

July 10, 1951

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2,560,072

APPARATUS FOR FRACTIONATION

Filed Nov. 12, 1948

2 Sheets-Sheet 1

Fig. 4.

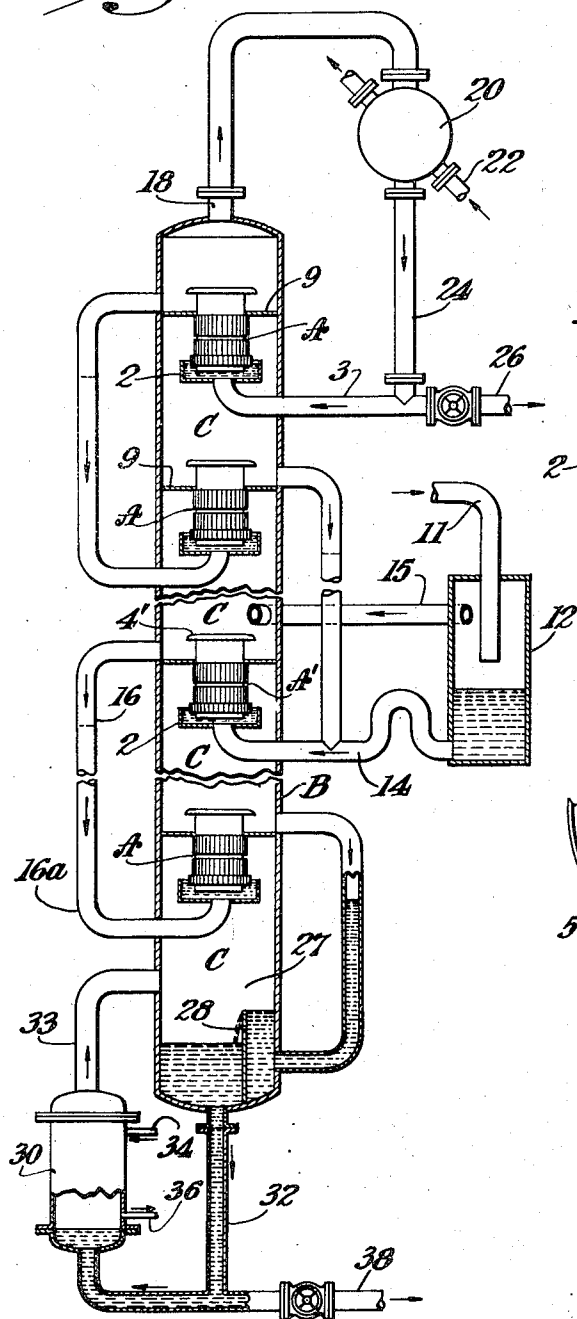


Fig. 1.

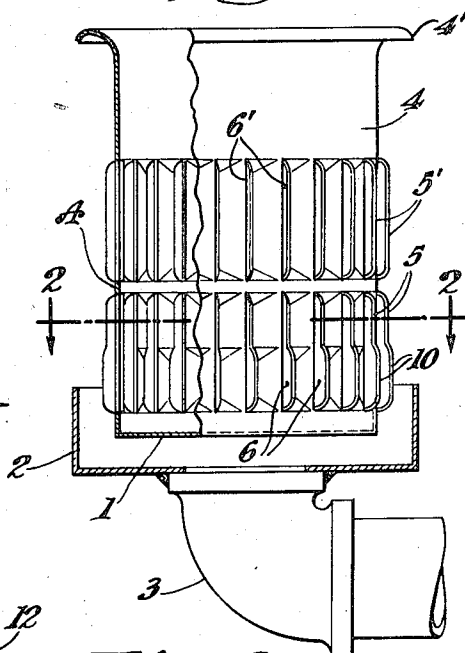


Fig. 2.

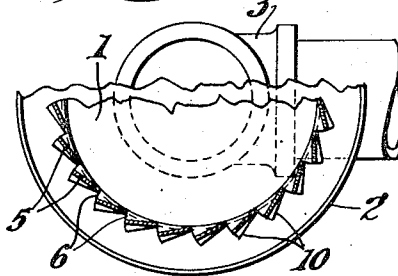
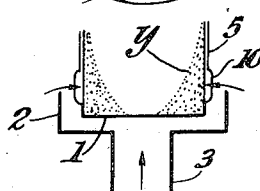


Fig. 3.



