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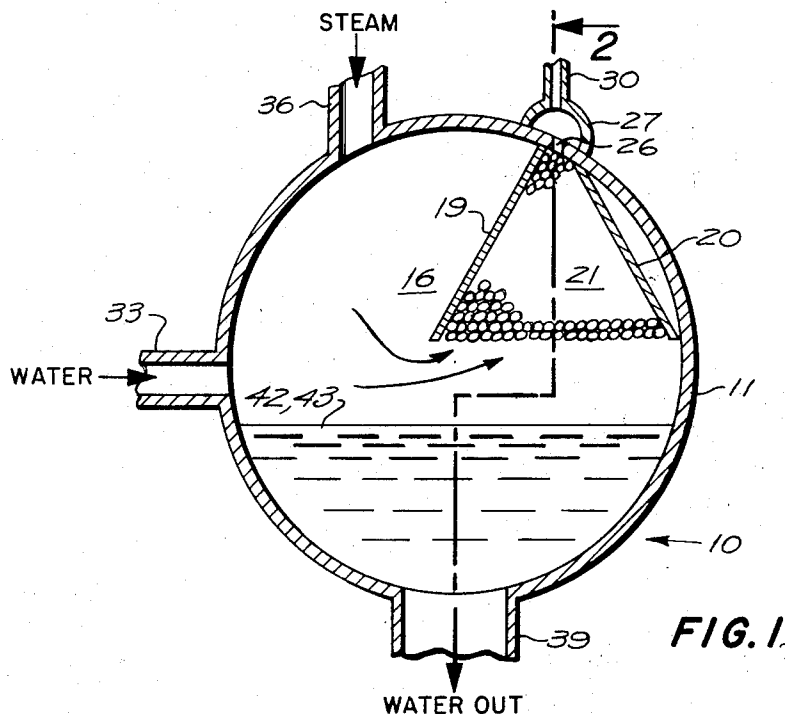
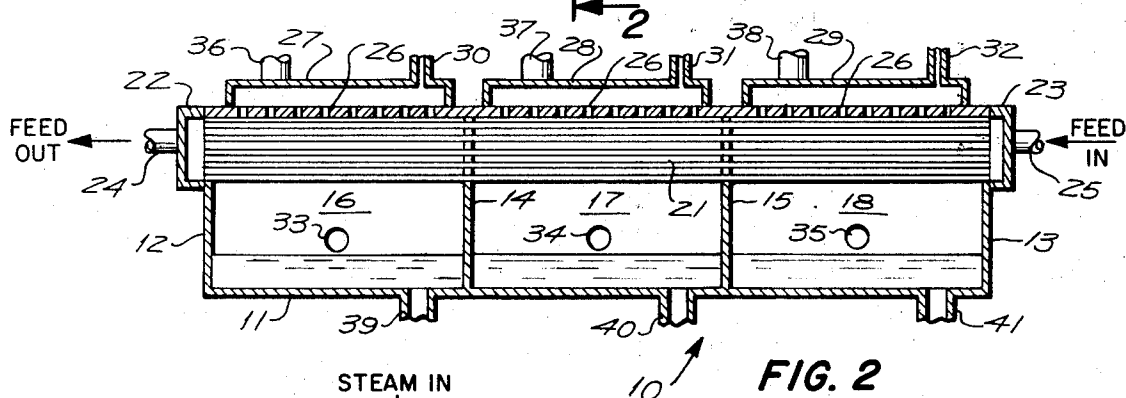
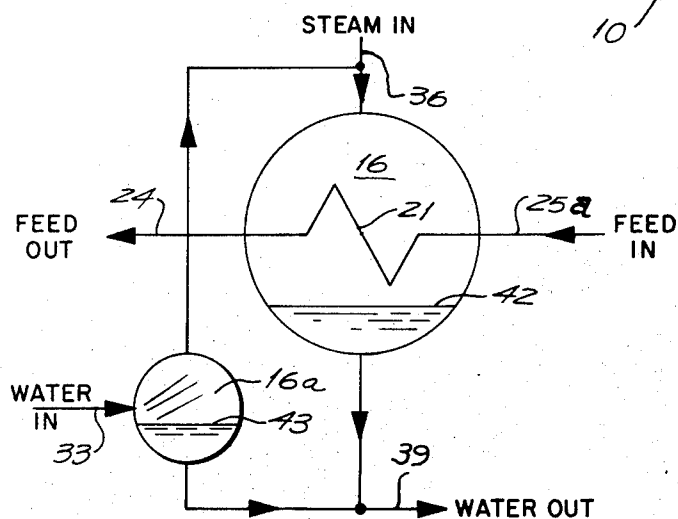
D. D. KAYS ET AL

