July 10, 1951 W. J. BLOOMER 2,560,070

EVAPORATOR

Filed Aug. 27, 1948

Fig. 1.

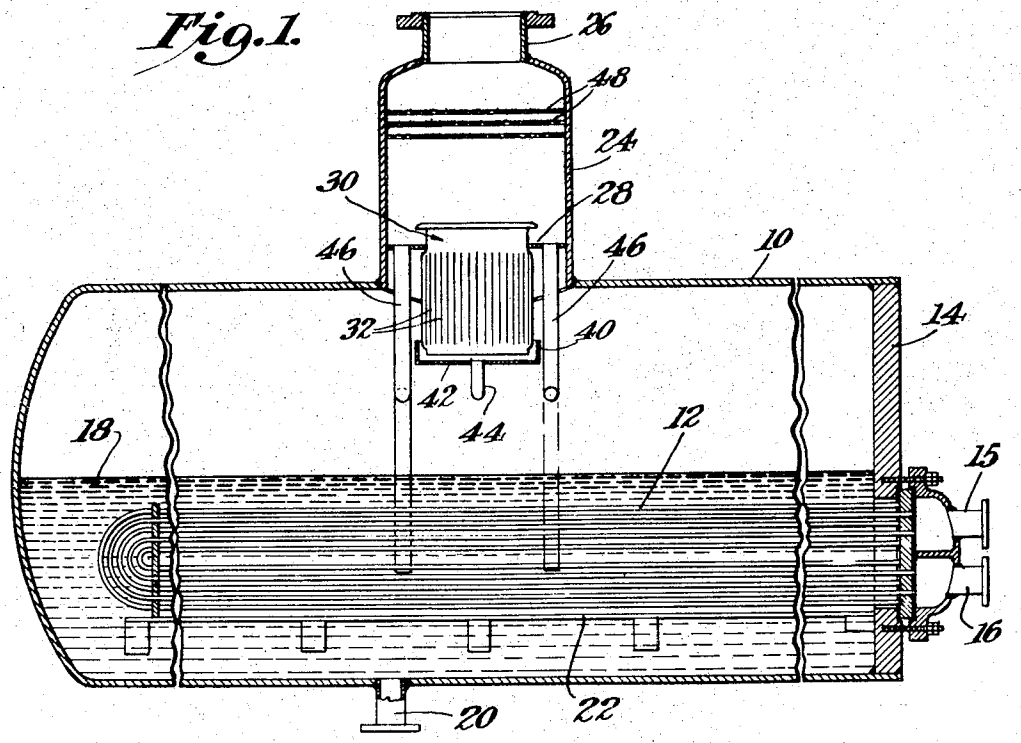


Fig. 2.

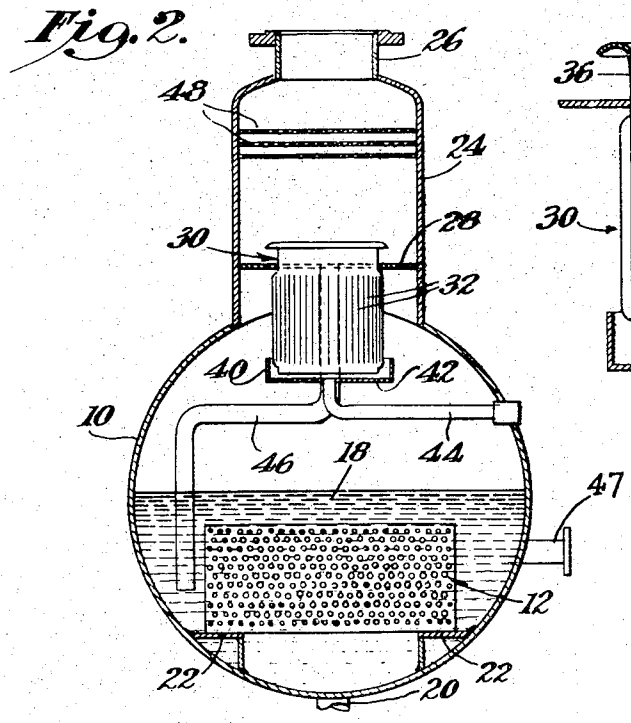
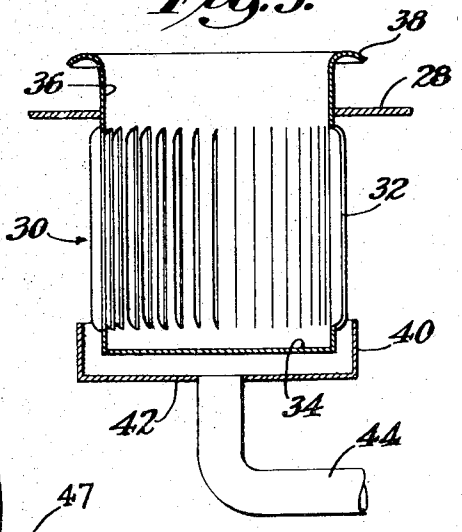


