

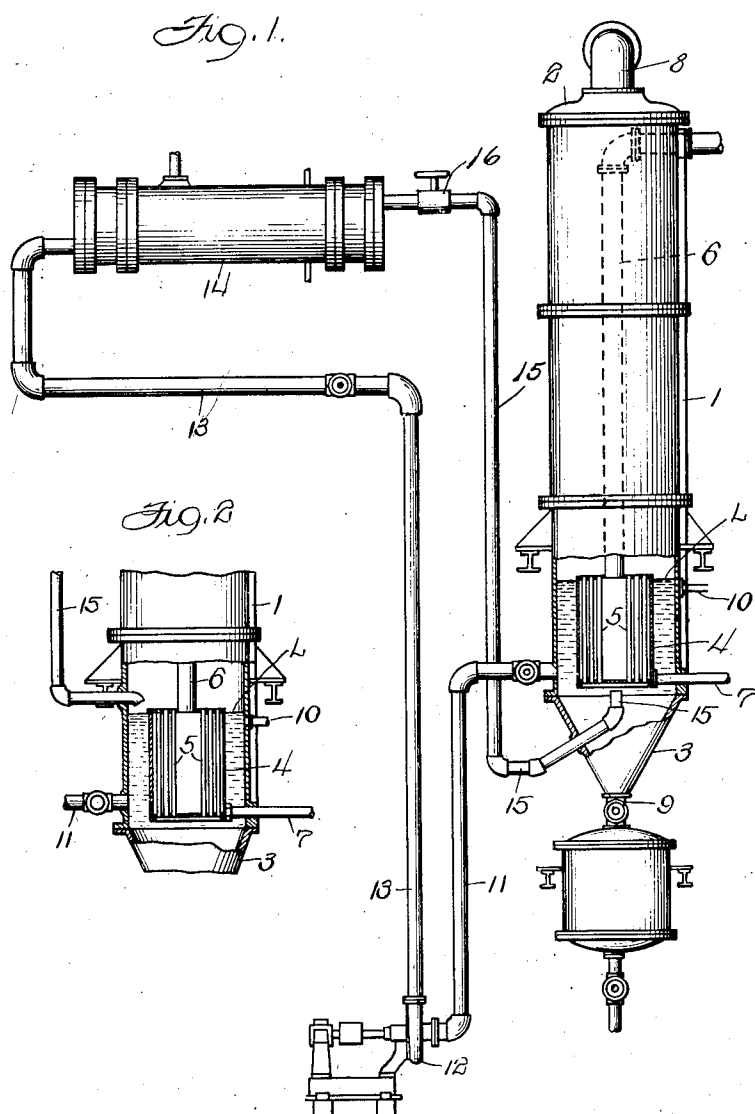
Dec. 7, 1926.

1,609,853

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PROCESS OF EVAPORATION.

Filed August 9, 1923.



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Patented Dec. 7, 1926.

1,609,853

UNITED STATES PATENT OFFICE.

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PROCESS OF EVAPORATION.

Application filed August 9, 1923. Serial No. 656,607.

This invention relates to a process of evaporation.

It will be explained as applied to the operation of a vertical tube vacuum type evaporator although it is applicable to other varieties of evaporators.

One of the objects of the invention is to provide an improved process of evaporation.

Another object is to provide an improved method of operating evaporators.

Another object is to accelerate the operation of evaporators.

Another object is to provide a method for efficiently and rapidly evaporating substances whose solubility curve is reversed, that is substances whose solubility decreases with increase of temperature.

Another object is to provide apparatus for augmenting the operation of evaporators.

Another object is to provide apparatus for facilitating the evaporation of solutions having reverse solubility curves.

Other objects and advantages will hereinafter appear.

The accompanying drawing illustrates apparatus suitable for the practice of the improved method.

In the drawing:

Fig. 1 is an elevation and partial section of apparatus including one typical form of evaporator, and

Fig. 2 is a partial sectional view of the evaporator showing a modification of the process.

It is well known that evaporation ordinarily is augmented and facilitated by agitation or circulation of the treated liquid in the evaporator. Mechanical agitators, such as paddle wheels, etc., and the introduction of relatively inert and buoyant agents have been employed to increase the agitation and circulation of the treated liquid.