3,832,289

PREHEATERS

Filed Dec. 3, 1971

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

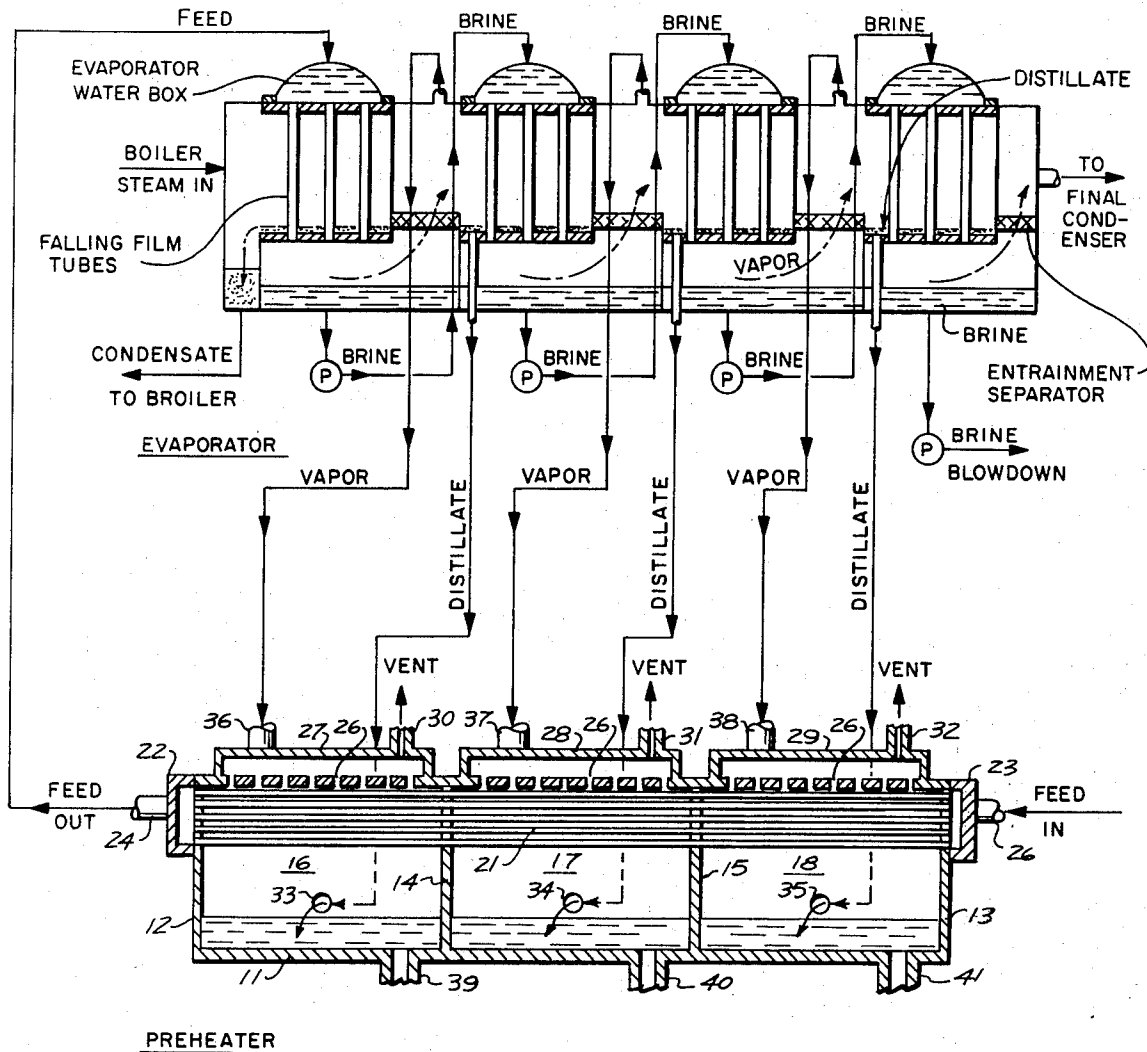


FIG. 4

1

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PREHEATERS

David D. Kays, Claremont, Kurt F. Frank, Pomona, and Paul A. Longwell, San Gabriel, Calif., assignors to Aerojet-General Corporation, El Monte, Calif.
Continuation-in-part of abandoned application Ser. No. 10,233, Feb. 10, 1970. This application Dec. 3, 1971, Ser. No. 204,757

Int. Cl. C02b 1/06

U.S. Cl. 202—174

5 Claims

ABSTRACT OF THE DISCLOSURE

A preheater for use in a multieffect distillation system comprising a housing having a plurality of chambers with a conduit means extending axially through each of the chambers for carrying feed liquor to a multiple effect evaporator. First inlet means is provided for introducing hot vapors into each of the chambers, second inlet means is provided for introducing superheated condensate into each of the chambers, and outlet means is provided for removing condensate from each of the chambers. The superheated condensate flashes to form more hot vapor which combines with the hot vapor introduced by the first inlet means. The combined vapor heats the conduit means which is, typically, a bundle of tubes. Baffle means is associated with the conduit means to maintain a high vapor velocity thereacross.

This application is a continuation-in-part of pending application Ser. No. 10,233, filed Feb. 10, 1970 now abandoned and succeeded by Serial No. 299,933, filed Oct. 24, 1972.

This invention relates to multiple effect evaporator apparatus, and particularly to preheaters for preheating feed liquor for multiple effect systems.