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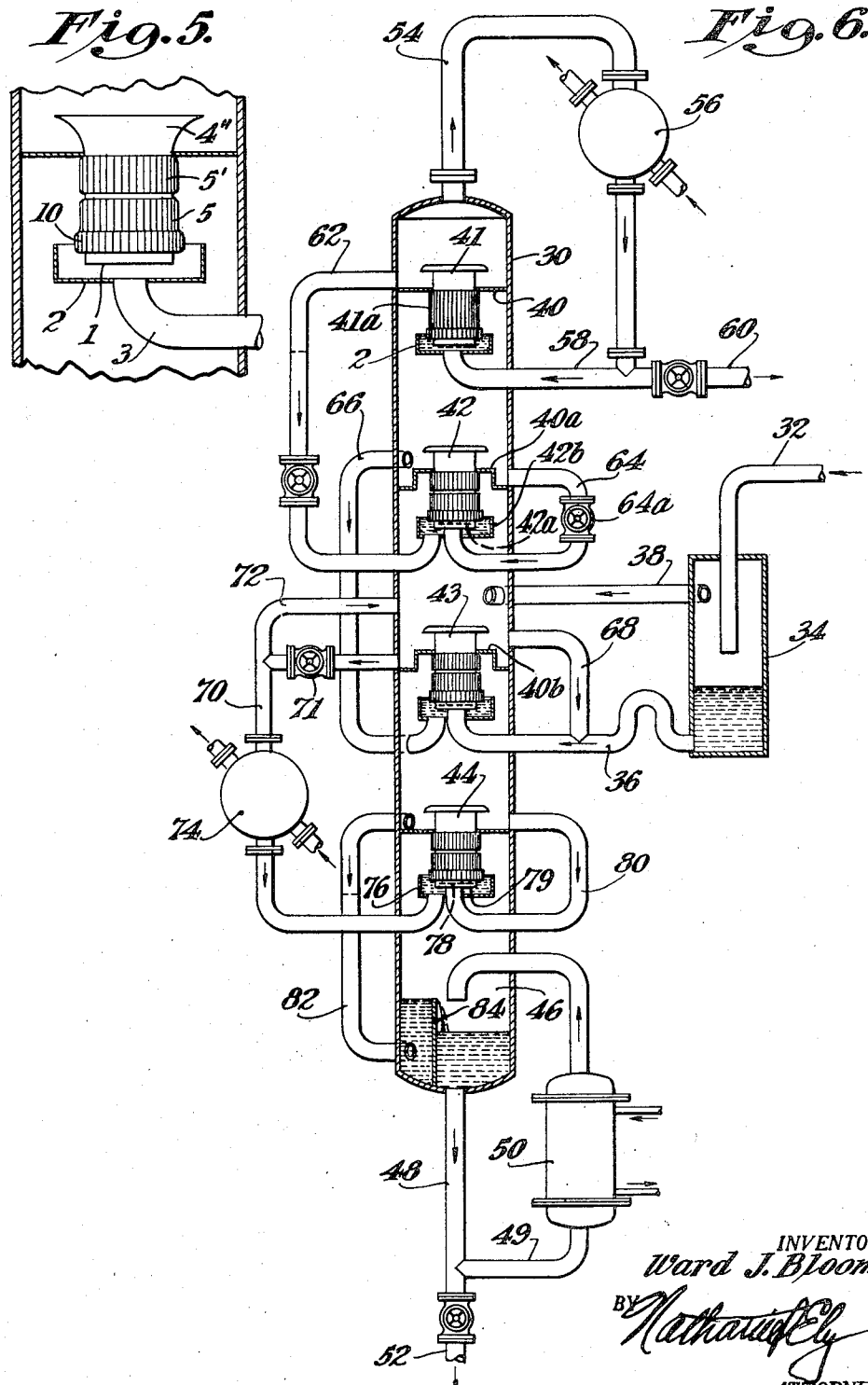
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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

2,560,072

APPARATUS FOR FRACTIONATION

Ward J. Bloomer, Westfield, N. J., assignor, by
mesne assignments, to Centrifix Corporation,
Cleveland, Ohio, a corporation of Ohio

Application November 12, 1948, Serial No. 59,719

13 Claims. (Cl. 183-21)

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This invention relates to an improvement in fixed centrifugal devices of the type heretofore used for contacting gases and liquids to effect concentration, fractionation, or the like; and, more particularly, of the type illustrated and described in United States Patent No. 2,189,491, dated February 6, 1940, to Charles Gilbert Hawley. It is a continuation-in-part of my copending application Serial Number 649,203, filed February 21, 1946.

