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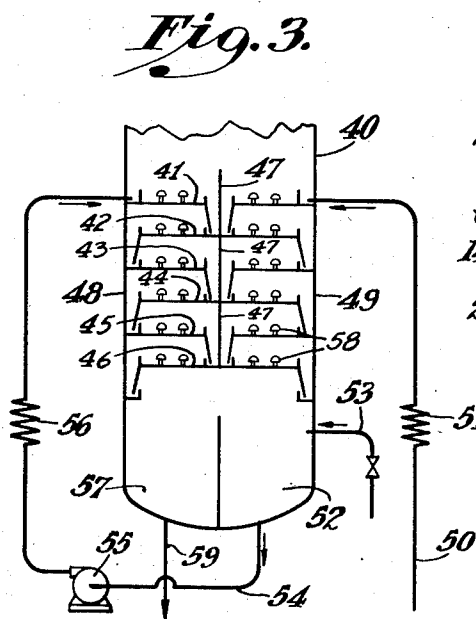
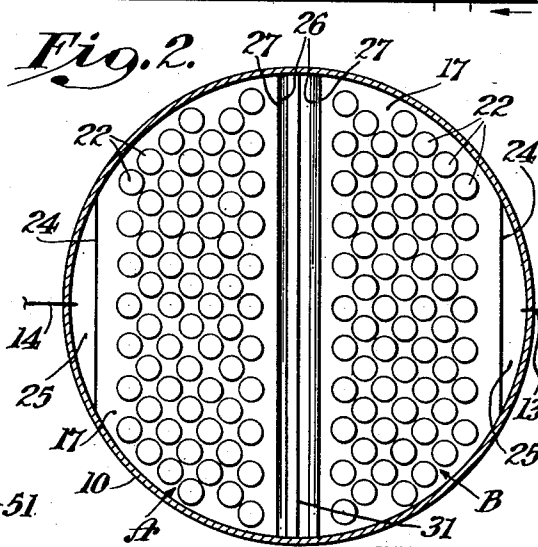
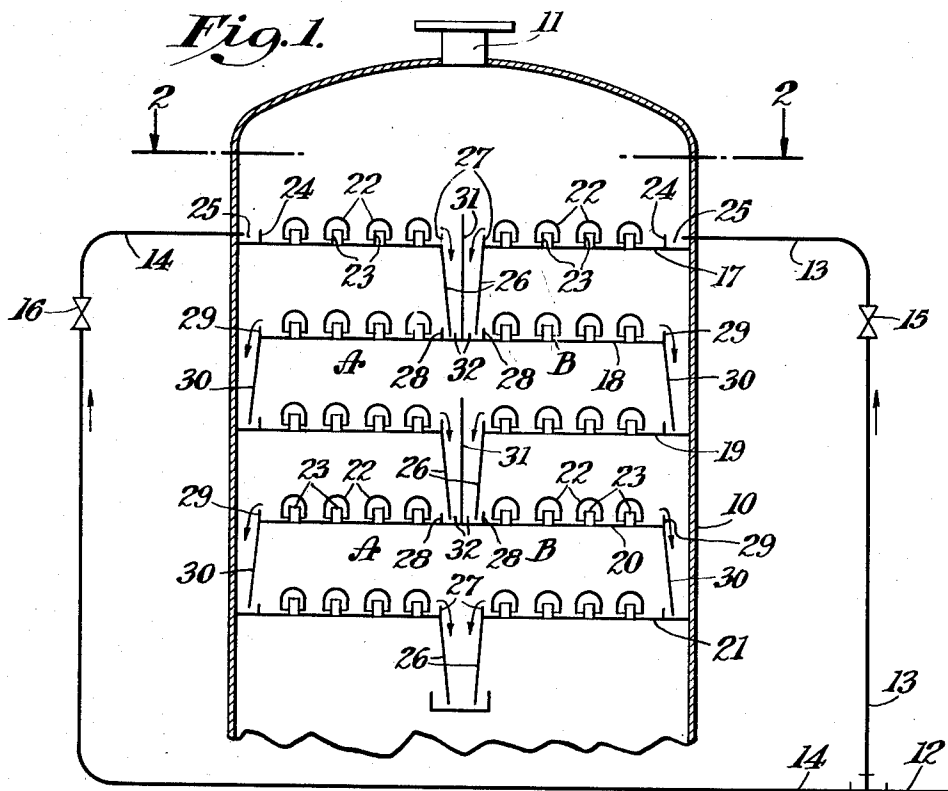
D. G. REYNOLDS

