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R. B. GALBREATH
FRACTIONATOR BUBBLE CAP

2,871,003

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2 Sheets-Sheet 1

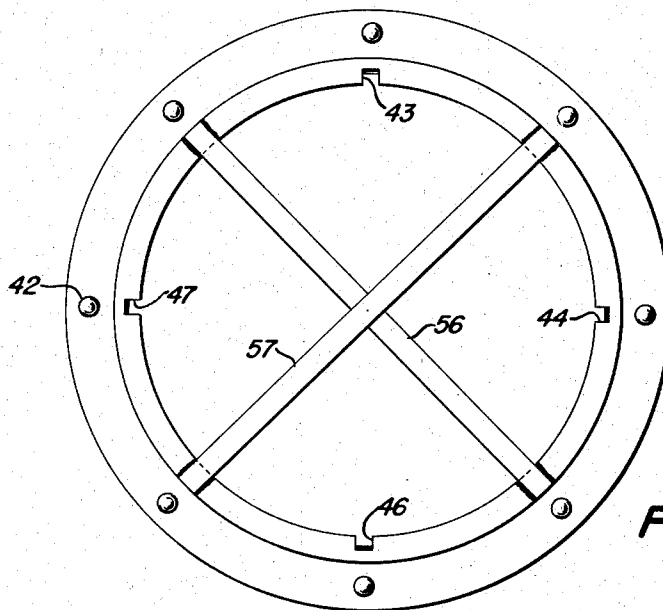


Fig. 2

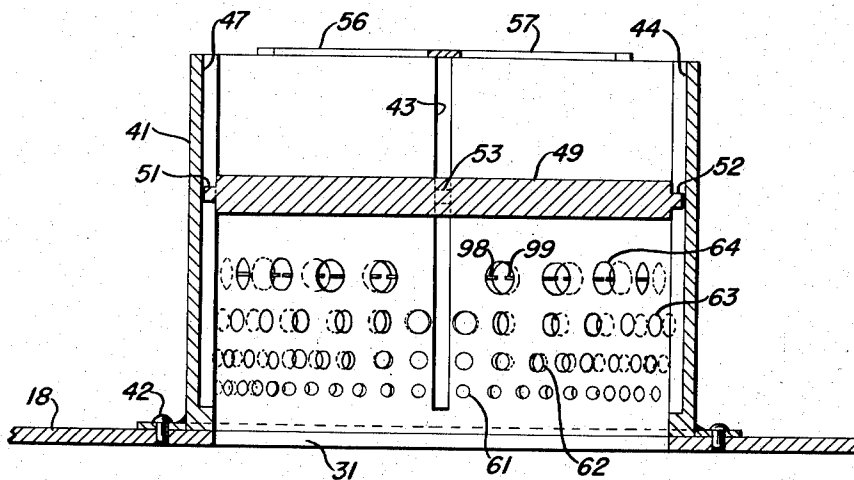


Fig. 1

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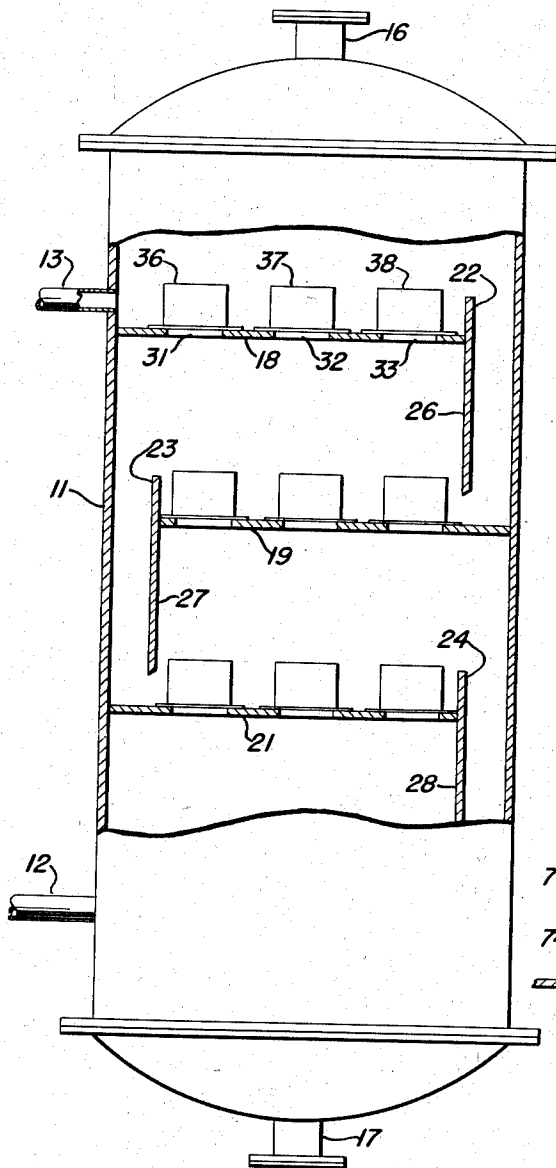


