

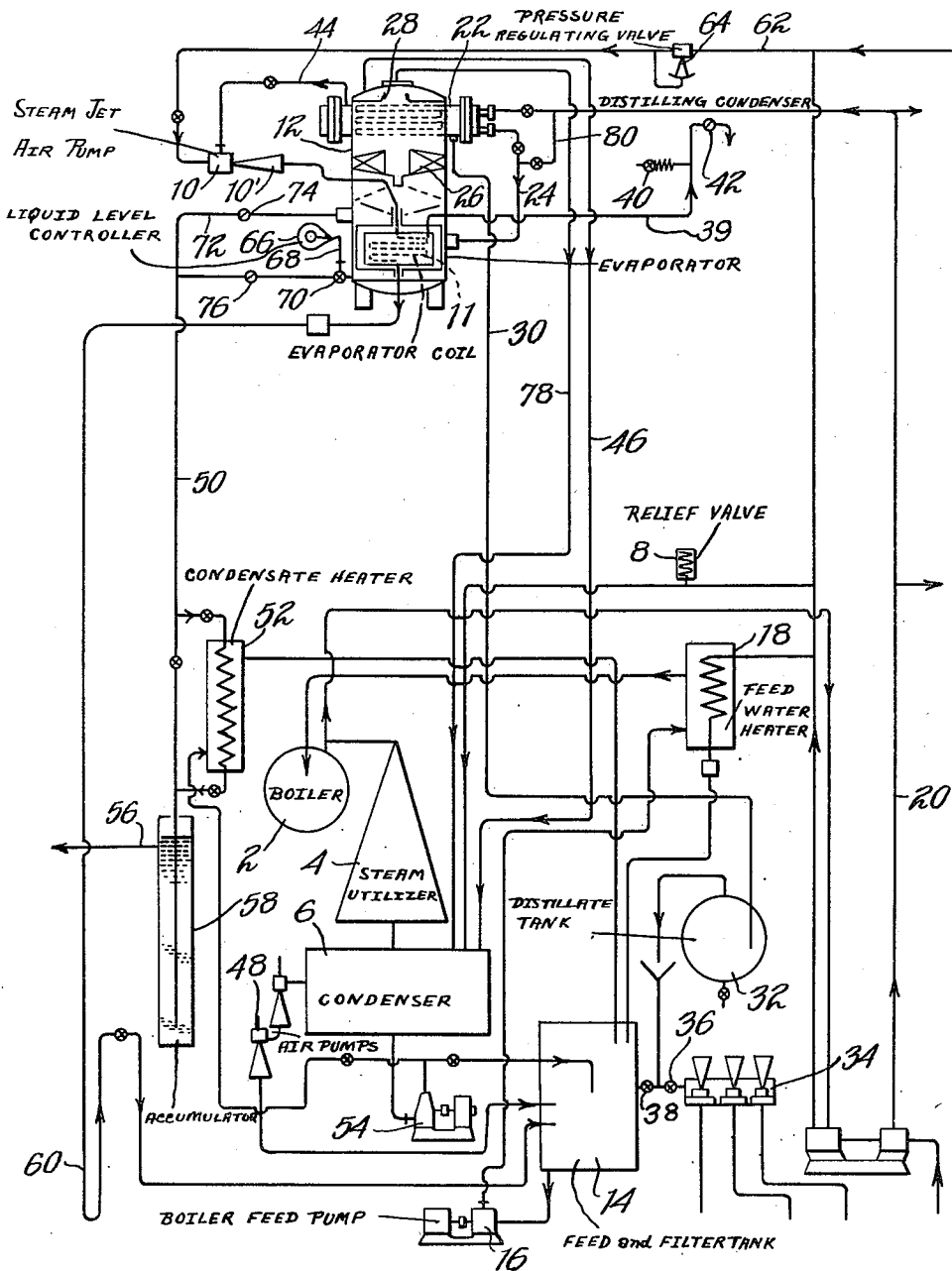
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DISTILLATION APPARATUS FOR STEAM PLANTS

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DISTILLATION APPARATUS FOR STEAM PLANTS

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1 Claim. (Cl. 202—180)

This invention relates to the operation of steam plants with particular reference to the economic production of fresh water by distillation.

More specifically my invention has reference to a steam plant in which sea water is readily available, my invention providing for the continuous production of fresh water in an unusually economical, simple and automatic fashion.

