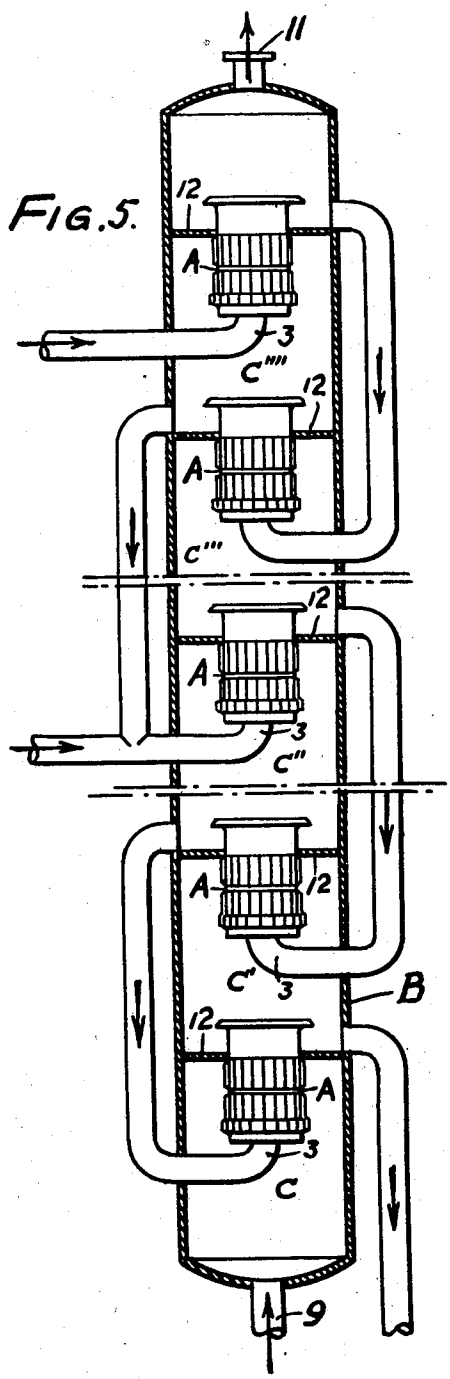
July 10, 1951 W. J. BLOOMER 2,560,073

FIXED CENTRIFUGAL DEVICE

Filed Nov. 12, 1948 2 Sheets-Sheet 1

FIG. 5.



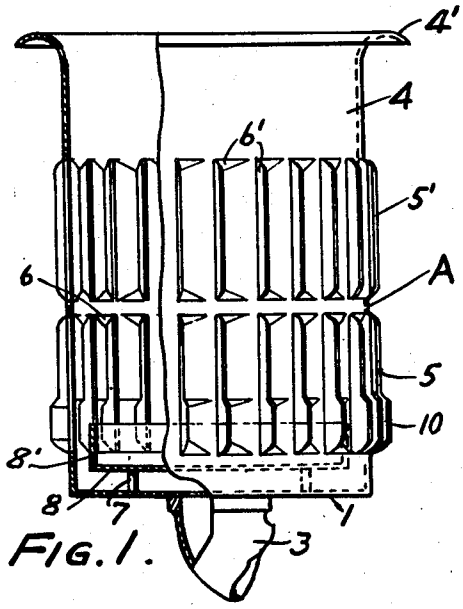


FIG. 1.

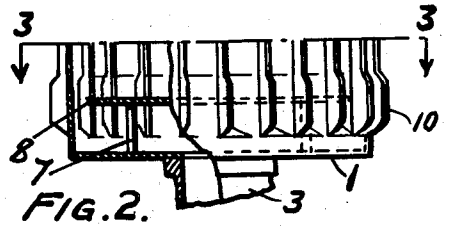


FIG. 2.

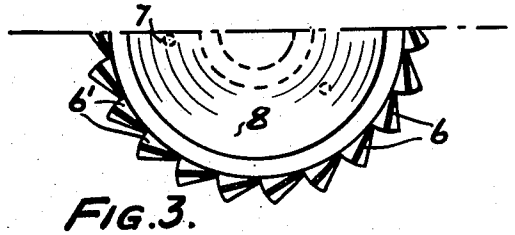


FIG. 3.

