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BUBBLE CAP TOWERS
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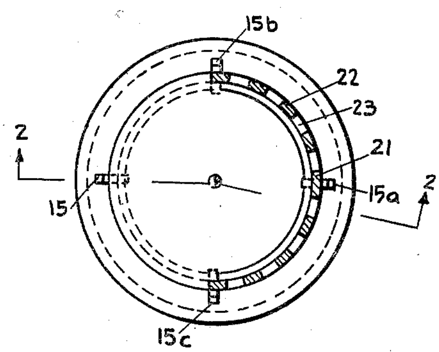

Fig.3

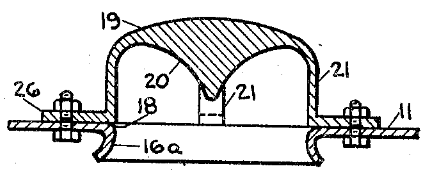

Fig.6

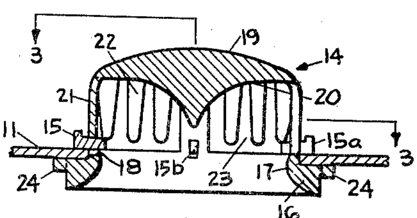

Fig.2

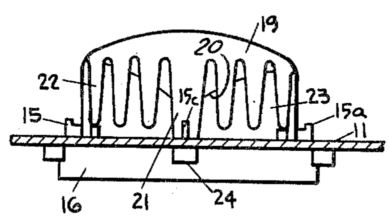

Fig.4

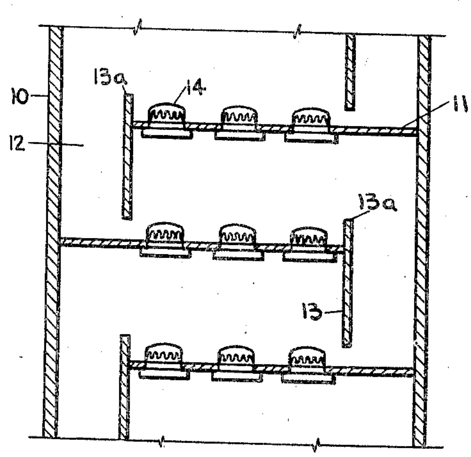

Fig.1

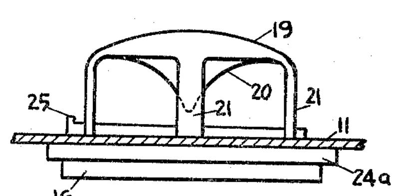

Fig.5

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BUBBLE CAP TOWERS

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3 Claims. (Cl. 261—114)

The invention relates to improvements in contacting towers having tray decks provided with bubble caps or bell caps, suitable for use in contacting liquid with gas, e. g., in fractional distillation of petroleum oils and other liquids, in gas scrubbers, and the like.

In the usual bubble cap design the cap assembly includes a riser tube communicating with the vapor space beneath the tray deck and extending above the upper level of the deck so as to retain on the deck a body of liquid even without upflow of vapor. The vapor-deflecting cap proper is positioned above the riser tube and has a skirt generally of the same geometric shape as the riser tube, but enclosing a horizontal area greater than that of the riser tube, extending downwards in horizontally spaced relation to the tube so as to provide a down-flow passage. Vapor ascends through the tube and after emerging from the top reverses direction and descends in the down-flow passage between the riser tube and skirt; it eventually flows out beneath the skirt or through openings in the lower part of the skirt into the body of liquid on the tray deck. These changes in direction of vapor flow cause turbulence and impose friction losses that severely limit the vapor handling capacity of the bubble caps. Attempts to reduce pressure drops by streamlining the riser tube and bubble caps have only partially alleviated this difficulty, and the use of larger riser tubes and caps reduces the number of caps that can be fitted on a tray of a given size.

It is an object of this invention to provide an improved tray deck with a bubble cap wherein reduced pressure drops are produced by given rates of vapor flow and/or wherein increased rates of vapor flow are possible for a cap of a given size and for a given permissible pressure drop. Ancillary thereto, it is an object to provide a construction wherein the total area for upflow of vapor is increased in relation to the total area of a tray deck.

A further object is to provide a simple, unitary bubble cap device that is easily installed on the deck.

