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METHOD OF EVAPORATION AND APPARATUS THEREFOR.

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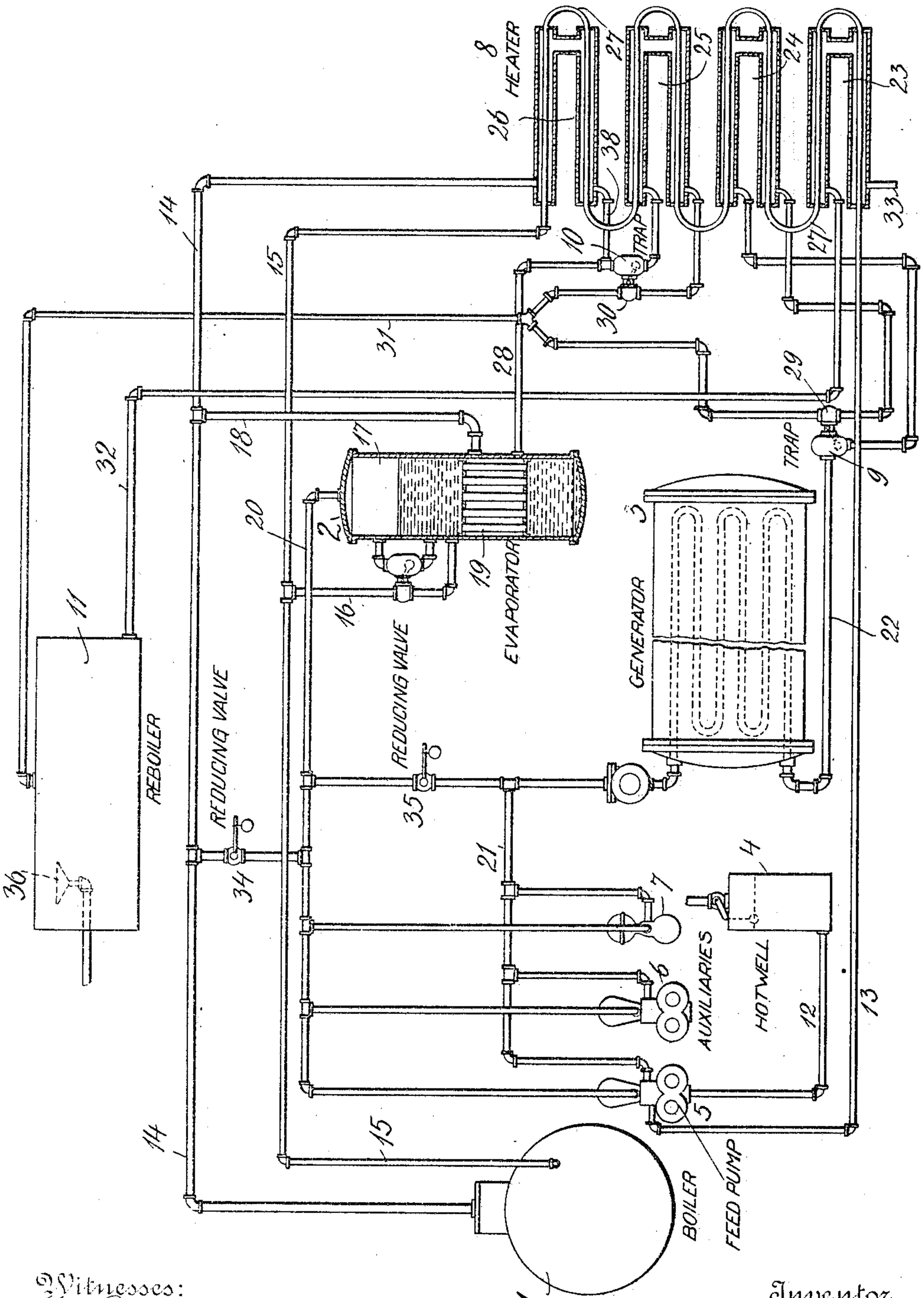
955,965. Patented Apr. 26, 1910.



