June 17, 1952 H. N. WADE 2,600,710

BUBBLE CAP FOR WASHING GASES AND VAPORS

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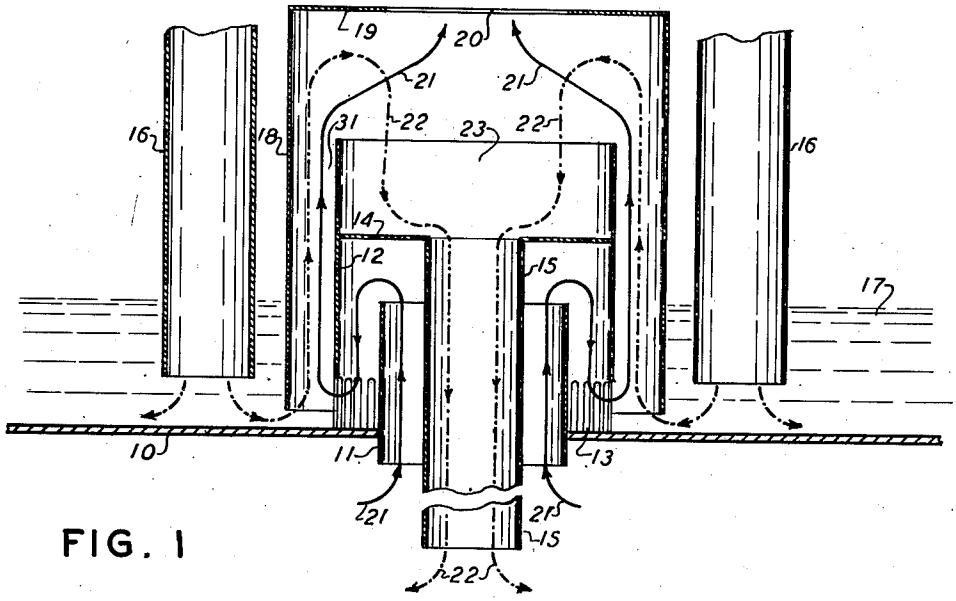