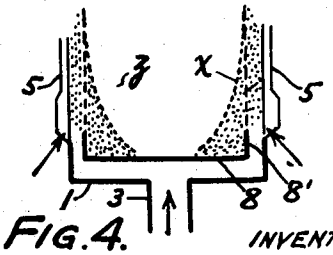


FIG. 4.

INVENTOR

Ward J. Bloomer

BY

Nathaniel Clay

ATTORNEYS.

July 10, 1951 W. J. BLOOMER 2,560,073

FIXED CENTRIFUGAL DEVICE

Filed Nov. 12, 1948 2 Sheets-Sheet 2

FIG. 6.

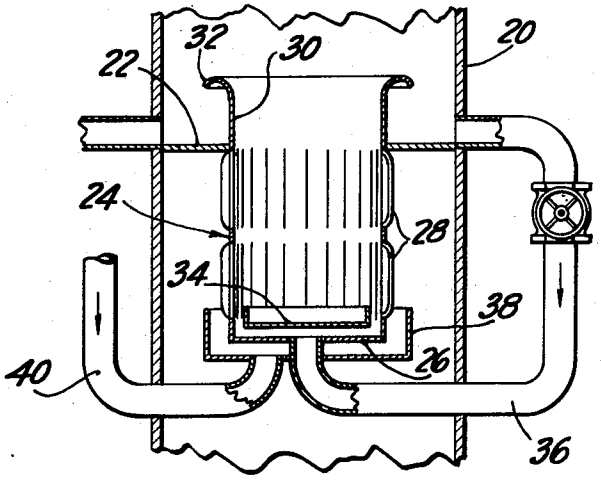
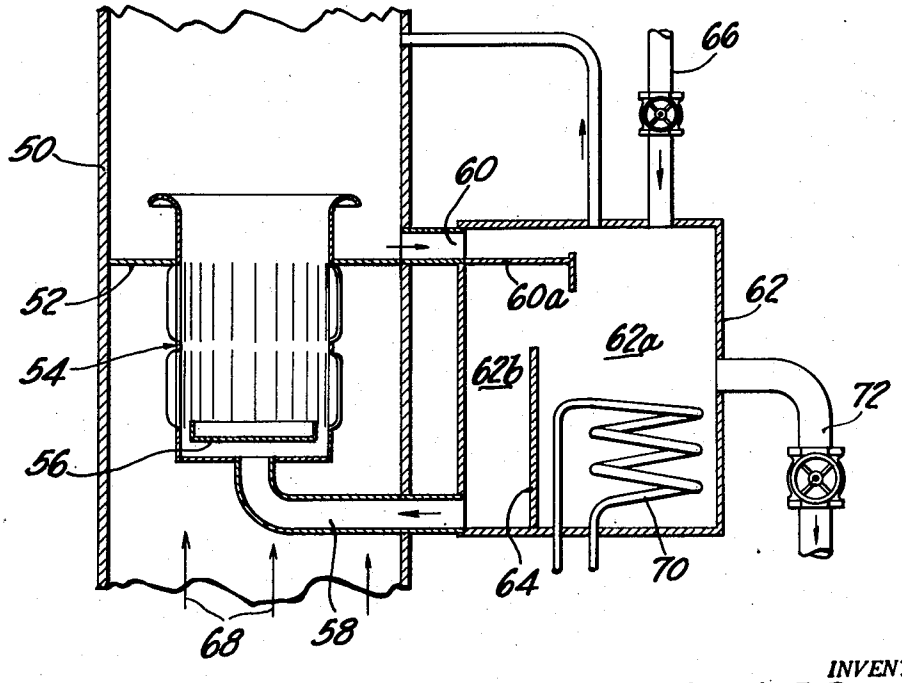


FIG. 7.



INVENTOR.
Ward J. Bloomer
BY
Nathaniel Ely
ATTORNEY

Patented July 10, 1951 2,560,073

UNITED STATES PATENT OFFICE

2,560,073

FIXED CENTRIFUGAL DEVICE

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. 59,720

7 Claims. (Cl. 183—21)

1

This invention relates to an improvement in a fixed centrifugal device of the type heretofore variously used for, among other purposes, contacting gases and liquids to effect concentration, fractionation, or the like, for removing entrained liquid from gases, and 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, in connection with the fractionation of petroleum. It is a continuation in part of my copending application Serial No. 580,804, filed March 2, 1945, now abandoned.

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 into the bottom 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 consolidated in an imperforate ring into which the tuyère discharges, and the liquid is finally collected and drained away from the gas.

