

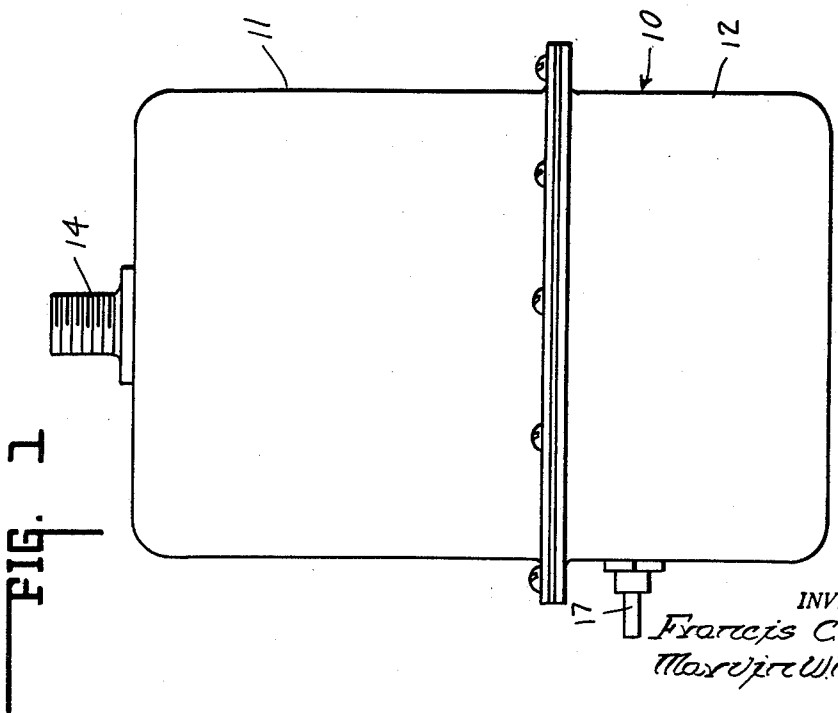
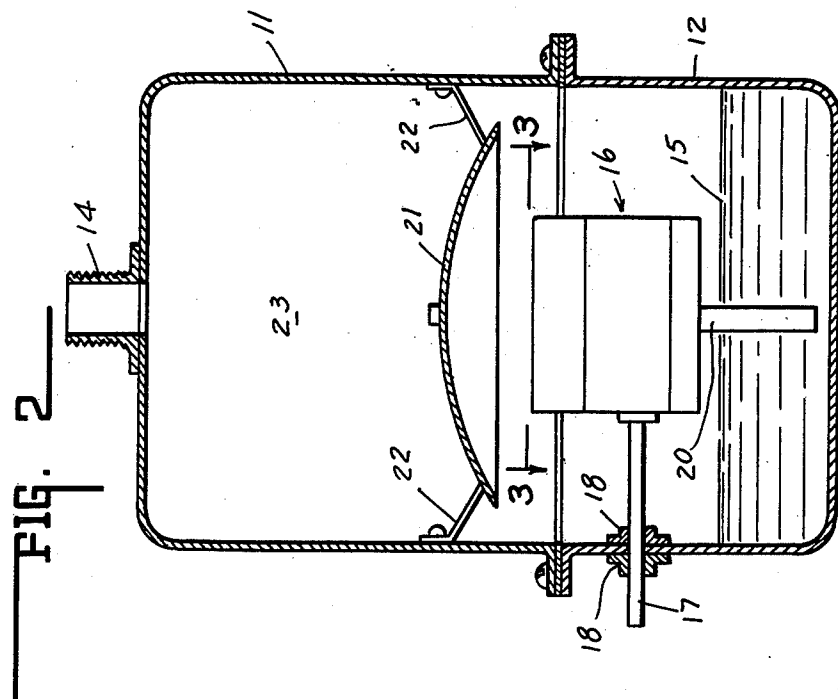
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F. C. MOORE ET AL
NEBULIZER

