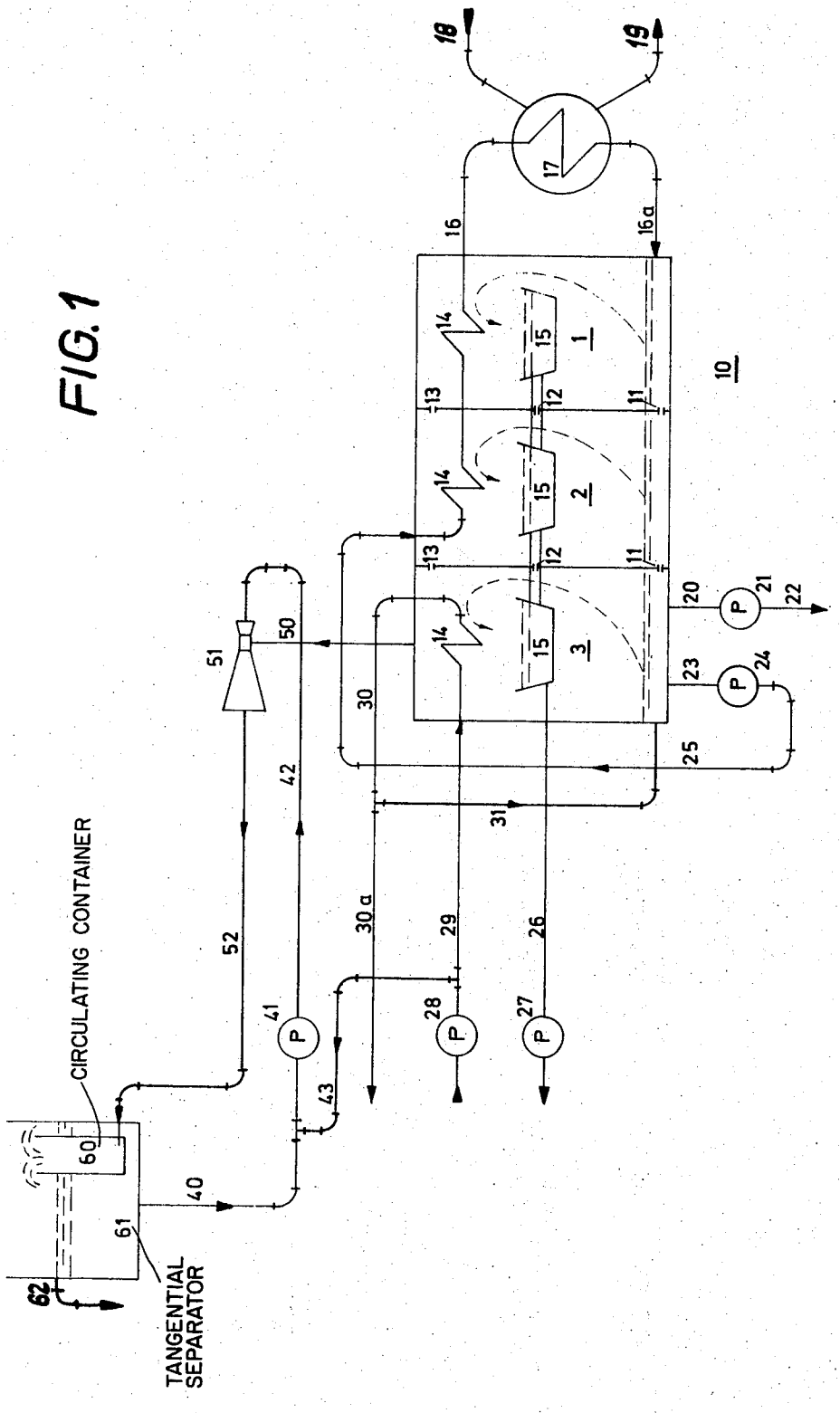
Sept. 10, 1974 K. D. PETER 3,834,994

MULTI-STAGE EVAPORATOR

Filed Nov. 1, 1971 4 Sheets-Sheet 1

FIG. 1

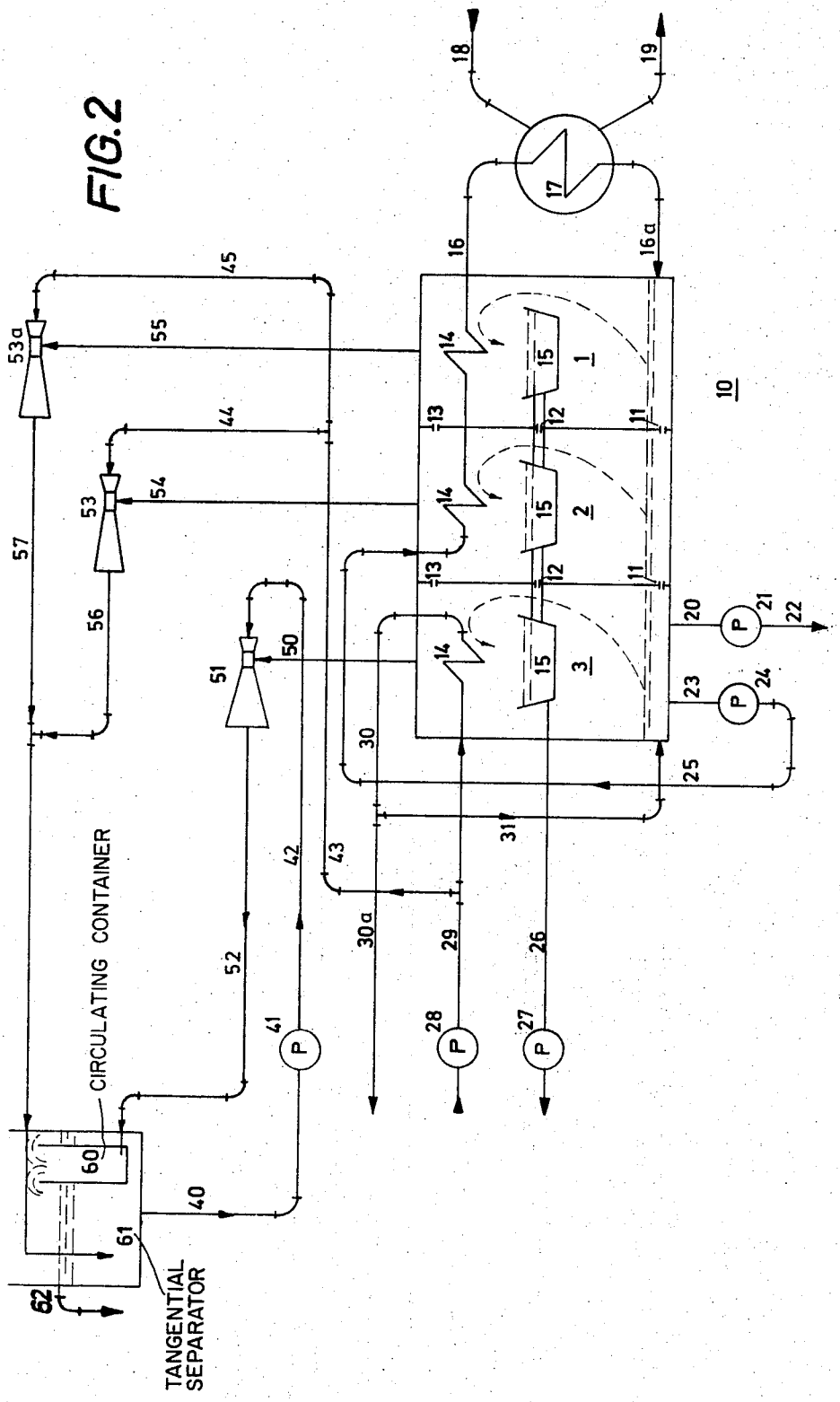


Sept. 10, 1974 K. D. PETER 3,834,994

MULTI-STAGE EVAPORATOR

Filed Nov. 1, 1971 4 Sheets-Sheet 2

FIG.2



Sept. 10, 1974

K. D. PETER

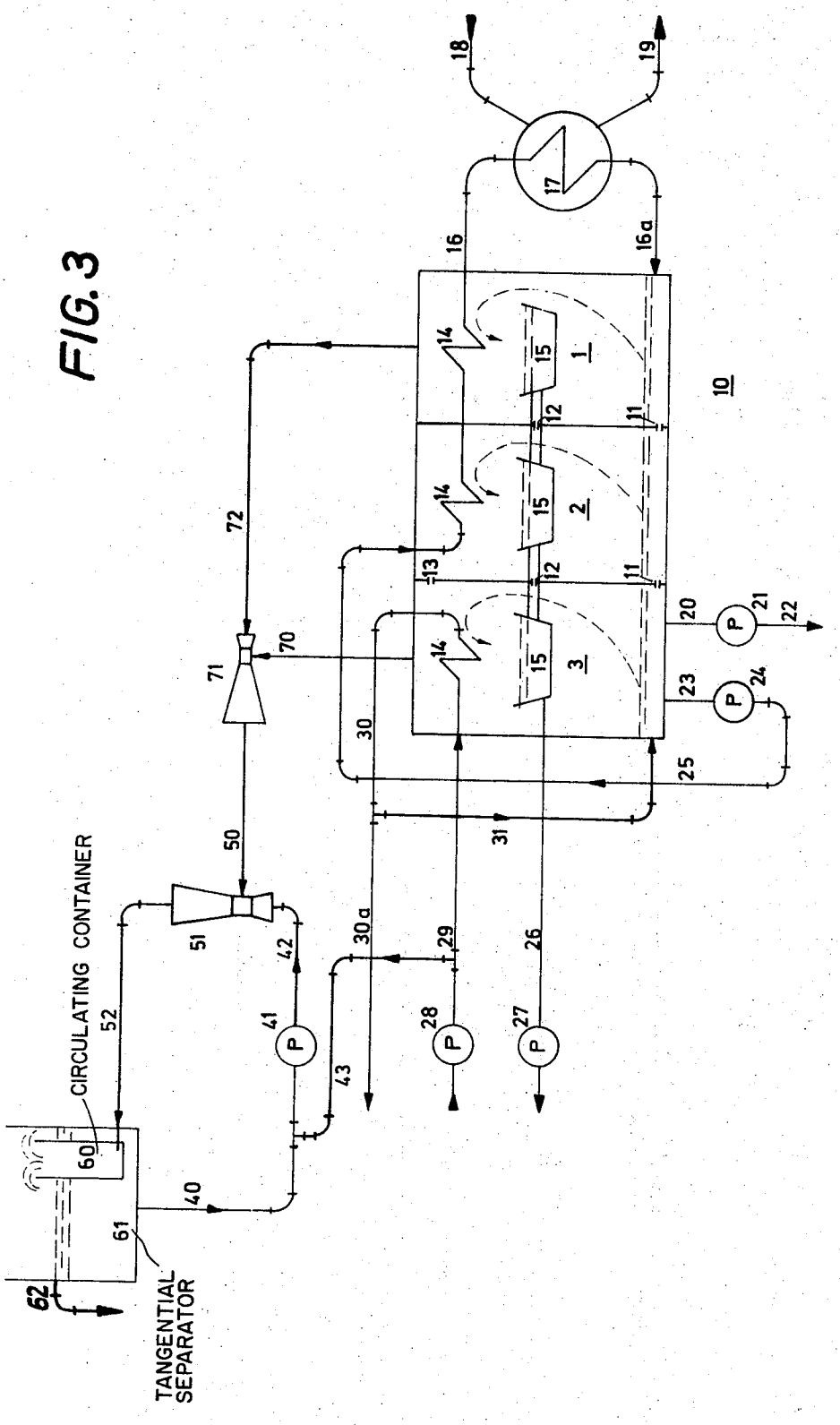
MULTI-STAGE EVAPORATOR

3,834,994

Filed Nov. 1, 1971

4 Sheets-Sheet 3

FIG. 3

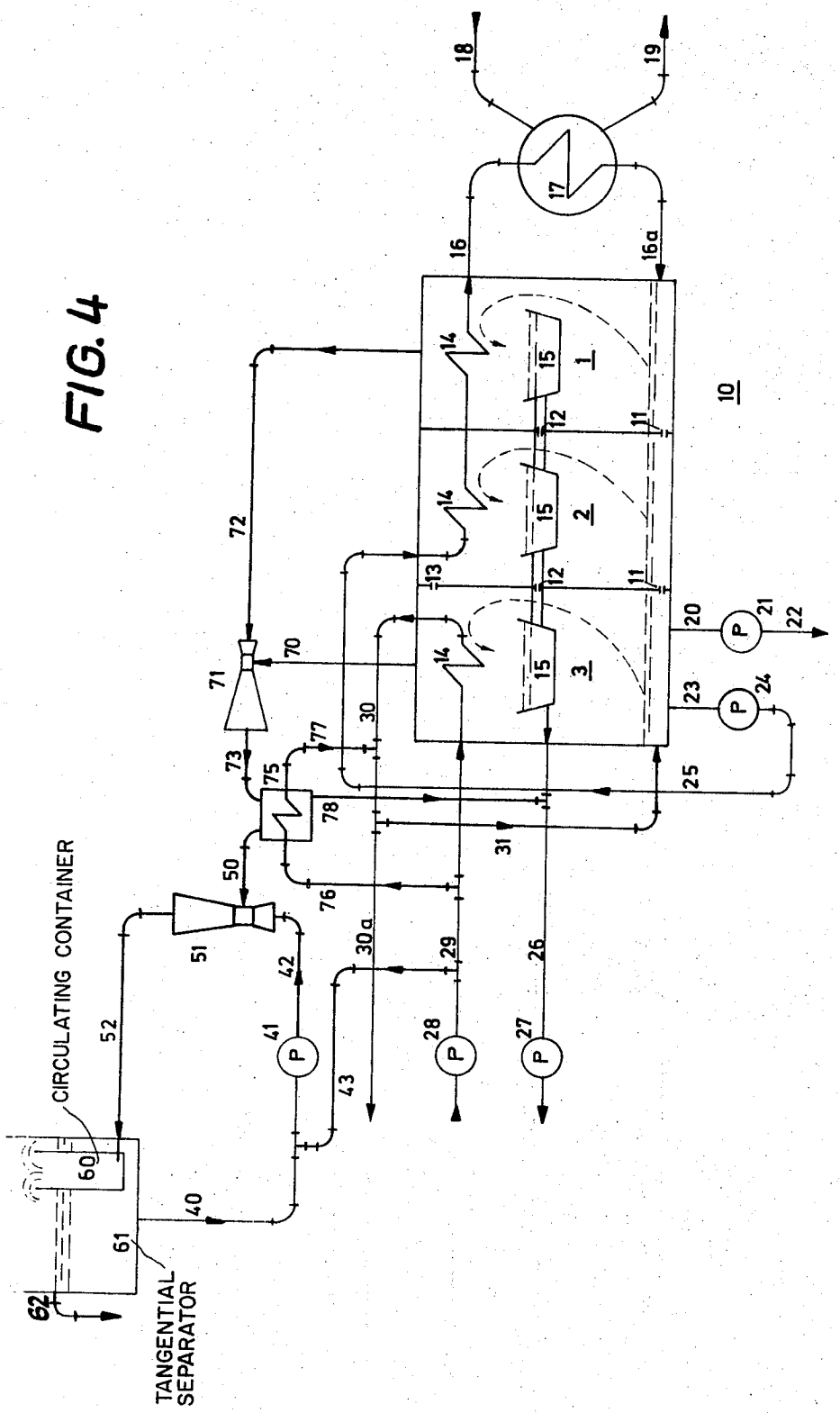


Sept. 10, 1974 K. D. PETER 3,834,994

MULTI-STAGE EVAPORATOR

Filed Nov. 1, 1971 4 Sheets-Sheet 4

FIG. 4



United States Patent Office 3,834,994 Patented Sept. 10, 1974

3,834,994

MULTI-STAGE EVAPORATOR

Klaus Dieter Peter, Varrel, Germany, assignor to Fried. Krupp Gesellschaft mit beschrankter Haftung, Essen, Germany

Filed Nov. 1, 1971, Ser. No. 194,148
Claims priority, application Germany, Nov. 6, 1970, P 20 54 587.3
