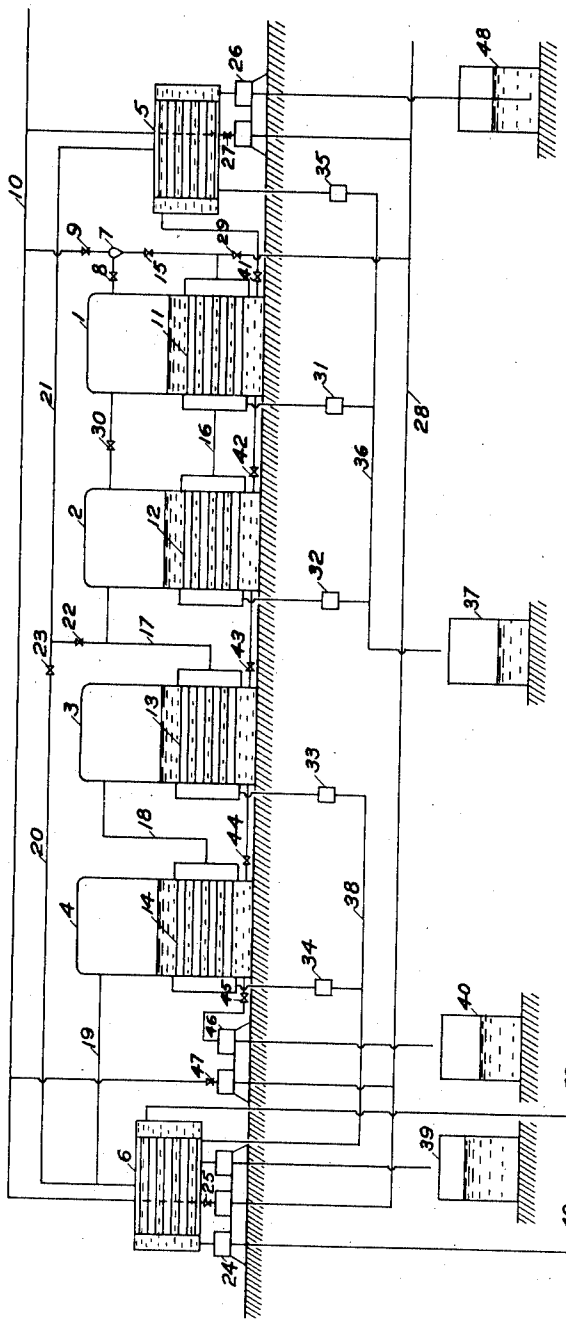
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APPARATUS FOR EVAPORATING LIQUIDS.

APPLICATION FILED JAN. 26, 1917.

1,390,676.

Patented Sept. 13, 1921.



Witnesses

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APPARATUS FOR EVAPORATING LIQUIDS.

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Application filed January 26, 1917. Serial No. 144,650.

To all whom it may concern:

Be it known that I, WILLIAM L. DE BAUFRE, a citizen of the United States, residing at Annapolis, in the county of Anne Arundel and State of Maryland, have invented a certain new and useful Apparatus for Evaporating Liquids, of which the following is a specification.

My invention relates to the evaporation of liquids, including solutions of salt, sugar, etc., and has for its object a reduction in the extent of heating surface required for the evaporation of a given quantity of vapor or the concentration of a given quantity of solution. A further object of my invention is an improvement in the economy of the operation, especially in connection with the employment of a compressor to compress vapor from the liquid undergoing evaporation for the purpose of using the compressed vapor to heat the liquid.

With the foregoing and other objects in view, my invention consists of the novel construction, combination and arrangement of parts as hereinafter specifically described and illustrated in the accompanying drawing, wherein is shown the preferred embodiment of my invention, but it is understood that changes, variations and modifications can be resorted to which come within the scope of the claims hereunto appended.

The drawing shows the combination "regenerative" and "multiple-effect" plant proposed to accomplish the object specified above. The several evaporator shells are numbered 1, 2, 3, 4, respectively; 5 is a preheater and 6 a condenser. An ejector 7 is connected to withdraw through valve 8 from the evaporating chamber of shell 1 the vapor produced therein. The steam to operate ejector 7 is supplied through valve 9 from steam main 10, and the commingled steam and compressed vapor passes through valve 15 into the evaporator tubes 11 which comprise the condensing chamber of shell 1.

