Nov. 27, 1956 H. J. HIBSHMAN ET AL 2,772,081

VAPOR-LIQUID CONTACTING APPARATUS

Filed March 6, 1951 3 Sheets-Sheet 1

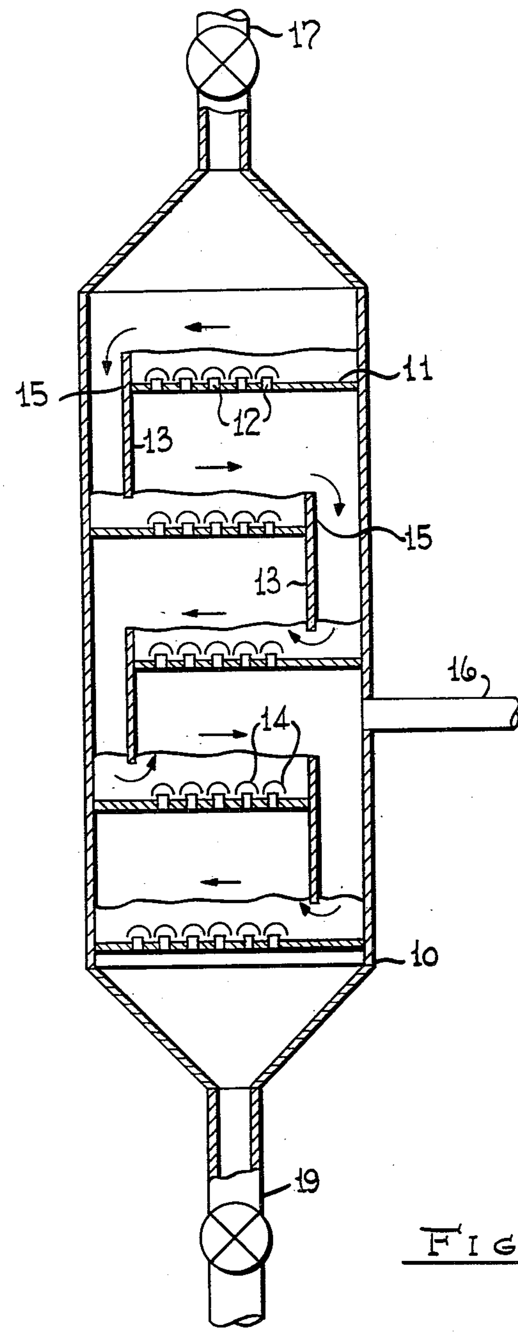


FIG.-1

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VAPOR-LIQUID CONTACTING APPARATUS

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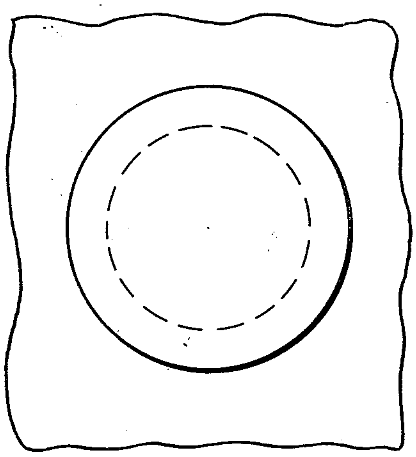

FIG.-3

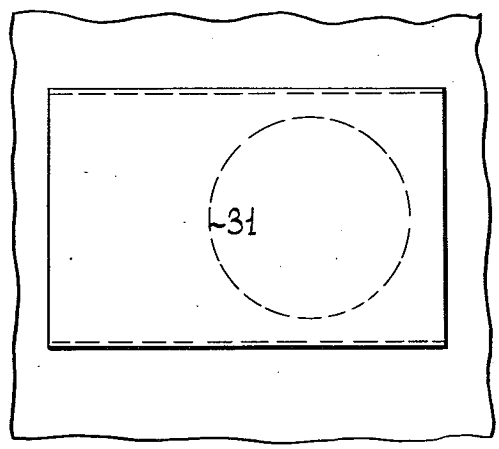


FIG.-5

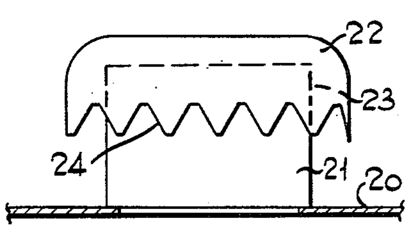


FIG.-2

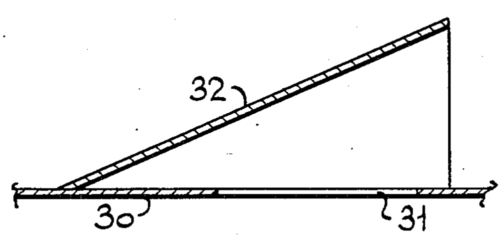


FIG.-4

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VAPOR-LIQUID CONTACTING APPARATUS