Int. Cl. B01d 3/06; C02b 1/06, 1/10
U.S. Cl. 202—174 1 Claim

ABSTRACT OF THE DISCLOSURE

An evaporator with a plurality of evaporating chambers between which a pressure and temperature drop exists, which is equipped with devices for conveying a liquid through the evaporating chambers for evaporation of a part of the liquid in each chamber, with condensers of which each communicates with one of said evaporating chambers, with means for withdrawing the obtained distillate from said condensers, and with withdrawing means for withdrawing inert gases from the evaporator, said withdrawing means including a liquid jet ejector and a water pressure pump and a separating device for separating inert gas, said jet ejector and said water pressure pump and said separating device being arranged in communication with each other in a closed circuit adapted to receive cooling water and to discharge warmed-up water.

The present invention relates to an evaporator with a plurality of evaporating chambers which have a pressure and temperature drop with regard to each other and which are equipped with devices for conveying a liquid through the evaporating chambers for evaporating a portion of the liquid in each chamber while condensers are provided each of which communicates with one of the evaporating chambers. The evaporator furthermore comprises means for removing the obtained distillate from the condensers, and is also equipped with withdrawing devices such as suction devices for removing the inert gases from the evaporator. With large scale plants, for withdrawing inert gases from the evaporator, primarily two and multi-stage steam jet ejectors are employed while each stage of the steam jet ejector is followed by a condenser for condensing the motive steam (Treibdampf) and the quantity of steam which hangs onto the inert gases.

