

May 19, 1970

B. C. CRANAGE
NEBULIZER SPRAY UNIT

3,512,718

Filed March 6, 1968

2 Sheets-Sheet 1

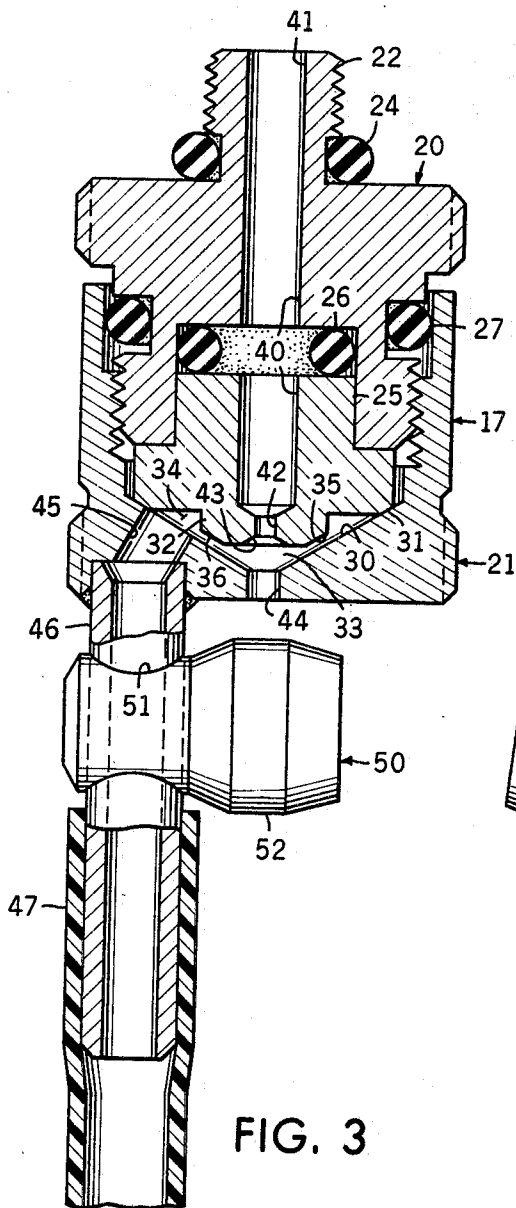


FIG. 3

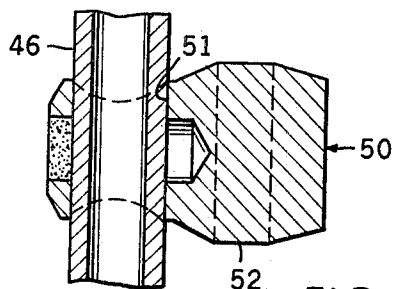


FIG. 4

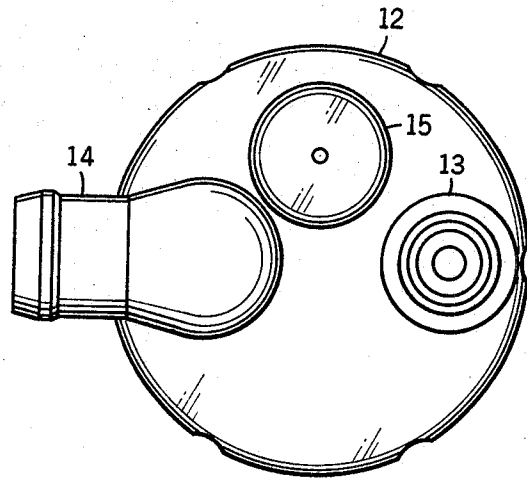


FIG. 2

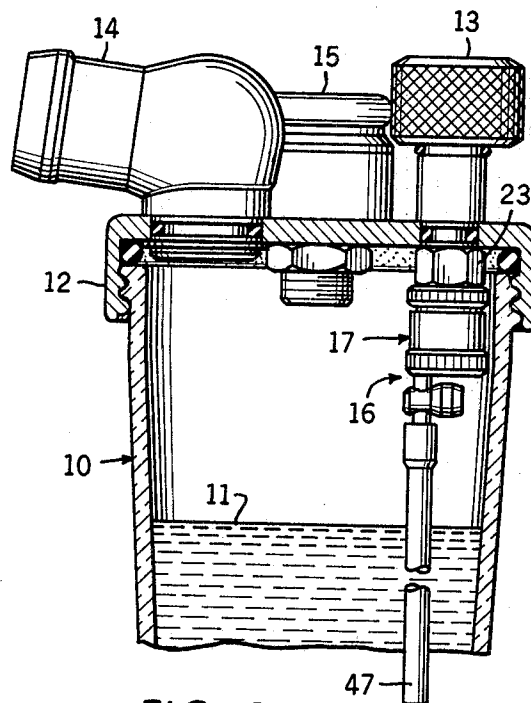


FIG. 1

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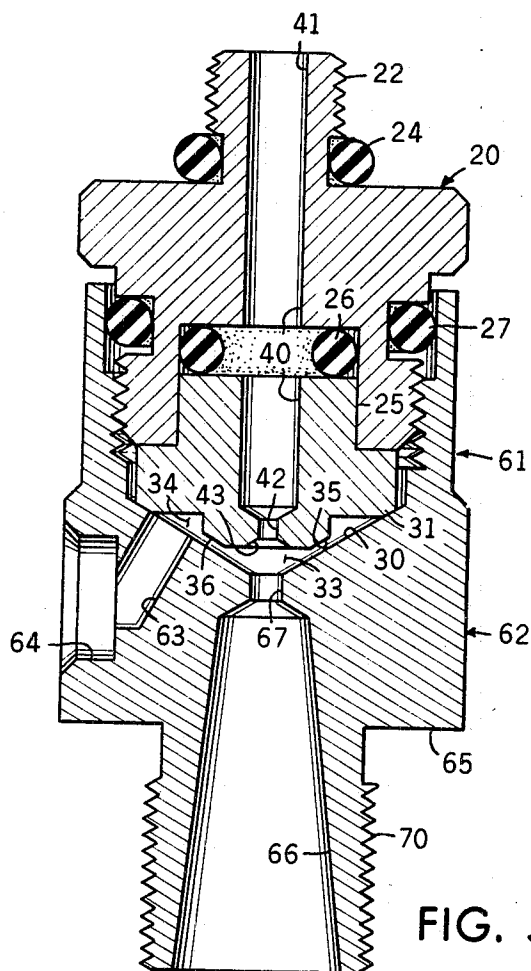


FIG. 5

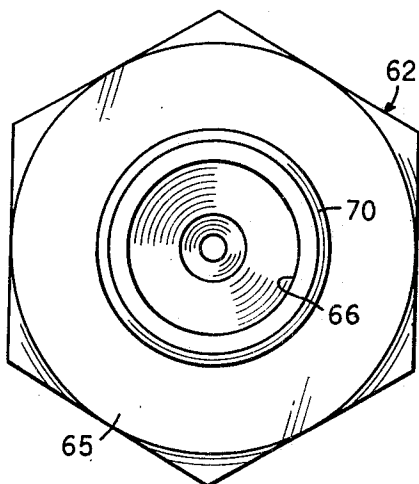


FIG. 6

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1

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NEBULIZER SPRAY UNIT

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11 Claims

ABSTRACT OF THE DISCLOSURE

The nebulizer includes a body having threadedly inter-connected plug and socket portions. The end face of the plug and the bottom wall of the socket are compatibly shaped to provide a central mixing chamber, an annular liquid chamber surrounding the mixing chamber, and a peripheral gap communicating between the liquid chamber and the mixing chamber. The plug includes a gas inlet having a passageway that converges into a constricted throat portion, and, thence diverges into an entrance orifice leading into the mixing chamber. The socket includes a gas and liquid outlet communicating with the mixing chamber and substantially aligned with the gas inlet. The liquid chamber is supplied from a reservoir. A baffle is spaced from the gas and liquid outlet to further reduce the particle size of the mist upon impingement.

BACKGROUND OF THE INVENTION

This invention relates generally to a spray forming unit, and more particularly to a nebulizer unit producing a fine spray.

The creation of a fine spray finds particular use in medicine, for example, when oxygen is required to relieve a deficiency caused by defective respiratory systems. Oxygen has high moisture absorption characteristics, and when used in a non-humidified state, tends to dry out or dehydrate the respiratory tissues.

The addition of water vapor to the oxygen to form a spray mixture is one solution to this problem. However, there remains the problem of providing a spray which is sufficiently fine to reach the alveoli of the lungs without being trapped out in the bronchia.

Up until now the common atomizer has been used to produce a spray mixture of gas and liquid. In the common atomizer, a blast of air from a tube is directed at right angles across an opening in the end of a second tube. The second tube communicates with a supply of liquid, and the effect of the blast raises the liquid and, by contact with it, dispose it in the form of a spray. However, the spray particle size is insufficiently small to accomplish the gas moisturizing function with the efficiency provided by the present spray unit, which represents a distinct improvement over such atomizer.