In the operation of such a device for contacting a liquid and a gas, it has heretofore been recognized that the entering gas, due to resolution of all the forces involved, forms within the tuyère a vortex or envelope, having the shape of a semi-parabola, about an area of low pressure or vacuum axially of the tuyère. Further, it is known that the useful working range of such a device requires a vapor rate just beyond that at which the envelope closes at the bottom, in order to avoid breaking of the envelope into the low pressure area within the envelope, with resultant vertical entrainment of liquid, and at least such as to lift all of the liquid offered to the tuyère.

It is the principal object of my invention to provide a fixed centrifugal device or tuyère so constructed that the entering gas or vapor will form an internal hollow whirling envelope or vortex to which the liquid is introduced axially within the tuyère and adjacent the wall thereof whereby the pressure drop or resistance to liquid

2

flow is substantially reduced in comparison to either an external feed or a throttled central internal feed.

A more specific object of my invention is to provide an inside feed for the tuyères of a multiple deck fractionation unit in which the lower pressure drop of the feed may be utilized in reducing the deck spacing or alternatively the throughput may be materially increased for a predetermined sealing requirement.

A still further object of the invention is to provide an improved fractionation column having a plurality of decks carrying fixed cylindrical tuyères for liquid-vapor contact in which the liquid feed is to the inside of the tuyère within and adjacent the walls of the vortex or envelope so that recyling from one deck back to the same deck can be accomplished.

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 elevation with parts in section of a modified form of fixed centrifugal device.

Figure 3 is a partial horizontal cross sectional view on line 3—3, Figure 2.

Figure 4 is a diagrammatic view indicating the method of admission of the liquid to the whirling vapor envelope.

Figure 5 is a central vertical section with parts in elevation of a countercurrent contacting tower.

Figures 6 and 7 are central vertical sections of still further modified forms of construction.

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 a bottom 1 and is supported in any suitable manner. A pipe 3, through which a liquid is supplied to the tuyère is connected centrally of the bottom 1. The top of the tuyère is open and discharges into an imperforate ring 4, provided with an outwardly curved lip 4' at its top.

The lower portion of the tuyère A presents a circumferential series of closely spaced tangential blades 5 forming narrow passages 6 between them for the entry of gas 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 10 of the passages 6 may be enlarged by bending out the lower end portions of the blades 5, as shown in Figures 1 and 3.

Above the series of blades 5 is a second circumferential series of tangential blades 5' forming passages 6' between them for the entry of gas. The blades 5 and 5' may be made as continuous blades to provide continuous narrow openings between them for the entry of gas, instead of, as shown, openings in series one above the other.

Within the tuyère and spaced and supported from the bottom 1 by legs 7 is a horizontally extending flat plate or baffle 8, which is centered with the discharge opening of the liquid supply pipe 3 and the periphery of which is spaced from the openings 6 a distance less than the thickness of the envelope formed by the gas entering through the openings 5' and 6' and whirling within the tuyère.

Referring to Figure 1, the plate or baffle 8 is provided with a peripheral upwardly extending flange 8' and the baffle is spaced from the bottom 1 with respect to the height of the flange 8', so that the flange will terminate at a point above the lower end of the enlarged portion 10 of the passages 6.

Referring to Figure 2, the plate or baffle 8 comprises merely a flat plate without a peripheral flange, and it is spaced from the bottom 1 so that it will lie above the bottom of the enlarged portions 10 of the openings 6. By way of example, the baffle 8 may lie about midway between the ends of the enlarged portions 10 of the openings 6.

Referring now more particularly to Figure 4, the form of the envelope of whirling gas and admixed liquid particles formed in a tuyère of the above construction is indicated by the area defined by the dotted lines X within the tuyère indicated, it being noted that the baffles 8 serve to lead the liquid, entering the tuyère through the pipe 3, peripherally to adjacent the enlarged portion of the openings 6, where it is at once picked up by the relatively large volume of air entering through the enlarged portions 10, given a whirling motion below the baffle and necessarily an upward motion to enable it to pass the periphery of the baffle or the flange 8', if the flange be provided before it enters the tuyère proper.

Figure 4 also illustrates, diagrammatically, the function of the baffle 8 in the formation of the envelope and in the prevention of the entry of liquid into the low pressure area and of the breaking of the envelope into the low pressure area Z within the envelope, it being noted that the baffle 8 prevents the direct entry of any liquid to the low pressure area Z and it leads the liquid to the whirling, vertically traveling envelope of mixed gas and liquid.

