughly deaerated at the time of entering such system, and particularly before entering stages where higher temperatures are involved, the entire evaporator plant may be formed from these relatively low cost steels, thereby resulting in great cost savings.

In the case of the recirculation type of flash evaporator plants, the deaeration of the recirculated main stream of feedwater is not a problem since, after the water has once passed through one or several of the flash chambers of the various stages, this water is effectively deaerated merely through the normal flashing process. In such a recirculation system it is necessary, however, to maintain the brine concentration of the recirculated main stream of feedwater at a workable level by discharging or blowing down a small portion thereof prior to the beginning of each circulation cycle and adding a quantity of make-up feedwater.

This make-up feedwater, since it is being newly added to the system, will contain relatively large quantities of dissolved oxygen and, therefore, is of a highly corrosive nature. It is, therefore, desirable to provide some means whereby this make-up feedwater may be deaerated just prior to or coincident with the introduction of the same into the evaporator system and it is, of course, desirable to accomplish such deaeration at a minimum of added cost in order that the cost savings from forming the unit from the cheaper common steel materials will not be greatly reduced or eliminated.

It has been suggested to merely pass the make-up feedwater through a separate deaeration system prior to introducing this make-up feedwater into the evaporator system. This, however, will require an expensive high vacuum deaerator with other various pumps and equipment which will again add greatly to the overall expense of the evaporator unit.

It is, therefore, desirable to provide some means for cheaply and efficiently deaerating the make-up feed water coincident with the introduction of this make-up feedwater into the evaporator system. Furthermore, it is desirable to accomplish this deaeration prior to this make-up feedwater mixing with the larger quantities of feedwater already in the evaporator system since the maximum of dissolved oxygen can be removed therefrom when such dissolved oxygen is in the concentrated state rather than in a more widely distributed lesser concentrated state.

Another problem involved particularly in the construction of the multi-stage recirculation type of flash evaporator plants concerns the point at wihch the recirculated feedwater is reintroduced into the evaporator system. Generally, in the multi-stage recirculation type of evaporator plants, the feedwater, after passing through the flash chambers or feedwater portion of the various stages progressively from the highest temperature stage through the intermediate stages to the lowest temperature stage, has a portion thereof reintroduced into the condensing tubes of one of the intermediate stages, where the feedwater then flows progressively through the condensing tubes of the progressively higher temperature stages ultimately to and through the condensing tubes of the highest temperature stage.

In this manner, the feedwater not only serves as the condensing medium in the condensing chambers or portions of certain of the stages, but also is at least partially preheated for eventually being again introduced into the flash chamber of the highest temperature stage. In this manner, a maximum amount of the heat originally introduced into the particular evaporator system is retained in such system to minimize the operating costs thereof.

Since the temperature of the feedwater leaving the flash chamber of the lowest temperature stage would be very close to the temperature of the water vapor to be condensed in such stage, it is not practical to reintroduce this feedwater back into the condensing tubes of the lowest temperature stage, but rather such feedwater is reintroduced into the condensing tubes of one of the higher temperature stages where the temperature of water vapor to be condensed is such that the feedwater will serve as a practical cooling medium. Thus, the cooling medium used in the condensing tubes of all of the stages below or of lower temperature than the particular intermediate stage is merely one which is readily available, such as raw sea water, and this water would merely circulate through the condensing tubes of these lower temperature stages and be discarded. The corrosion effect of this outside cooling medium is not a factor due to the lower temperatures involved in these particular stages. It has been discovered, however, that if the maximum efficiency of the particular multi-stage recirculation type of flash evaporator plant is to be maintained, the recirculating feedwater being introduced into the condensing tubes of the particular intermediate stage must be at substantially the same temperature as the raw sea water or other discarded cooling medium is leaving the condensing tubes of the next lower temperature stage. If this is not done, not only is the economy of the evaporator plant reduced, resulting in higher operating costs, but also the output of the plant, that is, the amount of resulting distillate is reduced.

It is, therefore, a general object of the present invention to provide a construction of recirculation type flash evaporator plant, multi-stage or otherwise, which will operate with a maximum of efficiency and may be constructed of materials having a minimum cost.