SUMMARY OF THE INVENTION

The present nebulizer spray unit produces a fine spray eminently suitable for the purpose of providing a vapor stream having the requisite characteristics to permit the spray to penetrate beyond the bronchia to the alveoli, and thereby preclude dehydration of the lung tissue.

A fine spray of gas and liquid also finds a useful application in the cooling of machine parts during the machining process. In this usage, the liquid is usually oil and the gas is air. The present nebulizer spray unit produces a highly satisfactory cooling medium which greatly facilitates the machining of parts.

Other uses of the nebulizer spray unit, for instance, the dispensing of perfume and other cosmetic and me-

2

dicinal sprays are sufficiently obvious as to require no discussion.

The nebulizer includes a body having a first portion and a second portion. The first and second portions include adjacent shaped faces disposed in spaced relation to provide a mixing chamber, a liquid chamber, and a communicating gap between said chambers and peripheral to said mixing chamber.

The first portion of the body includes a gas inlet communicating with the mixing chamber. The second portion of the body includes a gas and liquid outlet also communicating with the mixing chamber and in substantial axial alignment with the gas inlet. Conduit means supply the liquid chamber from a liquid source. The gas inlet includes a passageway which converges into a constricted throat portion and diverges into an entrance orifice leading into the mixing chamber. The gas and liquid outlet includes an exit orifice in substantial axial alignment with the entrance orifice.

The gap, peripheral to the mixing chamber, discharges liquid into the mixing chamber in a direction toward said axis of alignment, yet generally in a direction away from said entrance orifice. At least one of the adjacent faces of the first and second body portions forming the peripheral gap includes a conical face substantially symmetrically disposed transversely about the axis of alignment of the gas inlet and the gas and liquid outlet.

The first and second body portions are threadedly interconnected, one of said portions forming a plug, and the other of said portions forming a socket receiving the plug. The plug includes a tip providing one of said adjacent shape's faces, the tip including a frusto-conical face. The socket includes a conical bottom wall cooperating with the frusto-conical face of the tip to form the peripheral gap substantially symmetrically about the axis of alignment of the inlet and the outlet.

A curved baffle surface, on which the spray from the gas and liquid outlet violently impinges, is disposed in spaced relation from the gas and liquid outlet, the axis of alignment substantially intersecting its center of surface curvature.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a fragmentary view, partly in cross section, of a nebulizer jar assembly including the nebulizer jet unit, the input and output nozzles, and the safety whistle;

FIG. 2 is a plan view of the nebulizer jar assembly;

FIG. 3 is an enlarged fragmentary view of the nebulizer jet unit shown partly in cross section;

FIG. 4 is a fragmentary cross sectional view illustrating the baffle configuration;

FIG. 5 is an enlarged cross sectional view illustrating a modification of the nebulizer jet unit shown in FIG. 3; and

FIG. 6 is a bottom plan view of FIG. 5.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now by characters of reference to the drawings, and first to FIG. 1, it will be understood that the nebulizer jar assembly includes a jar 10 partly filled with a liquid 11, and a screw top cap 12. Attached to the outside of the cap 12 and communicating with the inside of the jar 10 are respectively: a gas inlet assembly 13, a combined gas and liquid outlet assembly 14, and a whistle assembly 15.

The nebulizer jet unit, generally indicated by numeral 16 includes a body 17 connected to the inlet assembly 13. The nebulizer jet unit 16 is shown in greater detail in FIG. 3.

The body 17 of the nebulizer jet assembly includes a plug 20, constituting a first body portion, threadedly

interfitting a socket of cap 21, the cap 21 constituting a second body portion. The plug 20 includes a nipple 22 which is threadedly interconnected to the inlet assembly 13 by means of a nut 23 (FIG. 1). An O-ring 24 facilitates interengagement of the inlet assembly 13 and the body 17. At its lower end, the plug 20 includes a tip 25. In the preferred embodiment, the tip 25 is separable, it being understood that the tip forms part of the plug 20 and that it therefore constitutes part of the first body portion. An O-ring 26 provides sealing engagement between the tip 25 and the rest of the plug. Another O-ring 27 facilitates the seal between the plug 20 and the cap 21.

