This present nebulizer is of the type employing a single jet system with appropriately formed separator-baffle or barrier disposed in the stream of the jet and arranged to direct any large particles of liquid back into the liquid reservoir so that the discharge from the nebulizer will be a true aerosol mist.

In the construction of the present invention certain elements are employed which are in common with my United States Patent No. 2,586,845, issued February 26, 1952. This patent explains the presently accepted principles and theories that distinguish the nebulizer from the long known and used that is a nozzler. This explains a highly developed nebulizer having embodied therein numerous details of structure not observed in any previous offerings in this field and which produce a nebulizer of unusually efficient design for the purpose intended and in which provision is made for wide variation of the degree of dispersion of the aerosol by simple adjustment of the separator-baffle. In the past various nebulizers have been produced which, though quite efficient in operation, were troublesome in use, for no adequate provision was made so that the small passageways could be kept clean. In my present invention I have provided a highly efficient nebulizer so characterized by design features as to permit economical manufacture of a design which is adaptable to a wide range of achievement.

A further object of this invention is to provide a nebulizer in which the various intricate elements, especially those having fine passageways therethrough, can be made as separable units to the end that cleaning and that changing the units a wide range of adaptability is provided.

A further object of this invention is to provide a definite arrangement between the air jet and the liquid supply tube and a variable arrangement of the separator-baffle between the liquid supply tube and the outlet from the container so that the variable, comparatively coarse aerosol can be produced from the device.

A further object of this invention is to provide an efficient separator, as a baffle, barrier or impingement target, which will separate the larger droplets from the desired aerosol and yet not allow liquid to be blown from its surface through the outlet from the container.

A further object of this invention is to provide a means of regulation of the primary spray from the jet and to provide a means of filtering the solution to the liquid jet in order to prevent clogging of this jet.

A further object of this invention is to provide means which will insure against the leakage of fluid from the nebulizer to the end that the same may be carried about in the handbag or pocket of a person without danger of soiling articles or clothing with which the nebulizer may come in contact.

Further objects, advantages and capabilities will be apparent from the description and disclosure in the drawings, or may be comprehended or are inherent in the device.

In the drawings:

Figure 1 is a typical vertical cross-sectional view through a nebulizer with the flexible bulb broken away, made after the teachings of my present invention;

Figure 2 is a bracketed, exploded view showing in perspective and in section certain elements making up the air jet assembly;

Figure 3 is a perspective view showing one form of liquid supply tube;

Figure 4 is a perspective view showing a form of barrier or impingement target adapted for association with the construction of Figure 3;

Figure 5 is a perspective view illustrating the outside appearance of a nebulizer made after the teachings of this present invention;

Figure 6 is a vertical cross-sectional view taken along the line 6—6 of Figure 1;

Figure 7 illustrates in a perspective view partially in section a modified form of the liquid supply tube and the barrier or impingement target associated therewith;

Figure 8 is an enlarged, vertical sectional view of the liquid supply tube and illustrating the throttling plug in place;

Figure 9 is a perspective view of the throttling plug used in the liquid supply tube.

Referring more particularly to the disclosure in the drawings, the numeral 10 designates the base unit of my nebulizer. It consists broadly of a cup-like molding to one end of which is attached the air valve and to the other end the enclosing cover 14. Axially disposed within the base unit is the air jet assembly 16. This consists of an inwardly directed flange or nozzle-like unit 18, axially disposed with respect to which is the jet tube 20. Tube 20 is secured to base unit 10 at one point as shown in Figure 6 at 22. The bore within jet tube 20 is preferably tapered so as to securely hold and position the valve seat member 24. On its inner end member 24 is provided with a tapering valve seat 26 in which is adapted to seat the valve 28. The possible forward travel of valve 28 is limited by a plurality of inwardly directed fins 30 occurring within the nozzle-like, reduced portion 32 of the jet tube 20. The stem of valve 28 is considerably reduced in diameter from the bore of seat member 24 so that when pressure is applied to bulb 12 there is no restriction of the flow of air through the jet tube until the nozzle portion 32 is reached. On the other hand when the bulb is released, after being squeezed, any air tending to be drawn back out of the enclosed portion of the nebulizer by the bulb action will be arrested by valve 28. This prevents any possibility of liquid or liquid vapor from within the nebulizer chamber being drawn back into bulb 12, which of course would be objectionable on the grounds of possible deterioration of the material itself if left within the bulb, and the fact that certain liquids will cause deterioration of the bulb itself.