In summary, according to the invention, the deck has a vapor opening or passageway, the top of which terminates substantially at the level of the deck, i. e., no vapor riser tube that extends above the tray deck is provided, and a vapor-deflecting cap is mounted directly over the passageway, the deck and cap being arranged so that the top of the vapor passageway is in free horizontal communication at the level of the deck with the body of liquid which is supported on the tray deck by the dynamic action of the vapor that escapes laterally from the assembly. The sides of the vapor passageway are preferably smooth and upwardly convergent with a throat near to the top, and may be constituted by the deck itself, e. g., by cutting a hole into the deck if of sufficient thickness, or by punching the deck to form a downwardly projecting lip or flange, or the sides of the passageway may be constituted by a separate tube that extends downwardly through the deck. The cap deflects the vapors laterally outwards and for best results is streamlined by giving it a downwardly concave ceiling that slopes upwardly and outwardly from the center and advantageously terminates at the highest point thereof at the outer part of the cap and is in free communication with the outside at that height, thereby differing from deflectors that were mounted within bubble caps according to prior designs, wherein the curved surfaces were arched and continued downwardly from the highest parts thereof to merge with the skirt for reversing the direction of vapor flow and inducing the vapor to flow downwards through the down-flow passage between the skirt and the riser tube. The bubble caps according to this invention do not have such downflow passage. For greatest economy of deck space and to permit many caps to be fitted it is desirable in the construction according to the invention to make the outline of the cap (in horizontal plan) substantially the same as that of the vapor passageway thereby providing a relatively greater total area of vapor passageway for a tray deck of a given area and further departing from prior arrangements wherein the vapor riser tube had a horizontal area materially smaller than that of the cap.

The cap, which may be formed separately from or attached permanently to the tube, e. g., made integral therewith, can according to a preferred construction be conveniently secured to the deck by inserting it upwardly through a hole in the deck and sliding one or more wedges hroizontally into slits formed in the cap structure, the wedges then resting on the deck.

The invention will be described in further detail with reference to the accompanying drawings illustrating certain preferred embodiments by way of illustration, wherein:

Figure 1 is a vertical sectional view through an intermediate portion of a fractionating tower provided with tray decks according to the invention;

Figure 2 is an enlarged vertical sectional view of a portion of the deck showing one bubble cap device taken on the broken line 2—2 of Figure 3;

Figure 3 is a view of the cap partly in plan and partly in section taken on the broken line 3—3 of Figure 2;

Figure 4 is a horizontal section through a tray deck showing cap device in elevation;

Figure 5 is a section view similar to Figure 4 showing a modified construction of the cap device; and

Figure 6 is a vertical sectional view of a further modified construction of the cap device and portion of the deck.

Referring to Figures 1–4 of the drawings in detail, **10** represents the shell of a fractionating column having flat, horizontal tray decks **11** extending transversely across the shell in vertically spaced relation and provided with downflow openings **12** situated alternately at opposed sides. The openings **12** are bounded by vertical plates **13** that are sealed at their vertical marginal edges to the shell **10** and extend above the respective trays to form overflow weirs **13a** and extend downwardly below the levels of the weirs **13a** on the respectively lower decks **11**. The decks **11** are thereby adapted to retain bodies of liquid up to the heights of the weirs **13a** and the plates **13** form peripherally enclosed liquid downcomers that are immersed within the retained liquid at their lower ends to prevent upflow of vapor. Each tray deck has one or more bubble cap assemblies **14** constructed in accordance with the invention.

The bubble cap device is shown more particularly in Figures 2–4, which illustrate an embodiment wherein the device is unitary and is constructed of a single piece of metal, in addition to one or more locking wedges **15, 15a,** etc. The cap device comprises a vertical tube **16**, circular in cross section, that extends downwardly from the upper level of the tray deck for a distance at least 1/12 of the diameter at the narrowest part of the tube and has inner side surfaces that are smoothly upwardly convergent; preferably, a throat **17** is formed near the top **18** and the tube diverges slightly above the throat. By way of example, the tube may have a throat diameter of six inches, bottom and top diameters of eight and six-and-one-half inches, respectively, and a height of one inch. Directly above the vapor passageway constituted by the said tube is a top wall 19 for deflecting vapors laterally outwardly. This wall preferably has the ceiling thereof formed as a smooth, concave, upwardly and outwardly inclined deflecting surface 20 that has the outermost part at the highest level thereof and substantially horizontal. In the embodiment shown, wherein the vapor opening is circular in cross section, the deflecting surface 20 is a surface of revolution about the axis of the vapor opening and has a 90° arc as generatrix. This shape differs from that employed in prior bubble caps having arched ceilings in that the surface does not turn downwardly through any appreciable arc, so that vapor will be discharged laterally in directions that are essentially horizontal. The wall 19 is united to the tube 16 by a small number of, e. g., four, narrow posts 21 that have their external surfaces coincident with a cylinder of diameter equal to the outside of the upper portion of the tube 16. These posts have vertical slots extending down to the level of the tray deck for receiving the locking wedges. To facilitate the upflow of vapor through the vapor passageway the throat of the latter is made as large as possible in relation to the cap; hence, in the preferred embodiment the cap has an external outline that is substantially the same, both with respect to size and shape as the vapor passageway. In the embodiment illustrated, the external outline of the cap device is circular and the diameter of the upper part exceeds that of the vapor passageway which lies immediately above the throat 17 only by the thickness of the material used in the tube. The top wall according to this embodiment is provided with an annular skirt 22 that extends almost to the tray deck and has suitable openings, such as serrations 23, that extend upwards fully to the deflecting surface 20 to permit vapor to be discharged directly from the said surface. A plurality, e. g., four, lugs 24 are optionally formed integrally with the tube for engagement with the underside of the deck to position the tube entirely beneath the upper surface of the deck.