FIG. 1

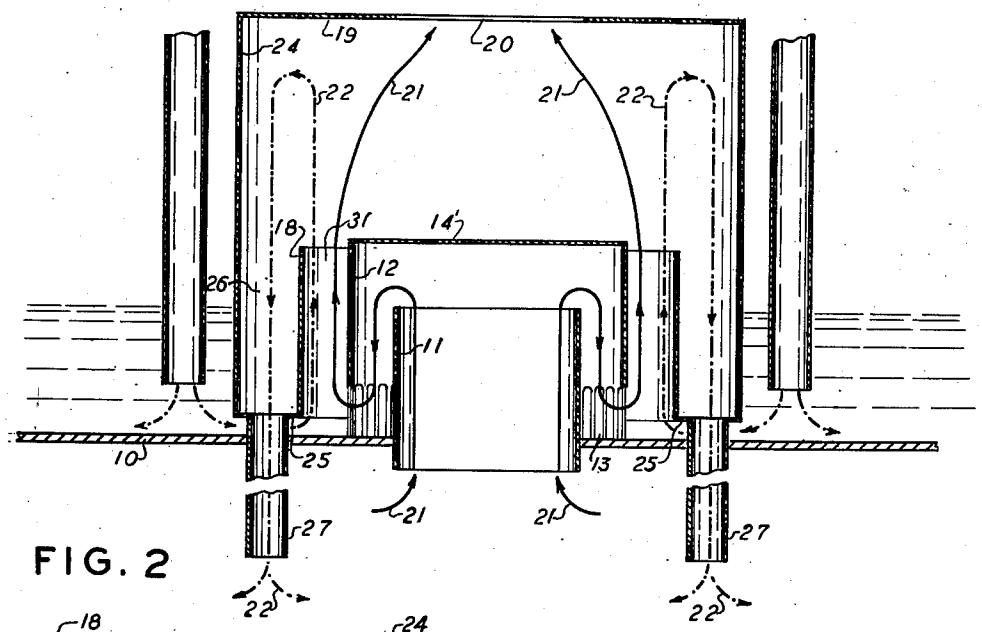


FIG. 2

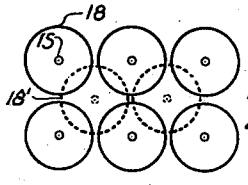


FIG. 3

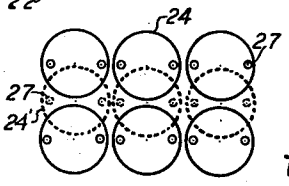


FIG. 4

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BUBBLE CAP FOR WASHING GASES AND VAPORS

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2 Claims. (Cl. 261—114)

1

This invention relates generally to a method of and devices for intimately contacting liquids with gases or vapors, and specifically to improved forms of bubble caps for use in vapor fractionating columns.

A purpose of the invention is to ensure that the liquid collecting on the fractionating plate is contacted once only with vapor before passing to the plate next below.

A purpose of the invention is to provide means for ensuring that the quantitative relation between liquid and vapor passing through each of the bubble caps on any one plate is substantially uniform.

A purpose of the invention is to avoid the bypassing and short-circuiting of vapor and/or of liquid which may occur in the use of other forms of bubble cap when the plates on which they are mounted are imperfectly levelled.

A purpose of the invention is to avoid the inequality in degree of treatment on different parts of a plate which follows from extended horizontal flow of liquid over the plate.

These and other advantages will be evident on inspection of the attached drawings and the following description thereof, in which

Fig. 1 illustrates in internal elevation a form of the bubble cap in which the contacted liquid is collected in a centrally disposed basin provided with a central downcomer;

Fig. 2 illustrates, in the same manner, a slightly modified form of the bubble cap in which the liquid-collecting receptacle and associated downcomers are disposed around the periphery of the cap proper;

Fig. 3 is a diagram, on a much reduced scale, suggesting a suitable arrangement on the plate of the form of cap shown in Fig. 1, and

Fig. 4 is a similar diagram suggesting an arrangement on the plate of the form of cap shown in Fig. 2.

Referring first to Fig. 1, 10 is a fragment of a plate extending from wall to wall of a fractionating column, scrubber or absorber. A vapor uptake 11 extends above the plate for a sufficient distance to maintain a pool of liquid of a desired depth on the plate when the apparatus is out of operation and preferably, but not necessarily, extends also to a slight distance below the plate.

The vapor uptake is surrounded by a sleeve 12 which is slotted or perforated along its lower edge in any conventional manner, as at 13. At a level somewhat below the upper edge of this sleeve a ring 14 is inserted, this ring carrying

2

a dependent downcomer 15, the ring and downcomer preventing upward flow of vapor and directing it through perforations 13. The downcomer seals in liquid on the plate next below, as is illustrated by the fragmental tubes 16—16 which represents the downcomers from two caps on the plate next above and which extend below the surface of liquid pool 17. The extension of sleeve 12 above ring 14 forms a relatively shallow catchment basin for contacted liquid, this liquid draining through downcomer 15.

Around sleeve 12 and preferably concentric therewith is placed an eduction shield 18 so supported above the upper face of plate 10 (by any means not shown) as to allow a free flow of liquid beneath its lower edge. The upper end of this ring-shaped shield may be open but I prefer to close it partially, as by means of a flat ring 19 having a central opening 20.

The functioning of this device is illustrated by the solid lines 21—21 showing, in a generalized manner, the directions of gas flow, and by the broken lines 22—22 showing the general directions of liquid flow.