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VAPOR-LIQUID CONTACT APPARATUS

Filed Oct. 11, 1950

2 Sheets-Sheet 1



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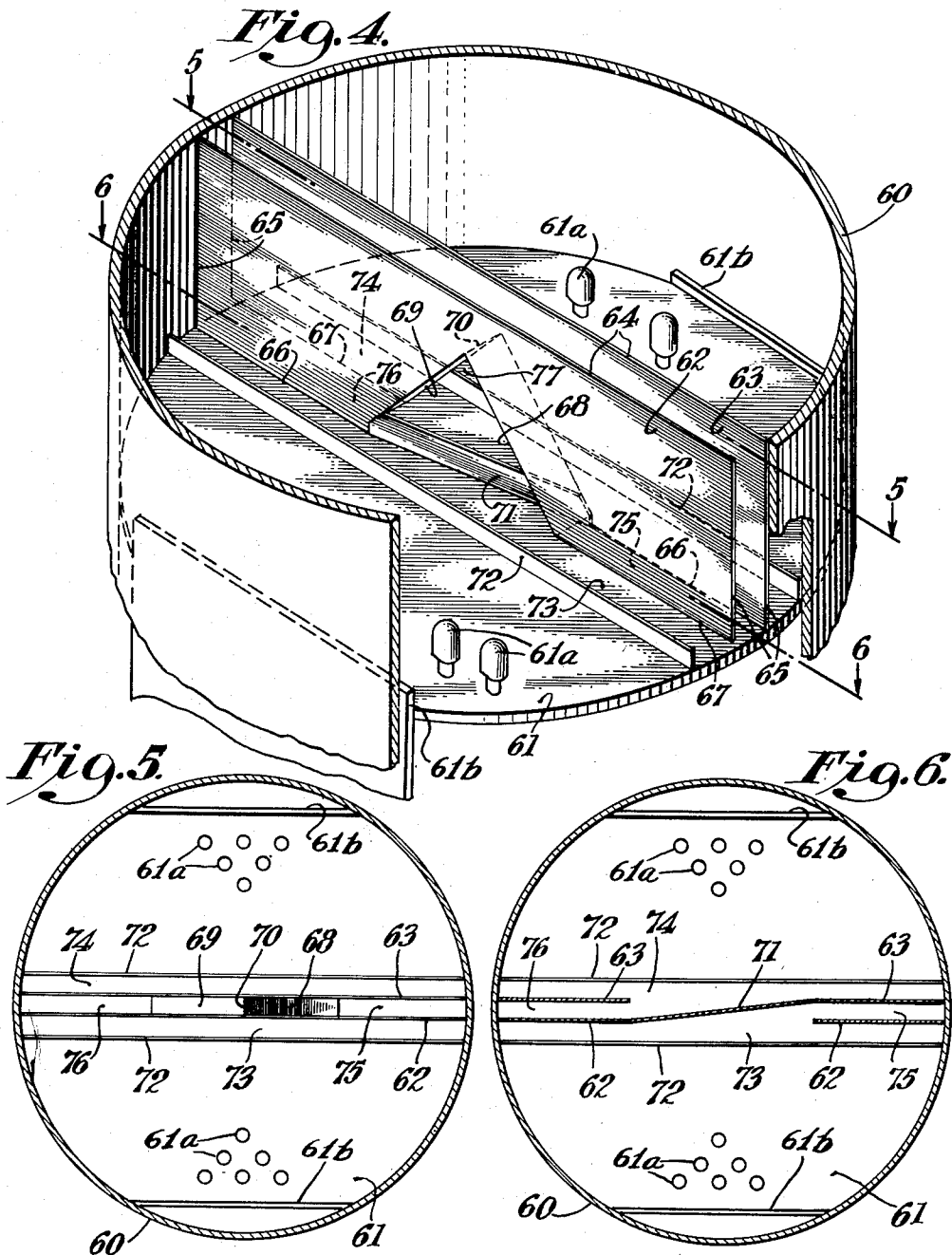
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VAPOR-LIQUID CONTACT APPARATUS

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5 Claims. (Cl. 261—114)

This invention relates to vapor-liquid contact apparatus and more particularly to a unique downcomer structure which is most advantageously used in combination with double cross-flow decks in larger diameter towers.

It is a general object of this invention to provide the proper hydraulic balance on a large deck and to thereby insure proper liquid distribution over the deck.

A second object is to provide a means whereby separate liquid streams may be individually and separately guided downwardly through the decks of a distillation tower.