3,077,307

Filed Oct. 12, 1961

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

FIG. 3

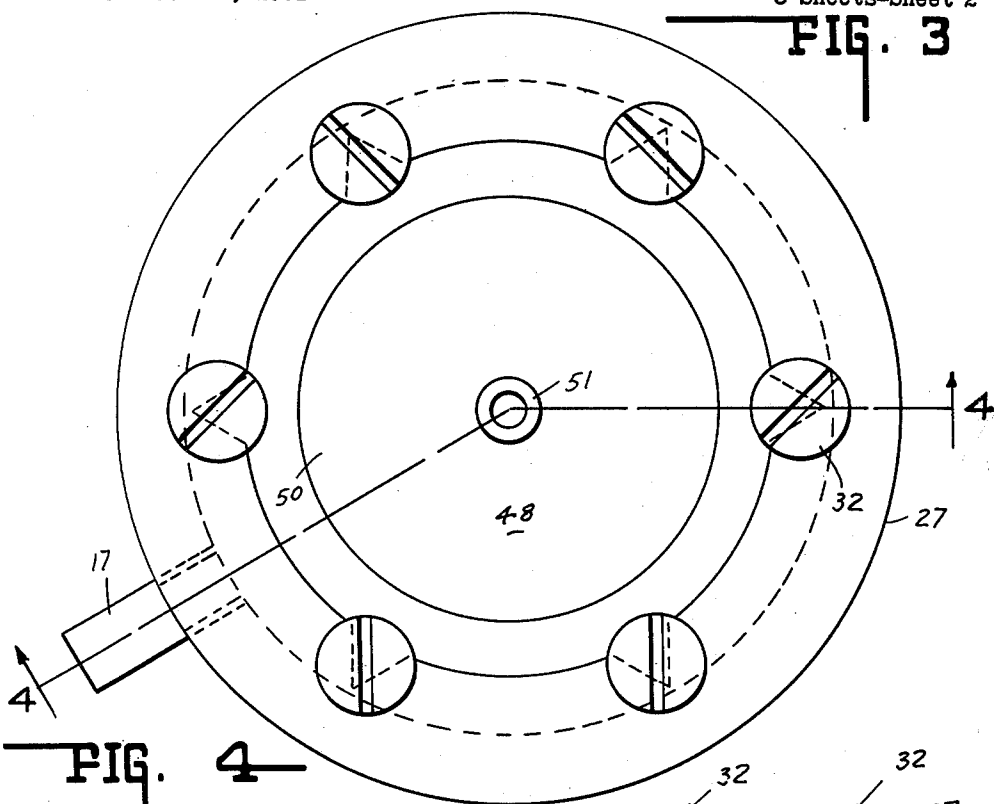


FIG. 4

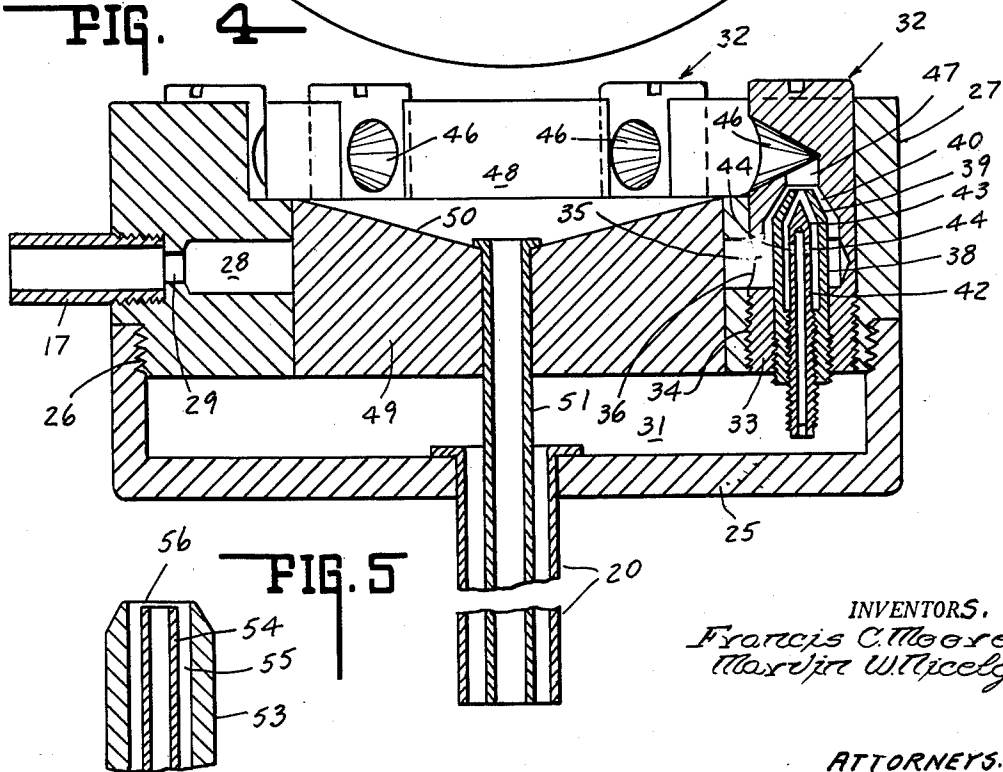
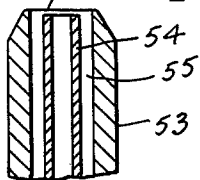