With small scale plants on the other hand, frequently water ring air pumps are employed for withdrawing the inert gases.

The above outlined arrangements have the drawback that the energy consumption for the withdrawal of the inert gases is relatively high.

It is, therefore, an object of the present invention to provide a device for withdrawing the inert gases from the evaporator, which device will have a considerably lower energy consumption than is the case with heretofore known devices.

This object and other objects and advantages of the invention will appear more clearly from the following specification in connection with the accompanying drawings, in which:

FIGS. 1 to 4 respectively diagrammatically illustrate four embodiments of the invention.

The evaporator according to the present invention, which is provided with a plurality of evaporating chambers having a pressure and temperature drop relative to each other, and equipped with devices for conveying a liquid through the evaporating chambers for evaporating a portion of the liquid in each chamber, with containers each of which communicates with one of the evaporating chambers, with means for removing the obtained distillate from the condensers, and with withdrawing devices for withdrawing the inert gases from the evaporator, is characterized primarily in that the withdrawing device comprises a water jet ejector, a motive water pump (Treibwasserpumpe) and a device for inert gas separation, which communicate with each other by means of pipes, said withdrawing device also comprising a closed water circuit having cooling water fed thereinto and having heated-up water withdrawn therefrom.

According to a further feature of the invention, the quantity of cooling water which is fed for withdrawing heat is used for operation by one or more liquid jet pumps, the outlet openings of which communicate with the inert gas separating device.