A third object of my invention is to alter the design of multiple fractionating decks to assure even liquid and vapor distribution, thereby greatly improving the efficiency of the decks.

An additional object is to permit the easy fabrication of internal stripping sections in large diameter towers.

Other and further objects and features of the invention will be apparent to those skilled in the art on a consideration of the accompanying drawings and following specification wherein are disclosed several exemplary embodiments of the invention with the understanding that such modifications may be made therein as fall within the scope of the appended claims without departing from the spirit of the invention.

Fig. 1 is a vertical central section through a tower having decks constructed in accordance with the present invention.

Fig. 2 is a horizontal section taken on line 2—2 of Fig. 1 and looking downwardly as indicated by the arrows.

Fig. 3 is a vertical central section through a tower having a modified form of my invention.

Fig. 4 is a perspective view with parts in section of a modified form of my invention.

Fig. 5 is a horizontal section taken along lines 5—5 of Fig. 4.

Fig. 6 is a horizontal section taken along lines 6—6 of Fig. 4.

It is generally recognized that the flowing liquid gradient across a fractionating column deck increases as the diameter of the tower increases because of the length of the liquid travel. The effect of this gradient is to permit uneven vapor flow through the decks because of the unequal liquid head at opposite sides of the deck. This effect is generally compensated for by the use of double cross-flow decks with two parallel flow liquid streams or multiple flow decks with multiple parallel liquid streams in larger towers. A double cross-flow deck is characterized by the admission of liquid to opposite ends of an upper deck, and its passage toward the center of this upper deck to a downcomer which carries the liquid to a central reservoir on the next lower deck. Thus it can be seen that since the liquid will generally flow only half-way across the diameter of the tower, there will be a correspondingly lower difference in liquid head between opposite ends of the liquid path. Multiple liquid flow towers are a substantial improvement over the single cross-flow decks but have led to inefficiencies caused by unequal liquid distribution between the various liquid flow streams. Unless the liquid down flow and rising vapor streams are divided proportionately, inefficient and imperfect contact will result, reducing the deck efficiency.

Fig. 1 shows a double-cross flow deck constructed in accordance with one embodiment of my invention in which the number 10 represents a shell of a bubble tower having a vapor off-take 11, and a reflux conduit 12.

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Conduit 12 is divided into two lines 13 and 14 controlled respectively by valves 15 and 16. Lines 13 and 14 feed to opposite sides of the top deck 17 of the tower 10. The decks 17, 18, 19, 20 and 21 each bear one or more bubble caps 22 and their associated risers 23 in each liquid flow stream. In the arrangement shown the tower may be best described as made up of a plurality of pairs of decks, it being apparent that the physical structure of the pair 17 and 18 is identical to that of the pair 19 and 20 etc. It is convenient to arbitrarily refer to deck 17 as the upper and deck 18 as the lower deck of the pair.

Upper deck 17 has weirs 24 which form reservoirs 25 at opposite ends of the deck. At the center of deck 17 is a central downcomer structure including a pair of upstanding downcomer plates 26, each surmounted by a weir 27 the purposes of which is to maintain a liquid level on the deck 17. The downcomer plates 26 extend downwardly to a point adjacent to the next lower deck 18. The weirs 28 on deck 18 are laterally spaced from the lower edge of the downcomer plates 26. Deck 18 bearing a plurality of caps 22 and risers 23, has at its opposite outer edges, two upstanding weirs 29 each surmounting a lateral downcomer 30. At the center of deck 18 there is mounted an upstanding plate 31 secured in liquid tight relationship to the deck 18 and extending upwardly within the confines of the downcomer i. e. between the downcomer plates 26. This plate 31 divides the lower deck 18 into two separate liquid compartments.

The nature of hydraulic unbalance which exists in a standard cross-flow tower without a means of dividing the liquid downflow may be briefly described by reference to Fig. 1. The decks in such a tower will not normally contain the improved downcomer of Fig. 1 but may contain much of the other structure. Reflux liquid to deck 17 can be split equally by the reflux distributor including pipes 12, 13 and 14 and valves 15 and 16. It has been observed that due to disturbances in the flow arising from external circumstances the distribution of liquid from the liquid reservoir in the central downcomer may be uneven. It is then possible to have a much greater liquid flow over side A of deck 18 than is found over side B. This results in all of the vapor passing through side B due to the lower pressure drop therein.

To illustrate more clearly the undesirable conditions which occur on decks 19 and 20 when the hereinbefore disclosed invention is not used, we adopt the following notation:

P_1 = pressure of vapor below deck 20. This is the same under side A and side B.