The improved device according to this invention, while of general advantage in uses for which a fixed centrifugal device is adapted, will be found of special advantage for use in the process and apparatus shown and described in the said United States Patent No. 2,189,491 above mentioned.

Fixed centrifugal devices of the type under consideration comprise essentially an element termed a tuyère, of cylindrical form and presenting a circumferential series of tangential blades extending upwardly from the bottom of the element and forming narrow passages between them. In operation, for contacting, for example, a liquid with a gas, the liquid is fed to the closed end of the tuyère and the gas is introduced through the narrow passages between the tangential blades at a high velocity. The gas thus enters the tuyère tangentially and hence within the tuyère travels circumferentially and longitudinally of the axis thereof, picking up and dispersing the liquid in fine particles within its whirling stream or vortex. The particles of liquid in the whirling stream of gas are next consolidated in an imperforate ring into which the tuyère discharges, and the liquid is then thrown out by the centrifugal effect, collected and drained away from the gas.

In the operation of such a device the whirling stream of gas and particles of liquid within the tuyère travel vertically, as well as circumferentially, toward the imperforate ring, into which the tuyère discharges, or which in effect constitutes a continuation of the tuyère. On reaching the imperforate ring the liquid particles coalesce in to a mass or stream due to the centrifugal force exerted on the liquid particles which are held to the wall of the ring by the centrifugal force exerted on them. The liquid, on reaching the upper edge of the ring, is released and discharged upwardly and laterally into a collecting chamber under the forces producing the upward spiraling movement of the gas and liquid in the tuyère and by which the liquid is raised, admixed with the gas and carried through the tuyère.

Now it has been found that on the release and discharge of the liquid mass from the imper-

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forate ring, a sharp edged perimeter of the ring exerts a cutting action on the liquid, which since the liquid, subject to considerable force tending to move it upwardly and outwardly, is traveling at a high velocity, effects atomization of some of the liquid. As a consequence a substantial amount of the liquid may be carried away with the gas. In such case the sharp edged tuyère has proved to be of low efficiency as an entrainment separator.

Various measures have been suggested for utilizing the advantageous features of the tuyère as a mixing and contacting device while also providing for release and separation of heavy liquid particles but without the provision of a satisfactory solution of the problem.

Now in accordance with this invention the atomization of liquid on discharge is substantially prevented by the provision of an outside lip at the discharge edge of the imperforate collector ring, over which the liquid is discharged laterally away from the gas in a stream or film, rather than outwardly and upwardly, due to the fact that the centrifugal force acting on the liquid, as it is released from the ring, is greater than the force tending to move it vertically, the fact that the force of the whirling gas exerts a plastering action tending to force the liquid onto the surface of the lip, and the fact that due to its surface tension the liquid tends to follow over the surface of the lip. It is thus found that the liquid will be discharged in a continuous dense mass rather than more or less atomized.

While broadly my invention contemplates an improved method of contacting for liquids and gases, a primary object of my invention is to utilize a series of fixed centrifugal tuyères in a suitable column for the fractional distillation of mixed component materials.

Having now indicated, in a general way, the nature and purpose of this invention, I will proceed to a detailed description of preferred forms of embodiment thereof with reference to the accompanying drawings, in which:

Figure 1 is a side view, partly in section and partly broken away, of a fixed centrifugal device embodying this invention.

Figure 2 is a partial sectional view on line 2-2, Figure 1.

Figure 3 is a diagrammatic view indicating the form of the envelope resulting from the passage of the gas through the tuyère openings.

Figure 4 is a view, partly in section and partly broken away, showing adaptation of the device shown in Figure 1 to an apparatus for fractionating petroleum.

Figure 5 is a fragmentary view, partly in elevation showing a modified form of tuyère structure.

Figure 6 is a view similar to Figure 4, of a modified form of fractionating apparatus.

