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FLASH-TYPE DISTILLATION SYSTEM

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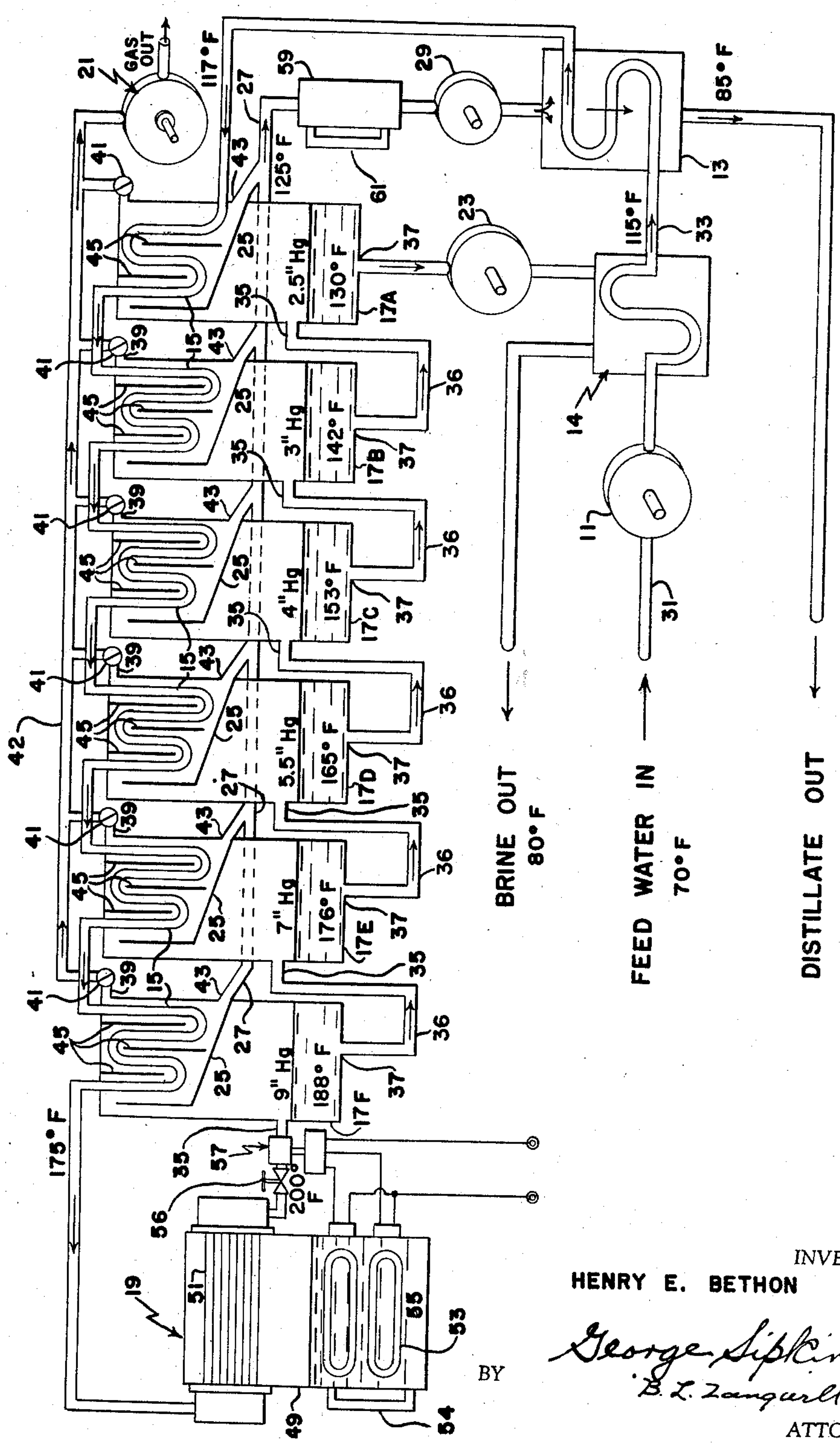

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FLASH-TYPE DISTILLATION SYSTEM

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3 Claims. (Cl. 202—174)

This application is a continuation-in-part of applicant's copending application Serial No. 365,301, filed June 30, 1953, for Flash-Type Distillation System.

The present invention relates to a system for distilling water and more particularly to a distilling system capable of quiet operation. More particularly, this invention relates to a sea water distilling system for use on submarines.

