June 21, 1955 O. H. MILMORE 2,711,307

CONTACTING TRAY CONSTRUCTION

Filed April 21, 1952. 2 Sheets-Sheet 1

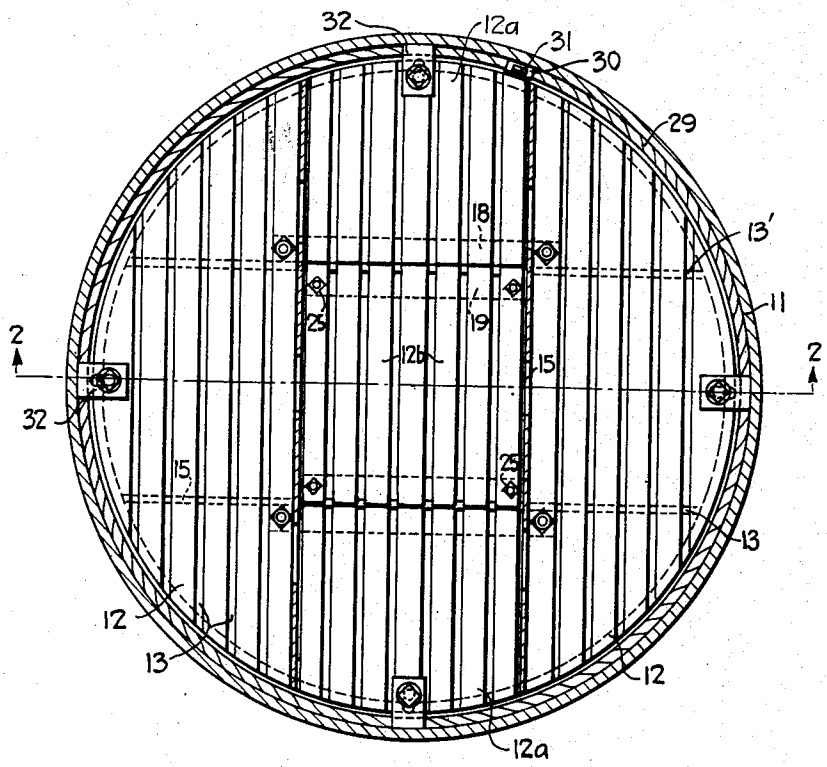

Fig. 1

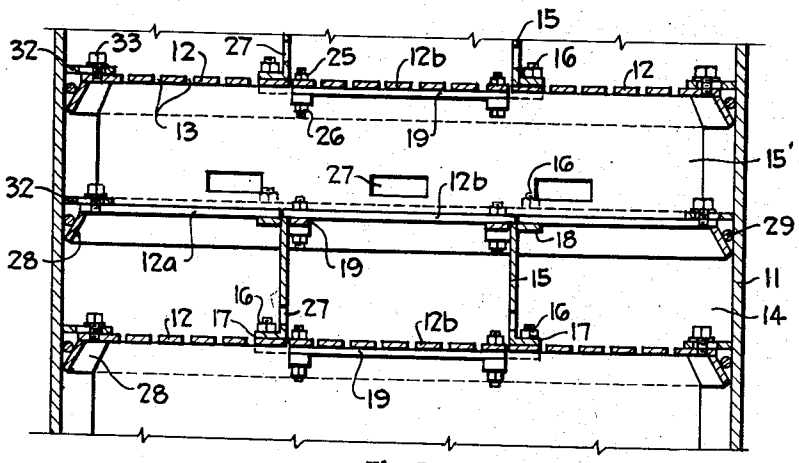

Fig. 2

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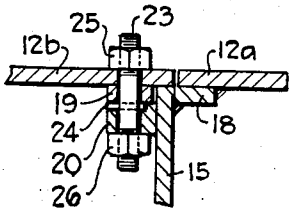

