

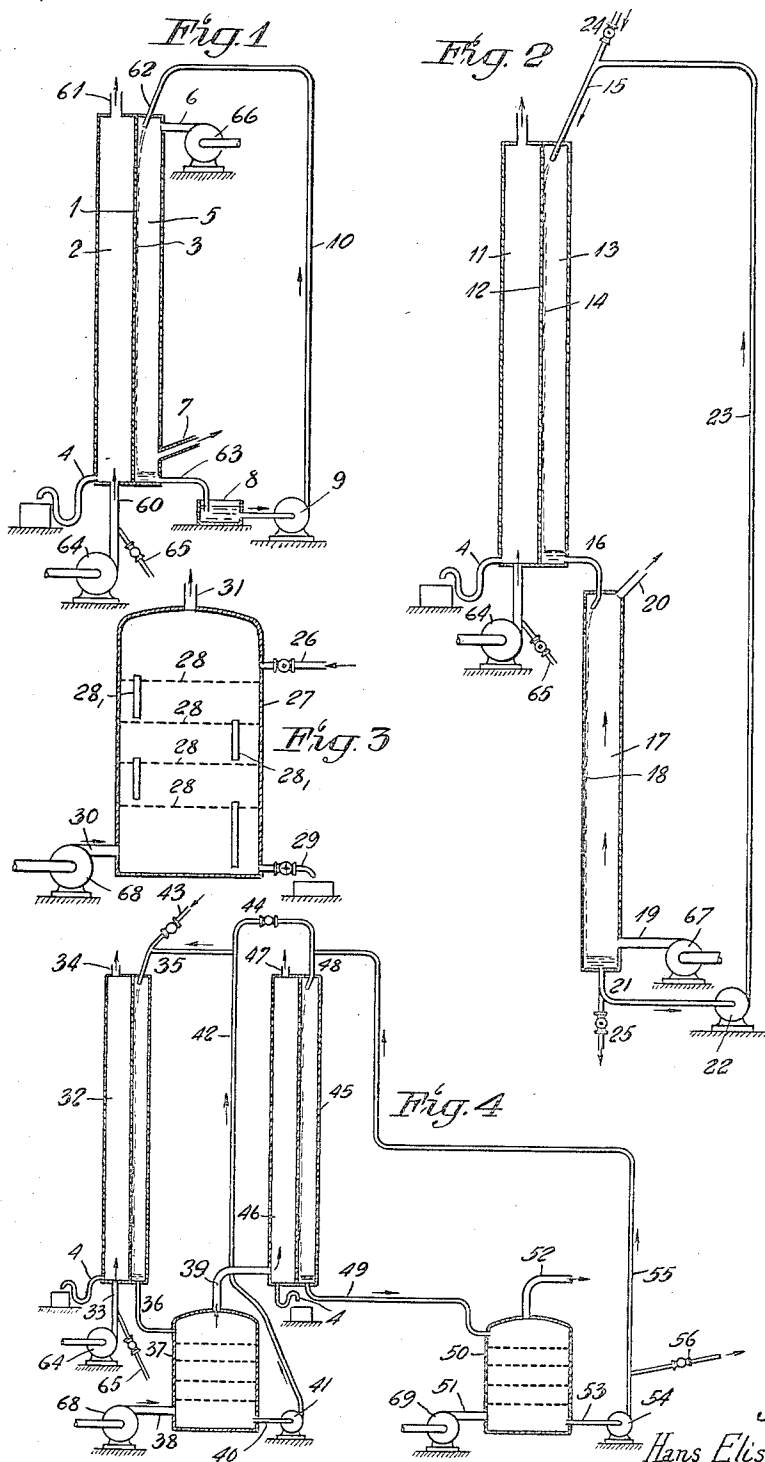
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MEANS FOR EVAPORATION

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MEANS FOR EVAPORATION

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Because of the great costs involved in liquid evaporation on a large scale, efforts have been made for a century to reduce the heat consumption in such evaporation as far as possible.

The most important means for carrying out such evaporation is still believed to be the multiple-effect evaporator.

As is well known, a pressure difference prevails between the condensation and evaporating chambers in apparatus of this character and, in comparison with the surrounding atmospheric pressure, a pressure above or below atmospheric also prevails within such a system (frequently in such manner that the first stages or effects of the system are under a pressure above atmospheric, while the last stages are under vacuum).

