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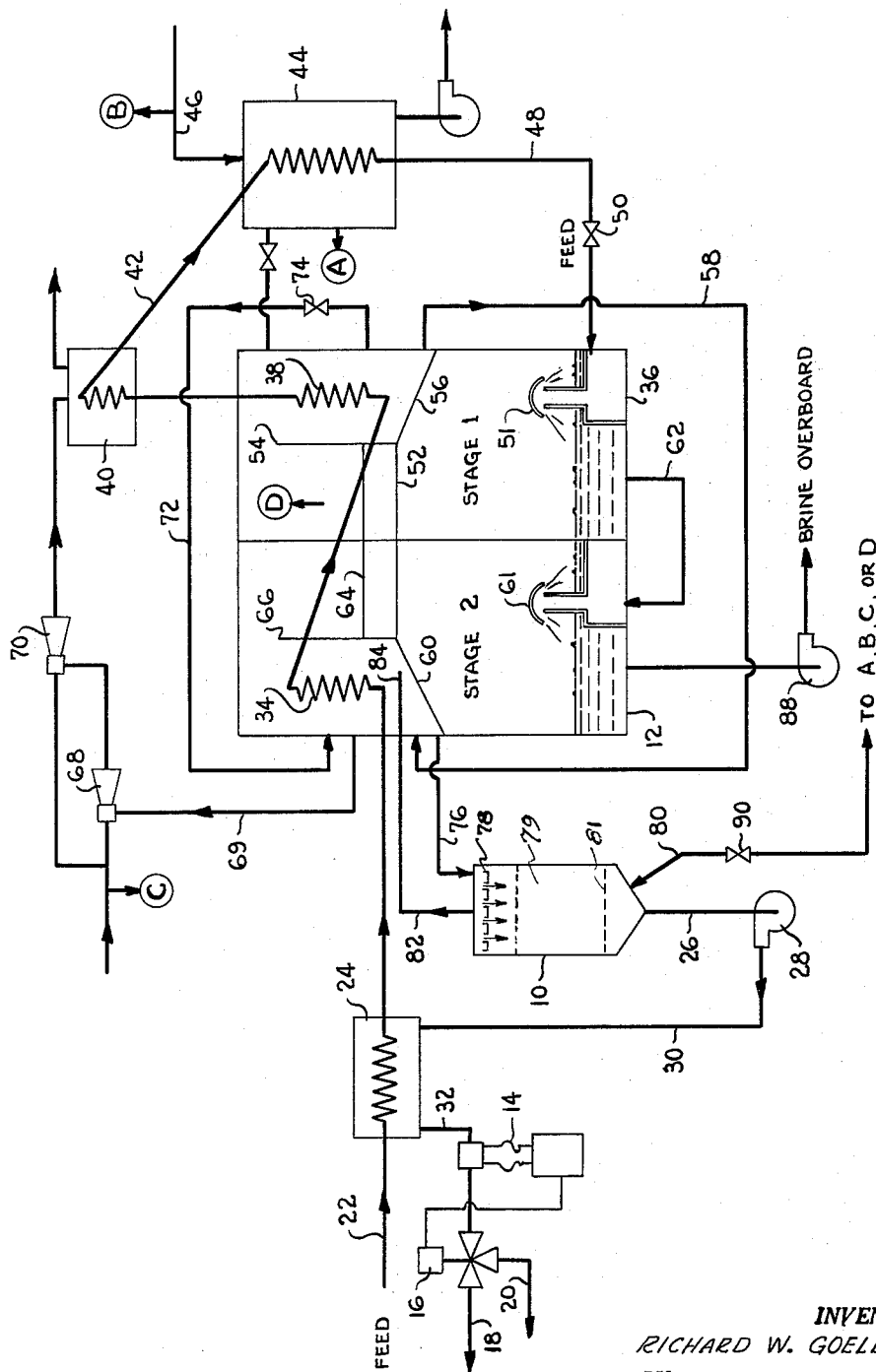


Fig. 1

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FLASH EVAPORATOR WITH DISTILLATE DEAERATOR

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The present invention relates to a method and apparatus for the treatment of the distillate product of a flash evaporation distilling unit. One aspect of the invention relates to degassing or deaerating the distillate produced in a flash evaporator. Another aspect of the invention relates to treating the distillate formed in a flash evaporator having particular reference to problems incurred by marine flash evaporators of the character found on board ship, especially where an automated quality control means is provided to monitor the distillate under conditions where the marine flash evaporator is being supplied with polluted water of the character found in harbors and polluted sea waters, and for purposes of the present disclosure is so described.