FIG. 5



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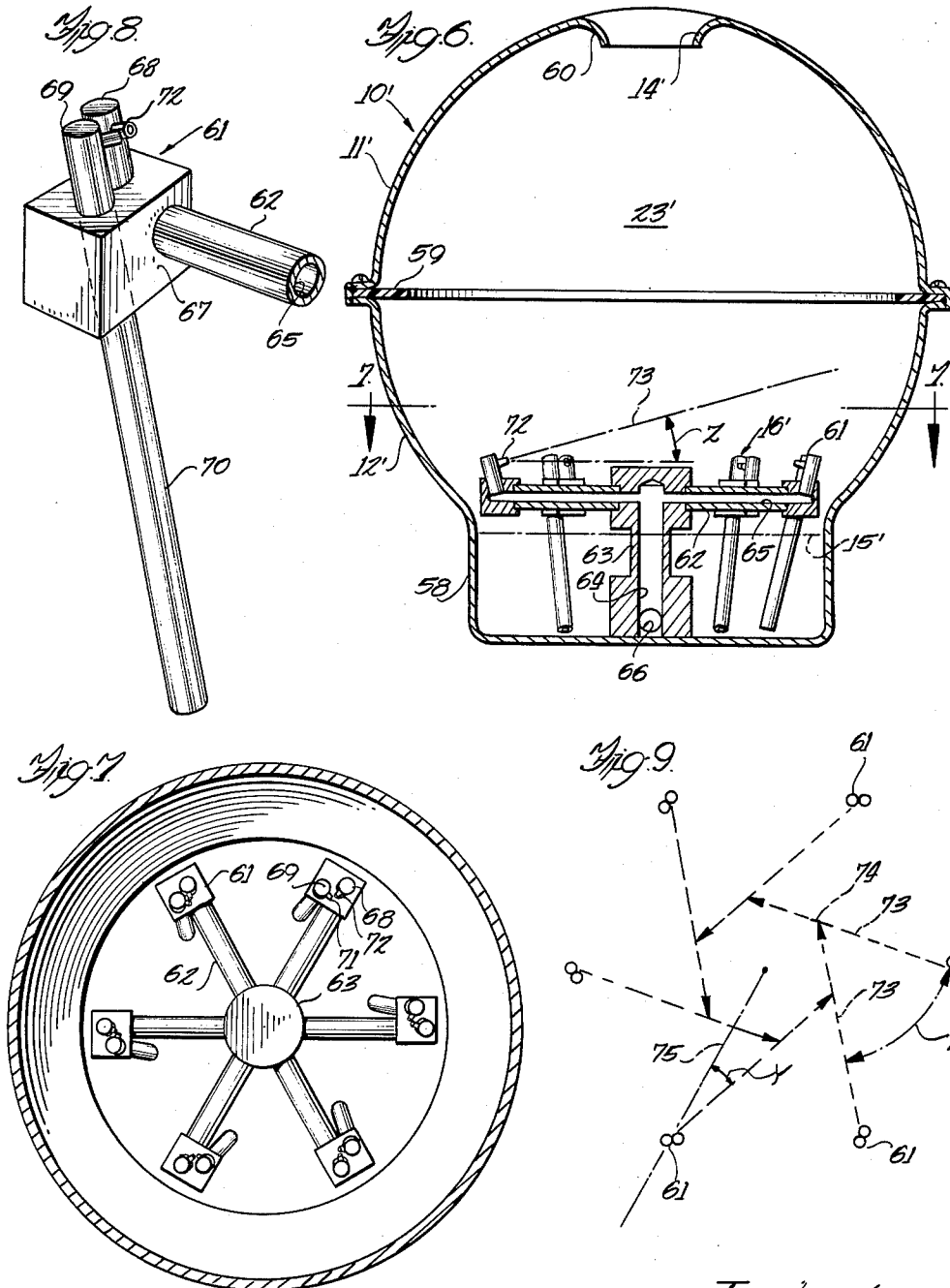
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1

