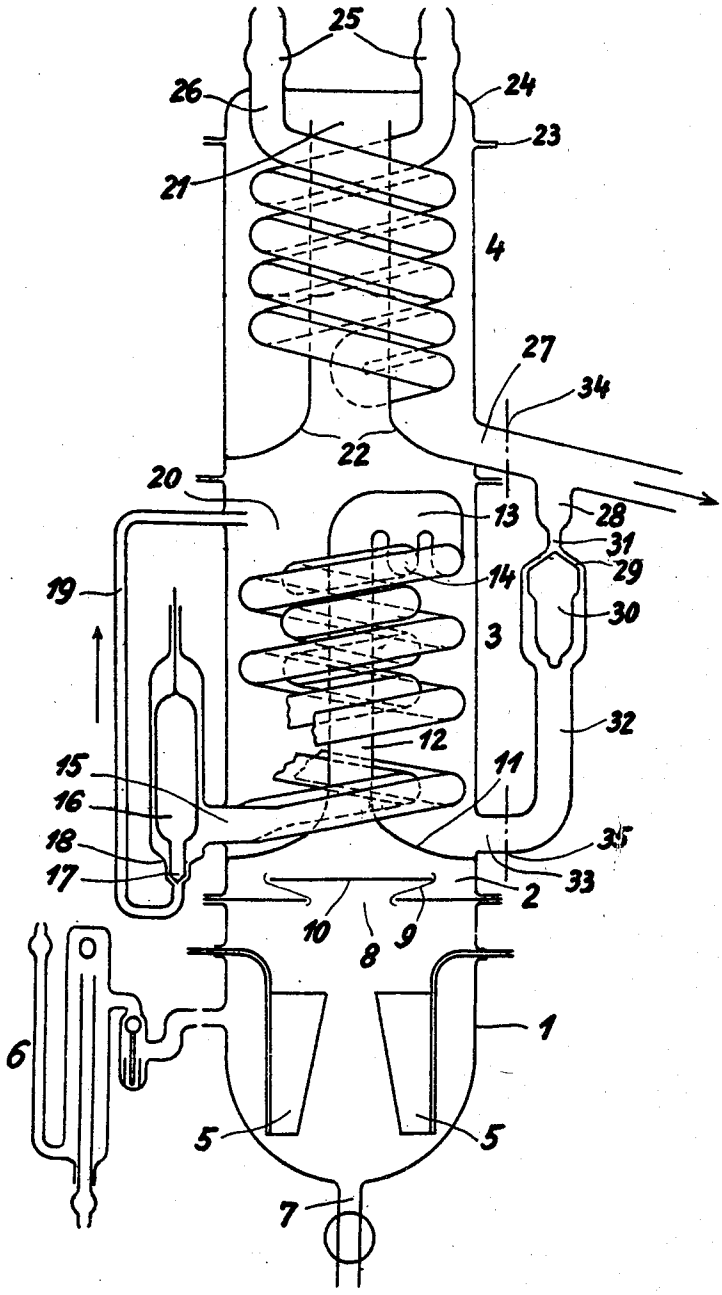
Feb. 4, 1958 H. ZELLNER ET AL 2,822,323

APPARATUS FOR BIDISTILLATION

Filed April 14, 1954



United States Patent Office 2,822,323
Patented Feb. 4, 1958

2,822,323

APPARATUS FOR BIDISTILLATION

Hugo Zellner, Linz, Austria, and Wilhelm Frank, Ludwig Kratz and Heinz Meinecke, Landshut, Germany, assignors to Jenaer Glaswerk Schott & Gen., Mainz, Rheinland-Pfalz, Germany