Fig. 5

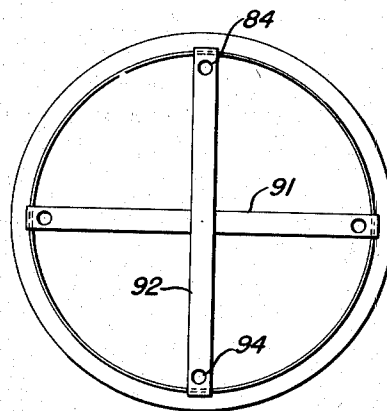


Fig. 4

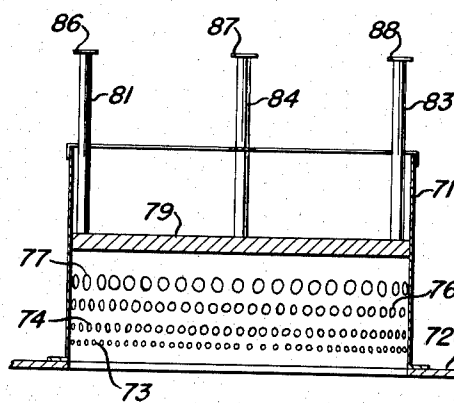


Fig. 3

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FRACTIONATOR BUBBLE CAP

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3 Claims. (Cl. 261—114)

This invention relates to a contacting apparatus, particularly for fractional distillation of a mixture of liquids or liquid-liquid contacting of two substantially immiscible liquids. More particularly the invention relates to an improved bubble cap means for use in such contacting apparatus.

In ordinary fractional distillation equipment, utilizing the well known bubble cap trays or decks, the vapors pass up through a chimney-like riser through slots in the bell of the cap and thence through the pool of liquid maintained on the deck. Such bubble cap fractionators are designed for one set of conditions; change in operations away from the design conditions results in a rapid decrease in fractionation efficiency of the apparatus because of the fixed slot area of the bubble cap bells. Attempts have been made to overcome this by the use of chimney-like members provided with discs set transverse to the chimney height, which discs ride up and down in the chimney, permitting more or less of the slots in the chimney wall to be exposed to vapor. While this is an improvement, where fluctuations in operations occur, over the regular bubble cap, efficiency of this type of chimney cap changes because of the larger and larger bubbles produced as the disc moves farther and farther up the chimney.

An object of the invention is a fractionating apparatus which will have high efficiency over a wide range of operating variables. A particular object is a variable opening bubble cap for use in fractionating apparatus. A further object is a contacting apparatus provided with bubble caps permitting high efficiency when used for liquid-liquid contacting as well as vapor-liquid contacting. Other objects will become apparent in the course of the detailed description.

The invention is described in connection with the illustrative embodiments set out in the annexed figures which form a part of this specification.

Figure 1 sets out a cross-section of a bubble cap means.

Figure 2 shows a plane view of the bubble cap means of Figure 1.

Figure 3 shows another embodiment of the bubble cap means of this invention.

Figure 4 shows a plane view of the bubble cap means of Figure 3.

Figure 5 sets out, in schematic form, a fractionating apparatus utilizing the bubble cap means of the invention.