According to the invention, sea water is introduced into an evaporator and distilled in such a manner that the latent heat of the fresh water vapor is conserved and restored to the steam plant system. Preferably cold sea water is utilized, and on shipboard the sea water discharged from the ship's sanitary pumping apparatus has been found to be a desirable source of cold sea water. The operation of the evaporator is preferably carried out by means of heat which is absorbed from the excess and/or waste heat of the system itself.

My invention provides for the operation of the evaporator under sub-atmospheric conditions, preferably under a vacuum which may be as high as twenty-eight inches of mercury. This not only facilitates and speeds up the rate of evaporation but requires less heat and permits other economies to be effected by virtue of the fact that the apparatus, particularly the evaporator, need not be heat insulated; then again the relatively low temperature of the evaporator precludes the formation of saline cake or scale on the heating coils and other interior portions of the evaporator.

I also obtain unusual economies in that the generating steam to the evaporator coils is not only drawn from the excess auxiliary steam circuit, but is utilized additionally for removal of non-condensibles from the evaporator shell and the development of the desired vacuum in the evaporator shell.

Another very important advantage accruing to my invention is the elimination of vacuum type pumping equipment from the coil drain condensate, distillate drain and evaporator feed circuits. Economies incidental to the elimination of vacuum pumping equipment is considered an important step in the art of fresh water distillation; while the advantages of a barometric arrangement, particularly as applied to marine engineering, makes available to the trade a distilling plant of utmost simplicity, safety and reliability in operation.

I am aware of course that the evaporation of liquids under a vacuum broadly is not new, but so far as I know to the contrary no prior at-

tempts have been made to evaporate sea water under sub-atmospheric conditions while at the same time eliminating sub-atmospheric pumping equipment, conserving the latent heat of the fresh water vapor and eliminating the possibility of water level rise above a predetermined point in the evaporator shell.

A further feature of the present invention resides in the utilization of the condensate from the main condenser of the power plant installation as a cooling medium for the surplus and overflow of sea water emanating from the evaporator.

The features above referred to as well as others which will be brought out hereinafter all contribute to the production of fresh water in useful quantities at unusually low cost and under unusually reliable operating conditions and largely by the use of existing equipment in steam plant installations.

Although my invention is applicable to all sorts of industrial plants wherever the distilling of water is or can be resorted to, it is particularly valuable for marine plants, and tests have shown that present installations and procedure can be employed in plants of this character at practically no extra cost and with practically no risk of contamination of the distillate.

In the accompanying drawing, which for clarity takes the form of a flow diagram, an embodiment of my invention has been illustrated.

Referring to the drawing in detail: 2 designates the steam generating apparatus, while 4 designates the prime mover and auxiliary steam consumers. The latter term is intended to include steam radiators, laundry, exhaust from pumping equipment or other apparatus utilizing steam from the generating apparatus 2.

The exhausts from the steam consumers lead ultimately to a condenser 6, the cooling medium of which is sea water which carries overboard the heats of vaporization of all vapors exhausted to the condenser. Under normal operating conditions a small percentage of excess auxiliary exhaust passes a spring loaded relief valve 8 to the condenser 6 where it is condensed and its heat of vaporization transferred to the sea water being discharged overboard. The excess auxiliary exhaust steam just referred to is used in whole or in part as generating steam for the steam jet air-vapor mixture gas removing pump 10 and the steam coils 11 of the evaporator 12, both of which will be referred to in more detail hereinafter. It is to be noted at this point that the heat transferred through the ship's main con-

denser constitutes one of the two major avenues of what today are considered inevitable heat losses. The other major heat loss is through hot gases leaving the boiler and escaping through the stack. The condensate from the condenser 6 is conducted to the feed and filter tank or hot well 14. This is an open tank at atmospheric pressure. The water from this tank is returned to the boiler 2 through a conventional boiler feed system including feed pump 16 and feed water heater 18.

According to the present invention sea water is conducted through the line 20 to the evaporator 12 above referred to. This sea water circulates through the distilling condenser 22 and is warmed by condensing the fresh water vapors rising from the surface of the sea water in the lower part of the evaporator shell, and after circulating through the distilling condenser passes through valve controlled line 24 and through the evaporator shell to the interior thereof on the outside of the steam coil nest 11 of the evaporator.

I have found it advantageous to draw this sea water from the ship's sanitary system and any suitable means may be provided for introducing the sea water into the evaporator, and inasmuch as the evaporator is under sub-atmospheric pressure the introduction of the sea water presents no difficulty and does not add materially to the duty of the ship's pump. Consequently I merely employ the valve controlled line 20, already referred to, for this purpose.