Application April 14, 1954, Serial No. 423,176

3 Claims. (Cl. 202—174)

In the copending patent application Ser. No. 382,924 of Sept. 29, 1953, there is dealt with a process for bidistillation in which for the purpose of reducing cost of energy the latent heat of the primary steam is utilized for renewed vaporization of the monodistillate. This is done essentially in that way that, by heat exchange between the primary steam and the monodistillate which is subjected to underpressure, the primary steam is cooled off—preferably down to partial or complete condensation—and thus the monodistillate is evaporated for secondary steam. In said patent application there is also dealt with an apparatus for carrying out the explained process which apparatus essentially comprises a heat exchanger of which one flow route carries the primary steam and is connected with a container to intecept the monodistillate, whereas the second flow route which conducts this monodistillate is connected with this container at its entrance side and is indirectly connected to a suction pump or the like on the exit side. Such apparatus will work steadily over long periods of time if the loss of heat of the apparatus by radiation to the surrounding air of the room is kept within certain limits. These radiation losses are defined by the form and surface of the heated parts of the apparatus as well as by the nature of their material and insulation.

In case of stepped-up operational demands as, e. g., especially high distillation output or extreme outside-air temperatures it has been found that the self-stabilization of such apparatus which is based on an equalized heat balance is no longer easily obtainable, and this fact has given rise to the following considerations on which the present invention is based.

The heat necessary for primary vaporization of e. g. water is composed of the latent heat of liquid necessary for heating from the initial temperature up to 100° and of the inner (latent) and outer vaporization heat. At 20° initial temperature it amounts to about 80+539=619 cal.

Assuming an ideal heat output in the heat exchanger and a mean vacuum in the secondary vaporization room of about 100 Torr is prevailing, there results a boiling point temperature of water at secondary vaporization of about 51° C. When cooling off the primary steam in the heat exchanger a quantity of heat is thus radiated which is comprised of the vaporization heats and the latent heat of liquid difference and in the assumed example is about 539+49=588 cal. For the renewed vaporization of the water of 51° C. in the vacuum of 100 Torr only the vaporization heats should now be spent. These amount without considering the change of the values of the vaporization heats as a function of pressure and temperature which do not have to be considered here—to roughly 539 cal. This results in a theoretical surplus heat of about 50 cal. for the secondary vaporization.

The following possibilities are given regarding the operation of bidistillation apparatus in accordance with the above patent application:

(A) The loss of heat in the exchanger corresponds to the theoretical surplus heat.

The loss of heat depends on the radiating surface, the outside-air temperature under which the apparatus is operated, the form and the area of the heat exchanger surfaces etc. Under to some degrees constant external conditions as e. g. in closed rooms with relatively little changes of room temperature and proper insulation as well as proper dimensioning of the heat exchanger surface and the external surface such apparatus, as emphasized in the main patent, work stably.

(B) The loss of heat in the exchanger is larger than the theoretical surplus heat.

In this case an increasing amount of monodistillate results because the heat of the primary steam available in the exchanger does not suffice for the complete secondary vaporization of the monodistillate.

When the external working conditions such as insulation and room temperature are comparatively constant such an apparatus operates steadily if care is taken that the excess amount of monodistillate for whose vaporization by the primary steam sufficient heat is no longer available due to the loss of heat in the apparatus, can constantly be removed. Equipments for the removal of this amount of monodistillate in the form of an overflow are described in the main patent.

Since in such an apparatus with high loss of heat, if removal of monodistillate would not be effected, an increasing amount of liquid would collect in the room of the heat exchanger provided for the secondary vaporization and with that the level of the liquid contained therein would rise, the term "rising tendency" is chosen for these conditions. Thus a "rising tendency" of the bidistillation apparatus coincides with high loss of heat.

(C) The loss of heat of the apparatus in the heat exchanger is lower than corresponds to the excess heat of the primary steam against the heat required for secondary vaporization in the vacuum.

In this case too much heat is offered in the heat exchanger and therefore more liquid is vaporized in the vacuum than can be continuously brought into the vaporization room by condensation of primary steam. Thus, the amount of liquid in the secondary vaporization room is continuously reduced until finally, when no more monodistillate is available in the storing container, air is sucked into the vacuum room instead of monodistillate, and the vacuum breaks down. Since in the case under consideration the level of liquid in the secondary vaporization room drops continuously the term "falling tendency" is used. Thus, "falling tendency" corresponds to insufficient loss of heat of the bidistillation apparatus.