Fig. 3

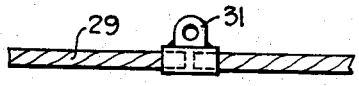

Fig. 5

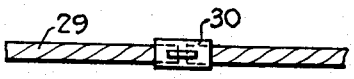

Fig. 6

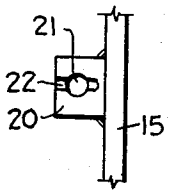

Fig. 4

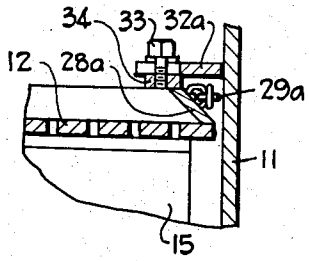

Fig. 7

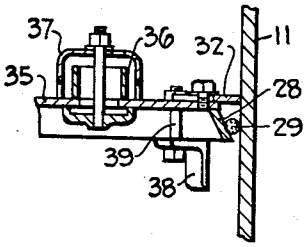

Fig. 8

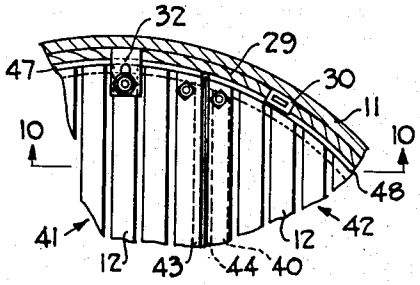

Fig. 9

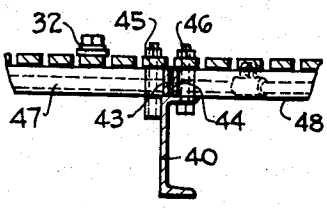

Fig. 10

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CONTACTING TRAY CONSTRUCTION

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Application April 21, 1952, Serial No. 283,430

7 Claims. (Cl. 261—108)

This invention relates to trays for effecting contact between liquid and gas, and is, more particularly, concerned with an improved arrangement for securing contacting trays, sometimes known as fractionating trays, within upright columns for effecting a closure between the tray and column wall despite variations in the shape of the latter.

In mounting contacting trays, such as bubble trays, perforated trays and spray grid trays, in columns, it is customary to fix a supporting annulus for each tray in fluid-tight relation to the inner face of the column wall to effect a seal between the periphery of the tray and the wall. This practice is derived from the fact that columns are not exactly uniform in cross-sectional shape but vary in diameter and/or circularity from level to level. By providing a supporting annulus with a plane upper surface on which the tray can rest, the tray can be made with a diameter that is slightly smaller than the inside diameter of the column and any irregularity in the cross-sectional shape of the latter causes merely a change in the width of the exposed, sometimes crescent-shaped part of the supporting annulus beyond the periphery of the tray, without creating an open gap through which contacting fluids can by-pass the tray. This mounting arrangement has the drawback of requiring a large amount of welding or rivetting for fixing the supporting annuli to the column wall at different levels and is expensive particularly when columns using many closely spaced trays are involved. A further difficulty with such arrangements is that it is not practical to vary the tray spacing as desired because trays can be mounted only at levels where supporting annuli are provided.

Special sealing arrangements on the trays that can be adjusted to conform to the outline of the column wall are cumbersome, difficult to fit and operate, and often become useless due to corrosion.

It is, therefore, an object of the invention to provide an improved contacting tray construction for mounting contacting trays within an upright column in flow-restrictive relation thereto which does not require annular tray supports that are sealed to the column wall. A further object is to provide a construction that permits the trays to be mounted at any desired height within a column, independently of supporting, sealing or other fixtures secured at the several tray levels.

In summary, according to the instant invention, each contacting tray is provided at the periphery thereof with an inclined flange, e. g., a frusto-conical ring, situated either at, slightly above, or slightly below the upper face of the tray, the outermost part of the flange being near to the inside wall of the column, so that the flange forms an annular trough with the wall. A limp closure member, such as a cable or chain, is placed into the annular trough, which has downwardly converging sides. This closure member becomes lightly wedged between the trough walls and assumes a position in the trough determined by the horizontal distance between the column wall and the flange, so that it is relatively lower at those parts of the periphery where the horizontal distance is greater and vice versa.