Referring more particularly to Figure 1, A indicates a tuyère of cylindrical form and fabricated from any suitable material, as, for example, sheet metal. The tuyère has an imperforate bottom 1 and is supported in any suitable manner in a pan 2, into which leads a pipe 3, through which a liquid is supplied to the pan. The top of the tuyère is open and discharges into an imperforate ring 4, provided with an outwardly curved lip 4' at its top, as shown in Figure 1, or with an outwardly extending lip 4'', as shown in Figure 5.

The lower portion of the tuyère A presents a circumferential series of closely spaced tangential blades 5 forming narrow passages 6 between them and which extend vertically from adjacent the bottom 1. The blades 5 may be readily formed by slitting and bending from the wall of the tuyère and the lower end portions of the passages 6 within the pan 2 may be enlarged by bending out the lower end portions of the blades 5, as shown at 10.

Above the series of blades 5 may be a second circumferential series of tangential blades 5' forming passages 6' between them. The blades 5' are equal in number to the blades 5. If desired, each of the blades 5, 5' may be made as one blade to provide continuous openings extending from the bottom of the tuyère, as shown in the United States patent to Hawley 2,189,491 to which reference is made. Alternatively, the construction shown in my copending application Serial No. 59,718 filed November 12, 1948, using differential blade openings may be used.

Referring now more particularly to Figure 4 the fractionating column is indicated generally B and is provided with a series of decks 9 in each of which is mounted one or more tuyères A. The spacing between the decks 9 represented by the volume of chamber C is largely a vapor space.

In a typical unit, a petroleum charge is preheated in a suitable heater, not shown, and is introduced at 11 to a liquid-vapor separator generally indicated at 12 which may be of any desired type. In such a unit, the unflashed liquid is cooled by evaporation and falls to the bottom and may be introduced by the line 14 to an intermediate tuyère A' through which vapors arise through chamber C. The flashed vapors from the separator enter chamber C above tuyère A' thru line number 15.

As the vapors containing hydrocarbons of mixed boiling points engage the liquid on the pan 2 as described with respect to Figure 1, a whirling or vortical motion is set up within the tuyère to establish highly intimate mixing. As a result, some of the lighter ends of the feed liquid are vaporized to join with the other light ends and any heavy ends carried by the vapors will be condensed and centrifugally thrown outward as the liquid vapor mix discharges over the lip 4'.

Again referring to an intermediate tuyère A', the liquid removed from the deck above is discharged through the external downpipe 16 and serves to supply the liquid feed for a lower deck and tuyère as indicated by the line 16a.

In a typical fractionation unit, a series of decks are used each of which accomplishes a small temperature change so that ultimately the vapors denuded of heavy components are removed through the overhead outlet 18 and, in turn, these

vapors pass through a condenser 20 suitably cooled as by heat exchange with a flowing liquid entering in line 22. The condensate discharging through line 24 is available for top reflux as well as product which may be discharged through the line 26.

At the same time, the heavier components are concentrated and collected in the lowermost chamber 27 and may be maintained at a desired level as by the weir 28. Usually a reboiling system including the reboiler 30 is interconnected with the lowermost reservoir 27 as by the discharge downpipe 32 and the external piping 33. Steam or other heating medium may be introduced at 34 in the reboiler for indirect heat exchange, with discharge at 36. The continuous heating of the bottoms will drive off vaporous portions in the well known manner and a net bottoms product may be removed through the line 38.

It is found that the lip 4' is of particular advantage in the removal of liquid from the gases discharging through the tuyère. Not only is it an aid in coalescing and carrying off the liquid and preventing re-entrainment but it materially aids in the efficiency of separation which is materially effected by the velocity of gases through the tuyère blades. With a high velocity there is a greater tendency of entrainment unless the lip and its curved shape is utilized.

While ordinarily I find it desirable to have a substantially semi-circular cross section for the lip 4' as shown in Figure 1 and with a radius of not less than $\frac{1}{4}$ " on a tuyère of 3" in diameter, I have found with certain liquids and relatively low velocities that the flared or arcuate lip shown at 4'' in Figure 5, is effective. It may also be unnecessary to have any cylindrical imperforate portion 4 and the curved lip may start at the junction of the blades 5'.

