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R. O. HENSZEY
SEPARATION OF LIQUID AND VAPOR IN
AN EVAPORATOR OR THE LIKE
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Fig. 1.

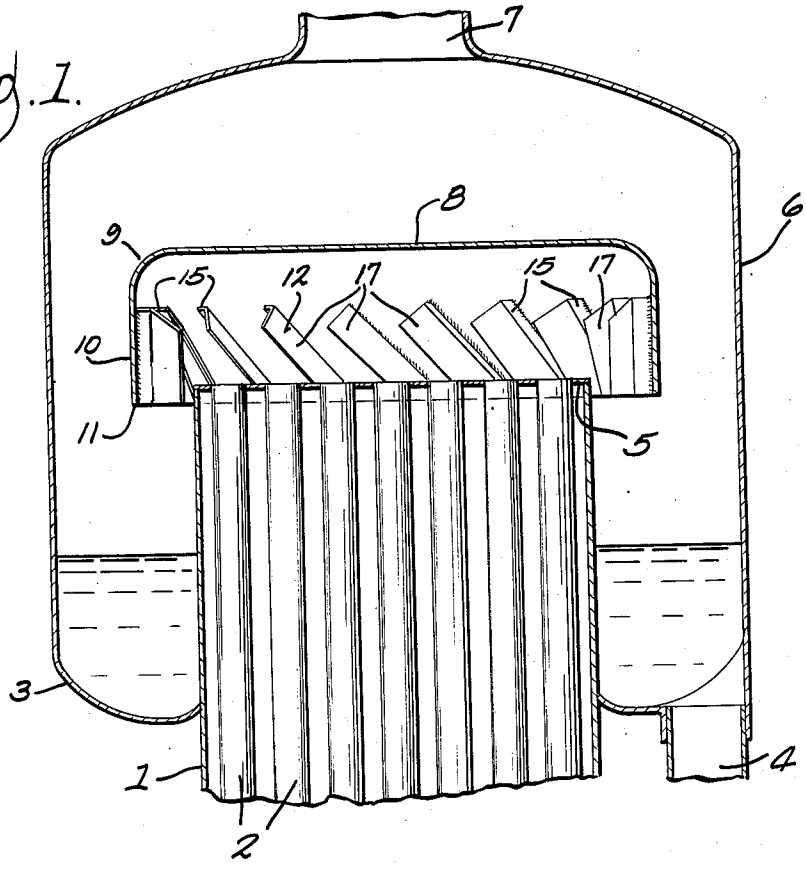
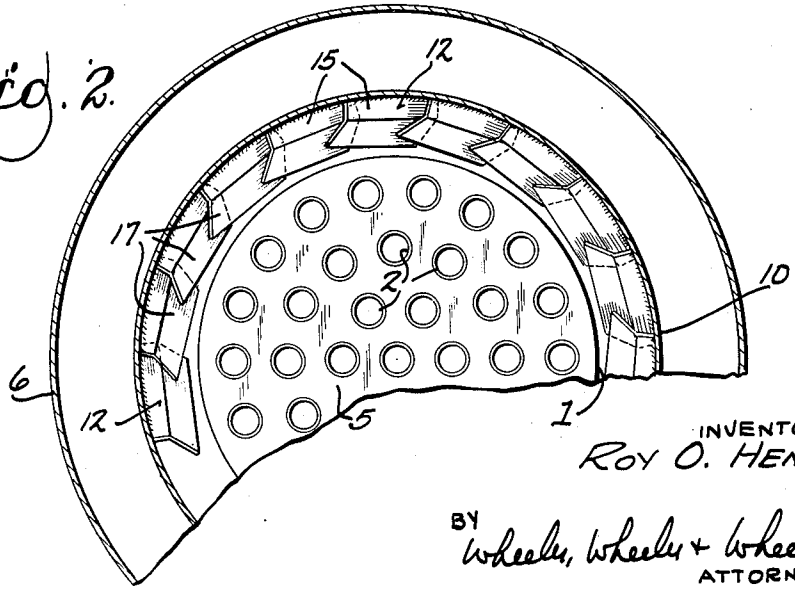


Fig. 2.



INVENTOR
ROY O. HENSZEY

BY Wheeler, Wheeler & Wheeler
ATTORNEYS

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SEPARATION OF LIQUID AND VAPOR IN AN EVAPORATOR OR THE LIKE

Roy O. Henszey, Oconomowoc, Wis.

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8 Claims. (Cl. 159—31)

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This invention relates to the separation of liquid and vapor in an evaporator or the like. The present application is a continuation in part of my application entitled "Evaporator and Separator," No. 606,097, filed July 20, 1945, and now Patent 2,512,938. While I may employ two stage separation as suggested in the companion application aforesaid, the present case is concerned primarily with such separation as is achieved in a single stage, or the first of successive stages, by means incorporated in the so-called umbrella baffles.