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UNITED STATES PATENT OFFICE.

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METHOD OF EVAPORATION AND APPARATUS THEREFOR.

955,965. Specification of Letters Patent. Patented Apr. 26, 1910.

Application filed December 3, 1909. Serial No. 531,164.

To all whom it may concern:

Be it known that I, NICOLAI H. HILLER, a citizen of the United States of America, and a resident of Carbondale, county of Lackawanna, State of Pennsylvania, have invented a certain new and useful Method of Evaporation and Apparatus Therefor, of which the following is a specification.

My invention relates to a method of evaporation and apparatus therefor, and is particularly intended for the production of pure distilled water such as is desired for the making of artificial ice, but is also applicable to the production of drinking water on shipboard and elsewhere, where purification of water by distillation is desired, also for the distillation of other liquids.

My invention is particularly applicable for uses in connection with absorption refrigeration apparatus, and comprises a combination of distillation apparatus and absorption refrigeration apparatus, wherein steam formed in the apparatus is supplied to the heated coils of the generator of the absorption apparatus, the condensate from said coils being passed to the feed water heater of the distillation apparatus and there mingled with water from other sources.

The invention herein described embodies improvements on the method of and apparatus for evaporation, set forth in my application filed Feb. 20, 1909, Sr. No. 479,049, wherein I have shown an evaporator supplying steam to the coils of the generator of an absorption refrigeration apparatus and to the auxiliaries of such refrigeration apparatus, together with means for supplementing such steam supply, when desired, by steam from a main steam line, the water condensed in the feed water heater and in the coils of the said generator being collected and used for ice making or for other purposes for which pure water is desired. In the apparatus herein described a similar arrangement of apparatus is employed, and to obtain further economy in the use of steam, I employ a progressive feed water heater for supplying feed water to the boiler from which steam for the operation of the evaporator and for the main steam line is obtained, water being heated in this feed water heater, not only by steam from said boiler, but also by water condensed in the evaporator and absorption apparatus generator and which is at a temperature higher than it need be for supply to the reboiler of the apparatus. I thereby effect notable economy in the use of steam in the apparatus.

As a method, my invention comprises evaporation of water into steam of a pressure suitable for operating pumps etc., by exchange of heat with steam derived from a primary source of steam supply (such as a boiler) and by condensation of the steam from such primary source of supply; the supply of steam, produced by such exchange, to pumps and other auxiliaries of the apparatus; the supply of the exhaust from such pumps or auxiliaries to the heating coils of the generator of an absorption refrigeration apparatus or other user of low pressure steam; the supply of the water of condensation from such generator, and the water formed by condensation of steam from the primary source of supply, to appropriate portions of a progressive feed water heater; the supply of water of somewhat lower temperature than the water so supplied, from the feed water heater to the reboiler or other point to which purified water is to be delivered; the further heating of water in the feed water heater by steam, and the supply of hot water by said feed water heater to the primary steam generator.

As an apparatus, my invention comprises combinations of apparatus whereby the process above referred to may be carried out.

The objects of my invention are, to purify water by evaporation and condensation, with a very small consumption of steam, or other source of heat supply, and with simple, compact, reliable and relatively inexpensive apparatus of standard types; and to make the apparatus as simple and inexpensive as possible.

In the accompanying drawing I illustrate diagrammatically apparatus embodying my invention, and adapted for carrying out the method of evaporation and purification herein described.

In said drawing, 1 designates a boiler or other suitable source of steam which, for the purposes of this specification, may be termed high pressure steam; 2 designates an evaporator; 3 the generator of an absorption refrigeration apparatus; 4 a hot well, from which the water to be purified is taken; 5, a feed pump; 6 and 7, auxiliaries of the absorption refrigeration apparatus; 8, a feed water heater; 9 and 10, traps through which water is supplied to the reboiler; and 11, a reboiler.