Until recently the submerged tube type of evaporator has been commonly used on board ship to distill water for use in drinking, boilers, and the like. Recently, however, flash evaporation distilling units have been increasingly employed in marine type equipment, not only on board ship but occasionally as portions of power generating plants and the like which derive their water requirements from a similar source, such as sea water.

In distilling operations, to produce potable and/or usable water from polluted seawater or from polluted harbor waters, volatile substances such as gases dissolved in the feed water are liberated in the heating and flashing process. The quantity of these substances liberated is particularly great in relation to the distilled product when the flash type of evaporator is compared to a submerged tube type of evaporator. The quantity of feed water boiled in the flash evaporator is, other things being equal, ordinarily from 3 to 10 times the quantity boiled in a submerged tube unit. Ordinarily, the quantity of feed water boiled is from 10 to 20 times the quantity of distillate for a marine unit while the quantity of feed water boiled runs from 2 to 3 times the distillate quantity for conventional units.

The increased quantity of feed water boiled by a flash type evaporator yields a correspondingly larger amount of volatile substances. Many of the volatile substances are soluble in the distillate. When operating on a polluted feed there is an even greater quantity of volatile substances produced, and their concentration in the resulting distillate is correspondingly higher. In flash type units, due to the larger amount of volatiles evolved, the concentration becomes exceedingly high. Thus, the problem of volatiles being distilled over into the product has been more acute with the flash type than with the submerged tube type because of the greater quantity of feed per unit product.

When a marine flash type distiller operates in polluted waters, the exceedingly high concentration of dissolved volatile matter liberated from the feed water changes the electrical conductivity of the distillate product. The change in electrical conductivity—or other physical property—is enough to cause a salinity controller to produce a control signal which does not coincide with the actual salinity. A salinity controller is used to operate a valve so that the distillate product is automatically either accepted or rejected in accordance with the salinity of the distillate product which is measured by the controller. The salinity reading occasioned by the dissolved gases frequently causes a rejection of water (distillate) which would be adequate for cooking, drinking and similar purposes.

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In addition to the rejection of otherwise satisfactory water, the distillate even if accepted by the salinity controller may contain dissolved therein deleterious volatile matter that causes corrosion or other undesirable chemical reactions in the potable water system or boiler water system aboard ships. For example, dissolved ammonia or carbon dioxide would cause danger to copper fittings and to steel (by reason of carbonic acid forming), respectively. Flash type systems operating without a salinity controller are likewise subject to such introduction of deleterious volatile matter.

In other words, the volatiles in the distillate can cause the controller to operate in a randomly erroneous fashion to reject satisfactory distillate and to accept unsatisfactory distillate product, according to a number of variables such as, for example, actual salinity of product distillate, controller sensitivity, and the specific chemical or physical constitution of the polluting substances. Also, systems having no controller are subject to introduction of deleterious volatile matter.

It is an object of the invention to provide a method and apparatus for minimizing the introduction of deleterious dissolved gases into the potable and boiler water supplies of shipboard and similar equipment.

It is a further object of the invention to provide a method and apparatus for improving the quality of the product of a flash evaporator, particularly of the marine type.

It is still another object of the invention to improve the efficiency of flash evaporators, particularly of the type found on board ship for producing from the fluid medium in which the ship floats a supply of potable, fresh or boiler water.

In the preferred embodiment, the invention comprehends contacting the product distillate with process steam thereby removing the gases dissolved in the distillate. Stated simply, the product distillate is deaerated in a deaerator between the last condensing stage and any monitoring means which is measuring the salinity or other characteristics of the product to determine its suitability. The process steam used for deaerating may be drawn from a suitable stage of the flash evaporator itself, from supplies of high pressure or low pressure steam available from associated equipment, or even from the vapor space of heat exchangers used in the heating system for treating the feed to the evaporator.