Fig. 3.



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EVAPORATOR

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11 Claims. (Cl. 122—491)

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This invention relates to improvements in evaporators. The principal object of the invention is to provide an improved evaporator unit for the production of high purity steam using integrated sections for steam generating, steam scrubbing and steam drying.

More specifically, my invention relates to an improved steam scrubber for the effective removal of impurities.

Further objects and advantages of my invention will appear from the following description of a preferred form of embodiment thereof taken in connection with the attached drawings in which:

Figure 1 is a partial elevation with parts in central vertical section through an improved form of evaporator;

Figure 2 is a substantially central transverse section through the evaporator shown in Figure 1; and

Figure 3 is an enlarged detailed view of a steam scrubber.

In the patent to Graham 2,302,993 patented November 24, 1942, and entitled "Evaporator" is shown a unit type of construction which is particularly adapted for the production of high purity steam. Such apparatus, in addition to the common evaporator section, includes as a steam scrubbing section a series of bubble caps mounted on a suitable deck for the desired interchange of solid matter in the steam whereby the purity of the steam may be greatly improved.

In my copending applications Ser. No. 550,933, filed August 24, 1944, now abandoned, and Ser. No. 580,804, filed March 2, 1945, now forfeited, I have disclosed new methods and apparatus for contacting liquids and fluids with gases for an intimate mixture in which the proposed amounts of the various materials may be carefully controlled.

In accordance with my present invention, I propose to use the improved mixing apparatus previously shown by me in the specific arrangement of an evaporator with the improved results as hereinafter described.

The principal elements of the evaporator include a substantially horizontal elongated vessel 10 provided with a heat exchange element 12 which conveniently projects through the heater end wall 14, such heat exchange element having

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an inlet 15 and an outlet 16 for the transfer of a heating medium therewithin.

The lower portion of the evaporator shell 10 is adapted to contain a body of water, generally indicated at 18, at least to a depth sufficient to cover the tubular heat exchange element 12 and for blow down purposes a discharge outlet 20 may be provided at the lower side of the shell. As described in the patent to Bertram 2,428,768, the heat exchange unit may be mounted on a suitable guide or track generally indicated at 22 to facilitate the insertion and removal of the unit.

Mounted above the shell 10 is the steam dome 24 having a suitable steam outlet nozzle 26 in the well-known manner. Preferably this steam dome which is usually vertical is provided with a transverse baffle plate 28 in which is mounted the steam scrubber 30 the details of which are shown in Figure 3.

The principal parts of the steam scrubber, generally indicated at 30 in Figure 3, is a cylindrical tuyère consisting of spaced substantially tangential vertical blades 32 which form a hollow cylindrical element supported by the baffle plate 28.

This tuyère is provided with a closed bottom 34 and is open throughout its upper surface so that all of the steam which rises from the body of water 18 must pass through the blades to discharge into the upper part of the steam dome 24. Preferably the blades are surmounted by an imperforate portion 36 having an integral annular lip curved outwardly and downwardly, as shown in 38, such lip being nearly 180° in extent and of at least one-quarter inch radius and for larger units, as for example 24 inches in diameter, it may be up to one inch in diameter.