This is especially the case for apparatus with a high distillation output (e. g. more than 5 lt. of water per hour) and is accelerated by the particular construction of large apparatus and the herewith connected reduction of the heat radiating surface. If the heat-radiating surface becomes relatively small a "heat accumulation" results.

In contrast to the above-mentioned cases (A) and (B) a satisfactory operation in case (C) of the bidistillation apparatus working in accordance with the above patent application can no longer be attained without encountering difficulties. In this connection it must be observed that apparatus which operate under normal conditions steady as under (A) or easily stabilized as under (B) may become subject to the conditions under (C) by changes of the external operational circumstances, especially outside-air temperature. Therefore, the present invention is concerned with designing the process resp. the apparatus of the above patent application in such a way that steady operation is guaranteed also under conditions designated by the term "falling tendency."

Within the scope of the invention for the process of bidistillation the working conditions such as radiating surfaces, heat insulation etc. are knowingly chosen in such a way that the unavoidable loss of heat in exchanging heat is kept lower than the theoretically attainable excess heat of the primary steam against the heat input necessary for secondary vaporization at under-pressure. In order to avoid that by dropping of the level of liquid in the monodistillation room the separation of the secondary vaporization room subjected to underpressure from the outside pressure is lost it is practical to provide for an automatic regulating device between these two rooms, e. g., in the form of a float valve which works in dependence of the available amount of monodistillate, and which in case of a complete damping out of monodistillate resp. of a dropping of same below a fixed level effects a complete cutoff between these two rooms so that a damaging drawing in of outside air into the underpressure-room is avoided.

In connection with this mode of operation, however, a dry operation of the heat exchanger heated by primary steam resp. an undue drop of the level of the liquid to be vaporized secondarily (monodistillate) due to the missing supply of monodistillate to the secondary vaporization room may occur which would lead to interrupted operation and especially to endangering the apparatus. Therefore, if according to the invention the procedure is in accordance with the main patent as regards "falling" tendency, a drop of the level of liquid in the secondary vaporization room below a fixed level because of too much vaporization at the effective underpressure is avoided by conducting part of the bidistillate into the secondary vaporization room by means of an automatically regulating device. A completely stable and continuous operation is obtained by this reduction of bidistillate.

The apparatus used to carry out this procedure, beside the regulating device operated in dependence of the amount of monodistillate and disposed between the monodistillation room and the secondary underpressure vaporization room is provided a return line for the bidistillate which is located between the bidistillation room and the secondary vaporzation room, which contains a regulating device controlled in dependence of the level of liquid in the secondary vaporization room which gives this return line free only when the level of liquid in the secondary vaporization room drops below a prescribed value.

The process according to the invention and an apparatus suitable for its realization in connection with other measures to be taken within the scope of the invention will now be described by means of the annexed drawing.

The drawing shows a schematic section through an apparatus for bidistillation in accordance with the invention which in its main parts consists of a primary vaporizer 1 with level regulator, an equipment 2 for sputter and droplet separation, a heat exchanger 3 and a cooling system 4 for bidistillation and is equipped with a return line, controlled by a float valve in accordance with the invention, between the bidistillation room and the secondary vaporization room.

In the depicted apparatus primary steam is developed in an electrode vaporizer which is run from an A. C. supply and has two metal electrodes 5. These electrodes are designed with a surface enlarging toward the top in order to attain a vaporization output increasing substantially logarithmically upon rising of the level of liquid controlled by a level regulator 6 in the vaporizer 1. The primary vaporizer 1 is further equipped with a draining device 7 for deposition silt. On the upper end of the primary vaporizer there is as a connection to further parts of the apparatus a ball-shaped or a plan ground flange. A sputter and droplet separator 2 follows which is designed as a baffle plate. This separator consists of an inserted plate with a center opening 8 over which a cover

plate 10 covering opening 8 is held in centered position by means of distance pieces 9. By this arrangement the steam is forced to accelerate its speed and change its direction whereby a separation of the particles pulled along is realized.

