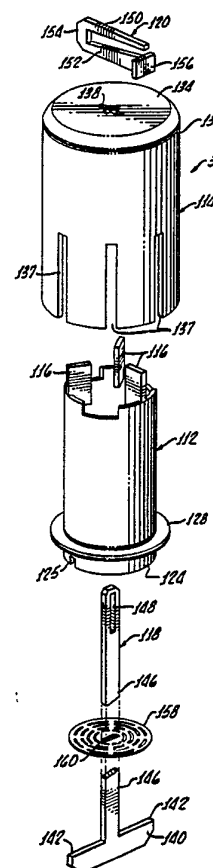




INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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(21) International Application Number: PCT/US92/02584 (22) International Filing Date: 30 March 1992 (30.03.92) (30) Priority data: 710,352 30 May 1991 (30.05.91) US (71) Applicant: UNION OIL COMPANY OF CALIFORNIA [US/US]; 1201 West 5th Street, Los Angeles, CA 90017 (US). (72) Inventors: SHIH, Chien-Cheng, J. ; 112 Cartier Aisle, Irvine, CA 92720 (US). CHRISTOLINI, Ben, A. ; 18061 Holly Circle, Yorba Linda, CA 92686 (US).		(74) Agents: ABRAHAMS, Colin, P. et al.; Ladas & Parry, 3600 Wilshire Boulevard, Suite 1520, Los Angeles, CA 90010 (US). (81) Designated States: AT, AT (European patent), AU, BB, BE (European patent), BF (OAPI patent), BG, BJ (OAPI patent), BR, CA, CF (OAPI patent), CG (OAPI patent), CH, CH (European patent), CI (OAPI patent), CM (OAPI patent), CS, DE, DE (European patent), DK, DK (European patent), ES, ES (European patent), FI, FR (European patent), GA (OAPI patent), GB, GB (European patent), GN (OAPI patent), GR (European patent), HU, IT (European patent), JP, KP, KR, LK, LU, LU (European patent), MC (European patent), MG, ML (OAPI patent), MN, MR (OAPI patent), MW, NL, NL (European patent), NO, PL, RO, RU, SD, SE, SE (European patent), SN (OAPI patent), TD (OAPI patent), TG (OAPI patent). Published <i>With international search report.</i> <i>Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>
(54) Title: A VAPOR-LIQUID DISTRIBUTION METHOD AND APPARATUS (57) Abstract A vapor-liquid distribution method and apparatus utilize a bubble cap assembly (100) for attachment over an opening in a deck tray of a gas-liquid contact apparatus (e.g., catalytic reactor). The bubble cap assembly (100) comprises a riser (112) located over the opening in the deck tray, and providing fluid communication from an upper surface to a lower surface of the deck tray. A bubble cap (114) encompasses an upwardly extending end of the riser. A key feature of the assembly is the provision of a dispersion plate (158) in a lower end of the riser (112) which provides a flow restriction for two phase fluids flowing through the riser to produce a mist flow of the two phases. Preferably, the dispersion plate (158) has a plurality of openings (162) therethrough, at least the outer openings being provided with tabs (164) to disperse the mist flow radially outward.		



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A VAPOR-LIQUID DISTRIBUTION METHOD AND APPARATUSField of the Invention

This invention relates generally to a method and apparatus for distributing a vapor-liquid, mixed phase feed to a contacting zone in a reactor. The invention particularly relates to an apparatus and method for uniformly distributing vapor-liquid phases into contact with granular solids in a catalytic contactor vessel.

Background of the Invention

Among the various commercial processes practiced, an important one involves the physical or chemical treatment of hydrocarbons and other organic materials with bodies of granular contact material. Frequently such a process involves contacting a two-phase mixture of liquid and vapor with the contacting material and the introduction of such mixtures into the bed of granular contact material in a uniformly distributed manner.

Uniform distribution of a liquid and vapor into a granular bed of contact material is a difficult goal to achieve. In a typical process a vapor-liquid feed material is introduced into a vessel which is divided into an upper and lower portion by one or more distribution trays. The distribution trays are provided with a number of overflow weirs, or the like, and provide the sole means of fluid communication between the upper portion of the vessel and the lower portion of the vessel, the latter of which contains a bed of the granular contact material.

The feed mixture is introduced into the upper portion of the vessel and the liquid collects in a pool or reservoir on the tray from whence it flows over the rims of the weir into the bed of contact material. An inherent disadvantage of such an approach is that the methods of fabrication normally employed in the construction of reactors are not sufficiently precise to ensure an absence of irregularities (differences in the outlet weir elevation, tilting

of the weir, tilting of the distribution tray, etc.) in the reactor. In addition the operating conditions within the reactor are frequently such as to bring about distribution tray warping, thus contributing to even more irregularities.