Some substances have the peculiar property of becoming less soluble above certain temperatures. Such substances are said to have "reverse" solubility curves. Sodium sulphate is one substance of this character. The solubility of sodium sulphate increases as the temperature rises until a temperature of about 33 degrees centigrade is reached. Above this critical temperature the solubility of sodium sulphate decreases as the temperature rises.

Heretofore it has been exceedingly difficult to evaporate these "reverse" solubility curve

substances, such as sodium sulphate solutions. Probably the principal reason for this difficulty is that ordinarily there is a region of relatively high temperature next to the wall of the heater. This condition exists in any case of heat transfer from a metal wall to a liquid. When the treated liquid has a "reverse" solubility curve crystallization is greatly augmented in the relatively hot region next to the wall of the heater and the heater wall soon becomes coated with a film or scale of crystals. This scale or film retards or hinders the transfer of heat from the heater to the treated liquid and the operation of the evaporator may be seriously affected, sometimes stopped altogether as far as commercial results are concerned.

The process herein set forth contemplates the introduction into the evaporating chamber of superheated quantities of the liquid undergoing evaporation. The superheated liquid, when free in the evaporating chamber, instantaneously vaporizes or flashes and, if introduced below the surface of the treated liquid, sets up a violent agitation and circulation. The diffused or dispersed vapors tend to rise through the treated liquid and further increase and spread the circulation.

If the superheated liquid is a saturated solution, the release and resultant vaporization of the same in the evaporating chamber, whether the release be above or beneath the surface of the treated liquid, causes the superheated liquid to provide small crystals of the soluble salts. These small crystals, which may be termed "seed crystals" are dispersed more or less through the body of the treated liquid in the evaporating chamber and form nuclei about and upon which the salts in solution in the treated liquid may readily crystallize. This agglomerate crystallization readily provides crystals of sufficient weight to settle in the bottom of the evaporator from whence they may be withdrawn in the usual manner.

The evaporator chosen to illustrate the application of the invention has a tubular outer shell or casing 1. Shell 1 has a cover 2 and an inverted cone shaped bottom 3. The tubular shell with its cover and bottom form the evaporating chamber.

The heater, illustrated as being of the steam type, comprises a cylindrical drum 4 through which a series of pipes 5 extend from end to end. The steam occupies the

space in the drum about the tubes while the treated liquid in the evaporating chamber fills and circulates through the tubes. The heater shown acts somewhat like a water

5 tube boiler, the heating medium being outside of the tubes and the liquid to be heated being in the tubes.

Steam is conveyed to the heater through an inlet pipe 6 and condensation may be

10 withdrawn from the heater through a condensate outlet pipe 7.

An outlet pipe 8 communicates with the evaporating chamber through cover 2. This outlet pipe is for the discharge of the vapors

15 driven off during the evaporating process, and for the application of the desired vacuum to the evaporating chamber. A discharge pipe 9 communicates with the evaporating chamber through bottom 3. This discharge pipe is for the removal of the products which settle to the bottom of the evaporating chamber during the evaporating process. The liquid to be evaporated may be injected into the evaporating chamber through

25 an inlet pipe 10.

In the practice of the invention according to the preferred method, relatively small quantities of the boiling liquid are withdrawn from the evaporating chamber, heated

30 to a temperature above the temperature of the evaporating chamber, and again injected into the evaporating chamber. The liquid thus withdrawn, when the evaporator is operating normally, ordinarily is a saturated solution. Preferably the superheated liquid is returned to the evaporating chamber below the surface of the boiling liquid therein, as shown in Fig. 1, although it may be introduced above the liquid level as shown

40 in Fig. 2, depending upon the results to be obtained.

An outlet pipe 11 leads from the evaporating chamber to a small pump 12. Pipe 11 communicates with the evaporating chamber

45 near the bottom but preferably above the level to which the crystal deposit is permitted to rise. A pipe 13 interconnects pump 12 and a superheater 14. An inlet pipe 15 interconnects superheater 14 and the evaporating chamber. The discharge opening of pipe 15 may be above or below the liquid level of the evaporator as will be hereinafter explained. Superheater 14 may be heated in any desired manner, such as by

55 steam coils, so that the liquid passing there-through will be heated above the temperature of the liquid in the evaporating chamber. A throttle valve 16 is provided in pipe 15 in order that any necessary or desired

60 pressure may be obtained and maintained in the superheater.