While the apparatus and method will be described in more detail below, the construction can be conveniently summarized as a deaerator connected in the product line between the last stage of condensation and the monitoring means alluded to above. The deaerator receives the distillate product in the top of a sealed vessel. Process steam is admitted to the bottom of the vessel. The steam and the product pass counter-currently through the vessel in intimate contact with each other whereby a gas-removing action takes place and the dissolved gases are removed from the distillate to thereby from a deaerated product stream. The off-gas formed during this operation comprises noncondensable gases mixed with condensable vapors and is termed a deaerator gas product stream. The deaerator gas product stream is directed from the top of the scrubber back into the last stage flash evaporator so that it is exposed to the condensing action therein, thus to recover any entrained or condensable fluids left therein. The noncondensable gases are subsequently removed from the condensing stage by appropriate venting means.

One of the features of the invention is the recovery of condensable values from the deaerator off-gases by directing them back into the last stage of a flash evaporator where they contact the condensing means therein.

An advantage of the present invention is the increase in efficiency of flash evaporators, particularly of the

marine type. Another advantage of the present invention is an improvement in the quality of the product. A further advantage is improvement in the effectiveness of automated control systems which are associated and used with the flash evaporators.

Other objects, advantages and features will become apparent from reading the following disclosure in conjunction with the associated claims and drawing, wherein the drawing represents a schematic diagram of a system embodying the invention and shows four alternative sources of steam for use in the scrubber, it being understood that only one steam source at a time would be employed although any given system could have valving appropriate for selecting one or the other of the steam sources.

Referring now to the drawing, a deaerator 10 is connected in the product line (76, 26, 28, 30) between the last stage 12 of a flash evaporator and the product quality monitor which comprises electrical conductivity controller 14. The controller manipulates a three way solenoid valve 16 to direct the distillate product to waste (overboard in the case of a shipboard unit) via conduit 18 or through conduit 20 to a place of storage or use such as a potable water reservoir or boiler supply tank.

The electrical conductivity controller is used by way of example and not by way of limitation. In operation it measures the conductivity of the product by passing an electrical current therethrough. Advantage is taken either of the voltage drop in the case of a constant current system or the decreased current transmitted in a case of a constant voltage supply system. The change in voltage or current, as the case may be, is compared to a standard or a set point. If the product is indicated to be too saline, it is rejected by turning valve 16 to pass the product into conduit 18 but if it is accepted valve 16 directs it through the conduit 20.

The invention is usable with an evaporator having any number of stages, preferably from one to five stages, a two stage marine flash evaporator being shown wherein the feed is directed through conduit 22 to a distillate cooler 24 where it is placed in indirect heat exchange with the product distillate. The degassed product distillate is removed from the bottom of the deaerator 10 by conduit 26 and pumped by pump 28 through conduit 30 into the distillate cooler. The liquid degassed product is moved from the cooler by conduit 32, in which is disposed the controller 14.

The feed after being initially heated in the distillate cooler is directed into the condensing coil 34 which is located in the last (or second) stage 12 of the multistage flash evaporator illustrated. The feed continues through the flash evaporator to condensers in succeeding upstream stages, (with reference to the flow direction of feed and vapors) here shown as the first stage 36. The feedwater goes through a condenser 38 located in the upstream stage and moves thence through an after condenser 40 to indirect heat exchange with vent gases comprising a heavy fraction of noncondensables drawn from the flash evaporator in the fashion described hereafter. The condensers 34, 38 aid in maintaining a low pressure in the respective stages.

The feedwater leaves the aftercondenser through conduit 42 and passes through a salt water heater 44 where it is in indirect heat exchange with some external source of heat such as low pressure steam brought in through conduit 46.

The feedwater is brought up to its initial temperature for flash evaporation in the salt water heater 44, and is directed from there to the first stage 36 flash evaporator by means of a conduit 48. A valve 50 controls the feed into the feed spray manifold 51 located in the first stage 36. The valve 50 also adjusts the pressure of the feedwater to encourage the flashing effect brought about by a sharp reduction in pressure as the feed enters the first stage.