The present invention is concerned with a preheater for preheating feed liquor for multiple effect evaporator systems. The preheater in accordance with the present invention is particularly useful in connection with the multiple effect evaporator described and claimed in the copending application Ser. No. 10,231 of Kurt F. Frank et al., entitled "Multiple Effect Evaporators" filed Feb. 10, 1970 and assigned to the same assignee as the present invention. The preheater in accordance with the present invention may be utilized with the evaporator described in the aforementioned Frank et al. application in the manner described in copending application Ser. No. 10,232 of David D. Kays entitled "Multiple Effect Distillation Systems" filed Feb. 10, 1970, now Pat. 3,672,960 issued June 27, 1972 and assigned to the same assignee as the present invention.

As described in the aforementioned Kays application, Ser. No. 10,232, a multiple effect distillation system is characterized by the use of several evaporator effects serially arranged so that feed liquor is partially vaporized in each evaporator effect sequentially. Ordinarily, each evaporator effect utilizes a falling film evaporator wherein the liquor forms a thin film on a heat transfer wall and flows by means of gravity down one side thereof. Hot vapor is applied to the opposite side of the heat transfer wall so that condensation of the vapor occurs on one side of the wall and evaporation of the liquor occurs on the other. The hot vapor (condensate) condensed on the heat transfer wall transfers heat to the thin film of liquor on the opposite side thereof to thereby vaporize some of the liquor. The enriched liquor (concentrate) is usually fed to the subsequent effect of the evaporator where it is further partially vaporized.