In Figure 5, the outer shell of the contacting apparatus is represented by numeral 11. Conduit 12 permits the entry of material into the shell, for example, a mixture of hydrocarbons to be separated into an overhead fraction and a bottoms fraction. Or, in a liquid-liquid contacting, the lighter liquid may be introduced through conduit 12 and the heavier liquid may be introduced through a conduit 13 near the top of shell 11. Material may leave the interior of shell 11 by way of conduits 16 and 17.

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Within the shell there is disposed a plurality of horizontal bubble cap decks or trays 18, 19 and 21 respectively. It is to be understood that more than three decks may be used, or, in some cases, only one deck may be present. The decks are in vertical spaced relationship usually spaced uniformly throughout the height of the shell 11. However, for a particular operation there may be some variation in the spacing of the decks. To maintain the liquid on the deck, the decks are disposed as close to horizontal as is possible under commercial equipment conditions.

Each deck is provided with a weir 22, 23 and 24 respectively. This weir maintains a depth of liquid on the deck at a predetermined level. Also, each deck is provided with a downcomer means 26, 27, and 28 respectively which carries the overflow of liquid from one deck down to the next lower deck. The lower end of the downcomer is below the level of liquid on the lower deck in order to prevent by-passing of the vapor or liquid up the downcomer.

Each deck is provided with a number of apertures 31, 32 and 33 shown on deck 18. These apertures 31, etc. permit communication between the upper side of the deck and the space below the deck. Vapor or liquid coming up the shell from deck 19, for example, pass through apertures 31, etc. into bubble cap means 36, 37 and 38 respectively, mounted on deck 18. The bubble cap means 36, etc. are positioned coaxially over the apertures 31, etc.

Thus, in the fractionation of a petroleum hydrocarbon mixture, the feed would enter the fractionating apparatus through conduit 12, would be vaporized by heating coils not shown set in the bottom of shell 11. Liquid would be maintained on decks 18, 19 and 21 by the addition of reflux not shown at the upper end of shell 11 and also by condensation due to temperature drop over the height of the shell. Vapors pass up the apertures, pass through the bubble forming means in bubble cap means through the pool of liquid maintained on the deck by the weirs. Excess liquid is passed down from one deck to the other over the weir and through downcomers.

In Figure 1, there is set out one particular form of the improved bubble cap means of the invention. The bubble cap means comprises a chimney 41 which is fastened to deck 18 by means of rivets 42, etc. Other methods of fastening the chimney to the deck will be obvious. Chimney 41 extends vertically above the deck to a height about equal to the height of weir 22. In some modifications, chimney 41 may extend below deck 18 for a distance. It is preferred not to operate in this fashion in order to avoid formation of dead spaces beneath the decks. Chimney 41 is provided with slots 43, 44, 46 and 47. These slots extend from the top of chimney 41 to a point close to the bottom of the chimney or may even extend all the way to deck 18. The end of the slot or the deck provides a means for preventing fall of disc-like member 49 through aperture 31. Other methods of retaining disc-like member 49 in chimney 41 may readily be devised.

A disc-like member 49 is positioned transversely within the interior of chimney 41. Disc member 49 is capable of up and down movement in slots 44, etc. Lugs or extensions 51, 52 and 53, and a fourth extension, not shown, are provided on the periphery of disc member 49. These extensions 51, etc. are adapted to ride in slots 44, etc. and guide the disc member 49 in its up and down movement. Also, the extensions 51, etc. are so fitted to slots 44, etc. so that disc 49 can not be tilted within chimney 41 and will always ride substantially horizontal, i. e., about parallel to the plane of deck 18.

Cross members 56 and 57 are provided at the upper end of chimney 41 to prevent disc member 49 rising out

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of chimney 41. Cross members 56 and 57 may be tack welded to the top of chimney 41 or may be fastened therein by other readily apparent means.

Disc member 49 is so proportioned within the chimney 41 that it essentially prevents flow of fluid in the chimney beyond or above the disc member. It may be described in another way as being made to a sliding fit within chimney 41.