This separator equipment 2 is followed by a welded tubular flange 11 which tapers upward to a tube 12 runnning along the center axis of the apparatus. On its upper end the tube 12 is equipped with a welded bend 13 which turns into the heat exchanger spiral 14. This heat exchanger spiral 14 can be bifilar as depicted (or even polyfilar) instead of monofilar for the purpose of increasing the heat exchanger surface. The primary steam from the vaporizer 1 flows downward through the heat exchanger spiral 14 and is thereby condensed. The condensate leaves through a welded tube 15 in front of which the bifilar tube coils reunite, and flows into the outer room of a float valve 16 which realizes the separation of this valve room from the following vacuum room. The float itself is a hollow body which is raised when the monodistillate in the outer valve room rises and thus frees the capillary discharge opening 17. When the level of liquid drops, the float by means of a bevelled sealing surface 18 seals the end of the capillaries, and this avoids a further suction of liquid.

Through the capillary tube 17 the monodistillate enters a tube 19 and through same enters the outer room of the heat exchanger 20. Even though, as presumed, the apparatus works with "falling tendency" the detrimental drawing in of air by the capillaries 17 when the level of liquid in the outer valve room drops, is avoided by the float which is controlled as a function of the offered amount of monodistillate. However, a dry operation of the heat exchanger room 20 can occur here which is avoided by the devices described below.

The heat exchanger container is closed on its upper end by a ball-shaped or a plan-ground flange to which the cooler system 4 is attached.

The cooler system 4 consists of a tubular body into which is welded a tube 22 which tapers upward to a cone. This tube has an uncovered opening 21 on its upper end. At 23 the outer jacket of the cooler system is connected by a ball-shaped or a plan-ground flange with a cap 24. Fused into this cap are the feed and outlet pipes 25 for the cooling water which turn into a spiral 26 which hangs in the space between tube 22 and the outer jacket of the cooler. This spiral is traversed by cooling water which in case of water distillation can be used for feeding the primary vaporizer over the level regulator. The cooling system 4 has an outlet pipe 27 through which the collected bidistillate can leave to the outside after it has dropped from the cooler spiral 26. Tube 27 leads to the receiver which is not shown and serves for collecting the bidistillate. Through the receiver, tube 27 is connected to the vacuum extending over the entire cooling system 4 and the outer room of the heat exchanger system to the capillaries 17. Tube 27 is equipped with a branch pipe 28 through which the bidistillate can flow down. The branch pipe 28 is followed by a float valve 29. This valve consists of a hollow float body 30 with clearing surface 31 which points upward. The lower end of the outer room of the float system 29 is connected with a tube 32 which at 33 is welded to the lower part of the outer room of the heat exchanger. Float 30 works in dependence of the level of liquid in the heat exchanger room 20. If the level of liquid drops, the liquid in the outer part of valve 29 also drops, the float frees the sealing opening 31 and bidistillate flows back into the secondary vaporization room of the heat exchanger until the fixed level is once more attained.

By this return line device it is avoided that the liquid in the secondary vaporization room of the apparatus operated with "falling tendency" decreases. The surplus heat is used up for the renewed vaporization of the bi-

distillate which is returned by branch 28 and had been condensed in cooler 26.

The described apparatus can also be used for monodistillation without constructive changes being necessary. For this purpose the vaporizer 1 with the spatter separator 2 is connected with the cooler system 4 by means of the provided plane-ground or ball-shaped flange joint directly, i. e. by eliminating the exchanger system 3. The return line system closed at 27 with valve and return line at 33 in this case is replaced by a simple drain-off pipe at 27.

In order to be able to effect this change from bidistillation to monodistillation quickly, plane-ground or ball-shaped flange joints are provided at points 34 and 35 which are indicated by dot-dash lines.