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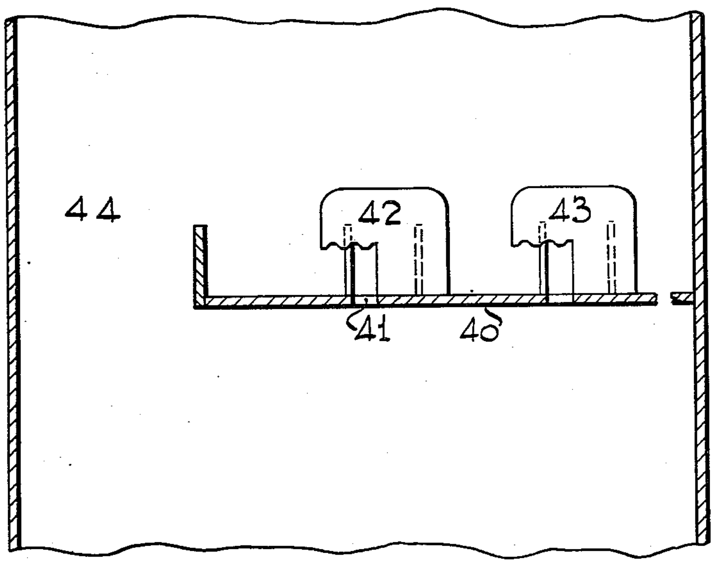


FIG.-6

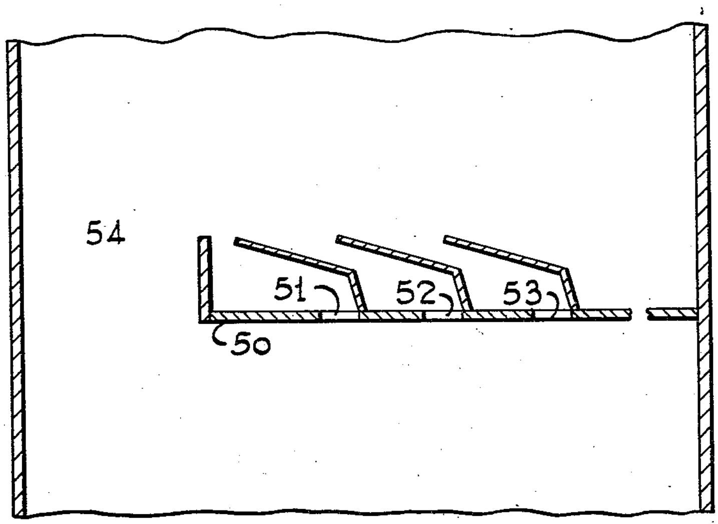


FIG.-7

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# VAPOR-LIQUID CONTACTING APPARATUS

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Application March 6, 1951, Serial No. 214,076

1 Claim. (Cl. 261—114)

The present invention is concerned with an improved apparatus for operating a countercurrent-vapor-liquid treating zone. The invention is more particularly concerned with an improved fractionation zone and is especially directed to apparatus for contacting upflowing vapor and downflowing liquid utilizing contacting trays or their equivalent. In accordance with the present invention, the capacity of a tray and the entire treating zone is markedly increased by providing apparatus for efficiently and readily contacting the countercurrent flowing phases. In accordance with the present invention, a directional vapor stream is produced on the respective trays which facilitates the passage of the downflowing liquid across the tray, thus reducing liquid holdup on the tray.

It is well known in the art to carry out many chemical reactions and separations wherein vapor and liquid are contacted in a countercurrent manner, such as in a hydrocarbon fractionation zone. Normally the liquid passes from one zone to a lower zone by means of downcomers or their equivalent while the vapors pass upwardly from zone to zone through chimneys in the tray, around various types of bell caps into the liquid phase disposed on the top of the tray. The liquid phase passes from zone to zone over weirs on the respective trays into downcomers and passes onto the tray in the zone below. The height of the liquid phase on the tray is determined by the height of the weir. The downcomer from the zone above must of necessity extend below the top of the liquid phase on the tray.

In liquid-gas contacting operations of this character, the capacity of the tray to a large extent is determined by the degree to which the downflowing liquid can be moved across the tray.

Aside from limitations of auxiliary equipment such as furnaces, feed pumps, and condensers, the capacity of a fractionation tower may be limited by any of several factors. Basically, these are limitations to passage of liquid down and vapor up the tower in such a manner that efficient contacting is achieved.