The cap device is attached to the tray deck by inserting it upwardly through a hole in the latter to bring the lugs 24 into abutment with the deck and securing the device by any suitable means, e. g., by inserting a plurality of thin vertical wedges 15, 15*a*, etc., radially inwards through slots formed in the posts 21. These wedges rest directly on the tray deck and have tapers less than the friction angle to insure tension under operating conditions.

According to the modification shown in Figure 5, the skirt 22 is omitted and the vapor is free to discharge laterally throughout the full height of the cap device except where obstructed by the narrow posts 21. A further modification shown in this view concerns the wedge arrangement. Here, a single wedge 25 is driven fully across the cap device and has tapered engagements with diametrically opposite posts. The wedge is situated diametrically in relation to the cap device and is thin, so as not to interfere with the free upflow of vapor. The lugs 24 are replaced by an annular flange 24*a*, which forms the abutment means for engaging the underside of the deck 11.

In Figure 6 the vapor passageway is formed by punching the tray deck 11 to form an annular lip that projects downwardly to form a short tube 16*a*, the resulting vapor passageway again having smooth sides the top 18 of which is at the level of the deck 11. The cap 19 has a deflecting surface 20 as described above and is secured to the deck by posts 21 that have horizontal tabs 26 which are bolted or otherwise fixed to the deck. The cap may be fully open at the sides between the posts, as shown, or provided with a skirt as shown in Figures 2–4.

In all of the embodiments shown, the top of the vapor passageway is in free horizontal communication at the level of the top of the tray deck with the body of liquid that accumulates on the deck at least as high as the weir 13*a* during operation of the column. It will be understood that the column is provided with the usual means, such as a reboiler or vapor inlet at the bottom, for causing vapors to ascend through the vapor openings, and with means for charging liquid at the top, e. g., a reflux condenser, for accumulation on the trays and passage over the weirs 13*a* and through the downcomer openings 12 onto the respective lower trays. The ascending vapor emerges from the top 18 of each vapor passageway and makes only one, smooth change of direction, assisted by the surface 20, through a right angle; hence it is discharged substantially horizontally outwards from the cap device both near the deck and at higher levels up to the surface 20 and comes into intimate contact with the liquid, entraining liquid to form a spray or froth that rises above the liquid level. By this entraining action the entry of liquid from the deck into the space beneath the deflecting surface and the consequent downflow of liquid through the vapor passageways are prevented and a contacting body of liquid is built up on the deck when the column is in operation; however, cessation of vapor flow permits the liquid to drain down through the vapor passages. It may be noted that the entraining action is entirely one of carrying the liquid radially outwardly from the vapor caps, as distinguished from devices, such as that of the U. S. Patent No. 2,523,126, wherein the vapor riser tube extends above the tray and liquid is drawn inwards into the tube.

The cap should be shaped to distribute the vapor in all directions at which the contacting body of liquid occurs so that the body of liquid on the tray deck is held back equally on all sides. This is achieved by forming the surface 20 as a surface of revolution, as described, although other geometric shapes will be apparent to those skilled in the art and would be used when the vapor passage is not circular.

The construction described leads to reduced pressure drops for given flow rates and cap sizes in relation to bubble caps of usual construction employing riser tubes. This advantage is particularly marked when operating at high vapor flow rates at which high pressure drops are encountered, and it was found that still higher flow rates can be used for the same pressure drop.