3,077,307 NEBULIZER

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13 Claims. (Cl. 239—338)

This invention relates generally to apparatus adapted to convert liquids, or liquids having solids dispersed or suspended therein, into vapor or gas form without the use of heat and, more particularly, it relates to a nebulizer for reducing vapor to micron size.

This application is a continuation-in-part of my copending application, Serial No. 806,876, filed April 16, 1959, now abandoned.

Conventional nebulizing apparatus may comprise a number of jets adapted to draw fluid from a tank and form a vapor by the application of air under pressure to the jet. The air pressure is usually created by means of a hand-operated bulb member. As a consequence, air pressure is applied intermittently and at a relatively slow rate, whereby the conversion of fluid to vapor form is limited as to quantity of output.

The principal object of this invention is to provide an improved nebulizing apparatus.

Another object of this invention is to provide nebulizing apparatus which is adapted to be operated continuously from a power-operated source of compressed air.

Still another object of this invention is to provide a nebulizer having jets or nozzles so arranged as to create high velocity streams of nebulized vapor and to direct those streams in such a manner that they intersect and provide further nebulization of vapor particles through collision of particles.

A further object of this invention is to provide a nebulizer having means for preventing egress of oversized particles of material. A still further object is to utilize centrifugal force in extracting larger droplets from nebulized streams of liquid.

In accordance with this invention there is provided nebulizer apparatus comprising a tank having arranged therein a plurality of jets or nozzles coupled to a source of liquid, and means creating turbulence for reducing the size of particles emitted by the jets or nozzles. Adjacent nozzles of the group are arranged so that streams of nebulized liquid emitted thereby travel along convergent paths and, upon collision of the droplets of the angularly-oriented streams, further nebulization occurs and a spray of fine micron-size particles continues in a new resultant direction. An important aspects of this invention lies in the discovery that where there is an angular relationship between the jet streams a surprising increase in nebulization occurs, and also, that such nebulization may be further increased where the converging streams angle upwardly within the nebulization chamber.

The full nature of the invention will be understood from the accompanying drawings and the following description and claims.

FIGURE 1 is a side elevation of the apparatus provided in accordance with this invention;

FIGURE 2 is a longitudinal cross section of the apparatus illustrated in FIGURE 1;

2

FIGURE 3 is a top plan view taken on line 3—3 of FIGURE 2;

FIGURE 4 is a cross section taken on line 4—4 of FIGURE 3;

FIGURE 5 is a partial cross section of a modified jet; FIGURE 6 is a vertical sectional view of a modification of the invention illustrated in FIGURES 1 through 4;

FIGURE 7 is a horizontal sectional view taken along line 7—7 of FIGURE 6;

FIGURE 8 is an enlarged perspective view of a nozzle assembly for the modified nebulizer of FIGURES 6 and 7;

FIGURE 9 is a schematic view illustrating the directions of the streams of nebulized material when the nebulizer is viewed from above.