5 As a result, some of the outlets will inevitably exhibit little or no overflow of liquid feed.

It has been proposed to provide slots or V-notches in the weir to minimize the effect of these irregularities. Such proposals have not eliminated the problems associated with irregular flow. Further, the liquid feeds have a tendency to channel down the inner surface of the outlet weir and impinge upon the catalyst bed in relatively thin streams which bury themselves deep in the bed before spreading laterally to any significant extent.

15 The more common practice is the use of a "bubble cap" assembly. A bubble cap assembly is disposed over each of a plurality of openings in the distribution tray. Each bubble cap assembly comprises a riser portion, generally having the shape of a hollow conduit, and a cap portion which is spaced apart from the riser forming an inverted U shaped flow path for the vapor and liquid. In most designs the cap portion may have a plurality of slots in its lower most outer periphery to accommodate irregularities of the type described above, and variations in liquid flow rates. Such designs have met with commercial success. Nonetheless, there is still need for improvement. It must be appreciated that even a one or two percent increase in yield, which could be obtained by more uniform distribution of the liquid-vapor upon the particulate bed, could amount to millions of dollars per year in, for example, a petroleum refining operation.

Summary of the Invention

According to one aspect of the invention, there is provided a bubble cap assembly comprising: a conduit defining a passageway for fluids, the conduit having an entry opening to the passageway and an exit opening from the passageway; a bubble cap located over the entry passageway of the conduit, the bubble cap having a top portion, a downwardly extending

skirt portion, and an opening located in the top portion; a dispersion plate, located adjacent the exit opening of the conduit, having a plurality of openings therethrough, the openings providing the sole means for fluid to exit the
5 conduit; spacer means for maintaining a gap between the exit opening of the conduit and the bubble cap; and locking means for affixing the bubble cap assembly to a deck tray.

According to another aspect of the invention, there is provided a method of forming a mist flow of a gas and
10 liquid comprising using the bubble cap assembly of the invention.

The present invention provides a method and apparatus whereby a mixture of gas and liquid may be dispersed as a fine mist onto a contact material. Broadly the invention
15 may comprise a bubble cap assembly for attachment to a distribution tray having an opening therethrough. The present invention may be particularly suitable for use in a gas-liquid contact apparatus comprising a housing enclosing one or more superimposed distribution trays. Each of the
20 distribution trays may be provided with a plurality of bubble cap assemblies.

The present bubble cap assembly preferably comprises a riser located over the opening, having an upwardly extending end, and a bubble cap encompassing and spaced apart from the
25 upper end of the riser. A spacer means may be located intermediate the riser and the bubble cap for maintaining the two in a spaced apart relationship with one another. The apparatus may further include means for maintaining the bubble cap in a stationary position over the opening in the deck
30 tray. A key aspect of the invention is a dispersion plate which is located in a filmed passageway within the riser.

Preferably the dispersion plate is located adjacent a lower discharge end of the riser and is provided with a plurality of openings therethrough. The openings in the
35 dispersion plate may provide the sole means for fluid communication between an upper portion of the gas-liquid contact apparatus and a lower portion of the gas-liquid contact apparatus which contains the body of particulate contact material. The openings in the dispersion plate

conveniently provide a substantially reduced fluid flow area which produces a mist flow of liquid and vapor. The mist flow preferably enhances the uniform distribution and contact of the gas-liquid feed with the contact material which enhances the product yield.

Brief Description of the Drawings

Figure 1 is an elevation view partly in section of a reactor incorporating the present invention;

Figure 2 is an exploded view of a bubble cap assembly construction in accordance with the present invention;

Figure 3 is a cross sectional elevation view of the bubble cap assembly of Figure 2; and

Figure 4a is an elevation and 4b a cross sectional view of the dispersion plate of the present invention.

Description of a Preferred Embodiment

It is to be understood that the vapor-liquid, mist phase feed distribution method and apparatus of this invention are broadly applicable to any contacting system and particularly to any down flow reactor contacting system. The method and apparatus are specifically applicable for use in catalytic hydrodesulfurization and hydrocracking reactors. They also can be used to conduct any contacting or treating in which a portion of the feed is in a liquid phase and the balance is in a vapor phase, such as in catalytic polymerization, isomerization, etc., of petroleum hydrocarbons, catalytic hydrogenation of liquid coal extracts, catalytic hydrogenation of aromatic compounds, such as the conversion of benzene to cyclohexane, catalytic oxidation, catalytic chlorination, and the like.