It is a primary object of the invention to reduce and, so far as possible, to eliminate entrainment of liquid in the high velocity stream of vapor moving out of an evaporator. Entrainment could be reduced by reducing the vapor velocity so that the force of gravity would allow the particles to fall out, but this would involve the greater expense and space required for a larger vapor chamber in the evaporator. Accordingly, the present invention seeks to accomplish its objectives first, by segregating peripheral streams of liquid from the paths of vapor flow, secondly, by discharging the segregated liquid streams through the peripheral vapor streams into a sump, and thirdly, by increasing the velocity of the peripheral stream of vapor, and turning it into a centrifugal force to throw out entrained liquid, all being accomplished by the umbrella and dome over the heating element.

Other objects of the invention will be made apparent by the following disclosure thereof.

In the drawings:

Fig. 1 is a view in vertical axial section through the upper portion of an evaporator embodying the invention.

Fig. 2 is a fragmentary view taken in cross section on the line 2—2 of Fig. 1.

In general, the evaporator construction is conventional, comprising a tubular jacket 1 for a heating fluid such as steam, and tubes 2 supplied from sump 3 through pipe 4 with liquid which is to be evaporated. The tubes 2 terminate at a header or tube sheet 5 which serves as a closure for the top of the jacket 1. The sump 3 is at the bottom of a vapor dome 6 from which vapor is discharged through an outlet pipe 7. Ebullition from the several tubes 2 will be quite violent, whereby both vapor and liquid will be discharged from the tops of the pipes. In order to preclude the discharge of liquid directly cut through the discharge pipe 7, it is common to provide a baffle plate at 8 with margins downwardly curved at 9, such plate being known to the art as an umbrella.

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The liquid jetted with the vapor from the tubes 2 strikes the umbrella 8 and tends, in the conventional apparatus, to be discharged radially outwardly and downwardly in a thin sheet from the margin of the umbrella. Through this sheet of liquid, all of the vapor formed in the evaporator must escape to the outlet pipe 7. In passing through the liquid, the vapor stream, if travelling at high velocity, can entrain a very considerable amount of liquid which is carried over with the vapor, thus reducing the efficiency of the evaporator.

In accordance with the present invention, the umbrella baffle 8 is provided with a depending flange or skirt at 10 which extends downwardly to at least the approximate plane of the tube sheet or header 5. The lower margin 11 of skirt 10 may be located in a range of levels such as to be slightly above the level of the tube sheet or considerably therebeneath. The preferred location is below the header but to an extent generally equal to less than the radial clearance. The shorter the overlap, the greater the radial component of velocity and the less the vertical component, and vice versa. In one satisfactory device in which the radius of the margin 11 is four inches greater than the radius of jacket 1, a very good location for the margin 11 was found to be one inch below the top of the jacket, leaving an annular cylindrical passage 4 inches wide and one inch high all around the top of the jacket.

While my invention broadly comprehends any means for breaking up into individual streams what would otherwise be a sheet of liquid issued from the rim 11, I obtain superior results through the use of turbine blades 12 of the particular form illustrated. These blades comprise plates 15, the top margins of which are approximately at right angles to the cylindrical skirt 10. However, the plates are inclined to the vertical at an angle which is preferably approximately 45°. Whatever the angle, the spacing between the plates is preferably worked out so that the top of one plate vertically laps the bottom of the next, leaving no clearance, or little clearance, in a vertical direction through which a downwardly moving stream of fluid may pass without encountering a plate. The flow of fluid ejected from the tubes 2 is such that the liquid tends to move radially outwardly over the lower surface of the umbrella 8 and downwardly about its curved flange 9 and thence straight downwardly on the skirt 10. In the arrangement illustrated, all particles of liquid following this course must encounter one of the fixed turbine blades 12 which

tends to deflect it upon a helically downward path.

It will be noted that the vapor will also tend to be deflected into a number of helical paths roughly corresponding to the number of helical paths followed by the liquid. The heavier liquid will, however, tend to be on and against the upper sides of the respective plates 15 while the lighter vapor will tend to move in the entire space between the liquid on the top surface of the blades and the surface behind the respective blades along their lower surfaces. Consequently, some separation between liquid flow and vapor flow is immediately achieved.

Nearly all of the liquid will move from the tubes into contact with the umbrella. Some small amount of the liquid striking the umbrella will spatter. Thus, some droplets of liquid will be entrained in the outwardly moving vapor without following the path which most of the liquid follows, as above described. In order to catch these droplets, and in order to give tangential and helical velocity to all of the vapor, each of the plates 12 is preferably provided with an inwardly and downwardly disposed flange 17 which tends to intercept the streams of vapor and such droplets as are moving radially outwardly. The droplets will encounter these flanges obliquely and will tend to flow downwardly along the flanges, whereby the droplets will lose their separate identities and become part of a downwardly moving stream of liquid which will be given an angular motion in the same general direction as the liquid streams flowing from the umbrella into contact with the plate portions 15 of the respective turbine blades. The vapor striking the vanes will be deflected in a like manner but on leaving the space behind the vanes it will immediately swing upwardly in the form of a vertically rising helix.