It is a primary object of the present invention to provide a recirculation type of flash evaporator plant, preferably multi-stage, in which all of the water passing through

both the evaporator chambers and condensing chambers of the higher temperature stages has been thoroughly deaerated to insure the maximum amount of removal of dissolved oxygen therefrom and thereby substantially eliminate any damaging corrosive effect of such water to the various elements of the evaporator plant.

It is a further important object of the present invention to provide a multi-stage recirculation type flash evaporator plant in which the feedwater being recirculated is injected into the evaporator system at a point which will maintain the proper heat balance of the plant and thereby retain the maximum efficiency and output thereof.

These and other objects are accomplished by the parts, construction arrangements, combinations and subcombinations comprising the present invention, the nature of which is set forth in the following general statement, a preferred embodiment of which—illustrative of the best mode in which applicants have contemplated applying the principles—is set forth in the following description and illustrated in the accompanying drawings, and which is particularly and distinctly pointed out and set forth in the appended claims forming a part hereof.

In general terms the improvements in evaporator construction of the present invention involve the introduction of make-up feedwater into a single or multi-stage recirculation type flash evaporator plant or system. Also, the improvements of the present invention involve the injection of recirculated or recycled feedwater into the condensing chamber tube bundle of an intermediate stage of a multi-stage recirculation type flash evaporator plant or system.

The construction of the evaporator stage into which the make-up feedwater is introduced in a single or multi-stage recirculation type flash evaporator plant may include a flash chamber and a condensing chamber, with means for introducing a main stream of feedwater into the flash chamber in order to flash a portion of said main stream into water vapor in said flash chamber, and with condenser tube bundle means in the condensing chamber for condensing the water vapor received into the condensing chamber from the flash chamber. Further, the flash chamber has make-up feedwater inlet means for introducing make-up feedwater into the flash chamber preferably at a temperature higher than the temperature of the main feedwater stream within the flash chamber, with a series of generally horizontally extending and vertically spaced deaerating trays positioned in the flash chamber above the level of the main feedwater stream for receiving the make-up feedwater from the inlet means thereon and downwardly thereover to ultimately mix with the main feedwater.

Further, the deaerating trays are positioned in the path of the water vapor flashing from the main feedwater stream and passing to the condensing chamber so that at least a portion of the water vapor flashing from the main feedwater stream must pass between the deaerating trays and through the downwardly flowing stream of make-up feedwater flowing between said trays. Finally, these vertically spaced deaerating trays are preferably positioned laterally offset from one to the next in a longitudinally vertical diagonal row, so that the make-up feedwater flows over a major portion of each tray, and so that the minimum resistance to the upward passage of water vapor therebetween is provided.

Thus, with such a construction for the introduction of make-up feedwater, the maximum deaeration of the make-up feedwater is provided prior to this make-up feedwater mixing with the main stream of feedwater within the flash chamber.

The construction of multi-stage recirculation type evaporator plant involving the injection of recirculated feedwater improvements of the present invention may include a series of operably connected flash evaporator stages of progressively decreasing temperature and pressure, each having a flash chamber and condensing chamber. The flash chambers of the evaporator stages are operably connected for the continuous flow of a main feedwater stream progressively from the highest temperature stage to the lowest temperature stage, and the condensing chamber tube bundles of the lowest temperature stage to an intermediate stage are operably connected for the flow of an outside condensing or cooling fluid therethrough from the lowest temperature stage to said intermediate stage, while the condensing chamber tube bundles from said intermediate stage to the highest temperature stage are operably connected for the continuous flow of recirculated feedwater from said intermediate stage to said highest temperature stage.

Further, the multi-stage evaporator construction includes inlet means for directing the outside condensing medium into the condensing chamber tube bundle of the lowest temperature stage and outlet means for discharging the outside condensing medium from the next lower temperature stage adjacent the intermediate stage. Still further, the multi-stage evaporator construction includes recirculation directing means for directing at least a portion of the feedwater from the flash chamber of the lowest temperature stage to the condensing chamber tube bundle of the intermediate stage.