Referring now to Figure 1, the apparatus therein shown consists essentially of a down flow catalytic reactor with its various internal parts. The reactor comprises a cylindrical vessel 12. Vessel 12 is typically constructed of corrosion resistant metal or an equivalent material such as

stainless steel, ceramic or the like, and is normally insulated internally or externally for operation at elevated temperatures. While vessel 12 is substantially cylindrical in the preferred form, it can also be of a non cylindrical shape if desired. Vessel 12 has an outlet conduit 18 in a bottom portion 16. A top portion 14 is provided with a conduit 20 for convenience in filling vessel 12 with catalyst, and for routine maintenance. A foraminous, cone shaped cylindrical grating 22 is located immediately above outlet conduit 18 to act as a barrier to prevent the escape of solids from within vessel 12 through outlet 18 while permitting fluid product to discharge therethrough. A gas - liquid feed is introduced through conduit 20 into the top portion 14 of vessel 12. Typically, quench conduit 24 is provided which includes a sparger 26 comprising a closed pipe with two identical radial slits 28 for injecting a quench gas in two sheet like jets. Additional quench gas can be introduced into vessel 12 through conduit 20 to control temperature if desired.

The features described in the foregoing paragraph are conventional in a great many catalytic reactors. The improvement of the present invention comprises a novel feed distribution system comprising a transverse partition or distribution tray 30 and a plurality of bubble cap assemblies such as shown at 32, 32A and 32B on the drawing. A more specific aspect the invention is directed to the bubble cap assemblies 32, which will be described in more detail later. Typically, distribution tray 30 is securely mounted substantially horizontally within vessel 12 by a circumferential support bracket 34. Distribution tray 30 is substantially vapor and liquid tight, except for the downward openings in the riser of the bubble cap assemblies 32.

Below distribution tray 30, and spaced apart therefrom in vessel 12, is the contacting zone of the reactor in which is disposed a bed of granular catalyst material 36. Typically the bed of granular catalyst material is under a layer of chemically inert pellets 38. The chemically inert pellets act to improve the uniformity of distribution of the feed from distribution tray 30 and prevent disruption of the

upper surface of the catalyst bed. Disposed below catalyst bed 36 there frequently will be provided another bed of inert ceramics spheres 40, or the like, surrounding and abutting grate 22. This layer of inert spheres also is optional and
5 may be eliminated completely or replaced by an equivalent or other volume of catalyst materials if desired.

There are many reactor design variations which may be used within the scope of the invention. Reactors suitable for use with the present invention can differ substantially
10 in non-critically aspects from that depicted in Figure 1. Such reactors can, for example, contain two or more distribution tray-catalyst bed combinations, or units, which can be arranged in series or parallel relationship. It also is not essential that the catalyst bed used in accordance with
15 this invention have layers of inert materials such as described.

The essence of the present invention is in the bubble cap assembly and will be more clear with reference to Figures 2-4.

Referring to Figure 2 therein is depicted an exploded view of the essential parts of a bubble cap assembly
20 100 constructed in accordance with a preferred embodiment of the present invention. Bubble cap assembly 100 comprises a riser 112, a bubble cap 114, spacer means 116, a retainer member 118, lock means 120, and dispersion plate 158.
25

The manner in which the various elements of the bubble cap assembly cooperatively interact will be more apparent by reference to Figures 2 and 3. Riser 112, which is generally cylindrical in form, preferably is provided with
30 a lower lip or extension 124 which is received within an opening 126 in a deck tray 122. Riser 112 may be cut from a length of tubular material or may be rolled from a length of sheet stock as desired. Riser 112 also includes a flange portion 128 adjacent its lower end which supports the riser
35 on an upper surface 130 of deck plate 122. As depicted, flange 128 is formed as an integral part of riser 112. Alternatively, the flange could be in the form of a separate ring attached to the riser by press fit, shrink fit, welding or any other manner. Riser 112 has an inner passageway 132

which provides substantially the sole means of fluid communication across deck tray 122 through dispersion plate 158.

Bubble cap 114 encompasses an upper end of riser 112. Bubble cap 114 comprises a top wall 134 terminating about its periphery in a downwardly extending skirt 136 which terminates adjacent upper surface 130 of deck tray 122. Frequently, skirt 136 will have a plurality of slots or openings 137 for the passage of fluid therethrough. The function of the slots 137 is to provide a pressure drop thereacross such that the liquid level in the annular space defined by cap 114 and riser 112 is higher than the liquid level on distribution tray 30. The higher liquid level in the annular space will offset any irregularities in liquid level on distribution tray 30 and ensure a substantially uniform gas-liquid flow through each bubble cap assembly, and substantially uniform mixing of the gas and liquid.