Since there is discharged from shell 1 only the vapor which is compressed in ejector 7 and returned to tubes 11, all the commingled steam and compressed vapor will not be condensed therein. In fact, there must be discharged through connecting pipe 16 into tubes 12 of shell 2 nearly one pound of commingled steam and vapor for each pound of steam supplied ejector 7 through valve 9. The condensation of the commingled steam and vapor in this second condensing chamber (tubes 12) will produce nearly an equal quantity of vapor in the second evaporating chamber (shell 2).

With valve 22 closed, this vapor from shell 2 will all pass through connecting pipe 17 to the tubes 13 of shell 3. Shell 3 with tubes 13 thus constitutes the "second-effect" of a "multiple-effect" arrangement, in which shell 2 with tubes 12 constitutes the "first effect" and shell 4 with tubes 14 constitutes the "third-effect." Shell 1 with tubes 11 may be called the "regenerative effect" of the plant. While more than three "effects" can be provided, the drawing shows the vapor from shell 4 passing through pipe 19 to condenser 6.

With valve 23 open, a part of the vapor from shell 4 will pass through pipes 20 and 21 to preheater 5. Reversing the positions of valves 22 and 23 so that the feed heater is supplied with steam from the first effect rather than from the last effect results in a higher temperature of the liquid fed to shell 1.

The commingled steam and vapor supplied tubes 11 may be augmented by exhaust steam through valve 29 from exhaust main 28. Valve 30 is provided in order to allow the "regenerative effect" (shell 1) to become a part of the "first effect" (shell 2) should it be desired at times to operate the plant with valve 8 closed.

The condensed steam and vapor in tubes 11, 12, 13, 14, and in preheater 5, are discharged by traps 31, 32, 33, 34, and 35, respectively, through drain main 36 to tank 37 or through drain main 38 to condenser 6 as shown in the drawing. The vapor condensed in condenser 6 and the condensate discharged therein are removed by pump 24 together with any non-condensable gases present, and the condensate may be stored in tank 39. The above arrangement is suitable when the last two effects are worked under a vacuum; if worked above atmospheric pressure, the corresponding traps might discharge directly into tank 37 or tank 39. Pump 24 is shown as also drawing cooling water from source 49 and discharging it through condenser 6 to waste at 50.

The liquid to be evaporated or concentrated is taken from storage tank 48 by feed pump 26 and forced through feed heater 5 into shell 1. The rate of feed may be regu-

lated either by pump throttle valve 27 or by feed valve 41. From shell 1 the partially concentrated liquid passes to shell 2 through valve 42 where it is further concentrated, through valve 43 to shell 3 where it is still further concentrated, and finally to shell 4 through valve 44, and from thence the completely concentrated liquid is drawn by pump 46 through valve 45 and discharged into storage tank 40.

It should be noted that the system is operative with a greater number than three effects, or with the "regenerative effect" and "first effect" only. Also, shells 1 and 2 may be combined to simplify the construction, two evaporating chambers and one condensing chamber being provided in a single shell.

The operation of this apparatus for evaporating liquids is carried out as follows:

First, shells 1, 2, 3, 4, are filled to the working level with the liquid to be evaporated, drawn by pump 26 from storage tank 48 and forced through preheater 5 and through valve 41 into shell 1, thence through valve 42 into shell 2, thence through valve 43 into shell 3, and thence through valve 44 into shell 4, valve 45 being closed. Pump 24 and condenser 6 are next put into operation. If exhaust steam is available, the system may be heated by opening valve 29. Otherwise, valves 15 and 9 should be opened to admit live steam from main 10. The liquid in shells 1 and 2 will be heated by the condensation of the live or exhaust steam within tubes 11 and 12, which practically form a single chamber. The vapor from shells 1 and 2, valve 30 being open, will heat the liquid in shell 3 by condensation within tubes 13, and the liquid in shell 4 will be heated by the condensation within tubes 14 of vapor from shell 3. The vapor from shell 4 will be condensed in condenser 6. Valve 22 or valve 23 may now be opened as desired to supply vapor for preheating the solution fed to shell 1.

The vapor condensed in preheater 5 and shells 1 and 2 will be automatically discharged into tank 37 by traps 35, 31 and 32, respectively. The condensation in tubes 13 and 14 will be discharged by traps 33 and 34 into condenser 6, from which it and the vapor condensed therein will be removed by pump 24 and discharged into tank 39.

When the liquid in shell 1 becomes sufficiently heated, valve 30 may be closed and valve 8 opened. The vapor produced in shell 1 will then be entrained in the live steam in ejector 7, compressed and forced into tubes 11.

As soon as an appreciable evaporation takes place, it becomes necessary to regulate valves 41, 42, 43, 44, to maintain the proper liquid levels in shells 1, 2, 3, 4, respectively. This may be done manually, or automatically by well known devices for this purpose.