The fresh water emanating from the surface of the sea water in the evaporator passes through a vapor separator 26 by means of which unevaporated parts of the water are prevented from traveling further through the evaporator shell.

The vapors leaving the vapor separator 26 pass upwardly and around the shell of the distilling condenser 22 entering the shell through a nozzle 28 so that the vapors are condensed in the shell by the water circulating through the condenser. The condensate from the fresh water vapors in the shell of the distilling condenser drain from the bottom of the shell and are conducted by line 30 to a distillate tank 32. From here the distillate may be conducted as desired by overflow past valve 36 to the manifold of fresh water tanks 34 or past valve 38 to the hot well 14.

It will be appreciated that the ship's fresh water transfer pump might be used to pump the distillate to any tank aboard ship having an elevation above that of the distillate tank.

A sub-atmospheric pressure is maintained in the evaporator 12 and in the shell of the distilling condenser 22 by the steam jet air-vapor mixture gas removing pump 10 already referred to, although any convenient vacuum producing device may be employed. However I prefer to expand the generating steam for the evaporator coils 11 through the ejector 10', thereby converting part of the pressure steam into velocity and confining the steam at high velocity, with air and generated vapors entrained, in a diffusing element of the pump 10, and exhausting the mixture of steam and the relative minute quantity of non-condensibles to the evaporator steam coils 11, where the heat of vaporization of the steam is transferred to the sea water circulating across the outside of the coil nest, the air and other non-condensable gases being liberated through a vent pipe 39 to the atmosphere. The atmospheric vent maintains the discharge from the pump 10 and the steam spaces of the evaporator coil nest 11 at constant temperature and pres-

sure. Spring loaded relief valve 40 is provided in the vent line 39 as a means of adjustment of back pressure on the discharge of the pump 10 and the steam sections of the evaporator coil nest 11, should it become necessary over long operating periods slightly to increase the generating steam temperature as a means of increasing evaporator output. I also employ a horizontal swing check valve 42 to prevent back flow of the atmosphere during intervals of operation when the quantity of non-condensable gases being removed by the pump 10 approaches zero.

The non-condensable gases are conducted from the shell of the evaporator 12 and from the distilling condenser 22 through valve controlled conduit 44 to the suction of pump 10.

Between the shell of the evaporator 12 and main condenser 6 I have shown conduit 46 whereby any desired vacuum up to approximately 28 inches of mercury may be maintained within the condenser 6 and the evaporator 12 by the ship's main air pumps 48.

In accordance with one novel feature of my invention the cooling medium passing through the coils of the distilling condenser 22 is ultimately conducted through conduit 24 into the evaporator shell as above explained. As a consequence the latent heat of the fresh water vapor is conserved and transferred into the sea water which is used wholly as evaporator feed, boiled off partly as distillate vapor, and passed on partially as brine to be conducted directly overboard through an overboard discharge in the side of the ship through conduit 50 if the quantity of excess auxiliary exhaust is sufficient, or through conduit 50 and tubular type closed main condenser condensate heater 52 supplied with condensate from condenser 6 by main condensate pump 54, should the quantity of excess auxiliary exhaust be sufficiently limited to make such an arrangement economical. The brine flowing through the heater would be cooled and would pass overboard through line 56 connecting an accumulator 58 to the ship's side.

In accordance with the principles of barometric apparatus all drains from the vacuum circuits are finally open to atmospheric pressure. Thus in order to maintain the barometric principle the accumulator 58 is employed. This accumulator which acts as a seal pot maintains a leg of water in conduit 50 high enough to equalize the pressure differential between the vacuum in the shell of the evaporator 12 and the atmosphere on the surface of the water in the accumulator seal pot 58. The barometric principle is also maintained in drain line 30 which conducts distillate from the evaporator to the distillate tank 32. The barometric principle is likewise maintained in drain loop 60 which carries the condensate of the generating steam from the evaporator coil nest 11 to the hot well 14.

The evaporator 12 may be operated by steam from the boiler 2 and/or by steam from the steam plant itself. In this latter connection 62 designates the exhaust steam line, and in this line I provide a steam pressure regulating valve 64. The line 62 leads to the steam jet air pump 10.

The pressure in the steam spaces of the evaporator coil nest 11 is usually kept at about zero but may vary up to five pounds per square inch gauge, for example, or even higher, depending upon adjustment of the manually controlled spring loaded valve 40, or down to a vacuum of about six inches of mercury, for example, when

the vapor pressure in the evaporator 12 is at a vacuum of about twenty inches of mercury.

