May 22, 1962 P. WAINE ETAL 3,035,634

EVAPORATORS

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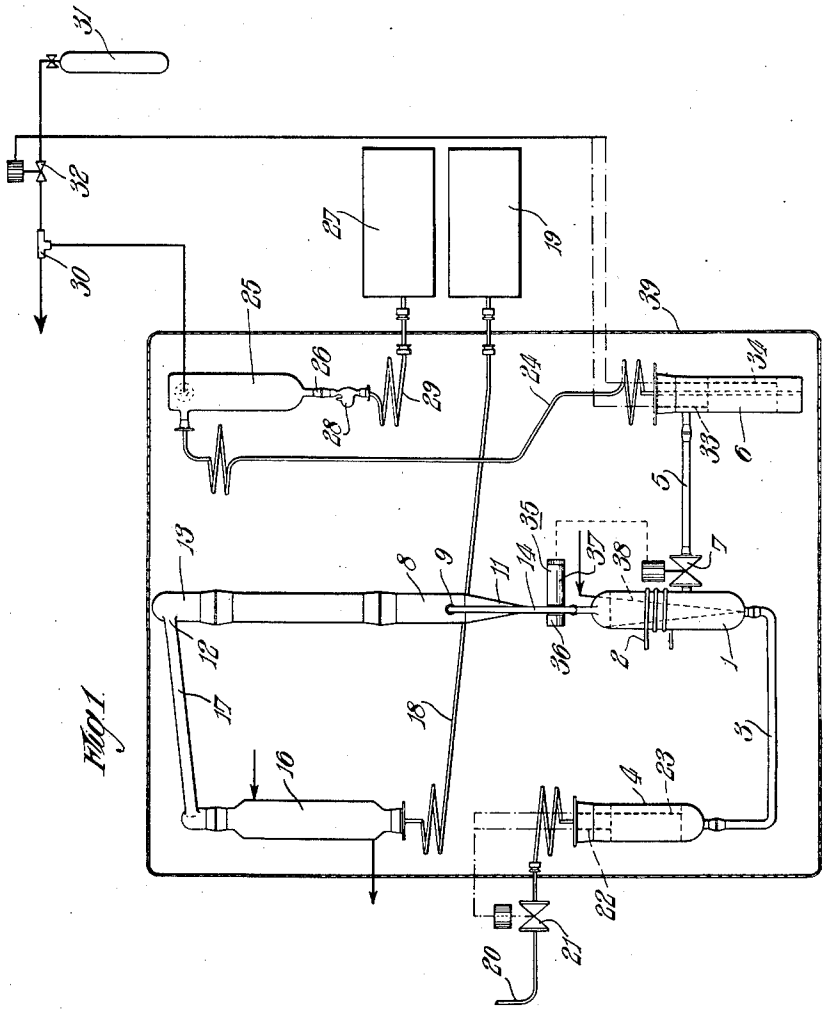


Fig. 1.

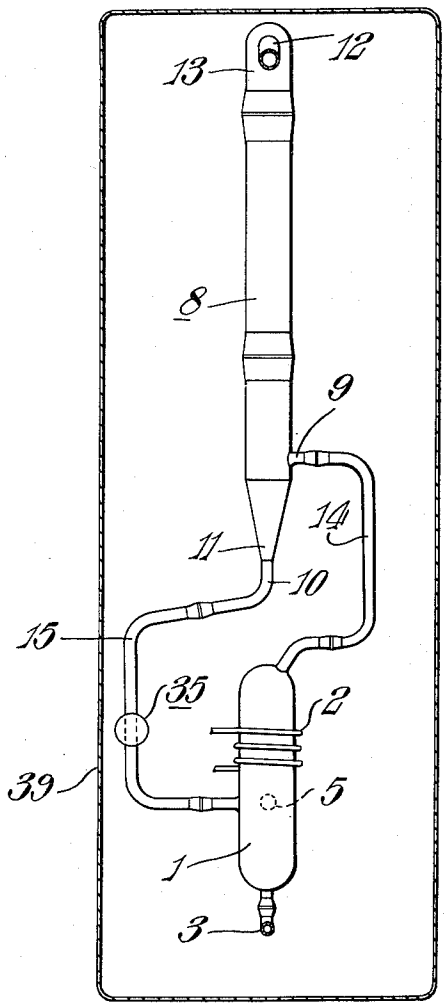
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Fig. 2.



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This invention relates to apparatus for the concentration of solution by evaporation and it provides a highly rated evaporator with continuous and automatic operation.

The evaporator according to the invention comprises a boiler, a vapour/liquid separator, a connection for the passage of vapour and entrained liquid from an upper level in the boiler to the vapour/liquid separator, a return connection for carrying separated liquid back to the boiler, a feed solution inlet to the boiler, a concentrated solution outlet from the boiler, and a valve in the concentrated solution outlet opened and closed under the control of a device sensitive to the concentration of separated liquid passing back to the boiler through the return connection arranged so that the valve is opened when the concentration of the separated liquid exceeds a predetermined level and is closed when the concentration falls to a lower level.

One embodiment of the invention will now be described by way of example with reference to the accompanying drawings in which:

FIG. 1 is a semi-schematic front elevation of the embodiment.

FIG. 2 is a semi-schematic side elevation of the embodiment.