P_2 = pressure of vapors above deck 20, side B.

P_3 = pressure of vapors above deck 19, side A and side B.

P_4 = pressure of vapors above deck 20, side A.

Assume a pressure drop of 6" of downflow liquid through decks 19 and 20, $P_1 - P_3 = 6"$. The pressure drop of the vapor flowing through side B would be divided approximately equal so that $P_1 - P_2 = 3"$ and $P_2 - P_3 = 3"$. However this is not true of side A. Although the same pressure differential exists through either side of decks 19 and 20 together, a larger portion of the differential could be taken in the liquid over the bubble caps on deck 19, side A. This will give a condition where $P_4 - P_3$ is less than 3" and $P_1 - P_4$ is greater than 3". For example, if $P_4 - P_3 = 2"$, then $P_1 - P_4 = 4"$ will satisfy the pressure conditions between $P_1 - P_3 = 6"$. The pressure existing above side A and side B of deck 20 is then such that the pressure, P_2 , in side B is 1" greater than the pressure P_4 , in side A. In this case, a 1" liquid differential could exist over the inlet weirs to deck 20, that is, inlet weir to side A would have a 1" head whereas side B could have no flow.

The pressure drop through deck 19, side A ($P_4 - P_3$), will be determined by the head of liquid over the top of the bubble cap slots. Very little vapor would come through side A; only that vaporized by heat transfer through the deck would pass upwardly. This would not create any noticeable pressure drop through the bubble decks in deck 19, side A.

Once this unequal flow started, it would continue down the column, thereby preventing the decks from operating

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with equal and efficient vapor-liquid contact thereby greatly reducing the desired efficiency.

To insure perfect tray hydraulics and adequate liquid submergence of the bubble cap, my improved downcomer has been placed as shown in Fig. 1. It is liquid tight and is sufficiently high to prevent liquid from opposite sides of the deck from mixing. It is generally as high as the liquid on the deck and may be higher. By means of this baffle, liquid may be kept separated in the various sides of the tower thereby insuring a controlled, even flow distribution. This method and apparatus is also adapted to trip and quadruple cross-flow decks.

Fig. 3 shows how this invention may be used to incorporate separate stripping section into a standard distillation tower. Tower 40 has decks 41, 42, 43, 44, 45, 46, etc., constructed in similar fashion to those of Fig. 1, and provided with bubble caps 58. Each of the decks is divided into two parts by a central upstanding plate 47 which extends from the bottom of a lower deck 46, upwardly within the confines of the central downcomer, past the next upper deck 45, and to the under part of the deck 44. Thus the tower 40 is divided into two independent sections: one section 48 and a separate section 49. These sections are separate from one another and may have independent and separate liquid downflow streams of different compositions and independent and separate vapor streams of different compositions.

To illustrate, oil feed to the tower 40 may be admitted through line 50 after having passed through heater 51. The oil descends through the decks of the separate section 49 to the tower bottom 52 where it is separately collected. Steam may be admitted through line 53. Stripped liquid is reboiled in the circuit including line 54, pump 55 and reboiler 56 and is returned to the tower above section 48. It then passes downwardly to chamber 57. Chamber 57 and chamber 52 are separated by partition 58 which may be extended to the under side of deck 46 if desired. Reboiled liquid is removed from the tower through line 59, which may be interconnected with line 54 if circulating reboiling is desired.

In Fig. 4 the tower 60 has a liquid dividing means resting on a lower deck 61 and bounded by the downcomer structure. Deck 61 is provided with outer downcomers 61b and a plurality of bubble caps 61a. The downcomer is made up of upstanding central downcomer plates 62 and 63 which are substantially identical. Each of these plates extends from lower deck 61 upwardly to the bottom of the next upper deck, not shown. Plate 62, for example has a substantially straight upper edge 64, and substantially straight side edges 65. One end 66 of the lower edge of the plate 62 is secured in liquid tight manner to deck 61. The other end 67 is raised above the deck 61 so that a passageway is formed between the plate and the deck. The raised end 67 of plate 62 is opposed to the lower end 66 of plate 63.

Plates 62 and 63 are joined at their midsection by divider plates 68 and 69 having an apex or crest at 70. These plates extend outwardly and downwardly from apex 70 to a point not lower than the level of the raised edge 67. The end 66 of plate 62 is joined to end 66 of plate 63 by dam 71. Weirs 72 extend laterally across the deck 61 on either side of the downcomer plates 62 and 63 and form liquid reservoirs 73 and 74.