The requirement of efficient contacting means that the limitation may be one of too rapid or free passage of one or more of the phases through the tower, as well as restrictions to flow of the phases. Tray dumping, liquid running down through bubble cap chimneys, is an example of too free flow of liquid. Downcomer filling with backup of liquid on the tray is the opposite type of limitation, resulting in poor efficiency because of excessive entrainment and ultimately in tower flooding. A similar high entrainment effect is produced by excessive vapor rates. In a typical bubble cap tower, each of these limitations predominates over a different vapor rate range.

One operating disadvantage comprises excessive liquid holdup which, in the absence of a downcomer limitation and obstructions on the tray, is determined by the linear velocity at which liquid is able to pass across the tray. For a given liquid velocity across the tray the liquid holdup is directly proportional to the volume of liquid flowing across the tray in a unit of time. Since the liquid on the tray is "aerated" by the vapor, the volume occupied by the liquid is proportional to the velocity of vapor in the tower and the amount of liquid holdup on the tray. At normal tray spacings a tower will ultimately be limited in capacity by the liquid flow approaching the tray above, resulting in excessive entrainment. Accordingly, higher capacities can be reached if the liquid holdup is reduced. Reduced holdup can be accomplished by the present invention which directs the vapor stream through the trays in such a manner as to push liquid across the tray at a faster rate.

In accordance with the present invention liquid holdup on the respective trays is prevented by providing concurrent flow of vapor and liquid across the tray. In other words, a directional flow of vapors is provided in order to increase the velocity of the liquid flowing across the trays, thus preventing liquid holdup.

The present invention may be readily understood by reference to the drawings illustrating embodiments of the same. Figure 1 illustrates a typical bubble cap tray fractionation zone. Figure 2 illustrates a typical bubble cap chimney and bubble cap, while Figure 3 is a top view of the same. Figure 4 illustrates a typical "lean-to device," while Figure 5 is a top view of the same. Figure 6 illustrates a portion of a tray wherein conventional bubble caps are partially blanked off, while Figure 7 illustrates a "Venetian blind type" of directional device.

Referring specifically to Figure 1, the numeral **10** designates a bubble cap tray column, contacting vessel. The vessel **10** is conventionally provided with a series of vertically spaced, transverse, perforated plate elements **11**, forming a vertical series of superimposed, contact chambers or zones. These chambers or zones are in communication one with another by way of the passageways **12** formed by the plate perforations, and downcomers **13** disposed at alternate sides of the vessel from plate to plate. The downcomers extend from the surface of one plate downwardly into vertically spaced relation to the surface of the plate next below. As shown in Figure 1, the passageways **12** through the plate are each provided with bubble cap elements **14**. In addition, each plate **11** is provided with a weir member **15**, at the entrance to the downcomer **13**, extending upwardly from the plate surface to a level above the lower end of the downcomer from the plate next above. The vessel is also provided with a feed line **16**. An outlet from the vessel for gaseous materials is provided as by conduit **17**. At the lower end of the vessel is an outlet **19** for heavier materials. In operation, it is to be understood that any number of trays may be utilized. In accordance with the present invention, for the purpose of description, it is assumed that a vaporous feed is introduced at an intermediate point of fractionating zone **10** by means of line **16**. Temperatures and pressures are adjusted so that vapors flow upwardly in zone **10** through the chimneys **12** and around bubble caps **14** into a liquid maintained on the top of the plate, the height of which is determined by weir **15**. The liquid phase on the plate comprises dissolved or condensed constituents of the vaporous feed introduced by means of line **16**. Vapors flow through the liquid phase on the top of each plate from the zone below through the chimneys and around the bell caps into the liquid disposed on the top of the plate, the height of which is determined by weirs.

Referring specifically to Figure 2, illustrating a conventional bubble cap, the vapors flow upwardly through chimney **21** on plate **20**, around the upper lip **23** of the chimney and down around the skirt **24** of bell cap

22 into the liquid phase maintained on the top of plate 20. Figure 3 is a top view of the conventional bubble cap.

Figure 4 illustrates a bubble cap or equivalent means for securing the directional flow of vapors as they flow upwardly from one plate to another. These vapors flow upwardly through a hole 31 in plate 30 into a lean-to baffle 32. The baffle resembles a lean-to with vertical side, open in front and faces the downcomer. Figure 5 is a top view of the lean-to baffle of the present invention.

Figure 6 shows two conventional bubble caps, half of which are blanked off with the opening in the direction of the downcomer. Vapors flow upwardly through chimneys 41 in plate 40, around the half-open skirt of bubble caps 42 and 43 into the liquid phase maintained on top of plate 40. Thus, the liquid and upflowing vapors flow concurrently, transversely, across plate 40 in the direction of the downcomer 44.

Figure 7 illustrates a "Venetian blind type" of tray. Vapors flow upwardly through holes 51, 52 and 53 in plate 50. These vapors then pass directionally in concurrent flow with the liquid flowing transversely across the plate in the direction of downcomer 54.