Chimney 41 is provided with a plurality of rows of apertures, which apertures are substantially circular in cross section. Each row of apertures consists of a number of apertures having the same diameter, i. e., equi-size, which are set in a uniform spacing, i. e., equi-distant around the periphery of chimney 41. The apertures in each row of holes are at an essentially constant elevation above the deck 18, for example, apertures 61, etc. in the lowest row of apertures in chimney 41 all have the same diameter and are set apart uniformly in equal distance in a plane which is parallel to the plane of deck 18.

The diameter, or size of the apertures in the rows of holes increases more or less progressively as the row is farther from the deck. Thus, in Figure 1, aperture 61 is the smallest in diameter, aperture 62, etc. in the next higher row is larger than aperture 61; aperture 63 in the row next above that containing aperture 62 is larger than aperture 62. Aperture 64 in the highest row is the largest of all. It is to be understood that the change in size of apertures in adjacent rows is not necessarily uniform. It may be desirable, in some cases, to have two or even three rows of apertures of the same diameter. Or it may be desirable, in some cases, to have two or three rows of progressively changing diameter and then several rows having the same diameter apertures. In general, the size of the apertures in each row of apertures progressively increases with the smallest apertures being nearest the deck; each row has apertures at least as large as the next lower row. It is preferred to have a chimney wherein each higher row has a somewhat larger aperture size than the next lower row.

Figures 3 and 4 show a simpler form of the bubble cap means of the invention. In this embodiment, the bubble cap means may be formed from economical thin sheets of material such as may be used in heavy duty cans. Instead of using machined slots, the disc member is retained within the chimney by means of posts passing through a simple cross member which clamps to the top of the chimney. The apertures may readily be punched out of the thin can-like material. Thus chimney 71 is formed of a sheet material such as may be described as a can-type sheet and chimney 71 may be described as can-like. Chimney 71 is fastened to deck 72 by spot welding preferably. Chimney 71 is provided with four rows of apertures 73, 74, 76 and 77. Each row of apertures has a different diameter progressively increasing from aperture 73 to aperture 77. Disc member 79, which has essentially the same area as the chimney transverse area in order to avoid by-passing of fluid along the walls of chimney 71, has joined to it four post-like members 81, 82, 83 and 84. These post-like members may be hollow tubes or may be solid pins which are driven into holes in disc member 79. Each post 81, etc., is provided at its upper end with a cap 86, 87, and 88 respectively. Cross-bar members 91 and 92 are provided at the top of chimney 71. These members may be made in a fashion similar to the top of a coffee can with the sectors punched out to form cross bars 91 and 92, the lip of the can then fitting over the outer edge of chimney 71. Posts 81, etc. extend through holes 94, etc. provided in cross bars 91 and 92. Caps 86, etc. on posts are placed thereon after the posts have been passed through the apertures 94, etc. Thus caps 86, etc. prevent disc member 79 from passing through the aperture in deck 72 and cross bar members 91 and 92 prevent disc member 79 passing up out of chimney 71.

The apertures in the chimney extend over a height

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somewhat less than that of the depth of pool of liquid maintained on the deck by the weir, for example, 22. The chimney extends above the deck to a point substantially equal to the height of the weir, in order to provide some depth of liquid between the top of the highest row of apertures and the top of the pool of liquid. Thus there is no practical advantage to having the chimney more than substantially equal to the height of the weir.

Since it is desirable to have the bubbles issuing from the apertures as small as possible because the fractionation efficiency is, in large part, determined by the vapor bubble-liquid interphase, it is desirable at times to provide means for reducing the size of the bubbles issuing from the large apertures. Thus in Figure 1, the largest apertures are provided with small extensions or spurs 98 and 99, for example, which break the bubble passing through the aperture into two or more smaller bubbles. These spurs may readily be formed, in the case of the embodiment shown in Figure 3, in the stamping operation.

Example

A bubble cap of the type of this invention was designed for petroleum distillation tower. In this tower, 280 pounds per hour of hydrocarbon vapor passes through each bubble cap. The maximum allowable vapor velocity of the tower was three feet per second. The average density of the hydrocarbon vapor in the tower was 0.3 pound per standard cubic foot and the pressure drop across each deck was taken at 0.1 p. s. i.