There is nothing, however, that will prevent the construction of a multiple-effect evaporating system in which one and the same total pressure (for instance atmospheric pressure) prevails within the various parts of the system, provided that suitable means are brought into use. This may be attained by causing the evaporation to take place in the presence of and with the aid of a permanent gas (or gases), such as air, and by reusing the heat content of the gas-vapor mixture then obtained for evaporating purposes in that the same is permitted in a subsequent stage of the system to deliver its heat indirectly (that is to say, through a heat transmitting wall) to a liquid from which evaporation is then effected with the aid of a gas (or gases), such as air. The air-vapor mixture escaping from this stage may subsequently be used as a heat deliverer in another stage, and so forth. Here, it is obviously desirable to be able with a certain given quantity of heat to evaporate as great a quantity of liquid as possible.

In a certain measure, this system is similar to the multiple-effect system referred to hereinbefore.

The above system, however, involves quite a number of advantages over the multiple-effect system. One of these advantages has already been stated, namely, that the whole system is under the same total pressure. This pressure may be chosen arbitrarily. If it be chosen the same as the atmospheric pressure, the advantage is obtained that the apparatus may be constructed without regard to any stresses caused by pressure differences. It is thus possible to employ very thin heat transmitting walls, whereby the costs of material are reduced, the apparatus need not be absolutely tight, and so forth.

A further advantage of the greatest impor-

tance is that a system of the character described makes it possible to utilize quantities of heat which otherwise might be lost by escape in the form of gas-vapor mixtures.

Finally, it deserves mentioning that incrustating solutions, such as sulphate and sulphite lye may be evaporated in such an apparatus, without any incrustation whatever occurring, this result flowing from the fact that the evaporation takes place from a free liquid surface and not at the surface of a heat transmitting wall. The incrustating substances are consequently precipitated in the solution proper, and not on the heat transmitting wall as occurs in the case of boiling.

To attain effective transfer of heat, it is of the greatest importance that the gas-vapor mixture be saturated; this condition is therefore always assumed to exist in the case of the present invention.

In order to obtain heat out of such a gas-vapor mixture, it is obvious that the heat transfer must take place by cooling the mixture, and that this in turn involves a reduction of the temperature of the gas-vapor mixture. In distinction from the case of heat delivery from a pure vapor, the temperature of the gas-vapor heat-delivering medium will vary at different points along the heat surface transmitting wall in the case here-

described. Obviously, it is desirable to recover as great a portion of the heat content of the gas-vapor mixture as possible; in other words, it is desired to cool down the gas-vapor mixture to a temperature as low as possible. In order that this cooling of the gas-vapor mixture shall take place, the liquid on the other side of the heat wall must evidently always have a lower temperature than the gas-vapor mixture.

An evaporating system of this kind is shown diagrammatically in Fig. 1 wherein 1 designates the heat transmitting wall and 2 the heat chamber into which the gas-vapor mixture is introduced through the pipe 60 at the temperature t_1° , through which it flows in contact with one surface of wall 1, and whence it escapes through the outlet 61 at the temperature t_2° . The air-vapor mixture may be formed, for instance as illustrated, in the pipe 60 to which is connected a blower or fan 64 for supplying the air as well as a valved pipe 65 for admitting vapor. The condensate escapes through the pipe 4. The solution 3 to be evaporated flows over the other side of the heat surface transmitting wall, and the temperature of this solution is assumed to be t_3° at the

intake 62 into the apparatus and t_4° at the outlet 63 therefrom. Air is introduced into the evaporating chamber 5 through the pipe 6 by means of a blower or fan 66, and escapes through 7.

5 The solution drawn off from the apparatus is collected in the receptacle 8 whence it is conveyed by means of a pump 9 through the conduit 10 back to the evaporating chamber 5 of the apparatus. It is understood that the gas in the evaporating chamber 5 may flow either with or counter to the solution 3; that is to say, the gas may flow either inwardly at 6 and outwardly at 7 or inwardly at 7 and outwardly at 6. If it flows with the solution, the temperature of the gas-vapor mixture escaping at 7 will be approximately the same as the temperature of the liquid escaping there, but in such case it will be difficult or even impossible to obtain a sufficiently low temperature of the discharged solution. If the

20 gas-vapor mixture flows countercurrent to the solution it is of course easy to maintain a low temperature in the discharging solution, although at the same time the temperature of the gas-vapor mixture escaping at 6 will also be low.

25 Under all circumstances the following conditions shall prevail: $t_3^\circ < t_2^\circ$ and $t_4^\circ < t_1^\circ$.

In order to obtain a multiple-effect system where the output will be as great as possible, it is necessary that the gas-vapor mixture escaping from the evaporating chamber 5 have a temperature as high as possible.