Another advantage of the present invention is connected with reduced tray inlet liquid heads. In a normal bubble cap tray there is a tendency for liquid to build up to a higher level at the inlet side of the tray than anywhere else on the tray. It has been found that the use of lean-to type baffles in place of bubble caps produces the opposite effect. In this case, the inlet head is lower than anywhere else on the tray. The baffles consist of sheet metal lean-to's with vertical sides with the open end facing the downcomer. In order to reduce the inlet head and prevent tower flooding due to premature downcomer filling, it is only necessary to have the first row or two of bubble caps and chimneys replaced with these lean-to type baffles. The rest of the tray may have Venetian blind type baffles.

Studies in a three tray vertical half section of a ten foot diameter distillation tower have shown that tower capacities may be increased as much as 41% by the use of lean-to type baffles in place of conventional bubble caps and chimneys. The baffles employed consisted of sheet metal lean-to's with vertical sides attached to the tray by conventional bubble cap tie-down bolts with the open end facing the downcomer. This design produced a directional vapor stream which facilitated the passage of the liquid across the tray, thus reducing liquid holdup on the tray. It has also been found that it may be beneficial to completely blank off the holes left by removal of bubble caps immediately adjacent to the downcomer. In this case, the action of the directional air stream produced by the lean-to baffles in conjunction with the curved side of the tower acts as a centrifugal device to throw out and deaerate liquid from the vapor stream.

The design of the lean-to baffles is not critical. Hemispherical baffles open on one side towards the downcomer, square or rectangular box-type baffles open towards the downcomer; elbow-type baffles and similar devices may be used. A simple and effective arrangement may be fabricated by punching plate trays to provide the required openings, leaving flaps of metal adjacent each opening inclined to direct vapors to the downcomer.

The baffles may be equipped with slots on their open ends and they may have holes or clearance with the tray floor on the sides other than that facing the downcomer. However, they must produce a directional vapor stream leaving the tray in the direction of the downcomer.

Studies in a three-tray vertical half section of a ten foot diameter bubble cap tower have shown that capacity may be increased as much as 21% when using directional baffles on standard bubble caps. The baffles used consist of a rectangular piece of sheet metal, curved to cover one half of the circumference of a standard bubble cap. The baffle is of such a size that it covers the entire slot area and extends down to the tray floor. With these baffles installed on the upstream side of all the bubble cap on a standard fifty-six bubble cap half-section tray, the capacity in it was increased 21% when using an enlarged downcomer. Although the baffles used in this work covered one-half of the bubble cap circumference, other lengths of baffles may be used. The baffle sizes should be determined by that giving the greatest directional effect to the vapor and liquid on the tray while effecting the least increase in tray pressure drop. The baffle may be attached to the bubble cap either by means of appropriate circumferential clamps, tack-welding or appropriate clips which engage the bubble cap slots as the baffle is slipped over the bubble cap.



It is a frequent occurrence that production is limited in refinery operations by distillation tower capacity. The limitation is often in the distillation tower itself as contrasted to auxiliary equipment such as furnaces, heat exchangers and pumps. When feed stock is available, there is a very attractive incentive in increased production of high profit incremental product through increased tower capacity.

Studies in a three-tray vertical half section of a ten foot diameter distillation tower have shown that increase in capacity results from removal of conventional bubble caps and chimneys and substitution of Venetian-blind baffles on the tray. The baffles consist of rectangular strips of sheet metal approximately 10 inches wide. These are positioned above the holes in the tray exposed by removal of the bubble caps and chimneys so that the baffles run across the tower perpendicularly to the direction of liquid flow across the tray. The baffles are arranged like an almost closed Venetian blind so that sufficient velocity and pressure drop are obtained so that essentially no liquid flows down through the baffles, and tray dumping is avoided. The distance between the overlapping portion of the baffles is from about one half to one inch. The baffles may be curved or bent and may contain slotted, corrugated, or grooved edges and surfaces.

What is claimed is:

Apparatus particularly adapted for fractionation comprising a vertical tower containing a plurality of horizontally disposed vertically spaced plates extending substantially across the tower intersecting vertically positioned conduits extending through each of said plates terminating above and below each plate, in which the said plates are provided with a large number of perforations distributed over a substantial portion of their area, and lean-to means associated with each of said perforations, said lean-to means being fixed to said plate and inclined upwardly towards the said conduit associated with and extending downwardly from each plate, said lean-to means being further characterized by having side closure members joined to said lean-to means and extending downwardly to the said plate adjacent to the perforation provided in the plate, said lean-to means being still further characterized in that the lean-to member covers a substantially greater area than the area of the corresponding perforation.


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