Finally, the multi-stage evaporator construction includes the improvements of the present invention of maintaining the temperatures and pressures of the various stages balanced such that the recirculated feedwater is injected into the condensing chamber tube bundle of the intermediate stage at substantially the same temperature as the outside condensing medium is discharged from the next lower temperature stage adjacent said intermediate stage, with any variation between said temperatures being not greater than plus or minus ½° F. Thus, with such a multi-stage evaporator construction, the maximum efficiency of the evaporator plant is maintained.

By way of example, a multi-stage recirculation type flash evaporator construction embodying the principles of the present invention is illustrated in the accompanying drawings forming a part hereof, wherein like numerals indicate similar parts throughout the several views, and in which:

FIG. 1 is a vertical sectional view, part in elevation and somewhat diagrammatic, looking in the direction of the arrows 1—1 in FIG. 2, showing one of the stages of the evaporator construction of the present invention and including certain of the improvements of the present invention;

FIG. 2, a fragmentary vertical sectional view, part in elevation, looking in the direction of the arrows 2—2 in FIG. 1;

FIG. 3, an enlarged fragmentary horizontal sectional view, part in elevation, looking in the direction of the arrows 3—3 in FIG. 2; and

FIG. 4, a diagrammatic view of an entire multi-stage recirculation type flash evaporator plant incorporating the principles of the present invention.

Referring to FIG. 4, the illustration of the multi-stage recirculation-type flash evaporator plant which incorporates the principles of the present invention is generally of usual construction having a series of operably connected evaporator stages of progressively decreasing temperatures and pressures numbered 1 through 27 in FIG. 4. The actual number of stages is not important to the principles of the present invention and it should be understood that such principles are not intended to be limited to the particular evaporator plant illustrated, since the principles have wide application to many forms of evaporator plants of various sizes and numbers of stages.

For example, the principles of the present invention involving the deaeration of make-up feedwater in a recirculation type flash evaporator might be incorporated in a single stage recirculation type flash evaporator, or as illustrated, may be incorporated in a multi-stage plant. The principles of the present invention concerning the manner

of injection of recirculating feedwater back into an evaporator system would, however, only be applicable to a multi-stage recirculation type evaporator plant although the total number of stages could vary.

Also, referring to FIGS. 1 through 3, which show the lowest temperature and lowest pressure evaporator stage, that is, the last stage 27 as numbered in FIG. 4, each of the evaporator stages of the multi-stage plant includes a flash chamber, generally indicated at 30 and a condensing chamber, generally indicated at 31, with the flash chambers 30 of the adjacent stages being operably connected for the progressive flow of feedwater from the highest pressure and highest temperature stage 1 to the lowest pressure and lowest temperature stage 27. Further, as will be hereinafter more clearly explained, the usual tube bundles 32 in the condensing chambers 31 of stages 1 through 23 are operably connected for the continuous flow of recirculating feedwater as a condensing medium progressively through all of these stages, and stages 24 through 27 are similarly connected for the continuous flow of another condensing medium progressively through these stages. As is usual, the flow of fluid through the various tube bundles 32 is counter to the flow of feedwater through the flash chambers 30, so that this flow through the condensing chambers is from stage 27 toward and through stage 24, and from stage 23 toward and through stage 1.

Referring particularly to FIGS. 1 through 3, there is shown, as previously pointed out, the internal construction of the last stage 27 as numbered in FIG. 4 or the lowest temperature and lowest pressure stage of the particular multi-stage recirculation type flash evaporator plant. With the exception that this stage includes particular construction for properly deaerating make-up feedwater which is added at this stage according to the principles of the present invention, this stage is generally representative of all of the stages of the evaporator plant, with the principal variation being as to size and the temperature and pressure at which the particular stage is maintained.

As shown, each of the evaporator chambers is preferably rectangular in overall configuration and is divided into the flash chamber 30 and condensing chamber 31, which chambers are connected through the usual vapor separator 33. The condenser tube bundle 32 in the condensing chamber 31 may be formed by a series of vertical tubes 34 connected between the usual headers 35 and 36.