Bubble cap 114 further includes a substantially centrally located aperture 138 located in top wall 134. Aperture 138 comprises two rectangular openings superimposed upon and at substantially right angles to one another forming an opening in the shape of a cross, that is, the central points of the two rectangular openings are coincident and preferably are on the axis of bubble cap 114. Typically, one of the rectangular openings is larger than the other, i.e., one has a longer length than the other opening. The function of these two openings will be described later.

Means are provided for maintaining bubble cap 114 and riser 112 in a spaced apart relationship with one another substantially as depicted. As shown in the drawing, this means comprises a plurality of spacers 116 which typically will be fastened to the cap, riser or both. Top wall 134 of cap 114 rests on spacers 116. Spacers 116 also extend radially outwardly and maintain bubble cap 114 substantially centered with respect to riser 112.

Means are provided for securing bubble cap assembly 100 in position on deck tray 122 in communication with opening 126. As shown in the drawings, this means includes a retainer member 118 and lock means 120. Retainer member 118 is

disposed within inner passageway 132. A lower end of retainer member 118 is provided with oppositely extending projections 140. Each of projections 140 is provided with an upwardly extending face portion 142 for engagement with a bottom surface 144 of deck tray 122. If the lower lip 124 of riser 112 extends below surface 144 of deck tray 122, it may be necessary to provide a notch 125 (Figure 2) in lower lip 124 to ensure that faces 142 of retainer member 118 engages bottom surface 144 of deck 122. Alternatively, a notch (not shown) could be provided in faces 142 to accommodate lower lip 124. Retainer member 118 further includes an upwardly extending stem portion 146 which is received through an opening 160 of dispersion plate 158 and through the smaller of the two rectangular openings forming aperture 138 in bubble cap 114. Retainer member 118 is provided with a vertical slot 148 for receiving therethrough a substantial portion of lock means 120.

A locking means 120 comprises two substantially parallel leg members 150 and 152 which are connected at one end by a base member 154. One of the leg members, for example, leg member 152, is in the form of a ramp to provide a wedge means for engagement with slot 148 in retainer member 118 which extends through top wall 134 of bubble cap 114. Leg members 150 and 152 and base member 154 are sized for passage through the larger of the two rectangular openings forming aperture 138 in bubble cap 114. To prevent locking means 120 from passing entirely through aperture 138, leg member 152 is provided with an end piece 156 which is sized to prevent passage of locking means 120 through aperture 138 during installation and removal of the bubble cap assembly. As depicted, end piece 156 is welded or otherwise attached to the end of leg member 152. It will be apparent, however, that it could also be an integral part of leg member 152, for example, by bending the end of leg member 152 to form a comparable end portion.

Referring specifically to Figure 3, which depicts locking means 120 installed in bubble cap assembly 110 for normal operation, the ramp portion of leg member 152 engages slot 148 in retaining member 118 and presses against top wall

134 of bubble cap 114. The ramp portion acts as a wedge for tightly urging bubble cap 114, spacer means 116 and riser 112 against upper surface 130 of deck tray 122 and concurrently urging faces 142 of retainer member 118 against lower surface 144 of deck tray 122 to retain dispersion plate 158 in position.

During installation of bubble cap assembly 100, retainer member 118 is suspended at its lowest position with respect to bubble cap 114 by locking means 120. The lower end portion 140 of retainer member 118 is inclined and inserted through opening 126 of deck tray 122. After the lower end 124 of the riser 112 is placed within opening 126, retainer member 118 is raised and bubble cap assembly 110 clamped in position by driving the wedge portion of locking means 120 into slot 148 to the position shown in Figure 3. A readily understood reversal of these steps will permit disassembly from the upper side only of the deck for cleaning or replacement.

Referring specifically to Figure 4, therein is depicted a preferred embodiment of the dispersion plate of the present invention. Dispersion plate 158 is provided with a centrally located opening 160 for the passage therethrough of the retainer member 118. Plate 158 further includes a plurality of openings 162. The number and size of openings 162 are such as to provide a substantial reduction in cross sectional flow area for the liquid-vapor passing through riser 112. Typically, the cross sectional flow area provided by openings 162 will be from 2 to 75 percent, generally from 5 to 85 percent and preferably from 10 to 40 percent of the internal cross sectional area passageway 132 of riser 112. The purpose of openings 162 is, of course, to ensure that the two phase liquid-vapor feed entering the upper portion of riser 112 will pass in close proximity to one another through the reduced size openings to effect a shearing of the liquid by the vapor and produce a mist flow.