Gas or vapor, as the case may be, flows upwardly through uptake 11, encounters ring 14 and is directed downwardly through the annular space between sleeves 11 and 12 and outwardly through slots or perforations 13. Assuming a sufficient depth of liquid on the plate to submerge the upper ends of the slots, the upward flow of vapor through the annulus between sleeves 12 and 18 entrains a flow of liquid which is ejected from the upper end of the annulus. At low vapor velocities the liquid will merely weil up and overflow; at higher velocities it will be ejected in the form of a spray. In either case the mixture of vapor and liquid is retarded in the enlarged space above the annulus, the liquid falls into catchment basin 23 and is delivered through downcomer 15 onto the plate next below, and the vapor passes through opening 20 into the vapor space below the plate next above.

The limit of capacity of the cap is reached at the point at which the vapor-liquid spray is ejected so forcibly that the liquid is unable to separate from the vapor within the confines of the cap, it being essential to the best functioning of the device that only an immaterial proportion of the liquid be carried over into the vapor space and thus returned to the pool on the plate from which it was withdrawn. The ring 19 in the upper end of the cap acts as a baffle and assists in separating and returning liquid to the collecting basin and is highly desirable where the vapor

velocity is high, though it may be omitted if the caps are to operate at low vapor velocities.

In the form shown in Fig. 2 a sleeve **24** is concentrically arranged around sleeve **13** and the annulus thus formed is closed at the bottom by a ring **25**, forming an annular catchment well **26**. This well is drained by one or more downcovers **27** which seal in liquid on the plate next below. The central downcomer **15** may be omitted, substituting a disc **14'** for the ring **14** of Fig. 1, or, if desired, it may be retained to afford additional drainage. It is preferable to omit it from the form of Fig. 2 to permit the caps to be placed closer together.

The form of Fig. 2 functions in exactly the manner above described, the only difference between the two forms being in the location of the collecting receptacle and downcomers. The second form allows somewhat more room above the ejecting annulus for the separation of liquid from vapor and will tolerate a higher vapor velocity through the perforations. On the other hand, this separating space is gained at the expense of a greater cap diameter, allowing a smaller number of caps on a plate of given diameter.

As the contact between liquid and vapor is produced solely within the confines of the cap, no exterior space for the bubbling of vapor through liquid is required. In consequence, the caps may be very closely spaced on the plate, even face to face as illustrated in Figs. 3 and 4.

In these figures, the solid circles **13** and **24** indicate the positions of the caps on one plate and the dotted circles **13'** and **24'** the relative positions of the caps on the plates immediately above and below. In Fig. 3 the downcomer **15** (of Fig. 1) is centered in the free space bounded by four adjacent caps. In Fig. 4 this space receives the downcomers **27** of two adjacent caps of the type shown in Fig. 2. These figures suggest merely a minimum spacing and the caps may in practice be distributed over the plate in any preferred pattern.

Columns equipped with these bubble caps have several advantages over columns of the conventional form in which the vapor is bubbled through a pool of liquid and in which the liquid flows from one side of the plate to the other before passing to the plate next below.

For example, in the conventional column the resistance to vapor flow through any one cap is a function of the depth to which the slots or perforations are submerged. It follows that if any plate departs from level by tilting, sagging or buckling, the higher lying caps will pass a greater amount of vapor through a shallower layer of liquid than those lying at a lower level, and the vapor will be unequally treated over different areas of the plate. In extreme cases the caps on the higher part of the plate may lose submergence and permit vapor to blow through, or those lying at lower levels may drown out and permit no vapor to pass, or permit liquid to flow down through the vapor uptake.

Even though the plates be maintained level, the flow of liquid across the plate requires a material hydraulic head and in columns of relatively great diameter, which are now coming into common use, the difference in depth of liquid between the two sides of a plate may be enough to cause a material difference in effectiveness between caps in different plate areas.

In the use of the form of bubble cap above described, the resistance to vapor flow is fixed by the pressure drop through the perforations or slots and by the height of the contacting annulus **31** and is largely independent of the depth of liquid surrounding the cap. As these factors are uniform for all the caps on a given plate, and as the quantity of liquid entering the contacting annulus is determined by the quantity which the gas flow is able to eject (assuming sufficient free space below shield **13**) the liquid flow through the annulus is at least substantially independent of the depth of liquid surrounding the cap. Thus it is impossible for a cap to unload or blow through until the liquid level falls below the lower end of the shield, and all of the caps on the plate will contact equal amounts of liquid with equal amounts of vapor.