This invention comprises nebulizer apparatus having a tank 10 consisting of an upper section 11 and a lower reservoir section 12. The tank is provided with a male outlet coupling member 14 threaded, as shown, to be connected with a vapor conducting tube (not shown). The reservoir portion 12 is adapted to store a quantity of liquid 15 which may or may not have solid materials dissolved therein or in suspension therein.

For nebulizing the material 1 there is provided a nebulizer 16 connected with an air pressure tube 17 sealed to tank section 12 and supported therefrom by means of conventional clamping nuts 18. The nebulizer 16 may be supported by tube 17 or additional supporting means may be provided as required. A liquid feeding tube 20 extends from the nebulizer 16 into the material 15. For collecting unnebulized globules of material 15 there is provided a baffle 21 supported from the tank portion 11 by means of the brackets 22.

Baffle 21 serves to prevent oversized globules of material from traveling outwardly through the coupling member 14 and also causes such globules to accumulate and drip back into the reservoir 12, whereby it is possible to nebulize the total quantity of material 15 before refilling the reservoir 12. Baffle 21 also causes turbulence in the air stream whereby nebulized particles are battered and further reduced in size. The space 23 above baffle 21 serves as an accumulator to provide smooth flow of nebulized material through outlet 14.

The nebulizer 16 consists of a casing having a lower cup member 25 threaded at 26 to receive a jet-supporting cover member 27. The cover 27 is formed to include a manifold 28 communicating with the air pressure tube 17 at 29. As shown in FIGURE 4, the cup 25 provides a secondary reservoir 31 into which opens the liquid feeding tube 20.

A plurality of jet or nozzle assemblies 32 are supported at equal intervals in annular array within the cover 27, each assembly comprising an outer casing 33 threaded within a bore in cover 27 as at 34. Each of the casings 33 includes a chamber 35 opening into manifold 28 as illustrated at 36 in FIGURE 4. Within the chamber 33 there is disposed a nozzle comprising an outer tubular member 38 having a frusto-conical upper end portion 39 which is smaller than and concentric with an upper frusto-conical portion 40 of the chamber 35 whereby there is provided an air conducting path around the outer surface of portion 39.

Within the member 38 there is threaded a tubular needle 42 which projects into the chamber 43 within member 38

3

and is formed to have at least two relatively small apertures 44 to provide communication between the chamber 43 and the inner bore of needle 42. The outer casing 33 is provided with a generally conical aperture 46 which communicates through port 47 with chamber 35. The apertures 46 of the jet assemblies 32 are arranged to direct streams of nebulized fluid radially of the cover member 27 into the open chamber 48 within the cover member so that these streams intersect in the area of the center of chamber 48.

For closing the lower side of chamber 48 and providing a drip pan there is an annular plug member 49 having a dished surface 50 for collecting fluid which may drip from the baffle 21 and such fluid is returned to the reservoir 12 by means of a centrally disposed drain tube 51 which extends downwardly through the tube 20.

In operation, a source of compressed air may be coupled to the tube 17 thereby to create air pressure within the manifold 28. Air escapes through each nebulizer assembly 32 by passing through the restricted passage 40 and outwardly through port 47 and aperture 46. This creates a vacuum within the chamber 43 drawing fluid from reservoir 12 upwardly through the tube 20 into the secondary reservoir 31, upwardly through the tubular needle 42, through the apertures 44 and into the port 47.

At this point the collision of the fluid with the stream of air causes the fluid and any material dissolved therein or suspended therein to be reduced to particles having a size of 10 microns or smaller. The stream of air and nebulized material is projected outwardly from each aperture 46, and these various streams collide in the vicinity of the center of the open chamber 48 whereby there is further reduction in size of the nebulized particles.