The shape of openings 162 may vary. The openings may be round, square, rectangular or the like. The best results have been obtained through the use of slots in a radial pattern as depicted. The slots also may be straight, forming a square or rectangular pattern. The width of the

slot may vary depending upon numerous variables including physical properties of the liquid, gas, flow rates, temperature and permissible pressure drop among other things. Generally, slots 162 will have a width of from about 1/16 to 1 inch, preferably from 1/8 to 1/2 inch, and most preferably from about 3/16 to 1/4 inch for most applications wherein a liquid hydrocarbon is treated with a gaseous hydrocarbon. The length and number of openings 162 will be selected to ensure a pressure drop which will both produce the desired mist flow and not be excessive for use in the selected system. Generally, the desired mist flow can be obtained across openings 162, which are usually selected to produce a pressure drop within the range from about 0.1 to 50 inches of water. A preferred pressure drop is within the range from about 0.5 to 15 inches of water and most preferred is in the range of from 1 to 10 inches of water.

It will be noted that dispersion plate 158 has downwardly and outwardly projecting tab members 164 on the outer openings. The function of tab members 164 is to divert the mist flow radially outward from the center of dispersion plate 158 to cover a greater area of contact material. The inner openings 162 are not provided with such tab members. The reason for this is to ensure that an adequate portion of the mist flow will pass downwardly and impinge upon that portion of the contact material located directly beneath the dispersion plate. An advantage of the present invention is that tab members 164 can readily be formed as an integral portion of dispersion plate 158. This is accomplished by not shearing off both sides of the openings 162 when those openings are formed. In a similar manner, of course, the inner openings are sheered on both sides to remove any projections which would divert fluids flowing therethrough. Obviously, tab members could be added to plate 158 by welding, riveting, or the like; however, such fabrication methods would increase the cost without any significant added benefit.

During the practice of the invention it has been found that there are certain criteria which will ensure optimum mist flow exiting from dispersion plate 158. Specifically, if the aperture sizes, pressure drop, and

materials are selected to ensure that the following conditions are met:

$$Re_v > 1.2 \times 10^6 / Re_l^{0.8} \text{ -----(1)}$$

where

- 5 $Re_v = G_v D_e / \mu_v = \text{Reynolds Number of vapor}$
 $Re_l = G_l D_e / \mu_l = \text{Reynolds Number of liquid}$
 G_l mass velocity of liquid, lb/hrft²
 G_v mass velocity of vapor, lb/hrft²
 D_e 4 x cross flow area / wetted perimeter
10 μ_l liquid viscosity, c.p.
 μ_v vapor viscosity, c.p.

Another flow parameter which may be used to ensure optimum mist flow is determinable by the equation:

$$G_v / \lambda = 22,000 \times (\Psi \lambda G_l / G_v)^{-0.43} \text{ -----(2)}$$

15 where

- $\lambda = [(\rho_v/0.075)(\rho_l/62.3)]^{0.5}$
 $\Psi = (73/\sigma)[(\mu_l(62.3/\rho_l)^2)]^{0.33}$
 σ = Surface tension of liquid, dynes/cm
 ρ_l = Liquid density, lb/ft³
20 ρ_v = Vapor density, lb/ft³

In a typical commercial hydroprocessing reactor the range of G_v / λ should be in the range of from 5,000 to 30,000, and preferably from 10,000 to 20,000.

25 Having fully described the invention and what is now considered to be its best mode, the invention is not to be limited to the details hereinabove set forth; rather, it should be interpreted in accordance with the spirit and scope of the appended claims.

Claims

1 1. A bubble cap assembly comprising:
2 a conduit defining a passageway for fluids,
3 said conduit having an entry opening to the passageway and an
4 exit opening from the passageway;
5 a bubble cap located over the entry passageway
6 of the conduit, said bubble cap having a top portion, a
7 downwardly extending skirt portion, and an opening located in
8 the top portion;
9 a dispersion plate, located adjacent the exit
10 opening of said conduit, having a plurality of openings
11 therethrough, said openings providing the sole means for fluid
12 to exit said conduit;
13 spacer means for maintaining a gap between the
14 exit opening of the conduit and the bubble cap and;
15 locking means for affixing the bubble cap
16 assembly to a deck tray.

1 2. A bubble cap assembly as defined in claim 1
2 wherein said openings in the dispersion plate are in the form
3 of elongated slots.

1 3. A bubble cap assembly as defined in claim 2
2 wherein said slots have a width of from 1/16 to 1 inch.