Thus, feedwater may enter the flash chamber 30 through a usual feedwater device 37 with a portion thereof flashing into water vapor within this flash chamber and passing upwardly through the vapor separator 33, which vapor separator will remove entrained water droplets therefrom. Thereafter, the water vapor passes into the condensing chamber 31 and the condensable portion thereof is condensed by the tube bundle 32 through which is flowing a condensing or cooling medium, in this case preferably raw sea water since this is one of chambers 24 through 27, although such cooling medium would be recirculating feedwater if this were one of stages 1 through 23.

The resulting distillate will collect at the lower portion of condensing chamber 31 and will be removed through the distillate drain 38, and all of the distillate drains of all of the chambers will preferably be connected to collect all of the distillate at one central point. Also, an air ejection line 39 is connected to the condensing chamber 31 for removing air to maintain the desired pressure in the particular evaportaor stage and also for removing any noncondensable gases entering the condensing chamber with the water evaporator. The air ejection lines of all of the evaporator stages may likewise be operably connected one to the other and to a single air ejector to be hereinafter described.

As hereinbefore pointed out, the evaporator stage construction to the extent described above is representative of all of the stages of the multi-stage evaporator plant. This last or lowest temperature and lowest pressure stage 27, however, includes additional structure for effectively deaerating make-up feedwater which is added into the flash chamber 30 of this particular last stage.

As shown in FIGS. 1 through 3, the make-up feedwater enters the flash chamber 30 of this last stage through the make-up feed pipe 40 beneath the overlying water baffle 41 and flows onto the uppermost of a series of vertically spaced deaerating trays 42 positioned offset in a vertical longitudinally diagonal line. These deaerating trays 42 are not only diagonally offset from the uppermost tray at the one chamber sidewall 43 progressively to the lowermost tray only slightly laterally spaced from the opposite chamber sidewall 44, as shown in FIG. 2, but may be alternately attached to the front chamber wall 45 and the rear chamber wall 46 of the flash chamber 30, as shown in FIG. 1, so as to be likewise alternately laterally offset.

Furthermore, each of the deaerating trays is provided with the upstanding side flanges 47 and downwardly curved edge lip 48, which edge lip is, of course, at the opposite edge of the tray from the particular chamber side wall 43 or 44 to which that particular tray is attached. Finally, vertically spaced below the lowermost deaerating tray 42 is mounted a perforated tray 49 and this perforated tray is constructed and positioned similarly to the deaerating trays 42 with the exception that this perforated tray extends completely laterally beneath the next overlying deaerating tray 42 and beyond this tray to the chamber sidewall 44 to which it is attached, as shown in FIG. 2. Also, the entire horizontal portion of tray 49 is provided with a series of perforations 50 extending vertically downwardly therethrough.

Thus, the make-up feedwater is introduced into the last lowest temperature evaporator stage 27 through the make-up feed pipe 40 and will flow progressively downwardly over the series of deaerating trays 42 to the perforated tray 49. The side flanges 47 of these trays insure that this make-up feedwater must flow from tray to tray over the downwardly curved edge lips 48, so that this make-up feedwater must travel the entire longitudinally diagonal extent of this series of deaerating trays 42 from one tray to the next and finally to the perforated tray 49. At the perforated tray 49, a large portion of this make-up feedwater will flow vertically downwardly through the perforations 50 with the remainder flowing over the downwardly curved edge lip 48 of tray 50, so that this make-up feedwater finally drops from the perforated tray 49 to the main feedwater stream at the lower portion of the flash chamber 30 over a broad area.