From the above considerations it will be understood that it is desired to cool the gas vapor mixture delivering its heat to the liquid to a temperature as low as possible, and at the same time to obtain a fresh gas-vapor mixture at a temperature as high as possible. These results and advantages may be attained through the method and various forms of apparatus to be described hereinbelow, which attainment constitutes one of the principal objects of the present invention.

Fig. 2 shows diagrammatically one arrangement of apparatus embodying the invention by means of which the desiderata pointed out above may be attained. In the heat chamber 11 the gas-vapor mixture intended to deliver up its heat is conveyed in the same manner as shown in Fig. 1. This chamber is separated by means of the heat transmitting wall 12 from the chamber 13 in which solution 14 is caused to flow over the surface of heat transmitting wall 12 but without evaporation taking place. The solution is introduced through the pipe 15 and is discharged through the pipe 16. This solution will thus be heated, and with a heat surface of infinite length the temperature of the solution escaping at 16 may become equal to the temperature of the gas-vapor mixture entering the heat chamber 11. But this temperature is also dependent on the quantity of liquid introduced at 15, as well as on the temperature thereof; that is to say, for a certain quantity of gas-vapor mixture of a certain temperature introduced into the heat chamber 11 the temperature of the solution leaving chamber 13 at 16 will vary dependent upon the quantity and temperature of the solution introduced into said chamber at 15.

In any event, the solution discharged at 16 will obtain a comparatively high temperature as a result of absorbing the quantity of heat given up by the gas-vapor mixture in the chamber 11. The whole apparatus 11 and 13 may preferably be called the heater.

75 The warm solution discharged at 16 is next

to be cooled down to a temperature equal to that of the liquid entering at 15. This cooling is effected by evaporation, with air or some other gas, which may take place, for instance, in the apparatus denoted by 17—21 in Fig. 2 and preferably called the evaporator. Here, 17 is the evaporating chamber wherein the solution 18 coming from the heater is caused to flow over a vertical or inclined surface. The solution is discharged from chamber 17 through the pipe 21. 10 At the same time, air or gas is conveyed through chamber 17 counter-current to the solution, said gas being forced in through the pipe 19 by means of a fan 67 and passing out through the pipe 20. When these gases move over the surface of solution 18 they absorb vapor from the solution whereby the solution is cooled, the vapor-generating heat being taken from the solution. This results in a cooling of the solution 18 on its way downwards and in a heating of the gas-vapor mixture in the chamber 17 on its way upwards. If this path be made long, the solution will be cooled to a low temperature by the time it reaches outlet 21, the gas-vapor mixture being at the same time heated to a high temperature by the time it reaches outlet 20. If a suitable quantity of air or gas is taken in at 19, the temperature of the solution discharged at 21 will be the same as the temperature of the solution entering at 15. The solution leaving chamber 17 at 21 is returned by the pump 22 through the conduit 23 to the heater into which it is introduced at 15. Evidently, a certain quantity of thinly liquid solution must be introduced into the system from time to time, and this is effected through the 35 valved conduit 24; likewise, a certain quantity of concentrated solution may be drawn off from the system through the conduit 25 which is also provided with a valve. In the manner herein described, the gas-vapor mixture escaping at 20 attains a high temperature while at the same time the solution discharged at 21 attains a temperature which is sufficiently low. By reason of the high temperature of the gas-vapor mixture escaping at 20, this mixture may be advantageously used as a heat deliverer in another evaporating stage or system operating at a somewhat lower temperature interval than that at which the system above described operates.

The system is, consequently, divided into two parts; namely, a heater wherein solution is heated (11—14), and an evaporator wherein the same solution is cooled with the aid of air or other gas (17—21). This is the feature which, in principle, underlies the novelty of the invention; and the effect obtained hereby resides in the fact that the gas-vapor mixture escaping at 20 has a high temperature while at the same time the solution discharged at 21 has a low temperature. Such a system, consisting of a heater and an evaporator with an appurtenant circulating pump, is preferably termed an evaporating aggregate.