A portion of the downflow plates 62 and 63 is left open to permit the passage of vapor through opening 77 so that no great pressure differential will exist between the portions of the decks divided by the downflow.

In operation, liquid falling from an upper deck, not shown, will be divided into two equal portions by the centrally located apex 70. One portion will pass downwardly along divider plate 68 to the receiving zone 75 of the reservoir 73. This liquid will then accumulate and pass under edge 67 of plate 62, through the reservoir 73 and over weir 72. Edge 67 extends below the upper edge of weir 72.

It is thus possible to evenly divide liquid passing downwardly through the column in a manner which is positive and simple, and to thereby obtain a suitable solution to the problems of unfavorable hydraulic gradient.

I claim:

1. In a distillation column containing a plurality of pairs of vapor-liquid contact decks in vertically spaced relation and wherein liquid on alternate decks flows in opposite directions with respect to the centers thereof,

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the liquid on said upper deck flowing toward a common central downcomer structure, the improvement which comprises a central downcomer in the upper deck of a pair of said decks, an upstanding plate secured to the lower deck of said pair of decks and extending upwardly within the confines of said downcomer completely separating the liquid on opposite sides of said downcomer, said plate extending laterally to the direction of liquid flow on said lower deck whereby each of the descending streams of liquid in said downcomer is independently guided to a separate reservoir in said lower deck.

2. In a distillation column containing a plurality of pairs of vapor-liquid contact decks in vertically spaced relation and wherein liquid on alternate decks flows in opposite directions with respect to the centers thereof, the liquid on said upper deck flowing toward a common central downcomer structure, the improvement which comprises a central downcomer in the upper deck of a pair of said decks, an upstanding plate secured to the lower deck of said pair of decks and extending upwardly within the confines of said downcomer to the underside of the lower deck of the next higher pair of decks completely separating the liquid on opposite sides of said downcomer, said plate extending laterally to the direction of liquid flow on said decks whereby each of the descending streams of liquid in said downcomer is independently guided to a separate reservoir in said lower deck, and the vapors ascending from each deck are maintained in separate courses as they pass upwardly through the decks.

3. In a distillation column containing a plurality of pairs of vapor-liquid contact decks in vertically spaced relation and wherein liquid on alternate decks flows in opposite directions with respect to the center thereof, the liquid on said upper deck flowing toward a common central downcomer structure, the improvement which comprises a central downcomer in the upper deck of a pair of said decks, a centrally located liquid partitioning plate structure in said downcomer, said plate structure positioned on the lower deck of said pair of decks, said plate structure extending upwardly within the confines of said downcomer, said plate structure having an upwardly pointed crest, said crest extending across said downcomer at the center thereof and having its horizontal projection in a vertical plane substantially parallel to the direction of liquid flow on said upper deck, and completely separating the liquid on opposite sides of said downcomer, whereby each of the descending streams of liquid in said downcomer is independently guided to a separate reservoir in said lower deck said liquid in said downcomer is divided into two controlled streams, means for passing each of said controlled streams to an independent portion of the lower deck of said pair of decks, and means for distributing each of said streams over its respective lower deck.

4. In a distillation column containing a plurality of pairs of vapor-liquid contact decks in vertically spaced relation and wherein liquid on alternate decks flows in opposite directions with respect to the centers thereof, the liquid on said upper deck flowing toward a common central downcomer structure, the improvement which comprises a central downcomer in the upper deck of a pair of said decks, an upstanding plate secured to the lower deck of said pair of decks and extending upwardly within the confines of said downcomer terminating below the underside of the lower deck of the next higher pair of decks and completely separating the liquid on opposite sides of said downcomer, said plate extending laterally to the direction of liquid flow on said decks and completely separating the liquid on opposite sides of said downcomer, whereby each of the descending streams of liquid in said downcomer is independently guided to a separate reservoir in said lower deck.

5. In a distillation column containing a plurality of pairs of vapor-liquid contact decks in vertically spaced relation and wherein liquid on alternate decks flows in opposite directions with respect to the center thereof, the liquid on said upper deck flowing toward a common central downcomer structure, the improvement which comprises, a central downcomer in the upper deck of a pair of said decks, a centrally located liquid partitioning plate structure in said downcomer, said plate structure positioned on the lower deck of said pair of decks, extending upwardly within the confines of said downcomer

and completely separating the liquid on opposite sides of said downcomer, whereby each of the descending streams of liquid in said downcomer is independently guided to a separate reservoir in said lower deck.

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