Since the blades are stationary, the liquid delivered from their bottom ends will not be moving either straight downwardly or directly radially. The streams of liquid will move from the blades with components of velocity mainly downwardly, but with components both tangential and radially of the interior of the dome or chamber 6 to strike the liquid in the sump or to strike the inner surface of such dome in a direction quite largely downward and tangential thereto. There the various streams will merge to comprise a sheet of liquid flowing down the dome in a helical direction and there will be but little splattering and most of the droplets not already merged into a stream will tend to lose their identity upon encountering this fluid flow, which will return all the liquid to the sump. Droplets which strike the liquid in the sump are below and out of the path of the rapidly moving vapor.

Because the flow of liquid from beneath the umbrella skirt will be concentrated in the streams instead of in a sheet, it will easily be possible for the accumulated vapor to pass between the streams without material entrainment. Nearly all of the liquid and vapor discharged from the tubes 2 must encounter the turbine blades or vanes 12 before leaving the umbrella and its skirt. The annular space between the skirt 11 and the jacket 1 is sufficiently restricted so that the vapor pressures will build up under the umbrella to accelerate the discharge of vapor and liquid over the turbine blades and thereby to increase the centrifugal effect utilized for separation. The annular space between the margin 11 of the skirt and the adjacent jacket wall 1 should desirably be small enough so that the vapor will have a very high velocity. I use velocities approximating as high as 10,000 feet per minute. Theoretically, a velocity of 10,000 feet per minute should yield a tangential component of as high as 7,000 feet per minute, but actually it is much less than this because of friction with the shells and liquid and because of eddy currents and other reasons. However, the starting velocity in a circumferential direction is believed in actual practice to be about half of the theoretical or as high as 3500 feet per minute, thus yielding a centrifugal force, at the start, of 53 G. Even if the average G were one-tenth of this, or only five, it would be a great improvement over mere gravity separation.

The velocity given to the liquid tends to throw it quickly out of the vapor. The velocity given to the vapor tends to make it flow rapidly in a path initially downwardly but abruptly turning upward in a rising helix causing any entrained particles to be thrown against the outer shell, from which they flow down to the sump.

Thus, due in part to the centrifugal force developed by the helical direction given to the fluids, and due in part to the segregation of the liquids and vapors into separate paths of flow, and due in part to the arrangement whereby the droplets tend to agglomerate rather than to become atomized by direct impact, a very high degree of separation of liquids from vapor is achieved in the apparatus disclosed.

I claim:

1. In an evaporator comprising a jacket having a tube sheet, tubes extending through the jacket and opening through said tube sheet, and a chamber into which such tubes open providing a sump and a vapor dome and having a vapor outlet, the combination with a centrally open umbrella overlying the tube sheet and of larger area than said tube sheet, of a skirt depending marginally from the umbrella downwardly in surrounding spaced relation at least to a level adjacent the level of said tube sheet, and baffles between the skirt and tube sheet in positions inclined to the vertical and peripherally spaced about the interior wall of the skirt for intercepting and channelling in separate streams the flow of liquid accumulating within the umbrella, whereby to afford clearance between such streams for the escape of vapor.

2. In an evaporator having a jacket closed by a tube sheet and tubes opening therethrough into a chamber providing a vapor dome and sump, the combination with a centrally open umbrella having a depending flange extending substantially below the level of the tube sheet in surrounding spaced relation thereto, said umbrella being positioned to intercept liquid ejected from the tubes, of baffle means comprising plates projecting inwardly from the inner wall of the flange of the umbrella and respectively inclined to the vertical at spaced points about the periphery of the umbrella flange, said baffle means adapted to intercept liquid discharged from the umbrella and to direct liquid flow into separate downward streams, whereby to afford passages for vapor to escape between such streams.

3. The combination set forth in claim 1 in which the skirt comprises a substantially continuous wall and the liquid channelling baffles are mounted on said skirt.

4. The combination set forth in claim 1 in which each blade has a top margin vertically lapping the bottom margin of a consecutive blade.

5. The combination set forth in claim 1 in which said skirt extends below the tube sheet to form an annular passage around the inner shell and in which the baffles are disposed.

6. The combination set forth in claim 1 in which said skirt extends below the tube sheet to form an annular ring of passage, and the several baffles are in mutually lapping positions in the passage between the skirt and the jacket.

7. The method of effecting separation of liquid from the liquid and vapor intercepted by an umbrella baffle, which method comprises channelling into separate streams the flow of liquid from beneath the baffle, directing said separate streams in one direction axially of the baffle and outwardly therefrom, and withdrawing vapor from the opposite direction axially of the baffle, whereby to provide spaces between said separate streams of liquid for the escape of vapor.

8. The method of separating liquid and vapor components of fluid ejected from the liquid tube of an evaporator, which method comprises intercepting and tangentially directing such fluid upon a predetermined path having a substantial downward direction and with substantial velocity, withdrawing vapor in an upward direction and changing the direction of the liquid component of such vapor in the course of its delivery to effect centrifugal separation of such components.

ROY O. HENSZEY.

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