Other parts of the apparatus, such as pipes, valves, etc., will be referred to from time to time, in describing the operation of the apparatus, in carrying out the method above referred to.

In carrying out the said method, water is drawn from the hot well, 4, by the feed pump 5, through a pipe 12, and is delivered through a pipe 13 into the colder or entrance portion of the feed water heater 8. Steam of high pressure passes from boiler 1, through a main steam line 14, into the hot or exit end of the feed water heater 8, the water to be heated and the steam or water to do the heating, flowing through separate conduits of this heater, in opposite directions, the steam being finally condensed therein. The water heated in this feed water heater passes, through a pipe 15, to the boiler 1, and through a pipe 16 to the evaporating chamber 17 of the evaporator 2. Steam to operate this evaporator is supplied from the main steam line 14, by a pipe 18 connected to the heating chamber 19 of the evaporator 2. Steam produced in the evaporator passes, through a pipe 20, to the feed pump 5, and auxiliaries 6 and 7, serving to operate said pump and auxiliaries, the exhaust steam from said pump and auxiliaries passing through a pipe 21 to the coils of the generator 3 of the absorption refrigeration apparatus. The water condensed in the coils of said generator passes through a pipe 22 and trap 9, into an intermediate section 24 of the feed water heater 8. I have shown said feed water heater as composed of sections 23, 24, 25 and 26, each composed of a plurality of pipe sections connected in series, a single feed water pipe 27 passing in series through these sections, and being connected at its lower end to pipe 13 and at the other end to pipe 15. A continuous double pipe heater, (a type well known in the art of feed water heaters), would be in a broad sense an equivalent of the sectional feed water heater illustrated. The water condensed in the chamber 19 of the evaporator 2 passes through a pipe 28 and trap 10, into another intermediate section 25 of the feed water heater 8, and the water condensed in section 26 of the feed water heater passes through a pipe 38 into the same trap 10 and so into heater section 25. Valves 29 and 30, controlled by floats of traps 9 and 10, respectively, control the passage of water from heater sections 24 and 25, through a pipe 31, into reboiler 11; and the gas-freed water from this reboiler passes through pipe 32 into the lowermost section, 23, of the feed water heater, and thence out through a pipe 33. From this it will be seen that the feed water, in passing through the pipe 27 of the feed water heater 8, is heated progressively by exchange of heat from fluids of progressively higher temperature. It will be heated, first, in section 23, by water from the reboiler, having a temperature of say 210 degrees Fahrenheit (*i. e.*, a temperature somewhat less than the boiling point of water at atmospheric pressure); it will be heated next, in section 24, by water from the generator 3, having a temperature of say 267 degrees Fahrenheit; it will be heated next in section 25 by water from the evaporator 2, having a temperature of say 350 degrees F.; and it will be heated, finally, in section 26, by steam from line 14, having a temperature of say 350 degrees F.

I am aware that it has been proposed heretofore to distil water in a succession of evaporators, the water evaporated in each but the last of the series being condensed in the next of the series, the succession of evaporators being operated with a considerable drop in pressure in passing from one evaporator to the next; the water condensed in the several evaporators being collected in a common pipe line and thence passed through a heat exchanger, wherein such water imparts heat to incoming raw water thence supplied to a boiler as feed water. In such a system, the water condensed in the several evaporators will naturally be at a higher temperature in each but the last evaporator than in the evaporator or evaporators operated at lower pressure; yet the condensates from these various evaporators, notwithstanding their different temperatures (in most cases above the boiling point of water at atmospheric pressure) are mingled in a common collecting line and passed through a single heat exchanger. It necessarily follows that there is much reëvaporation in this collecting line, and much loss of heat and of purified water for this reason, and that the water cannot be delivered to the heat exchanger at above 212 degrees F. (the last evaporator of the series being operated, of course, at about atmospheric pressure), and that the incoming water cannot be heated to more than 212 degrees F. But in the apparatus illustrated and described herein, since the feed water heater is connected separately to the several sources of supply of heating fluid of different temperatures, and since these different connections are to different parts of the feed water heater, the incoming feed water may be heated to nearly the temperature of the steam in the boiler 1, and without loss of heat by unnecessary evaporation.