Bulb 12 is preferably a closed bulb and the air required for the refilling of the same after it has been squeezed in the operation of the nebulizer is introduced through an air passageway 34 in base 10. This passageway communicates with the jet tube at a point where the
3 valve seat member 24 is slotted and thus provides an adequate channel for the air. With this arrangement it becomes necessary to provide a valve 36 so that air will be forced through the jet tube and not back out through tube 34 when the bulb is squeezed. Experience has proven that an inverted valve, as shown, is the most satisfactory. Valve 36 is provided with a conical seat in the removable valve seat member 38, which con-

7 strates well illustrated in Figure 1. The inward movement of valve 36 is arrested by a suitable abutment in the wall of base unit 10.

10 Within what is normally the lower portion of base unit 10 is a preferably dovetailed guideway. Adapted to be securely in place in guideway 40 is the liquid supply tube slipper portion 42. This unit has complementary sides adapted to fully engage the sides of guideway 40. On the slipper portion 42 is the liquid supply tube proper 44 which is in turn provided with a tapered bore through its length and has a discharge end normal to the bore. This slipper portion 42 communicates with a channel 46 formed in the slipper portion 42 and this construction insures that liquid will be drawn from the recessed portion 59 of the base unit 10. This portion of the base unit is normally the lowermost portion when the device is used, as normally the device is used in an inclined position and by the operation shown in Figures 1 and 3 it will be apparent, it is possible to place the device on a suitable surface to air flow past its surface; forms an excellent sepa-

20 rator and is particularly meritorious for very fine spray production. When in use an annular channel of liquid forms in the leeward area formed by the groove and this channel in further anchorage by the drainage liquid which collects on the supporting arm 74 and spaced through openings 76. This ever-changing liquid structure is strong enough to prevent droplets from being blown from this type of barrier and allows for proper drainage down the supporting member.

25 An extrusion from the jet and associated parts is pro-

30 vided by cover 14 which is generally dome-like in form as in the showing in Figures 1 and 5. It is secured to base unit 10 by threads 80 or some equivalent structure and preferably is provided with a tapered portion 82 adapted to seat on a similar taper formed in a slip portion of base unit 10. When the plug 57 having a finned taper plug portion 58 and a stabilizing base 59. This provides an excellent means for controlling the flow of various liquids through the supply tube 44.

35 In order to obtain maximum dispersion in the primary spray a small bevel cut is made in the tip of the liquid jet as at 61. This causes the spray to form along a straight line of shear tangent to the direction of air flow and the film of liquid aspirated from the jet is thereby subjected to maximum force of shearing action by the air stream. Such a bevel also acts as a deflector causing an area of increased turbulence to be formed immediately to the jet, and in which the spray first formed at the shearing edge is further broken up. It has been found in practice that such a bevel may be made by a knife cut in the otherwise completed molding and adjustment made for angle and depth until optimum spray is achieved.

40 In Figure 4 is illustrated one of the preferred forms of barrier or impingement targets. This unit is provided with a barrier 60, have a parabolical frontal area and an elongated lee area. This form of barrier offers the practical minimum of resistance to air flow past its sur-

45 face consistent with its function as an adjustable separa-

50 tor. The barrier 60, is provided with intersecting grooves as at 62 and 64 cut on its outer surface and at their intersection a passageway through into the hollow interior of 60. When in use this structure allows the liquid to col-