As described in the aforementioned Kays application, a feed heater receives condensate from either an evaporator

2

effect or from a previous feed heater stage or both. The feed heater is operated at a temperature below that of the received condensate so that a portion of the superheated condensate spontaneously evaporates or flashes in the presence of tubes carrying feed liquor to transfer heat to the feed liquor.

The present invention is particularly concerned with a preheater zone wherein superheated condensate, such as water, from an evaporator effect or a previous preheater stage or both, is spontaneously, partially evaporated to heat feed liquor by indirect heat exchange.

It is an object of the present invention to provide a preheater for use in a multiple effect distillation process.

Another object of the present invention is to provide a preheater for a distillation process wherein superheated condensate is partially evaporated or flashed to heat a feed liquor by indirect heat exchange. It is a further object to pass vapor over the condensate surface to desuperheat the vapor, thus improving heat transfer.

In accordance with the present invention, a preheater comprises a housing having a plurality of serially arranged chambers (stages). Conduit means extends longitudinally of the preheater through the several chambers for carrying feed liquor to a multiple effect evaporator. The feed liquor enters the last in the series of the preheater chambers and exits from the first chamber prior to introduction to the multieffect evaporator with the temperatures and pressures being respectively progressively less from the first to the last of the chambers. First inlet means introduces hot vapor from the evaporator into at least some of the chambers. A second inlet means introduces hot condensate from a previous chamber or effect, or both. Outlet means is provided for removing condensate from each chamber. The hot vapor from the first inlet means and the vapor produced by spontaneously partially evaporating or flashing the introduced, hot condensate liquid are directed to the conduit means to heat the feed liquor.

According to one feature of the present invention the conduit means comprises a bundle of a plurality of feed tubes so disposed and arranged that the area of vapor flow continuously diminishes as the vapor flows through the tube bundle in the respective chambers.

The above and other features of this invention will be more fully understood from the following detailed description and the accompanying drawings, in which:

FIG. 1 is a section view of a preheater in accordance with the presently preferred embodiment of the present invention;

FIG. 2 is a section view of the preheater illustrated in FIG. 1 taken at line 2—2 in FIG. 1;

FIG. 3 is a schematic diagram of the operation of one stage of the preheater illustrated in FIGS. 1 and 2; and

FIG. 4 is a view of the preheater of FIGS. 1 and 2 connected to a vertical tube evaporator.

Referring to the drawings, and particularly to FIGS. 1 and 2, there is illustrated a preheater 10 in accordance with the presently preferred embodiment of the present invention. Preheater 10 comprises a substantially elliptical or cylindrical housing 11 having end walls 12 and 13 and internal vertical bulkheads 14 and 15 dividing the housing into chambers 16, 17 and 18, respectively. Baffles 19 and 20 extend through housing 11 between end wall 12, bulkheads 14 and 15, and end wall 13. Baffles 19 and 20 define a region in each chamber containing a bundle 21 of substantially cylindrical tubes. Each end of the tubes of bundle 21 are in fluid communication with manifolds 22 and 23 supported by end walls 12 and 13, respectively. Outlet conduit 24 is in fluid communication with manifold 22 and inlet conduit 25 is in fluid communication with manifold 23. Baffles 19 and 20 (which together

provide a downwardly-facing trough) confine bundle 21 of tubes into a substantially triangular shape so that the lower portion or base of the triangular configuration of the bundle is exposed to chambers 16, 17 and 18 and the apex or upper portion of the trough or triangular configuration is in fluid communication through aperture 26 to manifolds 27, 28 and 29 above each chamber 16, 17 and 18, respectively. The manifolds 27, 28 and 29 include vent tubes 30, 31, 32, respectively, which tubes are adapted to be vented to a lower pressure region such as a vacuum header or vacuum system (not shown).