A numerical example will serve to make still clearer the important gain in economy due to this invention. Supposing the pressure in boiler 1 to be 120 lbs. per square inch, the steam in line 14 will have a temperature of about 350 degrees F., and the condensate discharged from chamber 19 of the evaporator and section 26 of the feed water heater will have about the same temperature. There will be some drop in pressure from

the steam line 14 to the secondary steam line 20, so that the pressure in said line may be supposed to be 90 lbs. The exhaust steam from the pump 5 and auxiliaries 6 and 7 will have a pressure of say 25 lbs. and the water condensed in the coils of generator 3 and supplied to section 24 of the feed water heater will have a temperature of about 267 F. The water from the reboiler will have about a temperature of 210 degrees F. The water in each of sections 24, 25 and 26 of the heater is kept under pressure while in one or the other of those sections, since the construction of traps 9 and 10 is such as to permit no steam to enter the pipes leading from them. Since the evaporator 2 may not supply all of the steam required by line 20, a reducing valve 34 is provided to permit regulated passage of steam from line 14 to line 20; and since the exhaust from pump 5 and auxiliaries 6 and 7 may not be sufficient for the operation of generator 3, a reducing valve 35 is provided to permit regulated passage of steam from line 20 to line 21.

For supplying 100 lbs. of water at the reboiler, the steam consumption, at the pressures assumed above, will be about as follows:—

Live steam to heater section 26	7.6 lbs.
Live steam to evaporator 2	32.4 "
Live steam, line 14 to line 20	28.1 "
Total live steam	68.1

The exhaust steam supplied by pump 5 and auxiliaries 6 and 7 to the generator will amount to about 31.9 lbs. Section 26 of the heater 8, and the evaporator 2, will together, therefore, supply to the pipe 31 about 40 lbs. of water, which will have been cooled in the heater from about 350 F. to about 240 F.; and generator 3 will supply to section 24 of the heater, and so to pipe 31, about 60 lbs. of water (28.1 plus 31.9) which will have been cooled in the heater to about 178 F.; so that the mean temperature of the water supplied by pipe 31 to the reboiler will be about 215 F.—a temperature just about sufficiently higher than the boiling point of water at atmospheric pressure to permit the reboiling necessary to drive off gases remaining in the water when it reaches the reboiler. There is also some waste in the reboiler, due to the necessary outflow of some water through the skimmer with which such reboilers are customarily provided (indicated diagrammatically at 36.) Placing this loss and the loss by evaporation from the reboiler at 15 per cent., we have a total of 85 lbs. of water delivered at 33, for 68.1 lbs. of steam supplied from the boiler.

A considerable increase in the total of pure water supplied, in proportion to the weight of steam used, may also be made by using a somewhat larger evaporator than indicated in the above figures. Supposing the evaporator used to be one capable of evaporating 40 lbs. of steam in the unit of time chosen for comparison, it will probably use about 43 lbs. of live steam from pipe 14 in doing so; and the supply of 40 lbs. of steam by the evaporator to line 20 will reduce to 20 lbs. the additional amount of steam required to be supplied from line 14 to line 20 through valve 34, and consequently the total of live steam used will be increased to about 70 lbs., while the total amount of distilled water supplied to the reboiler will be increased to about 110 lbs. It will be seen, therefore, that a slight increase in the size of the evaporator increases notably the economy of the apparatus.

The supply of feed water to the evaporator 2, from pipe line 15, is controlled by an automatic float valve 37, the float chamber of which is connected to the water space of said evaporator 2, so as to maintain a substantial uniform level in said evaporator.