55 lect in the lee areas of the grooves and to contact liquid draining within the barrier unit 60 thus forming three annular, ever changing chains of liquid fused together at their apexes. This liquid structure is strong and because it is anchored to the barrier, prevents any liquid which, passing over the surface and having once made contact with it, from being blown from the barrier as droplets. Formed, preferably, as part of the unit are two arms 65 and 66. Each of these units is provided with a detent 68 which detents are established to operably engage the recesses 54 occurring on each side of fin 55 of the liquid supply tube unit. Arms 65 and 66 are provided with a bowed center portion so that they will fit over the liquid supply tube and dispose substantially between the two arms is the tooth engaging lug 69. This lug is adapted to engage the teeth of comb member 52 after the showing of Figure 1. In Figure 7 is illustrated a simplified form of liquid supply tube and barrier or impingement target. In this form a guide member 70 is provided adapted to engage guideway 40. This guide member 70 is adapted to provide a channel similar to channel 48 and the liquid supply tube 44 is essentially the same as the preferred form. The barrier member 72 is formed with conical frontal portion and elongated or ovate lee portion, and has an annular groove in the lee of its greatest diameter and is provided with a supporting arm 74 which in turn is connected fixedly to tube 44. Openings are provided in arm 74 at 76. It should be noted that the form of barrier 72 ap-

65 proximates a cross-section of revolution of barrier 60, but so modified that an additional line of shear is formed by the base of the cone in order to give more complete dis-

70 persion. This form of barrier offers a small amount of re-

75 sistance to air flow past its surface; forms an excellent sepa-

rator and is particularly meritorious for very fine spray production. When in use an annular channel of liquid forms in the leeward area formed by the groove and this channel in further anchorage by the drainage liquid which collects on the supporting arm 74 and spaced through open-

ings 76. This ever-changing liquid structure is strong enough to prevent droplets from being blown from this type of barrier and allows for proper drainage down the supporting member.

Prior to use the reservoir formed by base unit 10 and cover 14 is partially filled with the desired liquid. The level of this liquid, however, should be such as not to exceed the height of the inlet opening, otherwise plugs 57 and 84 so that the liquid will not spill out of the reservoir in any position in which the device is held. When use is desired, plug 85 is removed and allowed to hang free. The user then squeezes bulb 12. This action starts an air stream which seats valve 36 and opens valve 28 and pro-

jects a stream of air out through nozzle 30 past the upper
end of the liquid supply tube 44 and out through sleeve 84. The velocity of the air passing out through nozzle 32 is quite high and acting as a siphon or injector draws air from the outside through passageway 90 which is in free communication with the outside air as soon as bulb 12 is distorted. The effect of this action is to first have a concentrated spray of liquid in a high velocity air stream passing out through nozzle 32, which is then diluted with the air that is drawn in through passageway 90. As the air stream now laden with minute and some larger particles of liquid impinges upon the barrier 60 this acts as a separator and the air carrying the minute particles glides around the barrier and out sleeve 84. The larger particles of liquid impinging upon the barrier 60 this acts as a separator and the air carrying the minute particles glides around the barrier and out sleeve 84. The larger particles of liquid are deflected from the air stream and collected in the container and the lesser portion adheres to the barrier and under the urge of the air stream is carried upon that surface until one of the grooves 62 or 64 is encountered, whereupon it fuses with the liquid in these grooves and drains down by gravity into the main reservoir. The effect of the injected air, entering through passageway 90, is to thoroughly remove from the chamber all of the fine aerosol produced therein, as the air supplied through the jet from the rubber bulb is insufficient to do this effectively.

Further adjustment of the spray, most particularly when used as an atomizer, may be achieved by removal or adding of a series of sleeve blocking plugs 97. The greater the restriction offered by the throating plug the finer the primary spray produced.

It is intended that this nebulizer be supplied and marketed complete with both exchangeable bubble systems as described. This is because one of the common uses, and the most exacting of all, is for the dispersion of epinephrine solutions for the treatment of asthma for which purpose an exceptionally fine dispersion is imperative and a bubble separator of fixed characteristics may be demanded by many physicians because some users might not be entrusted to make the required adjustment for this purpose.