A fractionating tower B of the type described is particularly useful in fractional distillation and, in a typical case, I provided a 9" tuyère having an 11" feed pan 2 in a tower of 15" in diameter. At 800 cu. ft. a minute of gas passage through the blades, the velocity was 32.1 feet per second. This is an apparent minimum velocity to obtain the desired lift on the liquid. In this case, the number of blades was 71, the blade width was .39" and the blade opening was $\frac{3}{8}$ ". The blade area was .416 sq. ft. which was approximately 94% of the tuyère cross sectional area. The height of the tuyère was also 9", the blades were straight and with 1200 cu. ft. per minute air, there was approximately 1400 gals. per hour picked up of water. In a construction of this type, the liquid level in pan 2 maintains an automatic balance, and overflow to a lower deck is not encountered. Careful control is not necessary although the unit may generally be adjusted to maintain a fixed level of liquid.

In the foregoing description I have referred to the conduit 3 and pan 2 primarily for the purpose of feeding liquid into the vortex formed by the gas entering the tuyère. It is, of course, possible, as described in my copending application Serial No. 649,203 above referred to, to mix two gases such as air and naphthalene and in such case effective mixing of approximately 40,000 lbs. per hr. of air saturated with water with approximately 3000 lbs. of air saturated with water and containing approximately 1500 lbs. per hr. of naphthalene can be accomplished in a tuyère of 16" in diameter mounted in a 24" tower.

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It is also to be understood that fluidized solids may be introduced to the gas path as for example, activated carbon as may be required in an absorption process. In such case, ethylene, as gas, may be introduced through the blades of the tuyère and an activated carbon picked up from the feed pan 2. Fine solids with adsorbed material will in such case pass over the lip 4' and may drain off in a typical drain pipe.

Figure 3 illustrates diagrammatically the formation of the envelope and the prevention of the entry of liquid in the central space bounded by the whirling envelope and the prevention of the breaking of the envelope into the low pressure area. This is accomplished in tuyères such as shown in Figures 1 and 2 as a substantially uniform amount of vapor will enter the tuyère A with the result that the vapor envelope formed within the tuyère will be a shape approaching a semi-parabola indicated by the dotted line Y. The liquid is thus drawn into the formation of a whirling, vertically, traveling envelope of mixed gas and liquid before the liquid reaches the tuyère proper, so that any tendency for the envelope to break at its lower end into the lower pressure area is avoided.

In Figure 6 I have illustrated a composite type of tower generally indicated at 30 to show several variations of tuyère connections. A feed of a mixed component charge as of petroleum, in line 32 first enters the separator 34 from which the liquid enters the tower through line 36 and the vapors enter the tower through the line 38. The tower is provided with a series of decks generally indicated at 40 and for purposes of discussion the topmost tuyère is indicated at 41 and lower tuyères at 42, 43, and 44 respectively. The lower part of the column becomes a reservoir generally indicated at 46 which may be interconnected through downcomer 48 with an external reboiling circuit 49 containing the reboiler 50. Steam stripping could also be used for heating purposes. In such a column a part of the bottoms will be removed at 52 as product. Overhead removed at 54, may be condensed at 56 with a portion returned as reflux at 58, the balance being removed as product at 60.

The topmost tuyère 41, which is of the outside feed type, is identical to the topmost tuyère A shown in Figure 4 except that it has a single row of blades 41a and as previously described the vapors which pass through the tuyère 41 to the outlet 54 will be suitably contacted with and cooled by the reflux liquid in pan 2 to control the end point of the product at 60. The high velocity vapor feed will develop a vortical movement in the tuyère 41 and as the vapor discharges from the tuyère the liquid will be thrown out and may be removed from the deck by the downcomer 62.

As in the typical bubble columns, it is usually found desirable to reheat this liquid by contacting it with the warmer vapors that pass through the next lower tuyère 42, and in such manner the volatile components at the particular temperature will be released. As the heat exchange is mutual the heavier components of the vapors rising from tuyère 43, are condensed and pass on downwardly in the liquid.

In some cases the operation of the tuyère may be such that a direct recycling is desirable. For this purpose tuyère 42 is provided with a separate recycle downcomer 64 which may have a valve 64a. This conduit 64 is interconnected with the interior of the tuyère 42 below baffle 42a so

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that the recycle liquid is fed to the inside of the envelope to seal the downcomer. The conduit 62 may feed the outside pan 42b.

In the case of the tuyère 42, I have provided a weir construction of deck 40a and by providing the downcomer 64 close to the lowermost part of the deck 40a and by spacing the downcomer 66 somewhat above the bottom of the deck, I can be assured of a preferential circulation of liquid as inter-tuyère recycle. As in the previous case, the recycle in line 64 preferably enters the interior of the tuyère.