The operation of the apparatus is as follows:

65 The treated liquid is injected into the evaporating chamber, the temperature is

raised to the desired degree by the heater therein and the desired vacuum is applied through outlet pipe 8 in the usual manner. If it is desired to produce "seed crystals" and increased agitation and circulation or,

70 primarily, only increased agitation and circulation, the discharge opening of inlet pipe 15 is located below the liquid level L in the evaporating chamber, as shown in Fig. 1. The relatively small quantities of

75 liquid which are withdrawn from the evaporating chamber through pipe 11 passed through superheater 14 and again, at a higher temperature, injected into the boiling liquid in the evaporating chamber, immediately vaporize or flash below the surface of the treated liquid in the chamber. The finely divided particles of vapor are more or less explosively projected into and through and begin to rise to the top of the

80 boiling liquid. The circulation is thereby increased and the evaporating activity is augmented.

If the treated liquid is a saturated solution, the flashing or sudden vaporization of

90 the superheated small quantities thereof causes crystals to form therein. Consequently when the superheated liquid is released and flashes in the evaporating chamber large numbers of small "seed crystals" are injected and more or less explosively

95 forced into the boiling liquid. These "seed crystals" form dispersed nuclei upon which crystallization of the treated liquid readily occurs.

If liquids having reverse solubility curves are to be evaporated, it has been found that the deposition of material from the treated liquid in the form of a scale on the heating surface can be avoided by keeping large

100 numbers of crystal nuclei or "seed crystals" in suspension in the boiling solution. If the saturated and superheated liquid flashes below the surface of the treated liquid, the agitation due to the boiling process, augmented by the agitation brought about by the flash below the surface of the treated liquid, causes these seed crystals or crystal nuclei to be brought into contact with the supersaturated hot film next to the heating

115 surface. The result is that larger crystals are formed and settle to the bottom of the evaporating chamber rather than collecting in the form of a more or less heat-insulating scale upon the heater walls. Ordinarily, the best results may be obtained by introducing the superheated and saturated solution into the evaporator so that the flash takes place beneath the surface of the treated liquid. However, satisfactory results sometimes may be obtained if the saturated and superheated liquid is introduced into the evaporator above the surface of the treated liquid. The flash of the superheated liquid then takes place above the surface of the

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boiling treated liquid but the crystal nuclei or seed crystals which are thereby formed are projected or drop into the boiling liquid. There they are circulated to bring the same into contact with the hotter film of the solution adjacent the heating surface by the agitation or circulation which normally results from the boiling of the treated solution in the evaporator.

10 Having described my invention what I claim as new and desire to secure by Letters Patent, is:—

1. A process of evaporation which utilizes seed crystals to facilitate crystallization and which includes boiling the treated liquid in an evaporator, and introducing into the evaporator relatively small quantities of the treated liquid in a saturated condition and at a temperature above the temperature of the boiling liquid in the evaporator where-
20 by the superheated liquid flashes upon entering the evaporator to form the seed crystals utilized to promote crystallization of the liquid therein.

25 2. A process of evaporation which comprises boiling the treated liquid in a vessel under a vacuum, withdrawing relatively

small quantities of the treated liquid from the vessel, heating the liquid thus withdrawn to a temperature above the temperature of the liquid in the vessel and returning the same to the vessel in a saturated and superheated state so that it will flash in the vessel and form seed crystals therein, and utilizing the seed crystals thus formed to promote crystallization of the boiling liquid in the vessel.

3. A process of evaporation which comprises boiling a treated liquid in an evaporator, withdrawing relatively small quantities of the treated liquid from the evaporator and heating the liquid thus withdrawn to a temperature above the temperature of the liquid in the vessel, returning the saturated and superheated liquid to the evaporator below the surface of the boiling liquid therein, and utilizing the flash of the returned liquid in the evaporator to promote circulation of the boiling liquid and form seed crystals to promote crystallization.

In testimony whereof I hereunto subscribe my name.

WALTER L. BADGER.