In addition, a cup-like container 40 is mounted below the closed bottom 34 and is spaced axially and radially from the bottom to form a liquid reservoir, generally indicated at 42. This will be supplied with pure water through the line 44.

The angularity and spacing of the blades is so designed that there will be a substantial velocity of the steam through the tuyère blades sufficient to set up a rotational effect which will form a vortex within the tuyère 30, such vortex or envelope apparently being of generally para-

bolic shape with its theoretical vertex below the bottom 34.

The rotation of this vapor envelope due to the high velocity of the steam which passes over the liquid in the reservoir 42, thus draws this pure liquid into the vortex accomplishing a highly intimate mixture of liquid and steam as it passes in a helical path through the tuyère and into the steam dome. The imperforate portion 36 aids in maintaining a sufficient path to improve the intimate mixture of steam and liquid so that by the time the mixture discharges from the top of the tuyère there is a complete interchange of any impurities into the liquid. The liquid in turn, due to its greater density and high centrifugal force as well as its surface tension, closely follows the curved lip 38 of the tuyère downwardly onto the deck or baffle 28 for discharge through the pipes 46 into the lower part of the evaporator.

By introducing feed water having 100–400 parts per million of impurities through the line 44 and causing a scrubbing of the steam vapors thereby, with a typical steam quality of 99.95% I find it possible to reduce the impurities to less than one part per million. I find that with the vortex so formed, it is possible to pick up as much as twice the weight of liquid for the weight of steam but ordinarily, a one to one ratio or less is sufficient for scrubbing purposes and if desired, a portion of the feed may be introduced directly to the evaporator through inlet 47.

If all of the feed is added at 47, the unit acts as a purifier or entrainment separator having an efficiency of 99% or better. This will produce a 99.95% quality vapor and in such case, with 2000 part per million of impurities arising from the evaporator, a vapor outlet of approximately two parts per million can be obtained.

If desired, a secondary entrainment separator 48 may be used. This may be of any desired type such as a multiple screen filter made of suitable mesh wire which removes the entrained moisture from the steam. Other devices are available for entrainment separation, if necessary, but ordinarily I find that the curved shape of the tuyère at 38 is sufficient to throw out the major part or substantially all of the liquid and by properly proportioning the diameter of the steam dome 24 there is no tendency of the discharged steam to re-entrain any liquid. In general, the dome 24 should be at least twice the diameter of the tuyère.

For a typical unit having an evaporative capacity of 23,550 lbs. per hour, it was found that a tuyère of 14 inch diameter by 14 inch open blade height and having 113 blades $\frac{25}{64}$ inch wide with a $\frac{3}{32}$'' opening which gives a total blade area of 148 sq. in. a steam velocity of 53 feet per sec. was established. The entrained water was constantly removed through the downpipe 46 to thereby remove all but approximately one part per million of total solids from the discharging vapors.

While I have shown and described a preferred form of embodiment of my invention, I am aware that modifications may be made thereto and I therefore desire a broad interpretation of my invention within the scope and spirit of the description herein and the claims appended hereinafter.

I claim:

1. An evaporator comprising a shell defining a liquid space in the lower portion thereof and a vapor space in the upper portion thereof, heating means within the lower portion of the shell to vaporize the liquid, a vapor exit chamber borne by the shell and having a vapor outlet in its upper portion and a lower end wall forming a baffle within said vapor space of the shell and formed with an aperture, a vertical cylindrical tuyère having its upper end portion open and protruding through said aperture and having at its upper extremity an outwardly extending curved annular lip, said tuyère having a solid bottom wall and a series of tangential spaced blades extending along the major part of the side wall below said baffle and forming lateral openings in said tuyère, the upper end portion being sealed, at a level spaced below said lip, to said baffle whereby steam vapor will pass between said blades into said tuyère and be directed into a hollow rotating envelope of steam vapor, a liquid container adjacent the closed end of said tuyère, means for continuously feeding liquid to said container, said container being exposed to stem flow through the tuyère, whereby the vapor will pass upwardly and over the surface of the liquid in said container and entrain said liquid and mix it with the vapor within the tuyère and solids entrained in the vapor will be removed by said entrained liquid over the curved lip of said tuyère, and conduit means to return said liquid to the lower liquid space.