Referring now more particularly to Figure 5, B indicates a countercurrent liquid vapor contacting tower, provided with a vapor inlet 9 and a vapor outlet 11 and divided, by means of decks 12, into a plurality of fractionating units C, C', C'', C''', and C''''.

Let into the several decks 12 and affording passage therethrough from one contacting unit C to another are tuyères A, the liquid supply pipes 3 of the several tuyère being connected variously, as shown, to a liquid supply or for reflux.

Assuming now that a vapor is to be contacted in the tower B, the vapor is introduced into the bottom of the tower through pipe 9 and a contacting liquid, as water, is introduced into the tuyères A through pipe 3 connected with a liquid supply and, as the operation proceeds, for reflux.

The liquid passes into the bottom of the several tuyères through the pipe 3 and is guided peripherally by the baffles 8, while the gas enters the tuyères tangentially through the passages 6, including the enlarged portions 10 formed by the blades 5 and their bent out portions.

The vapor entering the several tuyères, in passing up the tower from unit C to unit C', and from C' to C'', and from C'' to C''', and from C''' to C'''', assumes a whirling motion therein and picks up the liquid entering the tuyère through the pipes 3 as led peripherally by the baffles 8, with the formation in the tuyères of envelopes of mixed vapor and liquid particles and of substantially semi-parabolic form. Avoidance of entrainment of liquid or breaking of the envelopes into the low pressure area between the envelopes may be assured with sufficient vapor velocity.

As described in my copending application Serial No. 649,203, filed February 21, 1946, and entitled "Mixer," and my application Serial No. 59,719, filed November 12, 1948, entitled "Apparatus for Fractionation," the continued rotation of the envelope within the tuyère is accomplished by the continuous feed of the gas or vapor through the inlets 6 into the tuyère. The outer wall is limited by the inflow of this gas or vapor which thus establishes an equilibrium of envelope whch becomes hollow and shallow. The liquid which enters the envelope also soon reaches the equilibrium stage, becoming thoroughly intermixed with the gas or vapor.

The rate of longitudinal movement of the envelope depends upon the amount of fluids and the volumetric displacement and can be varied in accordance with the desired time of contact. This time of contact may be terminated by the use of the imperforate ring 4 between the end of the tuyère and the end of the openings 6 or, if more mixing is accomplished in the tuyère itself, the tuyère openings may extend substantially directly to the outlet.

As also described in my copending application Serial No. 59,719, filed November 12, 1948, above referred to, the curved lip 4' aids in the separation of liquid entrainment from the vapors. Theoretically, the liquid particles which have been gathered centrifugally in mass form should be ejected laterally in advance of escape of the gas. I have found that by utilizing the curved lip, as shown, a liquid which is picked up by the gas or vapor will tend to follow the lip outwardy and downwardly by virtue of its surface tension. This is particularly important with high gas rates which would otherwise tend to cause atomization and reentrainment in the gas.

As described in my prior copending application Serial No. 59,719, above referred to, I find it essential in mixing a second fluid such as liquid with the first fluid such as the gas, to introduce the liquid to the envelope at a relatively less resistant portion within the inner wall. This may be accomplished by the so called outside feed as described in my copending application Serial No. 59,719 above referred to, but I find particular advantages in introducing it adjacent the closed inner end of the semi-parabolic envelope between the outer and inner surface of the envelope.

This is particularly shown in Figure 4 and by such an application I can avoid some of the

pressure drop of the blade openings. Calculations have indicated that the pressure drop of the blade itself is approximately 80% of the total pressure drop, the balance being that necessary to overcome the centrifugal force of the whirling vapor liquid contact mass. If, therefore, the feed is introduced as shown in Figure 4, a substantial part of the pressure drop opposing the entry of the liquid can be eliminated and it is thus possible to increase the gas velocity thus increasing the capacity of the unit.

Alternatively it is possible, as shown in Figure 5, to decrease the spacing between the respective decks 12 which is largely determined by the height of the sealing liquid in the downcover. If, for example, a 22'' spacing is found desirable for a particular liquid with outside feed it is possible in utilizing the inside feed to reduce this to approximately 15''. While this will vary with different liquids, the proportion is approximately the same with different materials.