It is believed it will be clearly apparent from the above description and the disclosure in the drawings that the invention comprehends a novel construction of a nebulizer for producing aerosol mist.

Having thus disclosed the invention, I claim:

1. A device for producing aerosol mist adjustable to atomize and nebulize liquids therein, comprising: walls defining a chamber having at one end an air ingress opening and having at its other end an air discharge opening; jet means connected to said air ingress opening and disposed to direct an air stream through said discharge opening; a liquid supply tube assembly having its discharge end disposed between said ingress and discharge openings; an impingement target having a pair of bowed arms secured at one end to said target, said arms being pivotally connected to said liquid supply tube assembly at their other end, said supply tube assembly having a toothed portion adjacent said target, said toothed portion having an arc-shaped toothed surface with the center of the arc at the point of pivot connection between said arms and said supply tube assembly, and said impingement target having a tooth engaging lug engaging said toothed surface permitting adjustment of said target at various positions in relation to a line between the centers of said ingress and discharge openings, affording means for adjusting the fineness of dispersion of liquid in the aerosol by changing the air-stream blocking position of said target from a position of minimum interference when the liquid is atomized to a position of maximum interference when the liquid is finely nebulized.

2. A nebulizer, comprising: a cup-like base unit with annular side walls and a base portion, said base portion having a central opening and an annular central flange bordering said central opening and disposed between said side walls; a dome-like cover disposed on said base unit and interengaging, sealing means between said side walls of said base unit and the corresponding portion of said cover, said cover having a discharge opening aligned with said central opening of said base unit; jet means including a resilient bulb connected to said central opening and disposed to direct an air stream through said discharge opening; a liquid supply tube having its discharge end disposed between said central and discharge openings and having its other end disposed near a side of said nebulizer to pick up liquid therein; an impingement target; a support for said impingement target; said support having adjustment means permitting positioning of said impingement target at various locations in relation to a line between the centers of said central and discharge openings, affording means for adjusting the fineness of dispersion of liquid in the aerosol produced by adjustment of the air-stream blocking location of said target; and a sleeve bordering said discharge opening and extending inward toward said central flange, whereby liquids in said nebulizer are prevented from escaping through said openings by said central flange and said sleeve.

3. The subject matter of claim 2 in which the interior of said sleeve has a frustoconical shape tapering as it extends inward and a plug removable disposed in said air discharge opening and between the walls of said sleeve, said plug having a small opening; said sleeve comprises a seal said sleeve, and a flexible connector secured to said plug and to the walls of said nebulizer to prevent loss of said plug upon removal from said discharge opening.

4. A device for producing aerosol mist adjustable to atomize and nebulize liquids therein, comprising: walls defining a chamber having at one end an air ingress opening and having at its other end an air discharge opening; jet means including a resilient bulb connected to said air ingress opening and disposed to direct an air stream through said discharge opening; a liquid supply tube having its discharge end disposed between said ingress and discharge openings; an impingement target having an inwardly facing dome shaped impingement surface; a support for said impingement target, and said support having adjustment means permitting manual adjustment of said support to locate said impingement target at various locations in relation to a line between the centers of said ingress and discharge openings by movement substantially laterally of said line, affording means for adjusting the fineness of dispersion of liquid in the aerosol by changing the air-stream blocking location of said impingement surface from a location of minimum interference when the liquid is atomized to a location of maximum interference when the liquid is finely nebulized.

5. The subject matter of claim 4 in which said liquid supply tube is beveled on its top edge toward said jet means to adjacent the liquid passageway in the liquid supply tube in a plane forming an angle of approximately forty-five degrees to the path of travel of the air stream.

6. In a device for producing an aerosol mist, an air jet assembly, comprising: walls forming a chamber including a base portion having a central opening therethrough; a jet tube positioned in said central opening and connected to said base portion by web means and partially blocking said central opening, means forming a liquid reservoir in said device and a liquid supply tube extending from the liquid reservoir to adjacent the discharge end of said jet
tube, said jet tube extending outside of said chamber and a resilient bulb positioned thereon, said base unit having annular flange means bordering and forming a circular line of contact with the outer surface of said bulb when the bulb is uncompresses and said flange means being of a size and position to permit passage of air between said bulb and said flange means and through said central opening of said chamber when said bulb is compressed.