1 4. A bubble cap assembly as defined in claim 1
2 wherein the number and size of said openings in said
3 dispersion plate are selected to provide a cross sectional
4 flow area of from 2 to 80% of that of the riser.

1 5. A bubble cap assembly as defined in claim 3
2 wherein the length and number of slots provide a cross
3 sectional flow area of from 2 to 80% of that of the riser.

1 6. A bubble cap assembly as defined in claim 2
2 wherein a portion of the slots are provided with tab members
3 adjacent a down stream surface of the dispersion plate.

1 7. A bubble cap assembly as defined in claim 6
2 wherein the tab members are formed from the dispersion plate.

1 8. A bubble cap assembly for attachment to a deck
2 tray having an opening therethrough comprising:

3 a riser having an end for location over the
4 opening, an opposite end, and a fluid passageway extending
5 therebetween;

6 a bubble cap located over the opposite end of
7 the riser, the bubble cap having a top portion, a downwardly
8 extending skirt portion and an opening located in the top
9 portion;

10 spacer means located intermediate the riser and
11 bubble cap for maintaining a fluid flow path therebetween;

12 a retainer member disposed within the
13 passageway in the riser and having: (1) a lower end portion
14 for engaging a lower surface of the deck tray; (2) a stem
15 portion connected to the lower end portion and extending
16 upwardly to the opening in the bubble cap; and (3) an upper
17 end extending through the bubble cap;

18 a dispersion plate located adjacent the lower
19 end of the fluid passageway of the riser, said plate having
20 a plurality of openings, said openings providing the sole
21 means for fluid flow through said passageway, and a
22 substantially centrally located opening in the dispersion
23 plate for the passage therethrough of the stem portion of the
24 retainer member; and

25 locking means for urging the bubble cap, spacer
26 means and riser, and the lower end portion of the retainer
27 member together.

1 9. The assembly of claim 8 wherein the openings
2 in the dispersion plate are sized to produce a pressure drop
3 of from 0.5 to 15 inches of water.

1 10. The assembly of claim 8 wherein each of the
2 plurality of openings in the dispersion plate are in the form
3 of elongated slots.

1 11. The assembly of claim 10 wherein the slots have
2 a width of from 1/8 to 1/2 inch.

1 12. The assembly of claim 8 wherein the total cross
2 sectional flow area of the openings in the dispersion plate
3 is from 10 to 40 percent of the flow area of the riser.

1 13. The assembly of claim 12 wherein the openings
2 in the dispersion plate are elongated and extend substantially
3 radially about the center of the riser.

1 14. The assembly of claim 13 wherein said slots
2 have a width of from 3/16 to 1/4 inch, and the length and
3 number of slots to provide a pressure drop across the
4 dispersion plate of from 1 to 10 inches of water.

1 15. A method of forming a mist flow of a gas and
2 liquid comprising using the bubble cap assembly of claim 8.

1 16. The method of claim 15 wherein the number and
2 size of openings in the dispersion plate, and the flow rate
3 of the liquid and gas produce a pressure drop of from 3 to 20
4 inches of water.