The mode of operation of the apparatus for monodistillation is as follows:

After removing part 3 of the apparatus, the vaporizer 1 with feed regulator 6 and baffle plate 2 is connected by means of plane-ground or ball-shaped joints with cooler 4. The adapter piece at 27, after separating the return line device at 34 is provided with a straight piece of pipe as an outlet. The liquid boiling in vaporizer 1 which is fed to level regulator 6 known per se, gives off the developed steam through the opening 8 of the baffle plate. From there the steam passes between plates 8 and 10 into the cone pipe 22 which is now directly over the spatter separator. Through the upper opening 21 of the cone pipe 22 the steam passes under cap 24 and is condensed on spiral 26 through which the cooling water flows. The condensate collects in the outer condenser jacket of the cone pipe 22 and flows off at 27.

The described apparatus serves only as an example and can be varied, within the scope of the invention in many ways.

We claim:

1. An apparatus for bidistillation of a liquid containing not volatile impurities consisting of a primary vaporizer, a droplet separator arranged at the upper end of this primary vaporizer, a heat exchanger which is composed of a spiral tube surrounded by a mantle, this mantle forming a secondary vaporizing room between itself and the spiral tube, said heat exchanger being arranged above said primary vaporizer, a central tube which connects the upper end of the primary vaporizer with the upper end of said spiral tube and is surrounded by the spiral tube, a throttle valve being arranged within a pipe, this pipe connecting the lower end of said spiral tube with the upper end of said secondary vaporizing room, a further central tube, which is connected to the upper end of said secondary vaporizing room and is surrounded by a further spiral tube through which cooling water flows, this central tube being open at its upper end and being arranged within a mantle, this mantle forming a bidistillation room between itself and the central tube, an outlet for drawing off the bidistillate, said outlet being arranged at the lower end of said bidistillation room, a vacuum pump and a vessel for receiving the bidistillate, both connected to said outlet, further consisting of a return pipe containing a regulating device, said return pipe connecting said outlet with the lower end of said secondary vaporizing room, said regulating device being controlled in dependence on the level of liquid in the secondary vaporizing room.

2. An apparatus for bidistillation of a liquid containing not volatile impurities consisting of a primary vaporizer, a droplet separator arranged at the upper end of this primary vaporizer, a heat exchanger which is composed of a spiral tube surrounded by a mantle, this mantle forming a secondary vaporizing room between itself and the spiral tube, said heat exchanger being arranged above said primary vaporizer, a central tube which connects the upper end of the primary vaporizer with the upper end of said spiral tube and is surrounded by the spiral tube, a throttle valve being arranged within a pipe, this pipe connecting the lower end of said spiral tube with the upper end of said secondary vaporizing room, a further central tube, which is connected to the upper end of said secondary vaporizing room and is surrounded by a further spiral tube through which cooling water flows, this central tube being open at its upper end and being arranged within a mantle, this mantle forming a bidistillation room between itself and the central tube, an outlet for drawing off the bidistillate, said outlet being arranged at the lower end of said bidistillation room, a vacuum pump and a vessel for receiving the bidistillate, both connected to said outlet, further consisting of a return pipe containing a float valve, said return pipe connecting said outlet with the lower end of said secondary vaporizing room, said float valve being controlled in dependence on the level of liquid in the secondary vaporizing room.

3. An apparatus as in claim 2 in which the primary vaporizer, the secondary vaporizing room and the bidistillation room are superposed the one over the other by means of detachable ground flange joints, whereby the bidistillation room and the secondary vaporizing room are equipped with adapter openings for said return pipe which is also detachable.

References Cited in the file of this patent

UNITED STATES PATENTS

650,501	Bailey	May 29, 1900
2,152,164	Wentworth	Mar. 28, 1939
2,392,893	Williamson	Jan. 15, 1946
2,400,021	Podbielniak	May 7, 1946

FOREIGN PATENTS

833,796	Germany	June 23, 1952
518,226	France	June 27, 1920

OTHER REFERENCES

Liebig: "An All Glass Still," Indst. Engineering Chemistry Anal. Ed., vol. 12, 1940, page 174.