The operation of submarines in modern warfare requires an extremely low level of radiated noise in order to prevent detection of the vessel by hostile units in the area. However, large quantities of pure water are also required for use in batteries and for use by the crew, and it is impractical to use very high power for short periods of time to distill the required quantity of water for storage because of the space and power restrictions of the vessel. It therefore becomes necessary to provide distillation equipment which requires moderate power and produces a minimum noise so that it may be operated over extended periods of time.

The distillation equipment used at present has proved unsatisfactory, because it requires frequent cleanings (chemical), has inadequate capacity after extended periods of operation, and produces excessive noise. Many of these problems are caused or accentuated by the evaporation of contaminated water at pressures above atmospheric by contact with a heated surface which deposits the contamination on the heated surface in the form of a scale. In general, the scale is an insulator which reduces the efficiency of the unit, and must be removed periodically either by dismantling the equipment for mechanical cleaning or by resorting to chemical cleaning. The vapor compression distillation unit has been widely used but suffers from the defects that it scales rapidly, is hard to clean, and requires a large motor driven compressor which generates a high noise level.

It is an object of the present invention to provide a distillation system which is simple to operate and maintain.

It is another object of the present invention to provide a distillation system which requires only a moderate amount of power.

It is a further object of the present invention to provide a distillation system which is capable of continuous operation for extended periods of time.

It is a still further object of the present invention to provide a distillation system producing a minimum amount of noise.

It is a further object of the present invention to provide a distillation system wherein water is not evaporated in contact with externally heated surfaces.

Other objects and the many attendant advantages of the present invention will be made apparent to those skilled in the art by reference to the following detailed description and to the appended drawing in which the single figure illustrates in schematic form, a distillation system made in accordance with the present invention.

It is believed that a brief summary of the invention is helpful in understanding the operation and the detailed description. Referring to the drawings, contaminated water, such as sea water, is introduced into the distillation system by a feed pump 11 which forces this water through a pair or heat exchangers 14 and 13. The feed water is further heated in passing through a series of heat exchangers 15 positioned at the upper ends of respective evaporator units 17, and is still further heated to a temperature near its boiling point in a water heater 19. The heated feed water then passes into the first of a series of serially connected lower compartments of evaporator units 17.

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The evaporator units 17 are sealed vessels connected to a vacuum pump 21 which produces pressures therein below atmospheric pressure, the pump 21 being required to remove only the noncondensable gases and vapors in the system, so that it may be small. The pressures in the respective evaporator units are arranged in decreasing order, and water which does not evaporate in one evaporator unit may evaporate in a latter unit. As the water is evaporated, it leaves its contaminating materials in the remaining water, so that the contaminated water containing a concentration of contaminating materials is removed from the last evaporator unit 17 by a discharge pump 23 through the heat exchanger 14.

The vapor or steam produced in each of the several evaporator units 17 passes upward past a baffle 25, where it comes in contact with the heat exchanger 15 which is at a considerably lower temperature and therefore condenses the vapor to distillate. The distillate is conducted by a distillate line 27 through the heat exchanger 13 where it is cooled by heating the incoming feed water. A distillate pump 29 is used to remove the distillate from the system for storage.

It will be noted that the feed water is not evaporated by means of contact with heated surfaces which rapidly become encrusted with scale. The feed water is evaporated by its own internal heat, so that upon evaporation, the impurities are merely left in the remaining water to be removed from the last evaporation unit by the discharge pump 23.

The feed pump 11 may be of any desired type, and is connected to a source of water to be distilled by means of a tube 31, the discharge side of the pump being connected by a tube 33 to the heat exchanger 13. The heat exchanger 13 may be of any desired type, and is illustrated as having a single tube only to simplify the explanation thereof. The incoming feed water may have a temperature of 70° F. and be heated to about 115° F. in passing through the heat exchanger 14, and to about 117° F. in passing through the heat exchanger 13, while the distillate from the distillate line 27 is cooled from about 125° F. to about 85° F.