Referring now to the tuyère 43, I have again provided an off-set deck 40b and in this case the tuyère recycle line 68 is spaced substantially above the bottom of the deck 40b while the downcomer 70 is provided with the liquid drawoff line having valve 71 therein, the inlet to said line being closely adjacent the lowermost part of the deck for a preferential drawoff to the next lower tuyère 44. If desired, a vent 72 may be provided in this line 70. The tuyère 43 thus receives liquid feed from the separator 34 and reflux from the higher tuyère 42 as well as inter-tuyère recycle from line 68. All of the liquid will pass downward through the downcomer 70. If desired this may be heated as at 74 as it passes to the tuyère 44.

The tuyère 44 also is provided with both internal and external feed devices. This includes the outer pan 76 such as the pan 2 of Figure 1 and it also includes an internal baffle plate 78 which forms an annular space within the closed base 79 of the tuyère. The recycle line 80 may be connected with this annular space by opening through the plate 79. As the vapors pass upward through the tuyère 44, a vortex will be developed which induces the liquid from the outer pan 76 as well as the internal annular space. Liquid thrown out by tuyère 44 may be removed through line 82 and, if desired, a weir 84 may be provided in the lower part 46 of the tower 30 to maintain the desired level of such liquid.

Although various forms of liquid flow are illustrated and various arrangements may be used, depending upon the process requirements, it will be apparent that the tuyère serves to form the vortex of liquid and gas in substantially the same manner in each unit. This has the substantial advantage that it is possible to materially reduce the diameter of the tower as compared to the typical bubble tower.

In comparing a unit for the handling of 14,000 barrels per day of Pennsylvania crude, which is to be charged to an atmospheric topping tower running to 37% bottoms, the diameter of the bubble tray column will be at least 8' 4" whereas a multiple tuyère tray column will have a diameter of approximately 5' 6". Comparison of other sizes shows equally favorable benefits for the fixed centrifugal tuyère tower. This construction thus, not only materially reduces the tower size but also has the advantage of reducing the cost of decks and supporting structure.

Although emphasis has been placed on the fractional distillation of a mixed component material, it will be apparent that the tuyère is of general advantage to effect concentration, absorption, adsorption scrubbing or removing entrained solids or liquids from gases. One or more of these steps may be used in the general fractionation operation or in combination with it, as an example, caustic washing could be readily accomplished by simultaneous feed of liquid onto one or more of the decks.

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While I have shown and described a preferred form of embodiment of my invention, I am aware that other modifications may be made thereto and I therefore desire a broad interpretation of my invention within the scope and spirit of the description herein and of the claims suspended hereinafter.

What I claim and desire to protect by Letters Patent is:

1. In a fluid mixing device of the class described, comprising a cylindrical tuyère having a closed end wall and being fully open at the opposite end, the side wall having a plurality of inwardly directed blades forming inwardly convergent gas paths, an integral outwardly extending curved lip continuing from said tuyère side wall, a casing surrounding said tuyère and means to direct a gas current into said casing and through said gas paths between said blades to form a gas vortex in said tuyère, said vortex discharging out of said tuyère opening and across said lip whereby said lip serves to carry off any entrained matter heavier than the gas.

2. A fluid mixing device of the class described in claim 1 in which the lip has a tangential curve not less than $\frac{1}{2}$ " in radius.

3. A fluid mixing device of a class described in claim 1 in which the lip extends from the edge of the blades in an upwardly and outwardly flaring arc.

4. A fixed centrifugal device comprising a cylindrical shell closed at one of its ends and open at its other end and having a series of tangentially extending blades disposed circumferentially of said shell forming between them a series of passages extending from adjacent its closed end for the entry of a vapor into said shell, an integral imperforate portion of at least the same diameter extending beyond said passages to its open end, and an outwardly extending lip integrally disposed about its open end, said lip having a minimum diameter at least as great as the body of the shell.

5. A fixed centrifugal device as claimed in claim 4 in which the lip is upwardly, outwardly and downwardly extending from the open end.

6. In a fluid mixing device, as claimed in claim 1, a fluid container having a side wall surrounding a portion of the tuyère side wall, and means for continuously feeding a fluid to said container, the gas current moving upwardly over the surface of the fluid in said container and through said gas paths between said blades entraining said fluid and mixing it with the gas of said current.