7. A nebulizer, comprising: walls defining a chamber having at one end an air ingress opening and having at its other end an air discharge opening; jet means connected to said air ingress opening and disposed to direct an air stream through said discharge opening, said walls having means forming a dovetailed guideway and a liquid supply tube having its discharge end disposed between said ingress and discharge opening and having a slipper portion removably positioned in said guideway; an impingement target positioned between said ingress and discharge openings, said target being shaped in the form of two cones with their bases joined and with the apex of one directed toward said air ingress opening and with the apex of the other directed toward said air discharge opening, and an arm connecting said target and said liquid supply tube for support of said target, said arm having an opening therefor for anchoring of collected liquids on said target and arm.

8. The subject matter of claim 7 in which said liquid supply tube is beveled on its top edge toward said jet means so as to form an angle of approximately forty-five degrees to the path of travel of the air stream.

9. The subject matter of claim 7 in which there is a removable throttling plug positioned in the liquid passageway of said liquid supply tube having a size to restrict the effective size of said passageway to control the amount of liquid passing through the same.

10. The improvement in a nebulizer, comprising: a cup-like base with annular side walls and a bottom portion, a dome-like cover disposed on said base unit and interengaging, sealing threaded means between said annular side walls and the corresponding portion of said cover, said cover having an air discharge opening therein, said bottom portion having an opening therefor, said cover and bottom portion being of such size as to form a seal when they are engaged.

11. The improvement in a nebulizer, comprising: a body having walls defining a chamber having an air discharge opening, a liquid supply tube having a liquid passageway and having a discharge end positioned adjacent said jet means and between the jet means and said air discharge opening, said liquid supply tube having at its other end a slipper portion extending obliquely therefrom and removably positioned in said dovetailed guideway securing the liquid supply tube in position, said slipper portion having a hollow, open bottom for picking up liquid from said chamber, and a throttling plug similarly shaped to said liquid supply tube and slipper portion and removably positioned therein, said plug having a flared portion positioned in the liquid passageway of the liquid supply tube spacing it from the adjacent walls.

12. The improvement in a nebulizer, comprising: a body having walls defining a chamber, one wall having jet air means including air pumping means attached thereto and another wall having an air discharge opening, a liquid supply tube having a liquid passageway and having a discharge end positioned adjacent said jet means and between the jet means and said air discharge opening, said liquid supply tube having on the inner surface of a wall of said body forming a dovetailed guideway and said liquid supply tube having at its other end a slipper portion removably positioned in said dovetailed guideway securing the liquid supply tube in position, said slipper portion having a hollow open bottom having for picking up liquid from said chamber, and a throttling plug similarly shaped to said liquid supply tube and slipper portion and removably positioned in said liquid passageway and said hollow bottom.

13. The improvement in a device for producing an aerosol, comprising: a body having walls defining a chamber having an air discharge opening in one end and having an air ingress means including a jet nozzle and air pumping means attached thereto in the other end, a liquid supply tube having a discharge end positioned adjacent said jet nozzle and between said air discharge opening and said jet nozzle, said liquid supply tube being supported in said body and said liquid supply passageway tapering opening from an adjacent wall of said body to said air discharge opening and having a liquid ingress opening located near said adjacent wall permitting the tube to pick up liquid from the chamber, a throttling plug positioned in said liquid supply passageway near said adjacent wall and having a size to restrict the effective size of said liquid supply passageway to control the amount of liquid passing from the liquid ingress opening to the discharge end of said liquid supply tube, and manually operable means in the nebulizer providing access to the location of said throttling plug and said liquid supply passageway permitting removal of the plug.