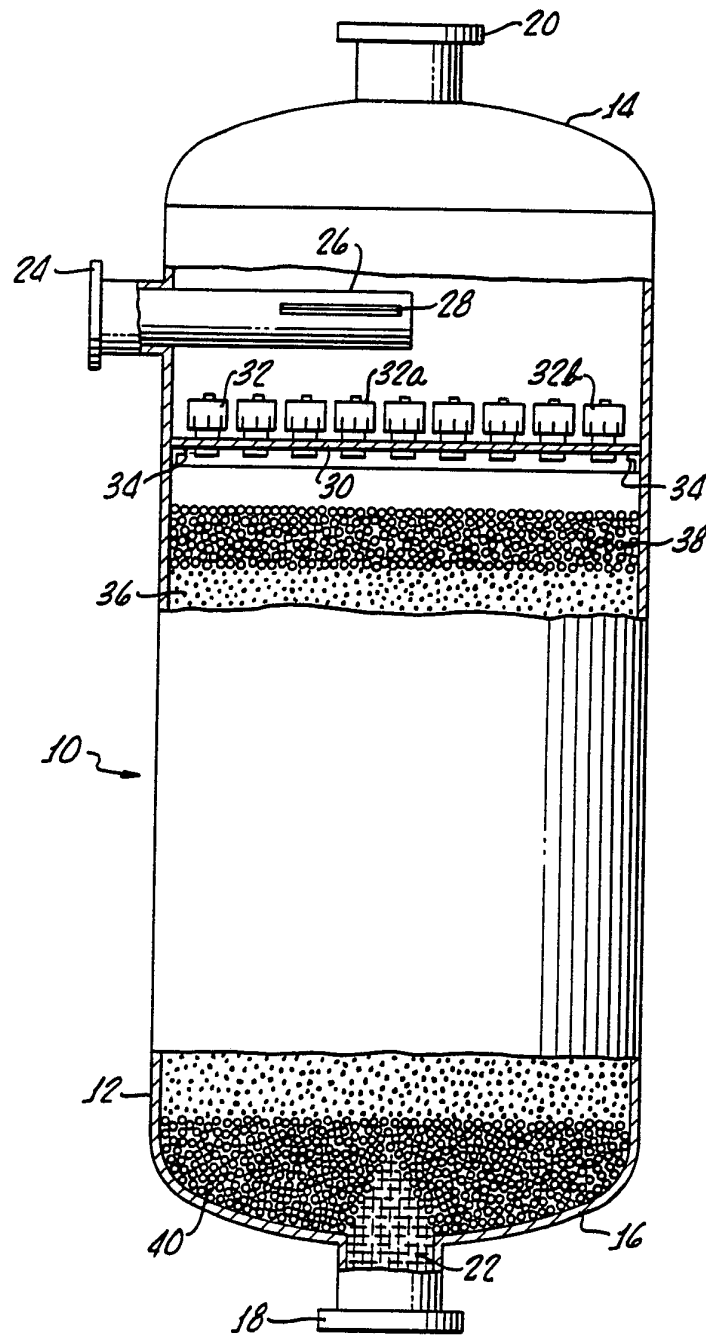
1 17. The method of claim 15 wherein the openings in
2 the dispersion plate are elongated slots.

1 18. The method of claim 16 wherein the gas and
2 liquid are passed through the dispersion plate at a rate
3 sufficient to produce a pressure drop of from 5 to 10 inches
4 of water.

1 19. The method of claim 15 wherein G_v/λ is in the
2 range of from about 5,000 to 30,000.

1 20. The method of claim 18 wherein Re_v is greater
2 than $1.2 \times 10^6 / Re_l^{0.8}$, wherein Re_v and Re_l are the Reynolds
3 numbers of the gas and liquid, respectively.

1/2

*FIG. 1.*

SUBSTITUTE SHEET

2/2

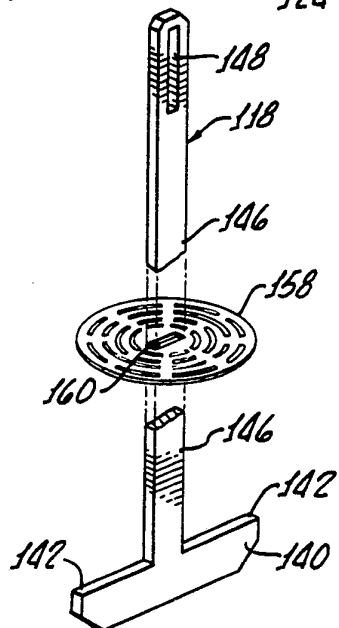
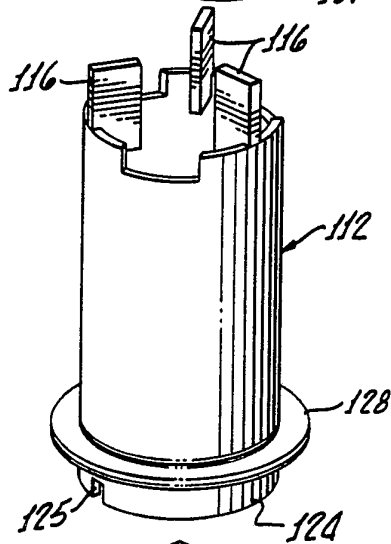
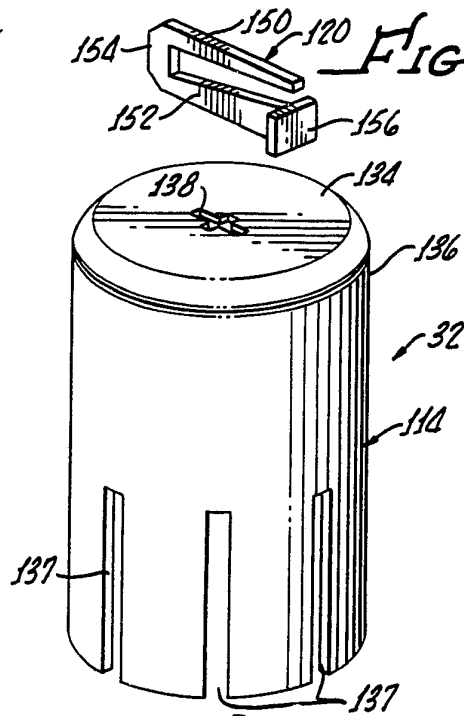


FIG. 2.