The make-up feedwater entering through the make-up feed pipe 40 is preferably at a temperature higher than the temperature of the main feedwater or brine stream at the lower portion of the flash chamber 30 and this increased temperature, as well as the flow over the relatively large combined surface area of the deaerating trays 42, will cause a relatively large amount of this make-up feedwater to flash-off into water vapor and result in a maximum amount of dissolved oxygen being released therefrom. Also, the upward flow of water vapor flashing from the main feedwater or brine stream at the lower portion of this flash chamber 30 between deaerating trays 42 and through the downwardly flowing make-up feedwater, as indicated by the flow arrows 51 and 52 in FIG. 2, will release an additional amount of dissolved oxygen from this make-up feedwater, so that the final make-up feedwater dropping downwardly from the perforated tray 49 will be thoroughly deaerated and this is prior to any mixing of this make-up feedwater with the main supply or stream of feedwater or brine at the lower portion of the flash chamber 30 to thereby accomplish the maximum deaeration prior to such mixing with the main feedwater stream.

The purpose of positioning the deaerating trays 42 in a longitudinally diagonal vertical line, as described above

and shown in FIG. 2, it is to present the downwardly flowing stream of make-up feedwater in such a manner as to present the maximum area for the upward flow of water vapor therethrough flashing from the main feedwater stream at the lower portion of the flash chamber 30, while still providing the least resistance to the upward flow of this water vapor from the main feedwater stream. Although certain of the advantages of the present invention could be obtained by positioning the deaerating trays vertically aligned rather than in this longitudinally diagonal vertical manner, it is believed that there is a block-off of less than thirty percent of the water vapor flow from the main feedwater stream with the particular diagonal positioning shown so that there will be a negligible pressure drop in this upward flowing water vapor from the main feedwater stream. In the case of vertical alignment, however, such block-off would be considerably greater and the resulting pressure drop no longer negligible.

As has been hereinbefore pointed out, although this deaerating tray construction described is shown in the last or lowest temperature stage of a multi-stage recirculation type flash evaporator plant, the advantages thereof can be gained equally as well in merely a single stage recirculation flash evaporator plant, and it is not intended to limit the scope of this portion of the present invention to multi-stage evaporator plants. Furthermore, in the case of different size evaporator chambers and different capacities, two or more longitudinally vertical diagonal rows of vertically spaced deaerating trays may be used for the introduction and complete deaeration of the make-up feedwater, so that it is again not intended to limit the principles of the present invention to the single longitudinally vertical diagonal row of vertically spaced deaerating trays shown, whether in a single or multi-stage evaporator plant.

Referring to all of FIGS. 1 through 4, the illustrative multi-stage recirculation type flash evaporator plant incorporating the principles of the present invention may further include a feedwater recirculating pump 53, an air ejector 54, an air ejector condenser 55, an auxiliary feedwater heater 56 and a drains heat exchanger 57. The construction of the various elements of the evaporator plant system is usual and the connection thereof into the evaporator plant system will be hereinafter described in conjunction with the description of the flow of feedwater through the multi-stage evaporator plant.

Furthermore, it is assumed that sea water is the liquid being evaporated to form a pure water distillate and that such sea water is available in sufficient amounts as required at a temperature of 60° F. Also, the amounts of flow involved and the amount of resulting distillate are representative of a typical evaporator plant which could be constructed.

Beginning with the introduction of preheated feedwater into the flash chamber 30 of the highest temperature highest pressure stage 1, the feedwater will be introduced into this flash chamber through line 58 and through a feedwater device similar to the feedwater device 37 in FIG. 2 in the amount of 243,000 pounds per hour and at a temperature of 239° F. In the evaporator stage 1, a certain amount of this feedwater will flash into water vapor and the remainder or the major portion thereof will continue to flow from stage 1 to stage 2 and ultimately through all of the stages to the flash chamber 30 of stage 27, with each of these subsequent stages being of progressively lower temperature and pressure and with a certain amount of the feedwater flashing into water vapor in each stage.

At stage 27, this feedwater in the flash chamber 30 of stage 27 is at a temperature of 79° F. and make-up feedwater in the amount of 52,500 pounds per hour is added to this main feedwater stream in this flash chamber in the manner previously described. This make-up feedwater originates from raw sea water which has been somewhat preheated as well as provided with the usual chemical treatment and originally enters the evaporator system at a temperature of 70° F. through the line 59, passes through the drains heat exchanger 57 and leaves through line 60 at a temperature of 80° F., passes through line 60 to and through the air ejector condenser 55 where it is heated to 83° F., and finally enters the flash chamber 30 of stage 27 through make-up feed pipe 40 as previously described.