The inclined flange or ring may be continuous or discontinuous, e. g., in sections, the latter arrangement being employed when the tray is made up of several sections each of which includes part of the tray periphery for convenience in placing the trays. The flanges are thus adapted to form troughs at any part of the column wall and the levels at which the trays are mounted is not determined by the locations of sealing fixtures carried by the column. The trays may be supported on an internal framework, by stacking or by brackets, beams or hangers carried by the column.

It is not essential in most instances that a perfect fluid-tight seal be provided; it suffices that the limp member adapt itself to the outline of the column wall so as to close off the relatively wide annular or crescent-shaped gap that otherwise occurs between the margin of the tray and the column wall, so as to prevent any significant by-passing of the contacting fluids around the tray of a nature to decrease the tray contacting efficiency. As is noted below, a certain amount of fluid flow around the tray is not detrimental. The invention is applicable to any type of contacting tray, whether of the bubble cap, grid or perforated construction and with or without downcomers.

The invention will be described with reference to the accompanying drawings forming a part of this specification and showing certain preferred embodiments by way of illustration, wherein:

Figure 1 is a horizontal sectional view through a fractionating column equipped with grid trays having the closure arrangement according to the invention;

Figure 2 is a vertical sectional view taken on the line 2—2 of Figure 1;

Figure 3 is an enlarged vertical sectional view showing a detail at the man-way of the tray;

Figure 4 is a plan view of a channel at the edge of the man-way;

Figures 5 and 6 are enlarged elevation and bottom plan views, respectively, of a portion of the closure cable;

Figure 7 is a fragmentary vertical sectional view of a modified arrangement using a frusto-conical ring higher than the tray and using a chain as the limp closure member;

Figure 8 is a fragmentary vertical sectional view of a further modification showing the invention applied to a bubble cap tray; and

Figures 9 and 10 are fragmentary horizontal and vertical sectional views of a further modification wherein the tray is in sections, the latter view being taken on the line 10—10 of Figure 9.

Referring to Figures 1 and 2, the column **11** contains a plurality of spray grid trays comprising grid bars **12** of any desired cross-sectional shape and spaced apart to provide intervening slots **13** which should preferably have uniform widths throughout any one tray. The present invention is not concerned with the particular arrangement for the upward flow of gas and the downward flow of liquid, and the arrangements shown are merely illustrative of such trays. Without in any way restricting the invention, it may be stated that grid bars of the type illustrated usually are spaced apart to provide slots **13** that are between about 0.05 and 1.0 inch in width, spacings between 0.1 and 0.6 inch being preferred in most cases, and the bar widths are selected in relation to the slot widths so that the aggregate of the slot areas throughout the tray (herein referred to as the free area) is from about 7 to 40% of the total area of the grid, free areas of from about 10 to 20% being most commonly used. Such trays are spaced apart vertically to provide intervening spray contact spaces **14** for the upward flow of atomized liquid to provide intimate contact between the

liquid and gas. These spaces are, for best results, made high enough to permit disengagement of the liquid droplets, so that the gas can ascend through the next higher tray without carrying over any appreciable quantity of liquid. Too close a vertical tray spacing limits the permissible gas flow rate and also the load point, i. e., the rate of gas flow at which liquid is prevented from descending through the slots in sufficient amount to maintain the necessary flow of liquid and at which the column therefore becomes inoperative due to flooding. In general, it is desirable to space such trays apart by distances at least about three times the bar widths, and spacings of from three to thirty inches are typical. The trays may be oriented as shown, whereby the grid bars of each tray extend at right angles to those of the adjacent trays.