FIG. 4a.

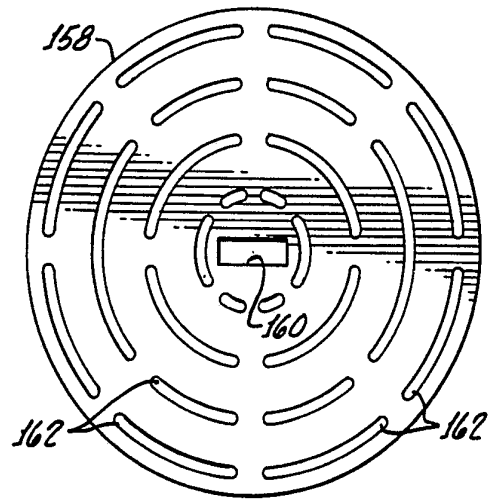


FIG. 4b.

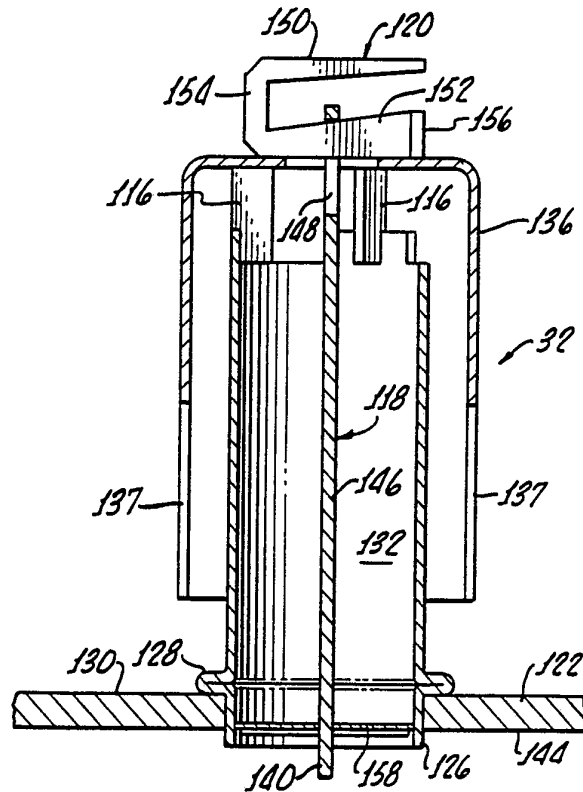


FIG. 3.

INTERNATIONAL SEARCH REPORT

PCT/US 92/02584

International Application No

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)⁶

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl. 5 B01D3/20; B01D3/00; B01J8/02

II. FIELDS SEARCHED

Minimum Documentation Searched⁷

Classification System	Classification Symbols
Int.Cl. 5	B01D ; B01J ; F28F

Documentation Searched other than Minimum Documentation
to the Extent that such Documents are Included in the Fields Searched⁸III. DOCUMENTS CONSIDERED TO BE RELEVANT⁹

Category ¹⁰	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³
A	GB,A,788 075 (MONSANTO CHEMICALS LIMITED) 23 December 1957 see page 2, line 89 - line 111; figures ---	1,8
P,A	DE,A,4 110 192 (TECHNISCHE HOCHSCHULE ZITTAU) 16 January 1992 see the whole document ---	1,4,8
A	FR,A,1 435 218 (UNION OIL COMPANY OF CALIFORNIA) 7 March 1966 see page 8, paragraph 2 ---	15
A	US,A,1 915 746 (HAROLD MOORE) 27 June 1933 see figures 1,2 ---	2,10

¹⁰ Special categories of cited documents :

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IV. CERTIFICATION

Date of the Actual Completion of the International Search

25 AUGUST 1992

Date of Mailing of this International Search Report

07. 10. 92

International Searching Authority

EUROPEAN PATENT OFFICE

Signature of Authorized Officer

VAN BELLEGHEM W.

ANNEX TO THE INTERNATIONAL SEARCH REPORT
ON INTERNATIONAL PATENT APPLICATION NO. US 9202584
SA 61311

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information. 25/08/92

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
GB-A-788075		None	
DE-A-4110192	16-01-92	None	
FR-A-1435218		None	
US-A-1915746		None	