In the illustration given six jet assemblies are provided and, since the uniformly-spaced jets are arranged so that the streams of nebulized material emitted thereby all extend radially inwardly, the horizontal angle X (FIGURE 3) formed by each pair of adjacent intersecting streams is 60 degrees. While acute angles are particularly desirable for obtaining nebulization without subsequent agglomeration, for any given nebulizer the nozzles may be arranged to provide any of a wide variety of angles of intersection. However, it is important that in any case the horizontal angles formed between the converging streams of adjacent nozzles be less than 180 degrees—that is, less than a straight angle. It has been found that where adjacent nozzles are disposed so that their streams converge at less than a straight angle, a surprising increase in nebulizer efficiency occurs with substantially less droplet agglomeration and greatly reduced formation and collection of oversized droplets. For example, a two-nozzle nebulizer having its nozzles arranged so that the streams of nebulized material converge at a horizontal angle of 20 degrees has been found to have an output at least 60 percent greater than a similar nebulizer in which the nozzles are arranged directly opposite from each other.

The flow of air carries the nebulized material upwardly toward the baffle 21 at which time any oversized particles collect on baffle 21, and the liquid created on the surface of baffle 21 may drip into reservoir 12 or on to the surface 50 and through drain tube 51 into the reservoir 12. It is found to be preferable that baffle 21 have the form of a portion of a sphere having a radius approximately equal to twice the distance between the plane of the nozzles and the uppermost surface of the baffle. Properly nebulized material is carried by the deflected stream of air outwardly and around the edges of baffle 21 and upwardly until it eventually passes out through the coupling member 14 into any apparatus which may be connected thereto. During this portion of travel, the particles are battered and further reduced in size.

In FIGURE 5 of the drawings there is illustrated an alternative nozzle construction wherein there is provided an outer cylindrical member 53 and an inner tubular member 54, the diameter of member 54 being substantially

4

smaller than the inner bore of member 53. Air may be introduced under pressure into the chamber 55 and liquid may be drawn upwardly through the tube 54 by the vacuum created in the region indicated at 56. This type of nozzle may be mounted in the nebulizer 16 in such a manner as to permit the lower end of tube 53 to open into the manifold 28. Otherwise, the operation of a nebulizer having the nozzle construction of FIGURE 5 is the same as that previously described.

The baffling means is found to eliminate oversized particles from the stream of nebulized material, and it also contributes to reduction in size of nebulized particles because of the battering action created by the turbulence resulting from impact of the air stream with the baffle. The baffle also provides recirculation of fluid accumulating as a result of collection of oversized particles.

In the embodiment illustrated in FIGURES 6 through 9, the tank 10' of the nebulizer apparatus is generally spherical in configuration, having a dome-shaped upper section 11' and a bowl-shaped lower reservoir section 12'. The lower section is provided with a cylindrical base portion 58 which accommodates nebulizer 16' and which is adapted too contain a quantity of liquid, the level of the liquid being indicated at 15'.

The two sections are securely connected along the tank's horizontal mid plane and a gasket 59 is clamped between the flanges of the upper and lower sections. It will be observed that the annular gasket projects inwardly into the space 23' within the tank and, as will be hereinafter described, serves as a primary baffle for extracting larger droplets from the streams of nebulized material emitted by the nebulizer 16'.

The upper section of the tank is provided with a central outlet 14'. Preferably, the portion 60 of the dome-shaped upper section immediately adjacent opening 14' curves inwardly and downwardly to increase the effectiveness of the upper section's inner surface as a secondary baffle.

Nebulizer 16' comprises a plurality of jet or nozzle assemblies 61 mounted at the outer ends of a plurality of air feed tubes 62 which radiate horizontally from a central manifold column 63. The column is welded or otherwise rigidly secured to the base of the tank's lower section 12' and has a vertical manifold passage 64 communicating at its upper end with the passages 65 of the radial tubes 62 and at its lower end with an air intake passage 66 extending through the side wall of base 58.