Inlet conduits 33, 34 and 35 are arranged to introduce condensate from previous preheater stages and from evaporator effects where appropriate, as described in the aforementioned Frank et al. application, into each respective chamber 16, 17 and 18. Likewise, conduits 36, 37 and 38 are adapted to introduce hot vapor, such as steam, from a respective evaporator effect where appropriate. In some cases each stage of the preheater will receive hot vapor and in other designs, only selected stages will receive vapor from an effect. Conduits 39, 40 and 41 are arranged to remove accumulated condensate from chamber 16, 17 and 18, respectively.

The drawing of FIG. 4 illustrates the preheater of the invention coupled as suggested in the preceding paragraph to a multiple effect evaporator with the respective vapor conduits 36, 37 and 38 being each connected to a separate effect of the multiple effect evaporator. Similarly, the inlet conduits 33, 34 and 35 are respectively connected to related effects of the associated multiple effect evaporator to remove distillate from the respective evaporator effects to the preheater for heat recovery.

The operation of each stage or chamber of the preheater in accordance with the present invention may be explained with reference to the schematic diagram of FIG. 3 wherein the reference numerals refer to corresponding portions of the structure illustrated in FIGS. 1 and 2. FIG. 3 is a schematic diagram of one of the stages; it being understood that the other stages operate in the same manner. As illustrated in FIG. 3, the feed liquor which is admitted through inlet conduit 25, flows through the heating portion of tube bundle 21 in each one of the successive stages or chambers 18 and 17 (FIG. 2), and enters stage 16 as stream 25a and is exited from stage 16 through conduit 24. Hot vapor, such as steam from an evaporator effect of the evaporator described in the aforementioned Frank et al. application, is admitted through inlet conduit 36 and directed at the heater portion or tube bundle 21 to heat the liquor therein.

Superheated condensate from a previous preheater stage or evaporator effect, as described in the aforementioned Kays application, is admitted through inlet conduit 33 into region 16a of the preheater stage. The condensate in conduit 33 is preferably at a pressure substantially above the pressure in region 16a so that as the superheated condensate is introduced into region 16a, a portion of the condensate spontaneously evaporates or flashes, thereby cooling the remainder of the condensate. Although shown separately in FIG. 3 for purposes of explanation, regions 16a and 16 comprise the same chamber in the physical embodiment as shown in FIGS. 1 and 2.

The vapor in region 16a mixes in region 16 with hot steam introduced through conduit 36. The combined vapors are directed by baffles 19 and 20 of the downwardly-opening trough to flow in a specific direction as it condenses to heat the feed liquor in the tube bundle 21. These baffles 19, 20 also force the vapor to flow across the surface of a pool of the liquid condensate 42, 43 before contacting the several tubes of the trough-confined bundle, thereby desuperheating the vapor. After the hot vapor condenses on the outside surface of the tubes of bundle 21 the condensate is collected in the pool below at 42 in each chamber. The cooled condensate produced by condensing vapor on tube bundle 21 is combined with cooled

condensate from the operation in region 16a and the combined condensate is exited through conduit 39.

This arrangement of structure within the several chambers or stages to force flow of vapor across the condensate pool and the use of the downwardly-facing trough about the tube bundle with removal of non-condensibles through the apex of the trough are features of the preheater of the invention. The housing is preferably cylindrical in configuration as illustrated in FIG. 1. The inlet means for the vapor or steam is preferably located as illustrated in the cross-sectional view of FIG. 1 to open into an upper first quadrant of the housing and the downwardly-opening baffle trough is located principally in an adjacent upper second quadrant of the housing. The flow area of the vapor flowing through the tube bundle 21 towards the apex of the trough diminishes in the direction of the vapor flow.

The condensate collected in chamber 16 is withdrawn through conduit 39 and may be joined with condensate from an evaporator effect for introduction into a subsequent and lower pressure stage of the feed heater, such as through conduit 34 for chamber 17, and so on for continual operation as described with temperature and pressure being progressively less from the first chamber 16 through the last chamber 18. It will be understood that the number of chambers or stages may be more than three depending on the needs of the particular design.