After the make-up feedwater is thoroughly deaerated by passing downwardly over the deaerating trays 42 and the perforated tray 49 in the flash chamber of stage 27, this make-up feedwater drops to and mixes with the main feedwater stream at the lower portion of this stage 27 flash chamber. Thereafter, the mixture leaves this stage 27 flash chamber through the line 61 at the rate of 260,500 pounds per hour, passes through the feedwater recirculating pump 53 into line 62 from which a portion thereof, that is, 17,500 pounds per hour, is discarded or blown down from the evaporator system.

The remaining feedwater which, of course, is at a temperature of 790 F. flows at the rate of 243,000 pounds per hour through the line 63 and is introduced into the tube bundle in the condensing chamber 31 of the stage 23. This recirculated feedwater flowing through the tube bundle of stage 23 and subsequently progressively through the tube bundles of stages 22 and through 1 acts as the cooling or condensing medium in the condensing chambers of the various stages for condensing the water vapor received from the flash chambers in order to produce the final desired distillate.

The cooling or condensing medium in the condensing chamber tube bundles of stages 24 through 27 is raw sea water and is introduced into the evaporator system merely for this condensing purpose, after which it is discarded. This raw sea water enters the condensing chamber tube bundle of stage 27 through line 64 at a temperature of 60° F. and at a rate of 240,000 pounds per hour, and after passing through the interconnected tube bundles of the condensing chambers of stages 26, 25 and 24, leaves the tube bundle of stage 24 at a temperature of 79° F. after which this water is discarded. There is not a corrosion problem involved with this raw sea water in the condensing chamber tube bundles of these stages 24 through 27 in view of the low temperatures involved.

The important thing is that the raw sea water which has served as the cooling or condensing medium leaves the condensing chamber tube bundle of stage 24 at a temperature of 79° F. and the recycled feedwater enters the condensing chamber tube bundle of the next adjacent stage 23 or the next higher temperature stage at the same temperature, or 79° F. This principle of injecting recirculated feedwater into the condensing chamber tube bundles of an intermediate stage at substantially the same temperature as a different cooling or condensing medium which is to be discarded is leaving the next adjacent lower temperature stage is an important part of the present invention and is necessary in multi-stage recirculation type evaporator plants in order to maintain the maximum efficiency of the evaporator plant and provide a minimum of operating cost with a maximum output of resulting distillate. It is believed that the optimum conditions will be proivded if the recirculated feedwater being injected into the system does not vary in temperature more than plus or minus ½° F. from the temperature of the other cooling medium, such as raw sea water, being discarded from the next adjacent lower temperature stage.

The recirculated feedwater leaves the condensing chamber tube bundles of stage 1 at a temperature of 220° F. and passes through line 65 to and through the auxiliary feedwater heater 56, from which this feedwater leaves through line 66 at a temperature 239° F. and re-enters line 58 to complete the recirculating cycle.

The heat for the auxiliary feedwater heater 56 is provided by steam from any usual source at a pressure of 60 pounds G and at the rate of 5400 pounds per hour, which

steam enters heater 56 through line 67 and leaves through line 68 as drains at a temperature of 300° F. These drains are then directed by line 68 through the drains heat exchanger 57 to provide heat for preheating the make-up feedwater as previously described. The drains finally leave the heat exchanger 57 through line 69 through which they may be discarded from the system.

The air ejector 54 is connected to the air ejector line 39 at stage 27 and this air ejector is operated by steam at 100 p.s.i. in the amount of 260 pounds per hour entering through line 70. The outlet for air ejector 54 is through line 71 through the air ejector condenser 55 to serve as additional heat for preheating the make-up feedwater as previously described.

Finally, all of the distillate produced from all of the chambers 1 through 27 may be collected at stage 27 and removed therefrom through the distillate drain 38 at a temperature of 78° F. and in an amount of 35,000 pounds per hour.