The construction of the nozzle assemblies is illustrated most clearly in FIGURE 8. Each assembly includes a block 67 having a pair of discharge heads 68 and 69 projecting upwardly therefrom. Head 69 constitutes the upper end portion of an elongated feed tube 70 which extends downwardly through the block and terminates at its lower end in an open intake below the level 15' of the liquid within the reservoir (FIGURE 6). The air discharge head 68 also extends downwardly into the block and, as indicated in FIGURE 6, communicates at its lower end with air feed passage 65. Both the liquid and air discharge heads 69 and 68 are closed at their upper ends and are provided with jet tubes 71 and 72 extending substantially normal to the axes of the tubular heads. The jet tubes for each pair of heads have their open ends disposed adjacent each other and are arranged at substantially right angles (FIGURES 7 and 8) so that air streaming from jet tube 72 will aspirate liquid from the jet tube 71 of head 69.

As in the embodiment already described in connection with FIGURES 1 through 4, the nozzle assemblies of the nebulizer are adjusted so that the streams 73 of liquid and air of adjacent nozzles are directed inwardly towards each other and the horizontal angle X defined by these converging streams is less than 180 degrees, and preferably, less than 90 degrees. However, unlike the streams of the previously-described form, streams 73 are directed to intersect at a point 74 spaced outwardly from

the center of the nebulizer unit but within the bounds of the ring of nozzle assemblies 61. The horizontal angle between each stream and a line 75 extending radially—such angle being designated by the letter "Y" in FIGURE 9—should fall within the range of between 15 to 25 degrees.

Referring to FIGURE 6, it will be observed that each stream 73 is not horizontal in direction but instead angles upwardly so that collisions of the droplets from the streams of adjacent nozzles will occur above the nozzle assemblies. The angle Z measured from the horizontal should fall within the range of 15 to 25 degrees for most effective nebulization of the liquid.

It has been found that when the nozzle assemblies of a nebulizer are arranged to direct air-liquid streams at angles within the ranges specified above, the rapidly moving droplets traveling from each nozzle are shattered upon impact with other droplets without at the same time interfering with the upward circulation of nebulized material. Thus, the angular relationship of the jet streams greatly increases nebulization rather than agglomeration of the droplets.

The tangential deviations Y in the directions of the streams of liquid and air from nozzles 61 produces a vortex within the chamber of tank 10'. As the mist swirls about and migrates upwardly in the lower section of the tank, any large droplets tend to be thrown outwardly and to impinge on the smooth side walls of the lower section. Gasket 59 acts as a baffle or barrier for preventing further upward migration of the large droplets along the inner surfaces of section 12' and immediately adjacent those surfaces, and for directing the liquid back into the lower reservoir.

It has been found that the dome-shape of the upper section 11' contributes significantly in extracting droplets which are too small to have been caught by the primary baffle 59 but which are still appreciably larger than 10 microns in size. While the operation of the dome as a secondary baffle is not completely understood, it is believed that the decreasing radius of the dome in an upward direction causes the vortex of nebulized material to increase in angular velocity as it travels upwardly toward the discharge opening 14' and, with the increase in velocity, the centrifugal force responsible for droplet extraction also increases. The inwardly and downwardly turned lip 60 about the discharge opening prevents liquid which has been trapped by the secondary baffle from passing outwardly through the opening 14' and instead directs such liquid downwardly through the center of the vortex towards the reservoir in lower section 12'.

While in the foregoing we have disclosed embodiments of the invention in considerable detail for purposes of illustration, it will be understood by those skilled in the art that many of these details may be varied without departing from the spirit and scope of the invention.

We claim:

1. A nebulizer apparatus comprising an outer casing forming a liquid reservoir and being provided with a baffle therein, and a nebulizer disposed between said baffle and said reservoir comprising a plurality of nozzles spaced in annular array to create a plurality of streams of nebulized material, said nozzles being positioned and arranged to direct said streams inwardly towards each other so that the streams from adjacent nozzles intersect at points between the central axis of the nebulizer and said nozzles, the streams from adjacent nozzles intersecting and forming an angle of less than 180 degrees at the point of intersection thereof.