To effectuate removal of on-condensable material from the outside surfaces of the tubes in bundle 21, the distance between the outermost tubes and the baffles 19 and 20 should not generally exceed the smallest distance between the tubes of the bundle. Furthermore, by maintaining the spacing between tubes and between the tubes and baffles uniform, the vapor flow in the tube bundle remains relatively uniform and turbulent over the entire transverse area at any point in the bundle and differential flow paths are substantially eliminated so the tubes are heated uniformly. Thus, in order to avoid channelling of gases along the two walls of the inverted baffle trough, the distance between the respective walls of the trough and the immediate first row of tubes of the bundle should not be greater than the average distance between adjacent tubes within the bundle.

Tube bundle 21 is so disposed and arranged that the area of vapor flow within the tube bundle continuously decreases along the direction of the vapor flow. Thus, as vapor condenses on the tubes of the tube bundle and the mass of vapor continuously decreases due to the condensation of the vapor, the decreasing area of the flow somewhat offsets the reduction of the mass of the vapor so that the velocity of the vapor exceeds a predetermined minimum in all downstream portions of the tube bundle. For this purpose, the tube bundle is preferably substantially triangular with the apex of the triangle being vented through manifold 27.

The present invention thus provides a preheater for a multiple effect evaporator system which is effective in operation and effectively transfers heat from condensate and from hot vapor to the feed liquor for such multiple effect evaporator system. Although the present invention has been described in connection with three stages of feed heating, it is to be understood that as many stages as desirable may be utilized, and that the specific example is not to be considered by way of limitation.

This invention is not to be limited by the embodiments shown in the drawings and described in the description, which is given by way of example and not of limitation.

What is claimed is:

1. A preheater for use in a multiple effect distillation process employing a multiple effect evaporator, said preheater comprising:

a housing having a plurality of sequentially-placed chambers, a conduit means extending longitudinally of the preheater through the several chambers for carrying feed liquor to a multiple effect evaporator,

5

said conduit means being constructed of heat conductive material and comprising a bundle of tubes suitable for condensing vapor coming into contact therewith;

first inlet means for introducing hot vapor into at least one of said chambers from a respective effect of said multiple effect evaporator;

second inlet means for introducing hot condensate to each of said chambers to form a condensate pool;

outlet means for removing condensate from each of said chambers; and

a downwardly-facing baffle trough within each chamber about the tube bundle therein with an extended opening at its bottom overlying and adjacent to the condensate pool with the apex of the trough opening through the housing to provide a vent for removal of vapor noncondensibles from the chamber, said baffle trough and contained tube bundle being located at one side of the chamber and the first inlet means located above the condensate pool and removed from the extended opening of the baffle trough, thus causing the introduced vapor to flow across the surface of the condensate pool before reaching the tube bundle.

2. A preheater in accordance with claim 1 wherein the housing has a general cylindrical configuration.

6

3. A preheater in accordance with claim 2 wherein the first inlet means opens into an upper first quadrant of the housing and the baffle trough is located principally in an adjacent upper second quadrant of the housing.

4. A preheater in accordance with claim 1 wherein the bundle of tubes is so disposed and arranged within the baffle trough that the vapor flow area of the vapor flowing in said tube bundle towards the apex of the trough continuously diminishes in the direction of vapor flow.

5. A preheater in accordance with claim 1 wherein the distance between the respective walls of the downwardly-facing baffle trough and the immediate first tube row of said bundle is not greater than the average distance between adjacent tubes of the bundle.

References Cited

UNITED STATES PATENTS

3,203,464	8/1965	Kingma	202—173
3,197,387	7/1965	Lawrence	202—173
3,213,000	10/1965	Ewing	203—11
3,486,985	12/1969	McGrath	202—173

NORMAN YUDKOFF, Primary Examiner

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