Referring now to the drawings in detail, FIG. 1 shows a multi-stage flashing evaporator **10** with three expansion chambers **1**, **2** and **3**. The here selected three stages are characteristic for this example only. The chamber **1** represents the first stage and has the highest pressure. In the next following stage—chamber **2**—the pressure is lower. The last chamber **3** has the lowest pressure. The flashing chambers **1** to **3** are formed by a pressure and vacuum-resistant housing. The partitions between the chambers are provided with passages **11** for passage of the liquid. These passages **11** are arranged in the vicinity of the bottom of the chambers.

In the vicinity of the chamber ceiling, the partitions have passages **13** for the passage of the inert gases from one stage to the next following stage. Each evaporation chamber furthermore comprises a condenser **14** and a collecting device **15** arranged therebelow for the obtained distillate. The collecting devices **15** are in communication with each other through pipe lines or passages with openings **12** for the passage of the distillate from one stage to the next following stage. From the collecting device or vat **15** of chamber **3**, the obtained distillate is withdrawn through pipe line **26** and pump **27** and is pressed to the consumer. Sea water, brackish water or raw water is, by means of pump **28** and conduit **29**, conveyed through the pipe side of the condenser **14** from stage **3**. This water in condenser **14** is heated up by the rising vapour from the flashing chamber **3** and is withdrawn through conduit **30**. The major portion of the withdrawn water passes through conduit **30***a* back to the sea or to the source. The smaller portion flows through a conduit **31** into the evaporation chamber **3** in order to thin the liquor to a predetermined or desired concentration, which liquor had thickened in the evaporator. This liquor is, by means of a pump **24** through conduit **23**, withdrawn from the flashing chamber **3** and through a conduit **25** is conveyed to the condenser **14** of the expansion chamber **2**. The liquor then flows successively through the condensers **14** of the flashing chambers **2** and **1** while being heated up stepwise. The condensers **14** of the flashing chambers **2** and **1** thus form the heat regaining portion of the evaporator, whereas the flashing chamber **3** forms the heat withdrawal portion of the installation inasmuch as here the quantity of heat is withdrawn which was conveyed to the end preheater **17**. After the liquor by absorbing the condensation heat in the condensers **14** of stages **2** and **1** has been heated, it enters the end preheater **17** through conduit **16**. A heating medium, for instance, steam or hot water is through conduit **18** conveyed to the end preheater **17**, and this heating medium is withdrawn through conduit **19** after effected heat exchange. The liquor heated in the end preheater then passes through conduit **16***a* into the flashing chamber **1**. Inasmuch as the pressure in this chamber is lower than the saturation pressure pertaining to the temperature of the liquor, a portion of the entering liquor evaporates by flashing off. The rising vapour flows through passages and

possibly interposed (not illustrated) moisture separators in condenser **14** where said steam gives off the latent heat to the cooling medium (in this instance, revolved liquor) flowing into the pipes. The obtained distillate is collected in the collecting device **15** and passes through suitable conveying means and the passage opening **12** to the collecting vat **15** of the flashing chamber **2**. The inert gases freed from the liquor and air which might have possibly entered pass through the passage **13** likewise to the flashing chamber **2**. The not expanded portion of the liquor flows through the passage **11** in the vicinity of the chamber bottom likewise to the chamber **2**. Here the above described flashing process is repeated. From the flashing chamber **2**, the remaining liquor and the distillate collected so far as well as the inert gases, flow through corresponding passages to the last flashing chamber **3**. Here the expansion process is again repeated. A portion of the liquor which remains after the last expansion in chamber **3** is, through conduit **20**, withdrawn by means of a suitable pump **21** and is pumped through the conduit **22**.