The evaporator units 17A, 17B, 17C, 17D, 17E, and 17F are of similar construction, and each comprises an upright sealed vessel which is divided into two compartments by the baffle 25, the lower compartment containing water to be evaporated in succeeding stages and the upper compartment containing a heat exchanger 15 which is in intimate contact with any steam moving from the lower compartment to the upper compartment and which provides a water path therethrough for feed water. An inlet 35 and an outlet 37 are provided in the lower compartment, while a vent 39 equipped with a valve 41 and a distillate connection 43 are provided in the upper compartment. A U-tube 36, containing a pressure-balancing liquid column of feed water, connects the outlet 37 of one evaporator unit to the inlet 35 of the next adjacent unit. The evaporating units are otherwise in open communication, one with another. Secondary baffles 45 are provided to insure an intimate contact between the heat exchanger 15 and vapor whereby to insure condensation of the distillate. The baffle 25 facilitates the separation of entrained contamination from the vapor and also serves to conduct the distillate to the distillate connection 43.

The vent connections **39** are connected through the valves **41** to a vacuum line **42** and thereby to the vacuum pump **21**, so that the valves **41** may be used to adjust the pressures within the respective evaporator units **17**. As shown in the drawing and as pointed out hereinafter, the pressures are successively decreased in the several evaporator units in the direction of flow of feed water therethrough.

The heat exchanger units **15** are serially connected, and receive feed water from the heat exchanger **13**. The feed water is heated in passing through the several units, and the outlet of the last of the heat exchangers **15** is connected to the inlet of the water heater **19**.

In a broad concept of the invention, the water heater **19** may be of any desired type, since the water is not evaporated therein. However, in the specific embodiment of the invention it is desirable to dispense with open flames and other direct heaters and to reduce scaling to a minimum, and for this reason, the water heater **19** is illustrated as employing distilled water to transfer heat from electric heating elements to the feed water.

The lower compartments of the several evaporation chambers **17** are also serially connected, the outlet **37** of the unit **17F** being connected by a pressure-balancing U-tube **36** to the inlet **35** of the unit **17E**, and so on. The inlet **35** of the evaporation unit **17F** is connected to receive heated feed water from the water heater **19**, and the outlet **37** of the unit **17A** is connected to the discharge pump **23**.

In accordance with this invention, the water heater **19** comprises a closed vessel **49** having a plurality of heat exchanger tubes **51** at the upper end and one or more electric heating elements **53** at the lower end. Distilled water, indicated at **55**, is placed in the vessel **49**, and the operation of the electric heating elements is controlled by means of a thermostat **57** to maintain a desired feed water temperature. In operation, the distilled water **55** is evaporated by the electric heating elements **53**, and the steam thus produced is condensed by the feed water in the heat exchanger tubes **51** to heat the feed water to a temperature below its boiling point. A gauge glass **54**, which may take the form of a water column is provided on the vessel **49** to indicate the level of the distilled water therein.

A back pressure valve **56** is provided in the outlet of the water heater **19** to maintain the inlet portion of the distillation system at a pressure which will prevent evaporation of the water therein before reaching the evaporation chambers **17**. Thus, by utilizing the back pressure valve and by employing distilled water, a constant boiling point secondary heat transfer medium, it is assured that there will be no boiling of feed water in the heat exchanger tubes **51**. The heated contaminated water is caused to flow through the back pressure valve **56** into the evaporator units **17**, one after another, wherein a large part of the water is evaporated as it is subjected to the series of decreasing pressures.

Since the introduction of steam into a hydraulic pumping system will interfere with proper pumping, the condensate line **27** is connected through a flash chamber **59**, which produces a water seal to prevent steam from reaching the pump. A gage glass **61** is provided on the flash chamber to indicate the water level therein. As an example of pressures and temperatures suitable for use in the several evaporator units, the following values have been found practical:

Unit	Pressure	Temperature, degrees F.
Water Heater 19	10 p.s.i.	200
Evaporator Unit 17F	9" Hg	188
Evaporator Unit 17E	7" Hg	176
Evaporator Unit 17D	5½" Hg	165
Evaporator Unit 17C	4" Hg	153
Evaporator Unit 17B	3" Hg	142
Evaporator Unit 17A	2½" Hg	130

There is, of course, heat remaining in the brine leaving the evaporation unit **17A**, and a part of this heat is recovered in the heat exchanger **14** which is inserted in the feed water line **33**.

It is desirable that all exterior surfaces of the heat exchangers, evaporator units, water heater and piping be insulated in order to minimize heat losses in the system and to thus reduce the quantity of electricity required by the water heater **19**. The pumps **11**, **21**, **23**, and **29** may be driven by separate motors or may be combined for operation from two or more motors. For instance, pumps **11** and **23** may be driven from a single motor while pumps **21** and **29** are driven from another.