Again, in wide columns having the downcomers alternated on the two sides of successive plates, the liquid flowing across the plate passes a number of bubble caps in succession. In so doing the liquid is successively contacted with several streams of vapor from a common source and of identical composition. The maximum difference in composition between the liquid and the vapor exists only at the point at which the first contact is effected and decreases as the contacts are repeated, only the first cap in the line of flow functioning at the maximum efficiency.

In the use of the bubble caps of the present invention this difficulty is entirely avoided, first by providing each bubble cap with at least one downcomer, thus bringing the downcomers so close that horizontal flow is reduced to an immaterial distance, second, by contacting liquid and vapor in a confined space in which liquid and vapor are again separated and from which the once treated liquid is withdrawn onto the next lower plate without returning to the liquid pool from which the untreated liquid was drawn. In the cooperation of these two provisions, difficulties due to imperfect liquid distribution entirely disappear and the liquid flowing from one plate to the next may be equally contacted over the entire area of the plate.

An important advantage in the described structure is the possibility of making the contacting annulus **31** as long as may be desired, permitting the time of contact to be extended and the intimacy of contact to be increased to any extent desired. With even a moderate depth of annulus and a moderate vapor velocity, the contact produced is much more intimate and effective than that produced by the free bubbling of streams of vapor through a pool of liquid.

While the drawings show the caps as consisting of cylindrical elements they may be formed with straight sides in any desired relative dimensions, so long as the walls **12** and **13** are kept parallel and the contacting annulus **31** of uniform width. No advantage is presently seen in such forms, which would probably be more costly than the cylindrical form.

The caps described are adapted to use in vapor fractionating columns as well as in gas scrubbers and absorbers. They may, if desired, be formed from sections of tubing and rings of thin sheet metal, by soldering, welding or brazing according to the temperature at which the column is to operate, and by reason of their relatively light weight may be mounted on plates of relatively slight thickness. As all of the caps in a column may be expected to perform in the same manner, a determination of

the capacity and the optimum proportions for a single cap permits a column to be designed for the best performance without the elaborate balancing of numerous variables otherwise required.

I claim as my invention:

1. In a gas-liquid contacting column having a plate, a contacting unit comprising: a gas uptake extending above said plate; an inverted cup surmounting said uptake and provided along its lower edge with means for dividing a gas stream into a plurality of minor streams; a ring-shaped shield surrounding said inverted cup and spaced therefrom to form a relatively narrow, vertical, annular conduit having parallel walls, the lower edge of said shield being spaced from said plate to allow liquid from said pool to enter said annular conduit; means disposed within said shield for collecting liquid educted through said annular conduit, said collecting means arranged to prevent return of the educted liquid to the pool from which it was withdrawn, and means for draining said collected liquid onto a lower-lying plate, said last means arranged to prevent overflow of liquid from said pool and to receive only said collected liquid.

2. A contacting unit adapted to be mounted on a horizontal partition plate in a gas-liquid contacting column and to maintain a liquid pool thereon, said unit comprising: a gas riser extending above the surface of said plate; a cup inverted over said gas riser and provided along its lower edge with means for dividing a stream of gas into a plurality of minor streams; a tubular shield surrounding said cup and forming

therewith a relatively narrow, vertical, annular conduit having substantially parallel walls, the lower end of said shield being spaced from said plate to allow liquid to enter said conduit from said pool and to be ejected therefrom by said gas streams; means disposed within said shield for collecting the liquid so ejected, said means being arranged to prevent said liquid from returning to the pool from which it was drawn, and a tube passing through said plate and sealed in liquid on a lower-lying plate for draining said collecting means without permitting the overflow of liquid from said pool.

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