The remaining liquor is thinned by the quantity of raw water fed through conduit **31**, and the initial concentration is reestablished. The withdrawal of the inert gases collected in the flashing chamber **3** and also the withdrawal of air which might have entered is, in conformity with this invention, effected by means of a water jet ejector **51** (Wasserstrahlers) designed specifically for this purpose, which ejector **51** has an extremely low energy consumption. The motive water pump **41** for the jet **51** draws operating water through conduit **40** from a circulating container **61** and presses said water through conduit **42** to the water jet **51**. The latter, through conduit **50**, draws the inert gases from the flashing chamber **3** and presses the mixture of inert gas and operating water through conduit **52** into a tangential separator **60** provided in the circulating container **61**. In order to withdraw the electric pump output converted into heat as well as the latent heat of the vapour adhering to the inert gases, a certain quantity of raw water is, through conduit **43** in a constant manner, fed into the circuit of the operating water of the jet. The same quantity of water is discharged through the overflow **62** from the circulating container **61**.

For purposes of comparing the energy consumption of the suction method according to the invention with other customarily employed methods, there will now be set forward an example:

From an evaporator there are to be withdrawn 10 kilograms per hour of air at an absolute pressure of 40 Torr. Cooling water with an onflow temperature of 30° C. is available. The adherent quantity of vapour amounts to 5 kilograms of steam per 1 kilogram of air. The following calculation clearly shows the advantage of the water jet pump with regard to the energy consumption:

1. Steam jet ejector:
   Suction stream: G_S=60 kg./h. (kilograms per hour)
   Motive steam consumption: G_D spec. approximately 2.5 kg./kg. mixture; G_D=2.5×60=150 kg./h.
   Steam condition: 10 ata. (atmospheres absolute) saturated steam; r=482.1 kcal./kg.
   Heat consumption: Q=482.1×150=72,315 kcal./h. (kilocalories per hour)
2. Water ring air pump:
   Suction stream: G_S=60 kg./h.
   Volumetric suction power: V_S=1845 m.³h. (cubic meters per hour-
   Power requirement: N=150 kw.=129,000 kcal./h.
3. Water jet ejector:
   Suction stream: G_S=60 kg./h.
   Motive water requirement: G=220 m.³h.
   Pressure: 1.5 kp./cm.² (kiloponds per square meter); delivery height of the booster water pump: H=16 m. Pl.S.; pump power: N=11.5 kw.=9,590 kcal./h.

A further reduction in the energy consumption can be obtained with the embodiment of FIG. 2. The raw water fed through conduit **43** for heat withdrawal has a certain pressure energy which in the embodiment of FIG. 1 is not used. There exists the possibility by means of this quantity of water to operate one or more small jet ejectors and by means of these ejectors to withdraw inert gases from the evaporator. In the embodiment of FIG. 2 the quantity of water fed through conduit 43 is divided up into two branch flow. These flows are, through conduits **44** and **45**, conveyed to two jet ejectors **53** and **53***a* respectively. The jet ejector **53***a* draws through conduit **55** a portion of the inert gases freed in chamber **1** of the evaporator and conveys the gas-water mixture through conduit **57** into the circulation container **61**. Similarly, the jet ejector **53** will, through conduit **54**, draw off a portion of the inert gases formed in chamber **2** of the evaporator and convey this gas-water mixture through conduit **56** into he circulaon conaner **61**. The whdrawal of he remaining inert gases from chamber **3** of the evaporator is as described above effected by means of the water jet ejector **51**. In the circulating container **61**, booster water flows of the individual water ejectors mix with each other. A portion of the quantity of water flows off through overflow **62**. The motive water pump **41** of the water jet ejector **51** will, as mentioned above, draw the operating water from the circulating container **61** through conduit **40** and will convey said operating water through conduit **42** to the jet ejector. The water-gas mixture passes through conduit **52** into the tangential separator **60** where gas and water are separated from each other. Due to the fact that already a portion of the inert gas obtained in the entire plant is drawn off from the first evaporator stages by means of the jet ejectors **53** and **53***a*, the output of the water jet ejector **51** and thus the power of the motive water pump **41** can be reduced by approxmately 20%.