The feed pump 5 and auxiliaries 6 and 7 may with advantage be steam-turbine-driven apparatus; that is to say, the steam from line 21 may be used in pump 5 and auxiliaries 6 and 7 in steam turbines, instead of the steam cylinders of ordinary reciprocating engines. The diagrammatic representation of these parts 5, 6 and 7, in the drawings, may be understood to be diagrammatic representations of turbine-driven apparatus. One great advantage of the use of turbine-driven pumps and other auxiliaries in water purifying apparatus such as this, is that turbines do not require internal lubrication, as do reciprocating engines, and so in such turbines the steam does not become contaminated with oil. The fifteen per cent. waste of water, in the reboiler, to allow for skimming and other losses at the reboiler, made in the above calculations, is ample to cover the waste necessary when pump 5 and auxiliaries 6 and 7 are operated by reciprocating engines and consequently mingles more or less lubricating oil with the steam. By using turbine-driven pumps and other auxiliaries, the waste at the reboiler will customarily be much less than fifteen per cent. and in such cases the apparatus will show corresponding increased economy. Pump 5 and auxiliaries 6 and 7, might also, obviously, be operated electrically with the same advantages.

What I claim is:—

1. The method of evaporation and purification herein described, comprising producing high pressure vapor of the liquid to be purified by evaporation under pressure in a suitable boiler, evaporating another body of said liquid under lower pressure in a suitable

evaporator by exchange of heat with and condensation of a portion of the high pressure vapor produced as described, doing work with the lower pressure vapor so produced and condensing the same, and heating a feed supply of liquid for said boiler by exchange of heat successively with the condensate of the low pressure vapor, with the condensate from the evaporator, and with another portion of the high pressure vapor.

2. The method of evaporation and purification herein described, comprising producing high pressure vapor of the liquid to be purified by evaporation under pressure in a suitable boiler, evaporating another body of said liquid under lower pressure in a suitable evaporator by exchange of heat with and condensation of a portion of the high pressure vapor produced as described, condensing the lower pressure vapor so produced and heating a feed supply of liquid for said boiler by exchange of heat successively with the condensate of the low pressure vapor, with the condensate from the evaporator, and with another portion of the high pressure vapor.

3. The method of evaporation and purification herein described, comprising producing high pressure vapor of the liquid to be purified by evaporation under pressure in a suitable boiler, evaporating another body of said liquid under lower pressure in a suitable evaporator by exchange of heat with and condensation under pressure of a portion of the high pressure vapor produced as described, condensing under a lower pressure the lower pressure vapor so produced and heating a feed supply of liquid for said boiler by separate exchange of heat with the two condensates mentioned, each at about its pressure of condensation.

4. The method of evaporation and purification herein described, comprising producing high pressure vapor of the liquid to be purified by evaporation under pressure in a suitable boiler, evaporating another body of said liquid under lower pressure in a suitable evaporator by exchange of heat with and condensation under pressure of a portion of the high pressure vapor produced as described, condensing under a lower pressure the lower pressure vapor so produced and heating a feed supply of liquid for said boiler by separate exchange of heat with the two condensates mentioned, each at about its pressure of condensation, reboiling the cooled condensates after such exchange of heat, and exchanging heat between the reboiled liquid and the feed supply, prior to heating of said feed supply by said condensates.

5. Evaporating and condensing apparatus comprising a primary vapor generator, adapted to evaporate under high pressure, a secondary evaporator connected to said primary evaporator to be operated thereby and arranged to evaporate at a lower pressure, by exchange of heat with and condensation of vapor produced by said primary evaporator, power generating means arranged to be operated by the vapor from said secondary evaporator, means for condensing the exhaust from said power generating means, and a heater for the feed supply of said primary generator arranged to exchange heat between such feed supply and the condensates of said secondary evaporator and said condensing means, under different pressures.