In the first stage 36, a fraction of the feed flashes and moves upwardly through the entrainment separator 52, over the baffle 54 and into condensing heat exchange relation with the condenser coil 38 through which incoming feed is passing. The condensate formed on the coil 38 drips down onto a collector tray 56 from whence it is withdrawn through condensate transfer line 58 and directed into the collector tray 60 which is located in the second stage of the evaporator.

The second stage 12 of the flash evaporator is constructed in a generally similar fashion as that of the first stage. The feed or brine is brought in to the spray manifold 61 of the second stage from the first stage by brine transfer line 62. An entrainment separator 64 and baffle 66 are provided to reduce the amount of entrained liquid in the vapors leaving, and the condenser coil 34 operates to extract condensable values from the gases coming over the baffle 66.

The spray manifolds 51, 61 and line 62 are so arranged as to provide a liquid seal between the two stages.

The demisters 52, 64 separate their respective zones into a liquid flash zone in the bottom of their respective chambers and a condensing zone adjacent the top of the respective chambers.

In addition, the second stage has a vent means 68, preferably a steam jet ejector, which withdraws through conduit 69 noncondensables as well as a fraction of condensable materials found in the second stage 12. The steam jet ejector 68 helps to maintain a low pressure in the second stage in conjunction with the condensing effect and also serves to draw the gases and vapors therein past the condenser 34, so that the condensable values have a maximum opportunity to be condensed and to drain off into the collector tray 60. Additionally, the vent means 68 feeds its stream of gases into the aftercondenser 40. Condensable values collected in 40 are either sent to the top of the scrubber 10 or drained through a conduit (not shown) down into the tray 56, as the case may be.

A second vent means 70, preferably a jet ejector, is provided to promote the venting action. Stage 1 is vented by line 72 which is connected between the vapor spaces of the first and second stage flash evaporators. The vent line 72 transfers vapors from the high pressure region of stage 1 to the low pressure region of the second stage 12, a valve 74 being disposed therein to adjust and control the quantity of flowing and to adjust the pressure.

Turning again to the deaerator 10, a condensate withdrawal conduit 76 is provided to transfer condensate from the collecting means 60 to the upper end of deaerator 10. A liquid level controller (not shown) may be used to control a valve in conduit 76 thus to control condensate withdrawal while maintaining a liquid level. An appropriate distribution means 78, a perforated tray, a spray, a bubble tray, or the like, is provided in the upper end of the deaerator to evenly distribute the liquid over the cross section thereby to promote the maximum contact stripping stream. The condensate travels down through the gas-liquid contact promoting means 79 (which may comprise a series of vertically arranged perforated plates, bubble cap trays, a body of rings or saddles supported on support 81, or the like) in intimate contact with steam delivered through the line 80. The steam travels counter-currently to the condensate and strips gases from the same. A fraction of the steam is condensed during this action. Preferably the stripping steam is admitted beneath the means 79, shown as beneath support 81.

The deaerator gas product stream, comprising gases remaining by the time the steam has moved upwardly through the tower, is collected in the vapor spaces over distributor 78 and transferred by the off-gas line 82 into the condensing zone of the last evaporator stage. The deaerator off-gases are introduced into the condensing zone above the body of liquid on the collector tray 60 in

such fashion that the venting means 68 will draw gases

over the condenser 34 thereby to extract condensable values therefrom prior to leaving the evaporator proper. Extension 84 of the off-gas line schematically represents in the drawing the means for off-gas introduction above the liquid and where the off-gases when venting travel past the condenser in condensing indirect heat transfer relation to the condenser.

Flash evaporation is in and of itself old. Therefore, the present system involving degassing, stripping or deaerating the condensate withdrawn from the last stage of the flash evaporator is usable in combination with any known type of flash evaporator. It is preferred to use the invention in conjunction with the marine flash evaporator where the bulk of feedwater is quite large compared to the quantity of distillate produced.

Brine remaining in the last stages is pumped overboard through the pump 88.