2. An evaporator as claimed in claim 1 in which the upper end portion of the tuyère forms an imperforate supplemental mixing chimney above the blades to give the steam and liquid a minimum mixing path substantially longer than the perimeter of the tuyère.

3. An evaporator as claimed in claim 1 in which the curved lip of the tuyère is approximately 180° in extent and the radius is at least one quarter inch.

4. An evaporator having a shell, a heat exchange coil in the lower part thereof submerged in water, a steam space in the upper portion of said shell, a vapor exit chamber borne by the shell and having a vapor outlet in its upper portion and in the lower portion a delimiting partition formed with an aperture, a vertical cylindrical tuyère protruding through said aperture and extending downwardly therefrom into the vapor space of said shell, said tuyère having its upper end portion open, its bottom wall solid and a side wall provided with a plurality of substantially tangential blades extending along the major part of said side wall and forming lateral openings in said tuyère the open end of the tuyère having an outwardly and downwardly extending curved lip and being sealed with respect to the delimiting partition, the bottom end thereof having adjacent thereto a container, means for introducing feed water to said container whereby within the vapor space of said shell, steam will pass upwardly and over the surface of the feed water in said container entrain said feed water and mix it with the steam flowing into said tuyère between the tuyère blades so that a hollow rotating envelope is formed having an upward whirling direction through the tuyère whereby the entrained liquid will be carried out of the steam by the tuyère lip, and means to return said liquid from the said partition delimiting the vapor exit chamber to the water in the lower part of the shell.

5. In an evaporator unit including a shell, a heat exchange coil in the lower part thereof submerged in water, a steam space in the upper portion of said shell, the improvement comprising

a steam discharge chamber borne by said shell having an imperforate lower wall, an annular vertical tuyère closed at the lower end thereof and fully open at the upper end extending through said wall and substantially above and below it, the portion of said tuyère above the wall being imperforate and the portion below the wall having therearound a series of longitudinal slots tangential in cross section for entry of steam and whirling thereof within the tuyère, the tuyère being of substantially uniform internal diameter from the lower end of said slots to the open end of the tuyère and said chamber having a steam outlet spaced above and in vertical alignment with the tuyère, an annular outwardly extending liquid discharge lip of substantial radial width at the open end of the tuyère having an annular upper surface continuous with the inner surface of the tuyère and curving therefrom upwardly, outwardly and then downwardly, the chamber affording a liquid collecting space surrounding the tuyère and beneath said lip, and a drain conduit leading downwardly from said collecting space.

6. A steam purifier for a steam generator comprising a steam discharge chamber having an imperforate lower wall, an annular vertical tuyère closed at the lower end thereof and fully open at the upper end extending through said wall and substantially above and below it, the portion of said tuyère above the wall being imperforate and the portion below the wall having therearound a series of longitudinal slots tangential in cross section for entry of steam and whirling thereof within the tuyère, the tuyère being of substantially uniform internal diameter from the lower end of said slots to the open end of the tuyère and said chamber having a steam outlet spaced above and in vertical alignment with the tuyère, an annular outwardly extending liquid discharge lip of substantial radial width at the open end of the tuyère and having an annular upper surface continuous with the inner surface of the tuyère and curving therefrom upwardly, outwardly and then downwardly, the chamber affording a liquid collecting space surrounding the tuyère and beneath said lip, and a drain conduit leading downwardly from said collecting space.