The several contacting trays have two or more subjacent beams **15** extending transversely to the directions of the grid bars and the bars are welded to the upper parts thereof whereby each tray forms a unitary structure that may be fabricated outside of the column and lowered through the interior. One or more trays are supported in any suitable manner, e. g., on the bottom of the column or on a suitable truss, (not shown) and higher trays are stacked successively, as shown. Thus, the beams **15** of each tray may rest on the upper surfaces of the adjoining lower trays and may be bolted thereto by bolts **16** extending through flanges **17**. When the grid bars on adjoining trays are 90° out of orientation, as shown, the beams **15** on successive trays will likewise extend in alternate directions, forming a shaft-like structure at the center of the column. This central part may be utilized as an access passage by using interrupted bars **12*a*** at the center of each tray so as to leave a central man-way and providing a central grid having grid bars **12*b*** for closing the man-way. As shown in Figure 3, the ends of the bars **12*a*** are supported on and welded to bars **18** that are, in turn, welded to the sides of the beams **15** away from the center, with the top faces flush. The ends of the bars **12*b*** rest on the upper edges of the beams; these bars are welded to horizontal spacer bars **19**, which extend transversely along the under sides of the bars and spaced inwardly from the ends, whereby the assembly of all bars **12*b*** forms a removable section of the tray. These removable sections are detachably connected to the other parts of the trays by any suitable fastening means. I prefer in many applications to arrange the fastening means to permit the sections to be loosened either from the top or from the bottom, and to this end bracket plates **20** having vertical holes **21** are welded to the beams **15** a short distance below the top thereof (Figures 3 and 4). These brackets have slots **22** milled in their upper faces. Bolts **23**, having transverse pins **24** resting in the slots **22** so as to prevent rotation of the bolts, extend through the holes **21** and through registering holes in the spacer bars **19** and grid bars **12*b***. These bolts have top and bottom nuts **25**, **26**. It is evident that it is possible to secure or remove the removable man-way sections either from the top or bottom of the tray by manipulation of the nuts **25** or **26**. When a section has been loosened, it can be pushed upward and then slid horizontally onto the grid bars **12*a***, between the beams **15** of the next higher tray, permitting a man to climb through the may-way. Handholes **27** are cut at intervals into the beams **15** to permit inspection of the sections of the grid trays beyond the beams and access to the bolts **16**.

A frusto-conical, downwardly diverging ring **28** is welded to the lower face of each spray grid tray, the lowermost part having an external diameter only slightly smaller than the interior diameter of the column so as to permit the tray to be moved vertically within the column despite the usual shape irregularities of the latter. The ring thus forms an inclined flange that forms a trough together with the column wall. The grid bars terminate at or near the smaller, upper part of the ring so as to afford access to the top of the trough. It may be noted that this ring further serves as a structural member in positioning the outer ends of the interrupted grid bars **12*a***. A limp closure member is placed into this trough to span the gap by its weight. In the embodiment shown, this member is a cable **29** (Figures 1, 2, 5 and 6) having a sleeve **30** receiving the cable ends so as to form a hoop. At least one of the cable ends preferably has a sliding fit within the sleeve, while the other end is secured, e. g., by crimping, so as to permit the circumference of the hoop to vary to adapt itself to the requirement of the trough. The sleeve has a perforated lug **31** to facilitate grasping the cable for removing it from the trough. While I have shown a limp closure member comprising a single turn of cable, and have provided for variations in the length of the cable by means of the slide sleeve **30**, the invention is not restricted to this specific arrangement. The cable descends by the weight thereof to different depths in the trough at different circumferential positions thereof, depending upon the horizontal distance between the ring **28** and the column wall, thereby substantially closing the annular gap. To prevent the cable from becoming displaced in the event of sudden pressure surges a plurality of slotted positioning lugs **32** are clamped to each tray by bolts **33**, extending across the trough above the cable.

In operation, liquid descends through the column, passing through the slots **13**, and gas ascends through the same slots. For example, in fractional distillation the gas may be provided by supplying heat to a lower part of the column. The upward gas velocity is usually maintained sufficiently high to interfere with the free drainage of liquid through the slots, whereby a body of liquid is built up on each tray and the ascending gas entrains some of this liquid and throws it up into the contact space **14** as an intense spray, thereby effecting intense atomization.

It is evident that the trays are adequately placed in flow-restrictive relation to the column wall if the leakage path is smaller than the width of the slots, and this requirement is met by the closure arrangement shown. By placing the ring **28** below the tray a body of water collects in each annular trough, which effectively prevents the upward by-passing flow of gas. A minor amount of liquid may seep through, down from the trough, but seepage is opposed by the pressure of the gas and the amount thereof is small in relation to that descending through the wider slots **13**.