An inside feed may be combined with the outside feed as shown in Figure 6 if different liquids are to be mixed simultaneously with the entering gas. In this case the tower, being generally shown at 20, is provided with a suitable transverse deck 22 on which is mounted a tuyère generally indicated at 24. As in the prior case, the tuyère is provided with a closed bottom member 26 and is open at the top and throughout the major part of its length is provided with blades 28 forming tangential gas openings. The upper portion of the tuyère may have an imperforate portion 30 and a curved lip portion 32, if desired.

In the particular construction a baffle or plate 34 is provided above the closed bottom 26 and within the tuyère thereby forming an annular space to which a liquid may be introduced through the line 36. This construction is thus comparable to the construction shown in Figure 1. In addition an external pan 38 may be provided surmounting the outer lower edge of the tuyère and forming a second annular space to which a liquid may be introduced through the line 40.

It will be apparent with a construction of this type that the two liquids may be the same and in a distilling tower the outside feed would balance a seal of reflux from the deck above. The inside feed would balance a seal of recycle reflux from the same deck and this would increase the vapor liquid contact for improved plate efficiency.

The liquids may be dissimilar but mutually soluble. The vapor would supply the energy for the mixing and might itself enter in part into the mix as a treating agent. This would give very efficient mixing. In addition, the discharge from the deck could be recycled in part or whole to the inside feed for extra contacting without the use of a pump.

The liquids may be dissimilar and mutually insoluble for the preparation of dispersions or suspensions. If, for example, one of the liquids is water and the other insoluble, an emulsion may be formed.

A still further modification of the inside feed is shown in Figure 7 which particularly permits continuous liquid recycling. In this case the column is generally indicated at 50 and is provided with the transverse baffle 52 supporting the tuyère generally indicated at 54. This tuyère is provided with the internal baffle 56 for the internal feed from line 58 as indicated in Figure 1.

Above the deck 52, a drawoff 60 is provided to the tank 62 which is provided with a baffle 64 serving as a weir. The compartment 62*b* which is spaced from the compartment 62*a* by the weir is interconnected to the liquid feed 58.

Assuming that a liquid is introduced to the compartment 62 through the feed line 66, a level will be established by the weir 64 with liquid passing over the weir and into the tuyère 54. Assuming a gas passing up the column as at 68, it will be apparent that an intimate mixing will be accomplished and the liquid which is thrown off from the tuyère will discharge through the conduit 60 back into the chamber 62. An extension 60*a* may be provided so that it will enter the main compartment 62*a* which may also be provided with a heating or cooling coil 70.

Assuming that the pressure drop through the tuyère is 10'' of water, the pressure required by the whirling wall is only about 20% of the entire drop through the tuyère, therefore, the pressure in the envelope of about 2'' will balance a seal of that height.

The device will thus permit washing or treating a gas or vapor by continuous recycling of the washing liquid. If desired, a drawoff 72 may be used for removal of partially saturated washing liquid. It will thus be apparent that the feaure of introducing the liquid within the tuyère but adjacent the closed end of the envelope and at a zone of substantially reduced resistance to feed permits effective feed of a second fluid which may be either a liquid, a gas or fluidized solids.

Tuyères constructed in accordance with this invention will be found to be generally of great advantage, due to the substantially cylindrical shape of the envelope of mixed gas and liquid formed, which gives efficient contact, and due to the avoidance of entrainment of liquid and of the breaking of the envelope into the low pressure area within the envelope, which promotes efficiency. They will also be found of special advantage for use in the fractional condensation of petroleum, or the like vapors as by the method of the Hawley Patent No. 2,189,491, due to the fact that with use of the tuyères according to this invention the throughput may be greatly increased for the same deck spacing and hot reflux downpipe seal, or for the same throughput the reflux seal may be greatly reduced with consequently decreased deck spacing and reduction in the overall height of an apparatus of a given capacity. In either case, as will be obvious, large saving in the amount of space and material required for apparatus of given capacity is obtained as a result of this invention.

I claim:

1. In a fluid mixing device of the class described, comprising a cylindrical tuyère having a closed end wall and a sidewall having a plurality of tangentially disposed blades extending circumferentially of said tuyère and forming a series of inwardly convergent gas paths, means to pass a gas under pressure through said gas paths to establish a vortical gas column within said tuyère, means for forming an anular space within the interior of the tuyère and adjacent the ends of the blades, means for feeding a liquid to said space, said space forming means providing a liquid communication with the remainder of the tuyère whereby the liquid will be entrained by the vortical gas column, said tuyère sidewall continuing into an integral outwardly

extending lip which has a minimum diameter at least as great as the tuyère, the continuing portion of the tuyère sidewall being imperforate to aid coalescence of the liquid.