14. The subject matter of claim 12 in which an impingement target is mounted in said chamber between said liquid supply tube and said air discharge opening in a manner permitting manual adjustment of position of the target relative a line between said air discharge opening and said jet nozzle so that said target can be changed from a position of minimum interference with the jet air stream when the liquid is atomized to a position of maximum interference when the liquid is finely nebulized.

15. The improvement in a nebulizer, comprising: a body having walls defining a chamber having an air discharge opening in one end and having a broad central air inlet opening at its other end; a jet tube positioned in said central opening and connected to said jet tube by a liquid supply passageway; the wall having a closed air passageway and an air jet valve having a valve stem of substantially smaller size than said air passageway slidably mounted therein and said valve having a valve head positioned at the chamber end of said jet tube and the valve being removably positioned within said liquid supply passageway between said jet tube and said liquid supply passageway and having coacting conical surfaces operative to block said air passageway when the valve is moved to closed position by passage of air when the valve is expanded, said jet tube having a nozzle positioned on the outer end of the jet tube; a tapered-tube-like valve seat member, removably positioned in said jet tube, having an air passageway and an air jet valve having a valve stem of substantially smaller size than said air passageway slidably mounted therein and said valve having a valve head positioned at the chamber end of said jet tube and the valve being removably positioned within said liquid supply passageway between said jet tube and said liquid supply passageway and having coacting conical surfaces operative to block said air passageway when the valve is moved to closed position by passage of air when the valve is expanded, said jet tube having a nozzle positioned on the chamber side of said valve having inner radial fins acting as a stop limiting movement of the valve when it is moved to an open position by passage of air when the valve is expanded, said liquid supply passageway between a liquid supply tube having a discharge end positioned adjacent the discharge end of the jet tube and said liquid supply passageway permitting removal of the plug; and air-supply means by-passing said valve providing a source of air for said bulb during expansion of the
bulb, said air-supply means being adapted to close during contraction of the bulb.

16. The improvement in a nebulizer, comprising: a body having walls forming a chamber having an air discharge opening in one end and having a broad air inlet opening at its inner end; a jet tube positioned in said inlet opening and connected to the wall bordering the inlet opening by a web, a resilient bulb positioned on the outer end of the jet tube; a liquid supply tube having a discharge end positioned adjacent the discharge end of said jet tube; a tube-like valve seat member, removably positioned in said jet tube, having an air jet passageway and an air jet valve having a valve stem of substantially smaller size than said air jet passageway slidably mounted therein and said valve having a valve head positioned at the chamber end of said jet tube and the valve head and jet tube having coating surfaces operative to block said air jet passageway when the valve is moved to closed position by passage of air when the bulb is expanding, said body having an air supply passageway communicating with the outside of the chamber and extending laterally of the jet tube through said web to join the same at a point to the outside of said valve, said valve seat member having a slot aligned with said air supply passageway permitting air to flow from the air supply passageway to the jet air passageway, said air supply passageway having a one-way valve therein air operated to permit air to pass therethrough only when said bulb is expanding.

17. The subject matter of claim 16 in which said air supply passageway has a removable annular valve seat plug positioned in the outer end thereof, said one-way valve being positioned on the inside of said plug and having a valve stem positioned in said plug, the one-way valve and plug having opposed beveled annular surfaces to seal the same when the one-way valve is moved by passage of air when the bulb is contracted, the air supply passageway having a lateral oblique surface adjacent said one-way valve and the plug having limited adjustment longitudinally of the passageway whereby the oblique surface forms an adjustable stop for the one-way valve.

18. The improvement in a device for producing an aerosol, comprising: a body having walls forming a chamber having an air discharge opening in one end and having a jet air tube in the other end including a nozzle; a liquid supply tube having a discharge end positioned adjacent the discharge end of said nozzle; a resilient bulb connected to said jet air tube and a first one-way check valve positioned in jet air tube between the bulb and the nozzle operable by the passage of air therethrough to slide axially of said tube to seal said tube against passage of air when the bulb is expanding; air ingress means forming an air passageway to the outside of said chamber and a second one-way check valve positioned in the air passageway of

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