The distillation system is preferably composed of several assemblies to facilitate installation and maintenance. However, it will be apparent to those skilled in the art that the several components may be mounted as a single package unit if desired. The pumps and the driving motors may be mounted on vibration-isolation mountings and are preferably enclosed in compartments containing sound insulation.

In order to place the system in operation, the vacuum pump **21** and the electric heating elements **53** are started. When the distilled water **55** is boiling and the vacuum in the evaporator units **17** reaches the proper operating pressure, the feed pump **11** and the discharge pump **23** are started, and the system soon reaches its normal operating temperatures.

When it is desired to take the system out of operation, the electric heating elements **53** are cut off, and when no more distillate forms, pumps **21** and **29** may be stopped. The pumps **11** and **23** are preferably left running for a few minutes to clean the system of brine, scum, etc.

While only a preferred embodiment of the present invention has been described, it will be apparent that many changes and modifications of the system may be made without departing from the spirit thereof and it is intended to cover all such embodiments as fall within the scope of the appended claims.

What is claimed is:

1. In a sea water distillation system, a plurality of closed evaporation units each having a lower evaporating chamber, an upper condensing chamber in vertical alignment with the lower chamber and a baffle therebetween, the lower evaporating chamber and upper condensing chamber of each of said units being otherwise in open and unobstructed communication one with the other for flow of vapor from the former to the latter, each of said evaporating chambers having inlet and outlet connections for flow of feed water therethrough with the outlet connection of one evaporating chamber forming the inlet connection to the next evaporating chamber for series flow of feed water through the plurality of evaporating chambers from the first to the last of such chambers in a predetermined direction of flow, said inlet and outlet connections each comprising a pressure-balancing U-tube having a down leg and an up leg with the up leg arranged to discharge feed water at a higher elevation than the level of feed water in the down leg thereby forming pressure-balancing liquid columns between adjacent evaporating chambers, said evaporating chambers being otherwise in unobstructed and open communication one with the others for series flow of feed water therethrough, a heat exchanger in each of the condensing chambers, each of said heat exchangers having an inlet and an outlet connection for flow of feed water therethrough with the outlet connection of one heat exchanger forming the inlet connection of the next heat exchanger for series flow of feed water therethrough, which feed water flows through the heat exchangers in opposite direction to the predetermined direction of flow of the feed water through the evaporating chambers, means for supplying feed water to be distilled to the first of the heat exchangers, means connecting the last of the heat exchangers to the first of the evaporating chambers in their respective directions

of flow for flow of feed water from the former to the latter, indirect heating means in said last-named connection for heating the feed water to a temperature near its boiling point prior to flow thereof into the first of the evaporating chambers, means connected to an upper portion of each of the condensing chambers, for reducing the pressure in each of the evaporating units below the vapor pressure of feed water therein at the existing temperature thereof whereby at least a portion of the feed water is vaporized by its own internal heat in each of the evapoarting chambers and the resultant water vapor is condensed by the heat exchanger in the respective condensing chamber, said pressure reducing means including a vacuum pump, a manifold connected to the inlet side of the vacuum pump, conduits connecting the upper portion of each of the condensing chambers to the manifold in a manner as to exhaust noncondensable gases therefrom while reducing the vapor pressure therein, a pressure regulating valve in each of said conduits, said pressure regulating valves being adjusted in a manner such that the pressures in the respective evaporation units are arranged in decreasing order in the direction of flow of feed water therethrough, means for removing condensate from each of the condensing chambers, and means for removing the residue feed water from the last of the evaporating chambers.

2. A distillation system as set forth in claim 1 wherein the indirect heating means includes a closed evaporation-condensation unit containing a secondary heat exchange medium, means for vaporizing the secondary heat exchange medium in said closed unit, and means for condensing the resultant vapor, said last-named means including a heat exchanger having an internal passage for flow of feed water therethrough and an external surface for contact with said resultant vapor.

3. A distillation system as set forth in claim 1 wherein the means for removing condensate from each of the condensing chambers includes the baffles between each of the evaporating and condensing chambers, a condensate manifold and a conduit between each of the baffles and the condensate manifold for parallel flow of condensate from each of the condensate chambers to the condensate manifold.

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