2. A fluid mixing device as claimed in claim 1 in which the annular space forming means is an upwardly flanged pan, the flange of which forms an annular passage for liquid flow with the tuyère side wall.

3. A fluid mixing device as claimed in claim 1 in which an external liquid reservoir is provided adjacent the closed end of the tuyère, and means to supply a liquid thereto whereby the gas passing over the liquid and through the gas paths will carry the liquid into the tuyère.

4. A liquid-gas contacting apparatus comprising a closed vessel, a cylindrical tuyère therein, said tuyère having a closed end wall and a sidewall having a plurality of tangentially disposed blades extending circumferentially of said tuyère and forming a series of inwardly convergent gas paths, means to pass a gas under pressure through said gas paths to establish a vortical gas column within said tuyère, means for forming an annular space within the interior of the tuyère and adjacent the ends of the blades, means for feeding a liquid to said space, said space forming means providing a liquid communication with the interior of the tuyère whereby the liquid will be entrained by the vortical gas column, said tuyère side wall having an imperforate portion continuing into an integral outwardly curved lip whereby liquid coalescing on the imperforate portion will be carried by the lip out of the gas path, an external reservoir, a weir in said reservoir to establish a column of liquid in said tuyère, and conduit means to draw off the removed liquid into said reservoir and other conduit means to return said reservoir liquid back to the liquid containing annular space within the tuyère.

5. A liquid-gas contacting apparatus as claimed in claim 4 in which the external reservoir has a heat exchange element therein.

6. In a method of mixing a liquid and a gas and thereafter removing liquid entrained in the gas in an open tuyère having an open end, a closed end and plural generally tangential blades forming its wall, which comprises providing a uniform supply of liquid outside said tuyère, communicating said liquid to the interior of the tuyère adjacent the wall thereof, providing a low pressure column of flowing gas outside said tuyère, and directing said low pressure gas between said blades and over said liquid for entrainment thereby, thence to impart a rotary component to said liquid and gas and form within said tuyère a hollow generally cylindrical mixing and atomizing zone for suspending said liquid uniformly in said gas, while applying sufficient linear component to said column in an axial direction outward of the tuyère adjacent the wall thereof to maintain the gas-liquid column in said mixing zone unclosed throughout its length and centrifugally passing said gas-liquid column through a liquid coalescing zone to form a liquid film, and thereafter progressively disentraining and recovering the liquid separate from the gas by diverting the coalesced liquid as a continuous film through a curved path in continuity with the coalescing zone and out of the tangential path of movement of the gas from the tuyère.

7. In a method of mixing a liquid and a gas and thereafter removing liquid entrained in the gas in an open tuyère having an open end, a closed end and plural generally tangential blades forming its wall, which comprises providing a uniform supply of liquid outside said tuyère, communicating said liquid to the interior of the tuyère adjacent the wall thereof, providing a low pressure column of flowing gas outside said tuyère, simultaneously feeding a second fluid to said gas, and directing said low pressure gas and second fluid between said blades and over said liquid for entrainment thereby, thence to impart a rotary component of said liquid and gas and said second fluid and form within said tuyère a hollow generally cylindrical mixing and atomizing zone for suspending said liquid uniformly in said gas, while applying sufficient linear component to said column in an axial direction outward of the tuyère adjacent the wall thereof to maintain the gas-liquid column in said mixing zone unclosed throughout its length and centrifugally passing said gas-liquid column through a liquid coalescing zone to form a liquid film, and thereafter progressively disentraining and recovering the liquid separate from the gas by directing the coalesced liquid as a continuous film through a curved path in continuity with the coalescing zone and out of the tangential path of movement of the gas discharging from the tuyère.

WARD J. BLOOMER.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,894,744	Hawley	Jan. 17, 1933
1,980,522	Hawley	Nov. 13, 1934
2,075,344	Hawley	Mar. 30, 1937
2,087,219	Dorfan	July 13, 1937
2,189,491	Hawley	Feb. 6, 1940
2,511,190	Wright	June 13, 1950