6. Evaporating and condensing apparatus comprising a primary vapor generator, adapted to evaporate under high pressure, a secondary evaporator connected to said primary evaporator to be operated thereby and arranged to evaporate at a lower pressure, by exchange of heat with and condensation of vapor produced by said primary evaporator, power generating means arranged to be operated by the vapor from said secondary evaporator, means for condensing the exhaust from said power generating means, and a heater for the feed supply of said primary generator arranged to exchange heat between such feed supply and the condensates of said secondary evaporator and said condensing means, under different pressures, a reboiler, means for conveying the cooled condensates from said heater to said reboiler and traps controlling the delivery of said condensates to said reboiler and operated by the said condensates in passing to said heater, and arranged to maintain each such condensate under substantially its pressure of condensation while in the heater.

7. Evaporating and condensing apparatus comprising a primary vapor generator, adapted to evaporate under high pressure, a secondary evaporator connected to said primary evaporator to be operated thereby and arranged to evaporate at a lower pressure, by exchange of heat with and condensation of vapor produced by said primary evaporator, power generating means arranged to be operated by the vapor from said secondary evaporator, means for condensing the exhaust from said power generating means, and a heater for the feed supply of said primary generator arranged to exchange heat between such feed supply and the condensates of said secondary evaporator and said condensing means, under different pressures, a reboiler, means for conveying the cooled condensates from said heater to said reboiler, and traps controlling the delivery of said condensates to said reboiler and operated by the said condensates in passing to said heater, and arranged to maintain each such condensate under substantially its pressure of condensation while in the heater, and means for conveying the reboiled liquid from

said reboiler to said heater at a point in advance of the point where the said condensates are received in said heater.

8. Evaporating and condensing apparatus comprising a primary vapor generator adapted to evaporate under high pressure, a secondary evaporator connected to said primary evaporator to be operated thereby, and arranged to evaporate at a lower pressure by exchange of heat with and condensation of vapor produced by said primary evaporator, power generating means arranged to be operated by the vapor from said secondary evaporator, a generator of an absorption refrigeration apparatus arranged to be operated by, and to condense, the exhaust from said power generating means, and a heater for the feed supply of said primary generator arranged to exchange heat between such feed supply and the condensates of said secondary evaporator and said condensing means, under different pressures.

9. Evaporating and condensing apparatus comprising a primary vapor generator adapted to evaporate under high pressure, a secondary evaporator connected to said primary evaporator to be operated thereby, and arranged to evaporate at a lower pressure by exchange of heat with and condensation of vapor produced by said primary evaporator, power generating means arranged to be operated by the vapor from said secondary evaporator, a generator of an absorption refrigeration apparatus arranged to be operated by, and to condense, the exhaust from said power generator means, and a heater for the feed supply of said primary generator arranged to exchange heat between such feed supply and the condensates of said secondary evaporator and said condensing means, under different pressures, a reboiler, means for conveying the cooled condensates from said heater to said reboiler, and traps controlling the delivery of said condensates to said reboiler and operated by the said condensates in passing to said heater, and arranged to maintain each such condensate under substantially its pressure of condensation while in the heater.

10. Evaporating and condensing apparatus comprising a primary vapor generator adapted to evaporate under high pressure, a secondary evaporator connected to said primary evaporator to be operated thereby, and arranged to evaporate at a lower pressure by exchange of heat with and condensation of vapor produced by said primary evaporator, power generating means arranged to be operated by the vapor from said secondary evaporator, a generator of an absorption refrigeration apparatus arranged to be operated by, and to condense, the exhaust from said power generating means, and a heater for the feed supply of said primary generator arranged to exchange heat between such feed supply and the condensates of said secondary evaporator and said condensing means, under different pressures, a reboiler, means for conveying the cooled condensates from said heater to said reboiler, and traps controlling the delivery of said condensates to said reboiler and operated by the said condensates in passing to said heater, and arranged to maintain each such condensate under substantially its pressure of condensation while in the heater, and means for conveying the reboiled liquid from said reboiler to said heater at a point in advance of the point where the said condensates are received in said heater.