The socket of cap 21 includes a substantially conical bottom wall 30. The plug tip 25 includes a compatible annular shoulder 31 that seats and aligns the tip 25 within the socket of cap 21 to provide adjacent shaped faces on the plug 20 and the cap 21 disposed in spaced relation from each other. Part of the adjacent shaped face of the plug tip 25 is provided by a projection 32, the projection 32 having a surface configuration which cooperates with the configuration of the conical bottom wall 30 to provide a mixing chamber 33 and a liquid chamber 34. The projection 32 is chamfered to provide a frusto-conical face 35 spaced from the conical bottom wall 30 to provide a substantially peripheral gap 36 communicating between the annular liquid chamber 34 and the mixing chamber 33.

The plug 20, including the tip 25, is provided with a bored passageway 40 constituting a gas inlet, communicating with the mixing chamber 33. The passageway 40 receives gas at its upper end 41, from the inlet assembly 13. At its lower end, the bored passageway 40 is constricted to provide a throat 42 immediately above an entrance orifice 43 into the mixing chamber 33. The entrance orifice 43 has a diverging configuration.

The gas and liquid outlet from the mixing chamber 33 is provided by a substantially circular exit orifice 44 located at the apex of the conical bottom wall 30 of the cap 21 and in substantial axial alignment or register with the bored passageway 40.

The conical bottom wall 30 of the cap 21 includes a bored hole 45 communicating with a tube 46 attached to the outside of the cap 21. The other end of the tube 46 is connected to a flexible tubular element 47, the bored hole 45 and the tubes 46 and 47 constituting conduit means adapted to interconnect the liquid 11 and the liquid chamber 34.

A baffle 50 is provided which includes a hole 51 to facilitate attachment of the baffle 50 to the tube 46. The baffle 50 includes a substantially cylindrical surface 52 disposed in spaced relation outwardly from the exit orifice 44. The curved surface 52 of the baffle 50 is in substantially diametrical alignment with the axially aligned bored passageway 40 and the exit orifice 44.

Only slight modification is required to the nebulizer jet unit as described above in order to provide a jet suitable for cooling machined parts during the machining process. FIGS. 5 and 6 illustrate the modifications, which concern the socketed cap only. The same number therefore will be given to those parts which are the same as for the embodiment of FIG. 3.

The cap 62 (FIG. 5) has a socket which is substantially the same as that for the embodiment shown in FIG. 3. A bored hole 63 corresponds substantially to the bored hole 45 in the prior embodiment, but this hole 63 is adapted for side connection by means of a laterally bored hole 64 which communicates with it. The laterally bored hole 64 communicates in turn directly with an oil source through pipe elements (not shown).

No baffle is required in the embodiment shown in FIGS. 5 and 6. However, it will be observed that the cap 62 includes an extension portion generally indicated by 65. The extension 65 is provided with a divergent aperture 66 which serves as a direction means for the jet spray emanating from an orifice 67, said orifice 67 cor-

responding substantially to the exit orifice 44 of the previous embodiment. A threaded nipple portion 70 permits the body 61 to be attached to a machine part.

It is thought that the structural arrangement of the nebulizer jet unit has become fully apparent from the foregoing description of parts. For completeness of disclosure, however, the operation of the unit will be briefly described with particular reference to the embodiment substantially as illustrated in FIGS. 1 through 4.

It will be understood that in the following discussion, some assumptions are made. The action of this nebulizer jet is highly complex and the nature or theory of the nebulizing action cannot be fully explained. However, certain observations have been made with reference to the disposition of parts as will appear.

In general, the nebulizer jar 10 contains a liquid, such as water 11. A gas, such as oxygen, is fed into the jar 10 under pressure, humidified by the nebulizer jet unit 16, and passes out of the outlet assembly 14. There is no significant build-up of pressure inside the jar 10, and the whistle valve 15 is calibrated to operate at some 2 p.s.i.

In particular, referring to the nebulizer jet unit 16 illustrated in FIG. 3, it will be understood that gas under pressure enters the bored passageway 40 of the plug 20 at the upper end 41, and is admitted to the mixing chamber 33 after being constricted in the throat 42. Because the slight countersunk configuration of the entrance orifice 43 provides a clean exit hole with minimum divergence, the gas enters the mixing chamber 33 with minimum turbulence.

The gas passes through the mixing chamber 33 and creates a partial vacuum which draws the liquid 11 up the conduit means, which is provided by the bored hole 45 and tubes 46 and 47, and into the annular liquid chamber 34. The liquid is aspirated into the mixing chamber 33 after passing through the annular gap 36.