Steam for use in the scrubbers is drawn from any one of the wide variety of sources which are denoted A, B, C, and D in the drawing. Low pressure steam is drawn from the vapor space from the salt water heater by opening a valve 90, assuming that A is connected to the valve 90. This provides low pressure steam to the deaerator. In similar fashion, low pressure steam of higher quality is provided to the deaerator by connecting conduit B to valve 90. Conduit B is a portion of the salt water heater's steam supply. The conduit C is connected to a source of high pressure steam which latter is used for driving the various steam jet ejectors 68, 70. Connection of C to the valve 90 provides high pressure steam for stripping out the gases.

The quantity of stripping steam used in the deaerator varies widely in accordance with the heat and material balance of the system steam quality, the nature of the gases to be removed, and the purity required of the product distillate. The temperature and contaminants of the feed effect a number of these factors. The amount of steam is ordinarily in the range from about 2 pounds of dry saturated steam per 1000 pounds of distillate treated to about 10 pounds of dry saturated steam per 1000 pounds of distillate treated, or a quantity and quality equivalent thereto.

Deaerator off-gases, including some noncondensables, may also be withdrawn from the first stage 36 or other upstream stage by a conduit D connected between the condensing zone thereof and the valve 90. The pressure in the upstream evaporator stage, or conduit D if used, must be great enough to insure the stripping gas withdrawn therethrough can overcome the pressure drop through the remainder of the system to the vent which includes the pressure drop through the deaerator 10.

On occasion a portion only of the product is scrubbed which reduces the level of dissolved gases. This is accomplished by withdrawing a portion of the collected distillate on tray 60, introducing the same into the scrubber, and then mixing the scrubbed distillate with that which is not scrubbed, preferably at a point between the scrubber and the monitoring means 14, 16. A conduit which has in series therein a valve and pump and which extends between conduits 76 and 30 (not shown) can be provided to this end.

It is preferred to deaerate the distillate upstream of the cooler 24 thereby minimizing corrosion and other deleterious actions affecting the heat transfer surfaces of 24 due to dissolved gases.

Deaerating and related terms have been used herein to refer to degassing, scrubbing, stripping and the like, i.e. in reference to removing gases from a gas-liquid solution or mixture, and covers not only the removal from a liquid of air or constituents thereof, but also other gases such as but not limited to carbon dioxide, ammonia, chlorine and mixtures of various gases including those named. Also, the invention is applicable to processes for concentrating the feed material and to processes for treating other feed materials than sea water

or brackish water, examples of such other feed materials being sulphite liquors produced in paper making, sugar solutions, and a host of others.

Although particular embodiments of the invention have been shown and described in full here, there is no intention to thereby limit the invention to the details of such embodiments. On the contrary, the intention is to cover all modifications, alternatives, embodiments, usages, and equivalents of the flash evaporator with distillate treatment as fall within the spirit and scope of the invention, specification and appended claims.

I claim:

1. A process for degassing the distilled water product from a plural stage flash evaporator system for extracting said product from a feed of saline water or impure water, said process comprising the steps of

withdrawing at least a part of said product from the last stage of said evaporator, said last stage including a condensing means;

introducing said withdrawn product into a deaerator; feeding steam into said deaerator; and

stripping gases from said product with said steam by flowing said steam through said deaerator counter-currently to said product to thereby produce a degassed product stream and an off-gas product stream; and

recovering said degassed product stream.

2. A process in accordance with claim 1 wherein said step of feeding steam includes

withdrawing steam from an evaporator stage upstream with reference to the feed of the last evaporator stage, said upstream stage having a pressure at least sufficient to drive the steam so withdrawn through the deaerator, and directing the steam into said deaerator.

3. A process in accordance with claim 1 wherein said step of feeding includes

diverting steam from a stream thereof which is being used to heat saline or impure water before the latter is introduced into said evaporator.

4. A process in accordance with claim 1 wherein a steam jet ejector is used for withdrawing a noncondensable gas stream from the last evaporator stage, and further including the step of withdrawing a portion of the steam being directed to said ejector and using said portion in said feeding step.

5. A process according to claim 1 wherein said feeding step includes introducing an amount of steam equivalent to a ratio in the range from about 2 pounds to about 10 pounds of dry saturated steam per 1,000 pounds of distillate treated.