The diameter of each aperture in each deck was 4.03 inches in order to provide a clear chimney diameter of 4 inches. Each chimney was 4 inches in overall height corresponding to the height of the weir on each deck. Cross-bar means were provided at the top of each chimney so that the bottom side of the disc positioned transversely in each chimney was 3.5 inches above the deck when the disc was at maximum height within the chimney. In order to permit operation under these conditions, the chimney was made of ordinary carbon steel at a thickness of 0.35 inch.

Eight rows of apertures were provided. The lowermost row was at an elevation of one-fourth inch, deck to mid-point; each hole was one-sixteenth inch in diameter and the holes were uniformly spaced around the chimney on one-quarter inch centers. The next upper row was set at a one-fourth inch center-to-center distance above the first row; each aperture was one-eighth inch in diameter and the apertures were set on one-fourth inch centers around the chimney. The next upper row (third from the bottom) was set at one-fourth inch center-to-center above the second row; each aperture was three-sixteenths in diameter and set on one-quarter inch centers around the chimney.

The fourth row of holes was set one-half inch center-to-center above the third row; each aperture was one-fourth inch in diameter and the apertures were set on one-half inch centers around the periphery. The fifth through eighth (last) row of apertures set on one-half inch spacing vertically, center-to-center, above the next lower hole. The fifth row of holes had the same diameter and the same spacing as the fourth row. The sixth, seventh, and eighth rows had the same diameters of apertures and the same spacing, namely three-eighths diameters set on one-half inch centers.

Thus having described the invention, what is claimed is:

1. A contacting apparatus comprising an outer shell provided with ingress and egress conduits for material to enter and leave the interior of said shell, a plurality of horizontal decks in vertical spaced relationship in said shell, each of said decks being provided with weir means for maintaining a depth of liquid thereon, with down-comer means for transferring liquid from a deck to the next lower deck, with apertures communicating with the space below the deck, and bubble cap means positioned

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coaxially over said apertures, wherein said bubble cap means comprise a chimney extending essentially vertically to a height above the deck about equal to said weir height, a disc-like member positioned transversely within said chimney and capable of up and down movement over substantially all the height of said chimney above said deck, said disc member preventing essentially any flow of fluid in the chimney beyond the disc member, means for maintaining said disc member essentially horizontal in said chimney, means for stopping the downward movement of said disc member, means for stopping the upward movement of said disc member, and said chimney being provided with a plurality of rows of substantially circular apertures, each row consisting of a plurality of equi-size apertures in substantial equi-distant spacing at a constant elevation above the deck, and the apertures in said rows progressively increasing in size, the smallest apertures being nearest the deck and each row having apertures at least as large as the next lower row.

2. The apparatus of claim 1 wherein the chimney wall is provided with bar members at the top of said chimney to stop upward movement of said disc-means and a plurality of vertical slots ending at about the deck elevation of said chimney and said disc member is provided with extensions adapted to ride in said slots.

3. A contacting apparatus comprising an outer shell provided with ingress and egress conduits for material to enter and leave the interior of said shell, a plurality of horizontal decks in vertical spaced relationship in said shell, each of said decks being provided with weir means for maintaining a depth of liquid thereon, with down-comer means for transferring liquid from a deck to the next lower deck, with apertures communicating with the

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space below the deck, and bubble cap means positioned coaxially over said apertures, wherein the bubble cap means comprises can-like chimney extending from the deck to an elevation substantially equal to said weir height, a disc member positioned transversely within said chimney having essentially the same area as the chimney transverse area and capable of up and down movement in said chimney, cross-bar members positioned across the upper end of said chimney to prevent further upward movement of said disc-member, a plurality of post-like members joined to the upper side of said disc-member and extending through apertures provided in said cross-members, said post-like members having means which contact said cross-members to prevent movement of said disc-member beyond the lower end of said chimney, said chimney being provided with a plurality of rows of circular apertures, each horizontal row consisting of equi-size apertures in equi-distant spacing around the chimney, the apertures in said rows increasing in size with the smallest apertures being in the row nearest the deck and each row having apertures at least as large as the next lower row.

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