Example

Some indication of the extent of the improvements may be had from the following data. The air flow rates corresponding to measured pressure drops were determined for a standard commercial bubble cap six inches in diameter with a riser tube and having serrated skirt, using a dry column. The flow rates that produce the same pressure drops were determined for bubble cap assemblies according to the invention by modifying the commercial cap in the following respects:

A. The riser tube was removed, leaving a 4⅝ in. vapor opening in the tray.

A–1. Same as A, but a plug providing a deflecting surface shaped like the surface 20 in Figure 2 was mounted within the cap.

A–2. Same as A, but a tube, shaped as shown for the tube 16 and of thin metal, was placed in the vapor opening entirely beneath the deck except for a thin supporting rim resting on the deck.

A–3. Both the plug of A–1 and the tube of A–2 were provided.

B. The riser tube was removed and the hole through the deck was enlarged to leave a vapor opening 6⅛ in. in diameter.

B–1 through B–3, same as A–1–A–3, respectively, but with a 6⅛ in. vapor opening.

The results were as follows:

Pressure Drop in Inches of Water	Percent Increase in Vapor Capacity over Standard 6-inch Bubble Cap with Riser							
	A	A-1	A-2	A-3	B	B-1	B-2	B-3
.10	99	141	65	52	188	158	186	------
.20	102	135	100	96	194	186	195	200
.30	104	132	120	119	196	204	200	226
.50	104	127	136	124	201	224	206	257
.70	105	124	160	132	204	------	209	------
1.00	108	120	------	139	------	------	------	------
1.50	115	116	------	------	------	------	------	------

A considerable increase in the vapor capacity was attained in all cases, and the data show that the several features specified in the appended claims are useful when employed separately or in combination. It may be noted that for the smaller vapor opening streamlining the tube alone (A–2) and the streamlining of the tube in conjunction with the streamlining of the deflector in the cap (A–3) were particularly beneficial at the higher pressure drops, while for the larger diameter runs, the combination of the streamlined tube and streamlined deflector (B–3) was particularly advantageous also at lower pressure drops.

We claim as our invention:

1. A bubble tower containing a tray deck which includes a flat, horizontal part adapted to support a body of liquid, said deck part having a single, substantially unobstructed vapor passageway extending therethrough and bounded by enclosing side surfaces that are situated substantially entirely beneath the level of the top of said deck part; and a vapor-deflecting cap device positioned directly over said vapor passageway and including a top wall spaced above the said deck part and a small number of narrow, peripherally located support members which collectively occupy only a small fraction of the cap periphery and the interior surfaces of which form substantial vertical extensions of said enclosing side surfaces, said top wall having an area and outline substantially the same as the area and outline of said vapor passageway and providing a downwardly concave, smooth deflecting surface having the lowest part at the center and rising to the outer periphery thereof, the said periphery being the highest part of the surface, to deflect vapor that ascends through the vapor passageway substantially through a right angle, said cap device being laterally open between said support members from said periphery of the deflecting surface to

the said deck part and the space beneath the deflecting surface providing a free and direct path for the flow of vapor from the top of said vapor passageway to the cap periphery at the level of said deck part for the efflux of vapor laterally into said body of liquid throughout the full height of the cap device.

2. A unitary bubble cap device comprising a single vapor tube adapted to extend through an opening in a tray deck and having positioning means for engaging the under side of the deck so as to position the tube substantially wholly beneath the upper level of the deck, a vapor-deflecting cap including a downwardly directed deflecting surface and peripherally located support posts joined to the top of said tube and to the cap, said posts being spaced apart to permit lateral discharge of vapor between them, the lateral external dimensions of said posts and cap being limited to those of the upper part of the tube so that the device can be inserted through said opening from the bottom, and downwardly directed abutment means on the cap device adjacent the upper surface of the tray deck adapted to receive a horizontal wedge for securing the device.

3. In a bubble tower, the combination of a flat, horizontal tray deck having an opening therein and a bubble cap device including a vapor tube extending through said opening and situated at least partly beneath said tray deck, a vapor-deflecting cap situated above said tray deck and directly above said tube, and a side wall forming an upward extension of said tube and joined to said cap, said side wall having lateral discharge openings, abutment means on said tube in engagement with the under side of said deck, and at least one horizontal wedge resting on the upper side of said deck and extending through an opening in said side wall.

References Cited in the file of this patent

UNITED STATES PATENTS

1,878,467	Clarke	Sept. 30, 1932
1,918,005	Urquhart	July 11, 1933
2,084,726	Duey	June 22, 1937
2,480,862	Johnson	Sept. 6, 1949
2,523,126	Long	Sept. 19, 1950
2,547,383	Glitsch	Apr. 3, 1951

FOREIGN PATENTS

874,509	France	May 4, 1942
884,837	France	May 8, 1943