As shown in FIG. 4, the representative multi-stage recirculation type flash evaporator is divided into two sections, one consisting of chambers 1 through 16 and the other consisting of chambers 17 through 27, and in such a case the flash chambers 30 of stages 16 and 17 would be connected for the flow of feedwater therebetween by the line 72 and the condensing chamber tube bundles 32 thereof would be connected for the flow of recirculating feedwater therebetween by the line 73. It should be understood, however, that the particular division of stages shown is not of importance to the principles of the present invention and could be in any manner desired.

Thus, according to the principles of the present invention an evaporator construction is provided in which the necessary make-up feedwater introduced into the evaporator system is cheaply and efficiently deaerated coincident with the introduction of this make-up feedwater into this evaporator system and without any appreciable cost. Furthermore, this deaeration of the make-up feedwater is accomplished prior to this make-up feedwater mixing with the main stream of feedwater already in the evaporator system, so that the maximum of dissolved oxygen can be removed therefrom.

Still further, according to the principles of the present invention, a multi-stage recirculation type flash evaporator construction is provided in which an outside cooling or condensing medium is used for the condensing of water vapor in certain of the stages and recirculated feedwater is used in certain other stages, yet the maximum efficiency and maximum output of the evaporator construction is maintained. This is accomplished by injecting or introducing the recirculating feedwater into the condensing chamber tube bundle of an intermediate stage at substantially the same temperature as the outside cooling medium leaves the evaporator system from the condensing chamber tube bundles of the next adjacent lower temperature stage.

In the foregoing description, certain terms have been used for brevity, clearness and understanding but no unnecessary limitations are to be implied therefrom, because such words are used for descriptive purposes herein and are intended to be broadly construed.

Moreover, the embodiment of the improved construction illustrated and described herein is by way of example and the scope of the present invention is not limited to the exact details of construction shown.

Having now described the invention, the construction, operation and use of a preferred embodiment thereof, and the advantageous new and useful results obtained thereby, the new and useful construction and reasonable mechanical equivalents thereof obvious to those skilled in the art are set forth in the appended claims.

We claim:

1. In multi-stage flash evaporator construction for distilling sea water and the like of the type in which a series of operably connected flash evaporator stages of progressively decreasing flashing temperatures and pressures are each provided with a flash chamber for receiving a main stream of feedwater therein and flashing a portion thereof into water vapor, and a condensing chamber operably connected to the flash chamber for receiving the flow of said water vapor from said flash chamber and condensing the condensible part thereof, through contact with a condensing tube bundle, to form distillate; in which an outside condensing medium is directed from a source thereof through the condensing tube bundles of the lowest temperature to an intermediate temperature stage condensing chamber forming the condensing medium therein; in which the main stream of feedwater flows at progressively decreasing temperatures through lower parts of the flash chambers progressively from the highest to the lowest temperature of the evaporator stages; and in which at least a portion of the remainder of the main stream of feedwater from the lowest temperature stage flash chamber is recirculated back into and forms the condensing medium in the condensing tube bundle of said intermediate temperature stage condensing chamber, and then flows progressively through the condensing tube bundles of the stages from said intermediate temperature stage to the highest temperature stage, and ultimately flows to and forms the main stream of feedwater in the flash chamber of the highest temperature stage; the improvements including, make-up feedwater inlet means operably connected into the flash chamber of the lowest temperature stage for directing make-up feedwater from a source thereof into said chamber above the main stream of feedwater therein, deaerating tray means mounted within the flash chamber of the lowest temperature stage above the main stream of feedwater in said chamber and subject to the flashing pressure of said chamber, and the deaerating tray means being constructed and arranged in communication with the make-up feedwater inlet means and discharging downwardly into the main stream of feedwater of said chamber for receiving and deaerating by partial flashing through subjection to the flash chamber flashing pressure make-up feedwater from said make-up feedwater inlet means and discharging the remaining deaerated make-up feedwater downwardly into and forming a part of the main stream of feedwater in said stage; whereby, the main stream of feedwater leaving the flash chamber of the lowest temperature stage is formed partially by the main stream of feedwater flowing therethrough from the next higher temperature stage and partially by the remaining deaerated unflashed make-up feedwater of said lowest temperature stage, with at least a portion of such mixture being recirculated back into the condensing tube bundle in the condensing chamber of the intermediate temperature stage.