It is apparent that my apparatus is extremely efficient in that the major portion of the heat entering the evaporator is conserved. It will be appreciated that the latent heat of the vapor rising from the surface of the feed water in evaporator 12 is absorbed by the cooling medium in the distilling condenser 22 and is restored to the system. The only heat which is definitely lost is that which is carried by the saline concentrate and this is a negligible amount. The saline concentrate or brine is disposed of by means of continuous circulation, my barometric arrangement eliminating the necessity for the use of a pump for saline concentrate removal. Disadvantages arising from an undesirable formation of scale and the consequent necessity for frequent interruption and cleaning are avoided by maintaining a low saline concentration, and also by the low temperature of the steam used in the heating coils 11 and the corresponding low temperature in the evaporator 12. I have provided a barometric arrangement, it will be observed, for a predetermined quantity of arm saline concentrate to flow across the tube nest in the evaporator shell which is constantly drained by gravity.

Salt water level in the evaporator 12 is maintained by an automatic liquid level controller 66 operating through a lever 68 and rotary type valve 70 to brine drain line 50. Should the liquid level controller fail for any reason, rise of the salt water in the evaporator to a level which would hazard the purity of the distillate is prevented by overflow connection 72.

Back flow to the evaporator shell is readily provided against by check valves 74 and 76.

I have referred to the pump 10 as a steam jet air pump, and its primary function is the removal of non-condensable gas. A further advantage inherent in the use of such a pump is that it reduces the temperature of the steam in the coils 11. A further advantage arises from the fact that it is characteristic of this type of pump that the steam leaving the mouth of the diffuser is always saturated and never superheated. Accordingly the steam entering the coils 11 is never in the superheated temperature range and undesirable scale formation on the outside of the coils 11 is avoided.

Should it be desired for any reason to bleed off the distilled vapors from the evaporator either wholly or in part, this can be done by way of line 78 which, as will be seen, runs from the top of the evaporator directly to the condenser 6.

It will be seen also that I have provided a bypass 80, valve controlled, whereby the sea water from the line 20 may be led directly to the evaporator instead of first going through the condenser 22.

It will be apparent to those skilled in this art that my invention broadens the field of application of low pressure distillation in so far as the simplicity of a barometric evaporator eliminates

the necessity of highly skilled operatives and so-called special evaporating men are concerned.

It will be apparent also that the use of the steam jet air pump 10 permits the use of the distillate plant when the vessel is in port as well as when she is at sea, the evaporator feed water and distilling condenser circulating water being one and the same complete circuit emanating from the ship's sanitary water system. This system circulates as a matter of routine at approximately the same rate in port as at sea. In other words, operation and output are constant in port as well as at sea. Inasmuch as my evaporator plant is independent of prime mover or main power apparatus my apparatus presents advantages over the prior practice wherein the evaporator must be shut down when in port.

It will be appreciated also that the feature of barometric arrangement with the resultant elimination of special pumping equipment makes the distillation of fresh water more attractive to operating personnel, thereby broadening its use, while at the same time providing against the rise of water in the evaporator above a predetermined level.

The invention hereinabove described is not necessarily restricted to marine work. I think this is self-evident. The expression "sea water" whenever used is intended to include within its scope any water for the steam plant. The term "ship" whenever employed is intended to include any power plant within its scope.

The evaporator 12 is a "single effect" evaporator. I wish it to be understood, however, that my invention comprehends the use of "multiple-effect" evaporators, which, for example, might consist of two evaporators arranged in tandem, one being heated by the coils 11, the other being heated by the fresh water vapor emanating from the first evaporator.

It is to be understood that other changes may be made in the details of construction and arrangement of parts hereinabove described without departing from the spirit and scope of my invention.

What I claim is:

In a steam plant a feed and filter tank, a distilling condenser whose cooling medium is sea water, a barometric evaporator for producing fresh water, the distilling condenser receiving the fresh water vapor emanating from the surface of the feed water within the evaporator shell, means for conducting a cooling medium through the said distilling condenser and thence to the evaporator shell in its entirety whereby all of the latent heat of the fresh water vapor is transferred to the evaporator feed water and finally to the feed and filter tank, a condensate heater, means for conducting the feed water by gravity at a constant rate through said heater, and from thence to overboard, a steam jet pump for maintaining a vacuum in said distiller, and means for heating the evaporator by the discharge from said steam jet pump.

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