It now becomes necessary to observe the concentration of the liquid in the last effect, shell 4, and when this concentration reaches the maximum desired, to start pump 46 and open valve 45, to withdraw the concentrated liquid for storage in tank 40.

During normal operation, the speed of pump 24 will be regulated by means of throttle valve 25 to maintain the proper vacuum in condenser 6 and remove the condenser vapor therein; the speed of pump 46 will be regulated by throttle valve 47 to remove the concentrated liquid from shell 4 and thus maintain the proper concentration therein; and the speed of feed pump 26 will be regulated by throttle valve 27 to maintain the proper rate of feed. Feed valves 41, 42, 43, 44 must be adjusted to preserve the proper working levels of the liquid undergoing concentration or evaporation within shells 1, 2, 3, 4, respectively.

With a given vacuum maintained in shell 4 by condenser 6 and a given initial steam pressure at valve 9, the several intermediate pressures and temperatures in shells 1, 2, 3, 4, will be determined by the physical properties of the liquid undergoing evaporation and the liberality of design of the several effects. In fact, the conditions within shells 2, 3, and 4, will be but slightly different from those obtaining in an ordinary triple-effect plant of the same dimensions using the same quantity of steam as supplied this combination plant. In shell 1, the pressure difference will be determined by the efficiency of ejector 7 and the efficacy of the heating surface in tubes 11.

By proper design, the difference between the temperature of the condensing steam or vapor and that of the vapor produced may be made larger within shell 2 than within shell 1, within shell 3 than within shell 2, and so on, increasing as the liquid becomes denser and more viscous. This is especially advantageous for shells 1 and 2, particularly when no additional shells are used, and a greater temperature difference may readily be obtained in shell 2 than available within shell 1 with reasonable economy of the ejector 7; thus, after the liquid has been partially concentrated within shell 1, the final concentration may be carried out within shell 2 under a greater temperature difference.

Having thus described my invention, I claim and desire to secure by Letters Patent, the following:

1. In an apparatus for evaporating a liquid, two evaporating chambers containing the said liquid non-communicating above the liquid level and separated by heating surfaces from communicating condensing cham-

bers under substantially the same pressure, a vapor operated compressor for withdrawing and compressing vapor from the first of the said evaporating chambers and discharging the compressed vapor commingled with the operating vapor into the communicating condensing chambers, means to discharge liquid from the first to the second evaporating chamber, means for discharging vapor from the second of the said evaporating chambers at a lower temperature than that in the first evaporating chamber independent of the first evaporating chamber.

2. In an apparatus for evaporating a liquid, two evaporating chambers containing the said liquid non-communicating above the liquid level and separated by heating surfaces from communicating condensing chambers under substantially the same pressure, means for discharging liquid from the first to the second evaporating chamber, a vapor operated compressor for withdrawing and compressing vapor from the first of the said evaporating chambers and discharging the compressed vapor commingled with the operating vapor into the communicating condensing chambers, and means for discharging vapor from the other of said evaporating chambers independent of the first evaporating chamber.

3. In an apparatus for evaporating a liquid, two evaporating chambers containing the said liquid non-communicating above the liquid level and separated by heating surfaces from communicating condensing chambers under substantially the same pressure, means for discharging liquid from the first to the second evaporating chamber, means for withdrawing and compressing vapor from the first of the said evaporating chambers and for introducing the compressed vapor into the communicating condensing chambers, and means for discharging vapor from the other of said evaporating chambers independent of the first evaporating chamber.

4. In an apparatus for evaporating a liquid, two evaporating chambers containing the said liquid non-communicating above the liquid level and separated by heating surfaces from communicating condensing chambers under substantially the same pressure, means for discharging liquid from the first to the second evaporating chamber, means for withdrawing and compressing vapor from the first of the said evaporating chambers and for introducing the compressed vapor into the communicating condensing chambers, means for discharging vapor from the other of the said evaporating chambers independent of the first evaporating chamber, and means for introducing additional vapor into the communicating condensing chambers.

5. In an apparatus for evaporating a liquid, an evaporating chamber containing the said liquid separated by a heating surface from a condensing chamber, means for withdrawing and compressing vapor from the said evaporating chamber and of introducing the compressed vapor into the said condensing chamber, a second evaporating chamber separated by a heating surface from a second condensing chamber, means for discharging the said liquid from the first evaporating chamber into the second evaporating chamber, means for discharging vapor from the first condensing chamber into the second condensing chamber, and means for discharging vapor from the second evaporating chamber independent of the first evaporating chamber.

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