2. Multi-stage flash evaporator construction as defined in claim 1 in which the deaerating tray means mounted within the flash chamber of the lowest temperature stage includes at least one generally horizontally extending deaerating tray positioned within said flash chamber above the main stream of feedwater therein and in the path of flow of the flashed water vapor from said main stream of feedwater to the condensing chamber of said stage.

3. Multi-stage exaporator flash construction as defined in claim 1 in which the deaerating tray means mounted within the flash chamber of the lowest temperature stage includes a series of vertically spaced generally horizontally extending deaerating trays, each tray being positioned horizontally offset from the tray next above and receiving the flow of make-up feedwater therefrom, the uppermost of said trays being positioned in communication with the make-up feedwater inlet means receiving make-up feedwater from said inlet means, and the lowermost of said trays being positioned spaced above the main stream of feedwater in said chamber and discharging the make-up feedwater downwardly into said main stream of feedwater.

4. Multi-stage flash evaporator construction as defined in

claim 1 in which the deaerating tray means mounted within the flash chamber of the lowest temperature stage includes a series of vertically spaced generally horizontally extending deaerating trays mounted for the flow of make-up feedwater from one tray downwardly to the next, the trays of said series being positioned offset horizontally one from the next progressively in one horizontal direction so as to form a vertical diagonal row of trays, the trays of said series also being positioned offset alternately in opposite horizontal directions one from the next which opposite horizontal directions are perpendicular to the progressive horizontal offsetting in said vertical diagonal row, the uppermost of said trays being positioned in communication with the make-up feedwater inlet means receiving make-up feedwater from said inlet means, and the lowermost of said trays being positioned spaced above the main stream of feedwater in said chamber and discharging the make-up feedwater downwardly into said main stream of feedwater.

5. Multi-stage flash evaporator construction as defined in claim 1 in which the deaerating tray means mounted withi nthe flash chamber of the lowest temperature stage includes at least one generally horizontally extending deaerating tray positioned within said flash chamber above the main stream of feedwater therein and in the path of flow of the flashed water vapor from said main stream of feedwater to the condensing chamber of said stage; and in which the make-up feedwater directed into the flash chamber of the lowest temperature stage from a source thereof is of a higher temperature than the temperature of the main stream of feedwater in said chamber.

6. Multi-stage flash evaporator construction as defined in claim 1 in which the deaerating tray means mounted within the flash chamber of the lowest temperature stage includes a series of vertically spaced generally horizontally extending deaerating trays mounted for the flow of make-up feedwater from one tray downwardly to the next, the trays of said series being positioned offset horizontally one from the next progressively in one horizontal direction so as to form a vertical diagonal row of trays, the trays of said series also being positioned offset alternately in opposite horizontal directions one from the next which opposite horizontal directions are perpendicular to the progressive horizontal offsetting in said vertical diagonal row, the uppermost of said trays being positioned in communication with the make-up feedwater inlet means receiving make-up feedwater from said inlet means, and the lowermost of said trays being postiioned spaced above the main stream of feedwater in said chamber and discharging the make-up feedwater downwardly into said main stream of feedwater; and in which the make-up feedwater directed into the flash chamber of the lowest temperature stage from a source thereof is of a higher temperature than the temperature of the main stream of feedwater in said chamber.

7. Multi-stage flash evaporator construction as defined in claim 1; and in which the make-up feedwater directed into the flash chamber of the lowest temperature stage from a source thereof is of a higher temperature than the temperature of the main stream of feedwater in said chamber.

8. Multi-stage flash evaporator construction as defined in claim 1 in which the main stream of feedwater from the lowest temperature stage flash chamber which is recirculated back into and forms the condensing medium in the condensing tube bundle of the intermediate temperature stage condensing chamber is recirculated back into said intermediate temperature stage condensing tube bundle at a temperature substantially the same as the temperature of the outside condensing medium leaving the condensing tube bundle of the next lower temperature stage from said intermediate temperature stage.

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