7. A steam purifier for a steam generator comprising a steam discharge chamber having an imperforate lower wall, an annular vertical tuyère closed at the lower end thereof and fully open at the upper end extending through said wall and substantially above and below it, the portion of said tuyère above the wall being imperforate and the portion below the wall having therearound a series of longitudinal slots tangential in cross section for entry of steam and whirling thereof within the tuyère, the tuyère being of substantially uniform internal diameter from the lower end of said slots to the open end of the tuyère and said chamber having a steam outlet spaced above the tuyère, an annular outwardly extending liquid discharge lip of substantial radial width at the open end of the tuyère and having an annular upper surface continuous with the inner surface of the tuyère and curving therefrom upwardly, outwardly and then downwardly, the chamber affording a liquid collecting space surrounding the tuyère and beneath said lip, and a drain conduit leading downwardly from said collecting space.

8. A steam purifier for a steam generator, comprising a steam discharge chamber having an imperforate lower wall, an annular vertical tuyère closed at the lower end and fully open at the upper end thereof to said chamber and extending through said wall and substantially above and below it, the portion of said tuyère above the wall being imperforate and the portion below the wall having therearound a series of longitudinal slots tangential in cross section for entry of steam and whirling thereof within the tuyère to form a vortex, the tuyère being internally free from obstruction from the lower portion to the open upper end thereof for free ascent of said vortex through the tuyère and into the steam discharge chamber, and said chamber having a steam outlet spaced above the tuyère, an annular outwardly extending liquid discharge lip at the open end of the tuyère and of substantial width radially of the tuyère and having an annular upper surface continuous with the inner surface of the tuyère and curving upwardly and outwardly, the chamber being substantially larger in horizontal section than the upper end of the tuyère and affording a liquid-collecting space surrounding said imperforate portion of the tuyère and below the level of said lip, and a drain outlet for said collecting space.

9. The steam purifier of claim 8 wherein the said curved upper surface of the tuyère lip is approximately 180° in extent and the radius of the curvature is at least one quarter inch.

10. A steam purifier for a steam generator, comprising a steam discharge chamber having an imperforate lower wall, an annular vertical tuyère closed at the lower end thereof and fully open at the upper end thereof to said chamber and extending through said wall and substantially above and below it, the portion of said tuyère above the wall being imperforate and the portion below the wall having therearound a series of longitudinal slots tangential in cross section for entry of steam and whirling thereof within the tuyère to form a vortex, the tuyère being internally free from obstruction from the lower portion to the open upper end thereof for free ascent of said vortex through the tuyère and into the steam discharge chamber and said chamber having a steam outlet spaced above the tuyère, means for supplying scrubbing water at the lower end of the tuyère for entrainment of said water by the steam and mixing therewith within said vortex the chamber being substantially larger in horizontal section than the upper end of the tuyère and affording liquid-collecting space surrounding said imperforate portion of the tuyère and below the level of the upper extremity of the tuyère, and a drain outlet for said collecting space.

11. A steam purifier for a steam generator, comprising a steam discharge chamber having an imperforate lower wall, an annular vertical tuyère closed at the lower end and fully open at the upper end thereof to said chamber and extending through said wall and substantially above and below it, the portion of said tuyère above the wall being imperforate and the portion below the wall having therearound a series of longitudinal slots tangential in cross section for entry of steam and whirling thereof within the tuyère to form a vortex, the tuyère being free from obstruction from the lower portion to the open upper end thereof for free ascent of said vortex through the tuyère and into the steam discharge chamber and said chamber having a steam outlet spaced above the tuyère, means for supplying scrubbing water

at the lower end of the tuyère for entrainment of said water by the steam and mixing therewith within said vortex, an annular outwardly extending liquid discharge lip at the open end of the tuyère and of substantial width radially of the tuyère and having an annular upper surface continuous with the inner surface of the tuyère and curving upwardly and outwardly, the chamber being substantially larger in horizontal section than the upper end of the tuyère and affording a liquid-collecting space surrounding said imperforate portion of the tuyère and below the level of said lip, and a drain outlet for said collecting space.

WARD J. BLOOMER.

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