In FIGS. 1 and 2 there is shown an evaporator having a glass boiler 1 with an associated R.F. induction heating coil 2. The boiler 1 has a liquid inlet pipe 3 connecting with a feed tank 4 and an outlet pipe 5 connecting with a water cooled sump tank 6 through a solenoid operated valve 7. A vapour-liquid cyclone separator 8 located above the boiler 1 has a vapour-liquid inlet 9, a separated liquid outlet 10 at the base 11 and a vapour outlet 12 at the top 13. The boiler 1 is connected with the cyclone separator 8 by pipes 14 and 15 respectively connecting with the vapour-liquid inlet 9 and the separated liquid outlet 10, the pipe 14 forming a connection for conveying vapour and entrained liquid from the boiler 1 and the pipe 15 forming a return connection for separated liquid back to the boiler 1. The vapour outlet 12 is connected with a water cooled condenser 16 by a pipe 17. The condenser 16 has a condensate outlet pipe 18 leading to a dump tank 19.

Entry of liquid into the feed tank 4 through an inlet pipe 20 is controlled by a second solenoid operated valve 21 opened and shut under the control of an electrical circuit including electrical probes 22 and 23 at high and low levels in the tank 4. A pipe 24 dipping nearly to the bottom of the sump tank 6 leads to a vacuum lift system comprising a closed tank 25 having a bottom outlet 26 connecting with a storage tank 27 through a flap valve 28 and a pipe 29. An air ejector 30 for evacuating the tank 25 is connected with a supply of compressed air 31 through a solenoid operated air valve 32 operated under the control of an electrical circuit including electrical probes 33 and 34 at high and low levels in the sump tank 6.

The solenoid operated valve 7 in the pipe 5 is operated under the control of a concentration meter 35 associated with the pipe 15. The meter 35 may conveniently be of the gamma-ray absorption type comprising a gamma ray source 36 located externally to the pipe 15 and a

detection chamber 37 located diametrically opposite to the source 36.

A nitrogen sparge 38 in the boiler 1 provides additional mixing of solution contained therein. The main parts of the device are contained within a casing 39.

In use of the evaporator electrically conductive solution to be concentrated is boiled rapidly in the boiler 1. A mixture of vapour and entrained solution passes up the pipe 14 into the cyclone separator 8 where the vapour is separated from the entrained solution. The separated vapour passes from the cyclone separator 8 to the condenser 16, is condensed and passes to the dump tank 19 via the pipe 18. Solution separated in the cyclone separator 8 returns to the boiler 1 through the pipe 15. The concentration of solution passing back through the pipe 15 gradually increases and is measured by the concentration meter 35. When the output of the meter 35 reaches a predetermined value (dependent on a required degree of concentration of the solution), the solenoid operated valve 7 is opened under control of the meter 35 to allow some concentrated solution to pass from the boiler 1 into the sump tank 6. Under the action of gravity fresh solution simultaneously enters the boiler 1 from the feed tank 4 mixing with and diluting the concentrated solution already in the boiler 1. However, owing to the high heat rating of the boiler 1, the diluted solution continues to boil. The valve 7 is shut under the control of the meter 35 when the solution in the boiler 1 is diluted sufficiently so that the concentration of solution returning to the boiler 1 through the pipe 15 falls below the degree of concentration at which the meter 35 causes the valve 7 to be opened.

A fall in level of solution in the feed tank 4 uncovers the high level probe 22 producing a break in the electrical circuit controlling the operation of the solenoid operated valve 21 thus causing the valve 21 to open allowing entry of fresh solution into the feed tank 4 until the probe 22 is covered again.

The sump tank 6 is gradually filled by the intermittent entry of concentrated solution from the boiler 1 until the high level probe 33 is covered completing the electrical circuit controlling the operation of the air valve 32. The air valve 32 is thus opened to connect the compressed air supply 31 with the ejector 30 to evacuate the tank 25. By evacuation of the tank 25 solution is drawn from the sump tank 6 into the tank 25. The flap valve 28 associated with the outlet 26 of the tank 25 is held closed by atmospheric pressure until the sump tank 6 is emptied, when the solenoid operated air valve 32 is automatically closed. The pressure in the tank 25 rises to atmospheric pressure allowing the flap valve 28 to open under the head of solution in tank 25. The solution runs from the tank 25 into the storage tank 27, from whence it may be removed for further processing.

We claim:

1. In an evaporator system for concentrating a liquid solution, a vertically disposed elongate boiler for said liquid solution, induction heating coil means disposed external to an upper portion only of the boiler for generating vapor with liquid entrained therein in said upper portion, feed means communicating with a base portion of the boiler for maintaining the surface of the liquid solution in the boiler so above said upper portion that said vapor and entrained liquid will pass directly therefrom, means communicating with the boiler between said upper and base portions for removing liquid solution from a quiescent region of the boiler, a vapor liquid separator disposed above said surface of the liquid solution and having a liquid phase portion, conduit means connecting the separator and the portion of the boiler above said surface of the liquid solution, return conduit means connecting the boiler and said liquid phase portion of the sepa-

rator, gamma ray detector means disposed transverse of said return conduit means for measuring the concentration of liquid solution returning from said liquid phase portion of the separator, electrically controlled valve means in said liquid solution removing means, and electrical means for opening said valve means when said detector means registers a concentration equal to or above a predetermined concentration.

2. A method of concentrating a liquid solution comprising applying heat to an upper portion of a quantity of the solution disposed in a vertically aligned elongate boiler to generate in said upper portion a vapor phase with a liquid phase entrained therein, supplying additional solution to the base portion of the quantity of solution to maintain the surface level of the solution so that above the heated region said vapor phase and said entrained liquid phase will pass directly therefrom, separating said vapor phase from said liquid phase and returning the liquid phase to the quantity of solution in the boiler, and removing concentrated liquid solution from a quiescent region between said upper and base portions of the quantity of solution only when the liquid phase returned to the boiler has a concentration equal to or in excess of a predetermined concentration.

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