2. The structure of claim 1 in which each of said nozzles is arranged to direct the stream upwardly therefrom at an angle within the range of about 15 to 25 degrees from the horizontal.

3. A nebulizer apparatus comprising a casing, a plurality of nozzles mounted within said casing, each of said nozzles including means for directing air over the end of

a liquid discharge tube to create a stream of aspirated and nebulized liquid, adjacent nozzles being positioned and arranged with respect to one another to cause said streams to converge to form an angle less than 180 degrees at the point of intersection and so that the streams from such adjacent nozzles intersect at a point between the central axis of the nebulizer and said nozzles.

4. The structure of claim 3 in which said nozzles are tipped to direct said streams upwardly at an angle within the range of 15 to 25 degrees from the horizontal.

5. A nebulizer apparatus comprising a casing having a top discharge opening and having a liquid reservoir therein, and a nebulizer disposed within said casing adjacent said reservoir and comprising a plurality of circumferentially-spaced nozzles arranged to direct streams of nebulized liquid upwardly and inwardly within said casing, the streams of adjacent nozzles converging and intersecting at horizontal angles less than 180 degrees, the inner surface of said casing being arcuate and providing a baffle for collecting and converting to liquid form any oversized particles of nebulized material and for returning said material to said reservoir, said nozzles being arranged so that the streams from adjacent nozzles intersect at points spaced between the axis of said nebulizer and a circular line passing through all of said nozzles.

6. The structure of claim 5 in which said nozzles are arranged to direct said streams upwardly at an angle within the range of between 15 to 25 degrees from the horizontal.

7. A nebulizer apparatus comprising a casing having a central discharge opening in the upper portion thereof and forming a liquid reservoir in the lower portion thereof, a nebulizer disposed over said reservoir within said casing and comprising a plurality of nozzles for creating a plurality of streams of nebulized material, adjacent nozzles being positioned and arranged to direct their streams upwardly and inwardly along paths converging at an angle of less than 180 degrees and at a point spaced between the central axis of said nebulizer and said nozzles, and a baffle having the form of a portion of a sphere and disposed over said reservoir for collecting and converting to liquid form any oversized particles of nebulized material and for returning said material to said reservoir.

8. The structure of claim 7 in which said baffle comprises the inner surface of the casing's upper portion.

9. The structure of claim 8 in which the wall of said casing's upper portion is turned to provide an inwardly and downwardly projecting lip about said discharge opening.

10. A nebulizer apparatus comprising a casing having an upper portion with a central discharge opening therein and a lower portion providing a liquid reservoir, a nebulizer disposed over said reservoir and comprising a plurality of nozzles for creating a plurality of streams of nebulized material, said nozzles being positioned and arranged to direct nebulized material chordally in streams flowing in the same direction relative to the circumference of said casing to produce a vortex of nebulized material within said casing, said nozzles also being positioned and arranged to direct said streams upwardly within said casing, and baffle means disposed above said nebulizer for collecting oversized particles of nebulized material and returning the same to said reservoir.

11. The structure of claim 10 in which said baffle means comprises an annular shoulder extending about the interior at an elevation between said nebulizer and said discharge opening.

12. The structure of claim 11 in which the upper portion of said casing is dome-shaped, said inner surface of said dome-shaped upper section comprising secondary baffle means for collecting particles of nebulized material and for returning the same to said reservoir.

13. A nebulizer apparatus comprising a casing having an upper portion with a central discharge opening therein

and a lower portion providing a liquid reservoir, a nebulizer disposed over said reservoir and comprising a plurality of nozzles for creating a plurality of streams of nebulized material, said nozzles being positioned and arranged to direct nebulized material chordally in streams 5
flowing the same direction relative to the circumference of said casing to produce a vortex of nebulized material within said casing, said nozzles also being positioned and arranged so that the streams from adjacent nozzles angle 10
upwardly within said casing and intersect at points spaced between the axis of said nebulizer and said nozzles, and baffle means disposed above said nebulizer for collecting

oversized particles of nebulized material and returning the same to said reservoir.

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