11. Evaporating and condensing apparatus comprising a primary vapor generator adapted to evaporate under high pressure, a secondary evaporator connected to said primary evaporator to be operated thereby, and arranged to evaporate at a lower pressure by exchange of heat with and condensation of vapor produced by said primary evaporator, power generating means arranged to be operated by the vapor from said secondary evaporator, a generator of an absorption refrigeration apparatus arranged to be operated by and to condense the exhaust from said power generating means, and a heater for the feed supply of said primary generator arranged to exchange heat between such feed supply and the condensates of said secondary evaporator and said condensing means, under different pressures, a pressure reducing valve connecting the primary vapor generator and the discharge of said secondary vapor generator, and another pressure reducing valve connecting the discharge of said secondary vapor generator and the said generator of the absorption refrigeration apparatus.

12. Evaporating and condensing apparatus comprising a primary vapor generator adapted to evaporate under high pressure, a secondary evaporator connected to said primary evaporator to be operated thereby, and arranged to evaporate at a lower pressure, by exchange of heat with and condensation of vapor produced by said primary evaporator, power generating means arranged to be operated by the vapor from said secondary evaporator, means for condensing the exhaust from said power generating means, a heater for the feed supply of said primary generator arranged to exchange heat between such feed supply and vapor from said primary generator, and means for collecting the condensates from the said heater, the said evaporator, and the said exhaust.

13. Evaporating and condensing apparatus comprising a primary vapor generator adapted to evaporate under high pressure, a secondary evaporator connected to said primary evaporator to be operated thereby, and arranged to evaporate at a lower pressure, by

exchange of heat with and condensation of vapor produced by said primary evaporator, power generating means arranged to be operated by the vapor from said secondary evaporator, a heater for the feed supply of said primary generator arranged to exchange heat between such feed supply and the condensate of said secondary evaporator, and also between such feed supply and the vapor from said primary generator, and means for collecting the condensates from said evaporator, heater, and exhaust.

14. Evaporating and condensing apparatus comprising a primary vapor generator adapted to evaporate under high pressure, a secondary evaporator connected to said primary evaporator to be operated thereby, and arranged to evaporate at a lower pressure, by exchange of heat with and condensation of vapor produced by said primary evaporator, power generating means arranged to be operated by the vapor from said secondary evaporator, a heater for the feed supply of said primary generator arranged to exchange heat between such feed supply and the condensates of said secondary evaporator and said condensing means, under different pressures, and means for collecting the condensates from said evaporator, heater and condensing means.

15. Evaporating and condensing apparatus comprising a primary vapor generator adapted to evaporate under high pressure, a secondary evaporator connected to said primary evaporator to be operated thereby, and arranged to evaporate at a lower pressure, by exchange of heat with and condensation of vapor produced by said primary evaporator, power generating means arranged to be operated by the vapor from said secondary evaporator, a sectional heater for the feed supply of said primary generator arranged to exchange heat between such feed supply and the condensate from said secondary evaporator, and, in a separate section, between such feed supply and the condensate from said condensing means, and means for collecting the condensates from said evaporator and condensing means.

16. Evaporating and condensing apparatus comprising a primary vapor generator adapted to evaporate under high pressure, a secondary evaporator connected to said primary evaporator to be operated thereby, and arranged to evaporate at a lower pressure, by exchange of heat with and condensation of vapor produced by said primary evaporator, power generating means arranged to be operated by the vapor from said secondary evaporator, a sectional heater for the feed supply of said primary generator arranged to exchange heat between such feed supply and vapor from said primary generator, and, in a separate section, between such feed supply and the condensate from said evaporator, and, in a further section, between said feed supply and the condensate of said condensing means, and means for collecting the condensates from said evaporator, heater and condensing means.

In testimony whereof I have signed this specification in the presence of two subscribing witnesses.

NICOLAI H. HILLER.

Witnesses:
E. M. HOLCOMBE,
FRANK ORCHARD.