A further embodiment for the invention is illustrated in FIG. 3. According to this embodiment, the withdrawal of the inert gas is effected by means of a low pressure steam jet ejector **71** and a following water jet ejector **51**. The water jet ejector **71** employed in this instance works satisfactorily already with motive steam pressures of less than 0.8 atmospheres absolute. As booster steam, therefore, the flash-vapour formed in chamber **1** of the evaporator is employed to which moreover adhere the inert gases freed in this stage. The mixture of inert gases and flash-vapour is conveyed to the jet ejector through the booster steam conduit **72**. Through conduit **70**, the jet ejector draws the remaining inert gases from the flashing chamber **3** of the evaporator and conveys these residual inert gases through conduit **50** to the suction side of the water jet ejector **51**. With this jet ejector, as described above, motive water is circulated and a certain quantity which is required for the withdrawal of heat is fed through conduit **43** to said jet ejector. A similar quantity is withdrawn from the circulating container through the overflow **62**. In the water jet ejector **51**, the quantity of motive steam of the jet ejector **71**, as well as the vapour adhering to the inert gases is condensed. Due to the fact that the inert gases and the broken-in air is precompressed already by means of the steam jet ejector **71**, the motive water requirement of the water jet ejector **71** as well as the power requirement of the motive water pump **41** can be considerably reduced.

According to the embodiment of FIG. 4, the steam jet ejector **71** obtains its motive steam as described above through conduit **72** from the flashing chamber **1** of the evaporator. As a result thereof, simultaneously the freed inert gases and the broken-in air are removed from the flashing chamber **1**. The jet ejector **71** draws through conduit **70** the remaining inert gases and the broken-in air from the flashing chamber **3** of the evaporator and conveys the gas-vapour mixture through conduit **73** into an intermediate condenser **75**. This intermediate condenser comprises a cooling system which is supplied with

cooling water by the raw water pump **28** through the conduit **76**. The heated-up cooling water is discharged through conduit **77** from the intermediate condenser and together with the raw water heated up by the evaporator is withdrawn through conduit **30**. The vapour entering the intermediate condenser through conduit **73** conveys its latent heat to the cooling water and condenses. The formed condensate passes through conduit **78** to the suction line **26** of a distilling pump **27**. The inert gases with a small quantity of adhering vapour are through conduit **50** withdrawn by the water jet ejector **51**, and the gas-water mixture is through conduit **52** conveyed into the tangential separator **60**.

Although the invention has been described in connection with a multi-stage flash evaporator plant, the invention is, by no means, limited thereto. Many variations are possible. Thus, there exists the possibility to employ the invention in connection with multi-stage submerged-tube evaporators, vertical tube evaporators and falling film evaporators.

It is also to be noted that the present invention is, by no means, limited to the particular showing in the drawings but also comprises any modifications within the scope of the appended claim.

What I claim is:

1. An evaporator for sea water, which includes in combination: a plurality of evaporating chambers adapted respectively to receive different temperatures and pressures so that temperature and pressure drops exist from evaporating chamber to evaporating chamber, intake means for liquid to be evaporated, means for conveying some of said liquid to and through each of said evaporating chambers for evaporating in each of said chambers at least a portion of said liquid into steam, condenser means respectively associated with said chambers and respectively communicating therewith, means communicating with said condensers for receiving the distillate formed in said condensers, withdrawing means for withdrawing inert noncondensable gases from said evaporating chambers, comprising a system in which each of a plurality of ejectors is connected to one of said evaporating chambers for removing non-condensable gases, and operated by liquid which in no instance flows through the condensing area of any of the evaporating chambers, separator means receive gas and water discharged by said ejectors for separating the gases, and a pump circulates water through said separator means, and a by-pass conduit means is connected to said system and to said intake means to receive liquid before it passes to said condenser means and to supply it to said system.

References Cited

UNITED STATES PATENTS

3,420,747	1/1969	Williamson	202—173
2,423,307	7/1947	Fraser et al.	202—174
2,759,882	8/1956	Worthen et al.	202—174

NORMAN YUDKOFF, Primary Examiner

U.S. Cl. X.R.

203—4, 11