It is also possible to locate the inclined flange at a different height in relation to the tray surface and to use other types of limp closure members. Both variants are shown in Figure 7, it being understood that either may be applied individually. In this embodiment, the frusto-conical flange **28*a*** is fixed to the upper faces of the grid bars **11**, and the limp closure member is a chain **29*a*** that is placed in the trough formed by the ring and the column wall **11**. The chain may be retained by slotted positioning lugs **32*a***, which are clamped by nuts **33** on studs held by base plates **34** welded at intervals to the top of the ring. The operation of this embodiment is similar to that described above, with the difference that the hydrostatic head of the liquid in the trough will be somewhat less.

As previously indicated, the invention is not limited to columns using spray grid trays without downcomers, but may be used with other types of trays. Thus, Figure 8 shows the invention applied to a conventional bubble tray **35** having vapor risers **36** and bubble caps **37** for the upflow of gas and for effecting contact between the gas and liquid on the tray. The tray may be provided with a conventional overflow weir and liquid downcomer (not shown) as understood in the distillation art. The tray has the frusto-conical ring **28** welded to the bottom and is supported through this ring by angle clips **38** that are welded or otherwise fixed at intervals to the column wall **11**. The closure cable **29** is placed into the resulting

annular trough and retained by the positioning lugs **32**, as previously described.

Figures 9 and 10 illustrate a variant wherein the tray is made up of sections and the inclined peripheral flange is discontinuous. Such a construction is desirable particularly in columns that do not have flanged heads, but having, instead, openings in the side near the top and bottom, such openings having diameters less than the internal column diameter. For introducing the prefabricated trays through such side openings, it is advantageous to construct the trays, in sections and to mount the sections on trusses extending across the column. As shown in the drawing, the column **11** has transverse beams or trusses **40** fixed thereto and extending from wall to wall for supporting the trays, again represented by spray grid trays having grid bars **12**. The trays are formed in sections, of which two sections **41** and **42** are shown, with their contiguous margins both over the truss **40** and supported thereon through spacer bars **43** and **44** that are welded to the lower faces of the grid bars that lie above the truss. The tray sections are bolted down by nuts **45** and **46**, respectively, on bolts fixed to the truss and extending through holes in the grid bars. Each tray section has welded thereto at the arcuate periphery thereof a section of a frusto-conical flange, indicated at **47** and **48**. The closure cable **29** with its sleeve **30** is placed in the trough formed between the flange and the column wall and retained by slotted lugs **32**, as previously described.

I claim as my invention:

1. A gas-liquid contacting column comprising an upright shell; a plurality of gas-liquid contacting trays positioned at different levels within the shell having openings for the passage of gas and liquid therethrough; and an annular closure between a tray and the wall of the shell, said closure comprising a downwardly and outwardly inclined flange at the periphery of the tray forming an annular trough with the said wall, and limp closure material within the trough in engagement with said flange and wall

and positioned by the weight thereof at each part of the tray perimeter at a height that is determined solely by the local horizontal distance between said flange and wall.

2. The column according to claim 1 wherein the limp closure material is an annular member that is substantially incompressible.

3. The column according to claim 2 wherein the annular member is a chain.

4. The column according to claim 2 wherein the annular member is a cable.

5. The column according to claim 4 wherein the cable has a length less than the circumference of the trough and the ends of the cable are in alignment and axially movable relatively to one another.

6. The column according to claim 4 wherein the cable has a length less than the circumference of the trough and is provided with a sleeve surrounding the ends of the cable, said sleeve being secured to one of said ends and the other of said ends being axially slidable within said sleeve, said sleeve having a lug by which the cable can be engaged for removal from the trough.

7. The column according to claim 1 wherein the tray is made of several separate sections each of which includes a part of the perimeter thereof, and the said inclined flange is discontinuous, with a portion thereof on each of said separate sections of the tray.

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