The evaporator itself may be devised in various ways, one of which is disclosed in Fig. 2. Another construction, illustrated in Fig. 3, comprises a device in which the gas or air is permitted to bubble through layers of the solution. In this embodiment, the solution is introduced into the apparatus 27 through the pipe 26, said apparatus being provided with a number of substantially horizontal plates or partitions 28 having apertures, slits or the like formed therein. The solution flows through overflow pipes 28 from partition to partition and is drawn off through the pipe 29. The gas or air is introduced 75

through the opening 30 by means of a fan 68, flows through the liquid layers on the partitions 28 while evaporation is taking place, and escapes, saturated with vapor, from the apparatus through the opening 31. With a sufficient number of partitions in the apparatus, an efficient counter-current is obtained between the solution and the gases.

As stated above, a heater and an evaporator in combination form an evaporating aggregate. Such an aggregate corresponds to a stage or effect in the multiple-effect evaporating systems. If two or more of such aggregates or units are combined with each other, an evaporating system is obtained which corresponds to two or more evaporating stages in the multiple-effect evaporating systems. Such a combination of two units is shown in Fig. 4.

In this latter view, the heater 32 and the evaporator 37 form the first unit, while the heater 45 and the evaporator 50 constitute the second unit. The solution is introduced into the system through the pipe 43, enters the heater of the first unit at 35 and is discharged therefrom through the conduit 36 to the evaporator 37. The gas-vapor mixture, the heat of which is to be utilized, is introduced into the heater 32 through the opening 33 and escapes therefrom through the opening 34. Air or gas is introduced into the evaporator 37 at 38 by means of the fan 68, and the gas-vapor mixture escapes therefrom through the pipe 39. This latter gas-vapor mixture is then used as a source of heat in the heater of the second unit, being introduced into the heat chamber thereof, as at 46, and escaping through the opening 47. The solution discharged at 40 from the evaporator of the first unit is conveyed by means of the pump 41 and the conduit 42 back to the first heater, into which it is again introduced at 35. Part of this solution may be passed through the valve 44 over to the second unit, into the heater thereof, as at 48, and discharged therefrom through the pipe 49 to the evaporator 50. From evaporator 50 the solution is discharged through the pipe 53 to the pump 54 which returns it through the pipe 55 to the heater, into which it is introduced at 48. The evaporator 50 is supplied with air or gas through the pipe 51 and the blower or fan 69. A certain quantity of thin liquid solution may be introduced into the system at 43 and at 48 also, if desired, while a certain quantity of concentrated solution may be drawn off through the conduit 56. The gas-vapor mixture escaping through the pipe 52 may obviously be used as a heat deliverer in a third unit, and so forth. Furthermore, the gas-vapor mixture escaping at 47 may be employed as evaporating gas in the evaporator 37, in which case it is introduced at 38, either separately or

in mixture with a certain quantity of gas or air, as desired. The gas-vapor mixture escaping from the first unit at 34 may also be employed as a heat deliverer in a subsequent unit, it being understood that the same should not be introduced where the temperature of the liquid leaving the heater is higher than the temperature of the mixture at its point of entry. Preferably, the said gas-vapor mixture is used to heat the solution to be evaporated. The condensate escaping from the heat chamber of the first unit may preferably be conveyed to the heat chamber of the second unit, and so forth.

It will now become apparent to those skilled in the art that various other changes may be made in the several embodiments of the invention illustrated without departing from the inventive concept. Reference is therefore to be had to the appended claims for a definition of the limits of the invention.

What I claim is:—

1. An apparatus for effecting evaporation without substantial difference in pressure between the interior and the exterior thereof including in combination, a plurality of heating and evaporating chambers arranged in pairs, each heating chamber having a heat transmitting wall, means flowing said liquid to be evaporated over each heat transmitting wall in indirect heat interchanging relation with a heating medium within said chamber, means delivering heated liquid from each heating chamber to the evaporating chamber of the pair, means passing a gas which is non-condensing under the conditions of operation in direct heat interchanging relation with the heated liquid in each evaporating chamber to remove heat and vapor therefrom by contact therewith, means conducting the gas-vapor mixture from an evaporating chamber of one pair through a heating chamber of another pair to provide the heating medium within the latter, and means for circulating said liquid through said heating and evaporating chambers.

2. An apparatus according to claim 1, wherein each evaporating chamber includes means for passing the gas through one or more layers of the heated liquid in the form of bubbles to remove heat and vapor therefrom by intimate contact therewith.

3. An apparatus according to claim 1, wherein each evaporating chamber includes one or more apertured partitions therein, means for flowing the heated liquid across said partitions in relatively thin layers, and means for passing the gas through the apertures in said partitions and through the layers of liquid thereon in the form of bubbles to remove heat and vapor from said liquid by intimate contact therewith.

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