7. In a fluid mixing device as claimed in claim 6 in which the tuyère has an imperforate portion extending vertically beyond the blade passages and to the outwardly extending curved lip.

8. In a fluid mixing device, the combination comprising a cylindrical tuyère having a solid bottom wall and a side wall provided with a plurality of blades forming inwardly convergent gas paths, a fluid container having a side wall surrounding a portion of said tuyère side wall and in discontinuous relation thereto to form a fluid outlet external of the tuyère, means for continuously feeding a fluid to said container, and means for supplying a gas current upwardly over the surface of the fluid in said container and through said gas paths between said blades for entraining said fluid and carrying said fluid into said tuyère and mixing it with the gas of said current.

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9. As a subcombination, a unit of a fractionating column, comprising a fixed cylindrical tuyère adapted to be sealed within said column, said tuyère having its side wall formed of a series of substantially tangential blades forming gas passages therebetween, one end of said tuyère having a substantially closed wall, the other end of said tuyère being fully open and having an integral outwardly projecting lip portion, said lip portion having a minimum diameter at least as great as the tuyère diameter, the edge of said lip portion being spaced from any part of the column, a liquid reservoir adjacent the closed end of the tuyère and means to supply a liquid to said reservoir, the upper surface of said liquid being in the gas path through the tuyère whereby a vortical path of gas and liquid is established within said tuyère, the lip portion being curved and adapted to disentrain liquid carried by said gas discharging from said tuyère.

10. A liquid and vapor contact apparatus comprising a tower having a vapor inlet and a vapor outlet, a plurality of decks dividing the tower into a plurality of units, a fixed centrifugal device mounted in each deck comprising a cylindrical shell open at its upper end and having a series of tangentially extending blades disposed circumferentially of said shell forming between them a series of passages extending vertically from adjacent its lower end for the entry of a gas, means for forming an annular liquid space at the lower ends of the passages, and an outwardly extending curved lip disposed about its upper end, said lip having a minimum diameter at least as great as the tuyère diameter and being integral therewith, means for admitting liquid to the annular liquid space at the lower ends of each centrifugal device, and means for conducting the liquid with entrained material from each deck.

11. A liquid and vapor contact apparatus as claimed in claim 10 in which an imperforate portion is provided in each centrifugal device, said portion extending vertically beyond said passages from below the deck to its open end above the deck.

12. A liquid and vapor contact apparatus comprising a tower having a vapor inlet and a vapor outlet, a plurality of decks dividing the tower into a plurality of units, a fixed centrifugal device mounted in each deck comprising a cylindrical shell open at its upper end and having a series of tangentially extending blades disposed circumferentially of said shell forming between them a series of passages extending vertically from adjacent its lower end for the entry of a vapor, means for forming an annular liquid space adjacent the bottom of each of the centrifugal devices at the lower end of the passages, an imperforate portion on each centrifugal device extending vertically beyond said passages from below the deck to its open end above the deck and an outwardly extending curved lip disposed about its upper end, said lip having a minimum diameter as great as the tuyère diameter and being integral therewith, means for admitting liquid to the annular liquid space at the lower end of the upper centrifugal device, means for conducting the liquid from each deck to the annular space of the centrifugal device below the deck, and heat transfer means in at least one of said means for conducting liquid from one deck to the annular space of a centrifugal device below said deck.

13. A stationary mixer for separate fluid

streams at least one of which is gaseous, which comprises a housing forming a substantially gas tight chamber, said chamber having a gas inlet thereto, means for supplying a gas stream to said inlet, a hollow tuyère within the chamber, said tuyère having a closed end wall, and a side wall provided with a plurality of blades forming inwardly convergent air paths therebetween, the tuyère being fully open on the end opposite the closed end, said tuyère being sealed with respect to the chamber adjacent the open end of the tuyère whereby the passage of the gaseous fluid in the chamber through the tuyère will cause a vortex therein, a fluid reservoir for a second fluid adjacent the closed end of the tuyère, communicating means connecting the reservoir with the interior of the tuyère whereby the vortex formed therein by the gaseous stream will uniformly distribute the second fluid, said tuyère having an imperforate portion beyond the blades

and an integral continuous curved lip portion extending from the wall of the tuyère in the path of fluid discharge from the tuyère to separate the heavier fluid from the lighter fluid discharged therefrom.

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