6. A process for degassing the distilled water product of a flash evaporator system for extracting said product from a feed of saline water or impure water, said evaporator system having an automatic controller for rejecting the water product that does not meet predetermined test conditions, said process comprising the steps of

withdrawing at least a portion of said product from said evaporator, said evaporator including a condensing means;

introducing said withdrawn portion into a deaerator; feeding steam into said deaerator;

contacting said product with said steam by flowing said steam upwardly through said deaerator while said withdrawn portion flows by gravity countercurrently thereto thereby producing a liquid degassed product stream and an off-gas product stream;

admitting said off-gas product stream into said evaporator into contact with said condensing means, and directing said liquid degassed product stream to said automatic controller.

7. A process for degassing the distilled water product of a single stage flash evaporator system for extracting said product from a feed of saline water or impure water, said evaporation system having an automatic controller

for rejecting product water that does not meet predetermined test conditions, said process comprising the steps of

withdrawing all of said product from the single stage of said evaporator, said stage including a condensing means; 5
introducing all of said product into a deaerator; feeding steam into said deaerator; contacting said product with said steam by blowing said steam through said deaerator countercurrently to said product thereby producing a liquid degassed product stream and a scrubber off-gas stream; 10
admitting said scrubber off-gas stream to said stage of said evaporator into contact with said condensing means, and 15
directing said liquid degassed product stream to said automatic controller.

8. In a flash evaporator system having automatic monitoring means for inspecting product quality and having means for accepting or rejecting such product in response to said monitoring means, the improvement in the flash evaporation product withdrawal system comprising means for defining a flash evaporation stage in said system; 20
an entrainment separator disposed inside of and between the top and bottom of said means to separate said means into a liquid flash zone adjacent the bottom and a condensing zone adjacent the top; means disposed in said condensing zone for condensing vapors; 25
means for venting gases from said condensing zone by drawing gases to be vented past said means for condensing; 30
a deaerator, including a deaerator vessel and means inside said deaerator vessel for promoting liquid-gas contact; 35
a condensate withdrawal conduit connected between said means for collecting and the upper end of said deaerator vessel; 40
conduit means for providing a stripping fluid to the bottom of said deaerator vessel; and
an off-gas conduit connected between the top of said deaerator vessel and into condensing zone so as to expose gases delivered into said condensing zone to heat exchange with said condensing means responsive to eduction by said means for venting from said condensing zone. 45

9. A system in accordance with claim 8 wherein said conduit means is connected to receive a gaseous heat exchange fluid from a means for heating the feed stream. 50

10. A system in accordance with claim 8 wherein said flash evaporator is a multi-stage system and wherein said conduit means is connected between the bottom of said scrubber vessel and the condensing zone of a flash evaporator stage upstream of said final stage. 55

11. A process for degassing the distilled water product of a flash evaporator system for extracting said product from a feed of saline water or impure water, said evaporator system having an automatic controller for directing such product to a system for use or for rejecting such

product in response to measurement of a characteristic of said product, said process comprising the steps of withdrawing at least a portion of said product from said evaporator, said evaporator including a condensing means; 5
introducing said withdrawn portion into a deaerator; feeding steam into said deaerator; contacting said product with said steam by flowing said steam through said deaerator in direct contact with said withdrawn portion; 10
separating the liquid and gaseous products after said contact thereby producing a liquid degassed product stream and an off-gas product stream; admitting said off-gas product stream into said evaporator into contact with said condensing means; 15
heat exchanging said liquid degassed product stream with said feed; and
directing said liquid degassed product stream to said automatic controller after said heat exchanging step.

12. A process for degassing the distilled water product of a multi-stage flash evaporator system for extracting said product from a feed of saline water or impure water, said evaporator system having an automatic controller for directing such product to a system for use or for rejecting such product in response to measurement of a characteristic of said product, said process comprising the steps of

withdrawing all of said product from the last stage of said evaporator, said last stage including a condensing means; 25
introducing all of said product into a deaerator; feeding steam into said deaerator; stripping gases from said product with said steam by flowing said steam through said deaerator countercurrently to said product to thereby produce a degassed product stream and an off-gas product stream; admitting said off-gas product stream to the last stage of said evaporator into contact with said condensing means, and 30
directing said degassed product stream to said automatic controller. 35

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