Because of the annular nature of the liquid chamber 34, which communicates with the mixing chamber 33 by means of the annular gap 36, the liquid enters the mixing chamber 33 circumferentially rather than in a single stream. In addition, the mixing is performed interiorly of the body 17, namely in the mixing chamber 33. These features are not present in the common atomizer, such as that provided by a perfume dispenser, which merely forces a stream of gas from one tube over the opening of another tube which is at right angles to the first, the second tube communicating with a liquid source.

It has been observed that the width of the gap 36 is critical for the effective mixing and formation of a nebulizer spray. The following relationships between nebulizer capacity and size of parts has been found satisfactory with a nebulizer jet unit body of approximately half-inch diameter:

With oxygen supplied at fifty pounds per square inch through an adjustable flowmeter having an output of zero to fifteen liters per minute (with flood at approximately twenty liters per minute), the annular gap in the nebulizer jet assembly is from 0.010 to 0.012 inch wide.

The peripheral area of the gap 36 at the entrance to the mixing chamber 33 is preferably from two to four times the area of the exit orifice 44. The contained angle of the conical bottom wall 30 of the socket is between one hundred and ten and one hundred thirty degrees. (110°-130°).

There is an optimum value for the contained angle of the entrance orifice 43 which leads to the mixing chamber 33. This angle may be determined experimentally in each case. Too great an angle results in a back-up pressure which diminishes, and it may even preclude, the aspiration of the liquid 11 into the mixing chamber 33. An angle between one hundred and ten and one hundred and thirty (110°-130°) has been found to give good results.

In the preferred embodiment, the constriction of the throat 42 is such as to render it substantially smaller in area than the area of the exit aperture 44. In the pre-

5

ferred embodiment, the proportioned relationship between these two areas is that the exit orifice area is between two and four times greater than the throat constriction area.

In the range at which the nebulizer jet is used in the preferred embodiment, namely from zero to fifteen liters per minute, visible vaporization does not occur.

The system acts to provide a vacuum of at least six inches water column when one liter of oxygen per minute is being used, and at least fourteen inches water column when two liters of oxygen per minute are being used. A visible fog appears when oxygen is being used at the rate of two and one-half liters per minute. The fog becomes progressively denser in a virtually linear curve as the flow rate of the output is increased.

The resulting mixture of gas and liquid, which is emitted through the exit orifice 44, impinges violently on the cylindrical surface 52 of the baffle 50. The mixture is thereby broken up into fine droplets, the larger of which, because of their mass, drop out of suspension and re-enter the water 11 in the lower part of the nebulizer jar 10. The smallest particles remain in suspension in the gas and will pass through the outlet assembly 14 with minimal coalescence of the fine water particles.

The particle size of the vapor is presumed in the 0.5 to 10 micron range. Some indication of the very small size of the water particles can be observed by placing an eye glass in the stream of vapor, whereupon fogging of the glass does not occur. In a test of the nebulizer related to its medicinal usage, inhalation of the vapor has been observed to penetrate beyond the sinuses and even the bronchia, thereby providing a strong presumption that the vapor was reaching the alveoli of the lungs where it markedly assists in the prevention of dehydration of the tissue in that respiratory area.

In its use as a coolant during machining processes, the nebulizer jar 10 is dispensed with but, because the pressure within the jar 10 is substantially at atmospheric pressure, the action of the jet is not substantially different. No baffle is necessary in this embodiment.

I claim as my invention:

1. A nebulizer connected to a gas source and a liquid source, comprising:

- (a) a body including a first portion and a second portion,
- (b) the first and second portions including adjacent shaped faces disposed in spaced relation to provide
 - (1) a mixing chamber therebetween,
 - (2) a liquid chamber therebetween disposed upstream of the mixing chamber, and
 - (3) a communicating aperture between the liquid chamber and the mixing chamber including a gap substantially peripheral to said mixing chamber, the gap being disposed upstream of the mixing chamber,
- (c) the first portion of the body including a gas inlet communicating with the mixing chamber,
- (d) the second portion of the body including a gas and liquid outlet communicating with the mixing chamber, said gas and liquid outlet being in substantial axial alignment with said gas inlet, and
- (e) conduit means adapted to supply the liquid chamber from the liquid source.

2. A nebulizer as defined in claim 1, in which:

- (f) the gas inlet includes a passageway terminating in a divergent entrance orifice leading into the mixing chamber,
- (g) the gas and liquid outlet includes an exit orifice, and
- (h) the entrance orifice has an area at least as great as that of the exit orifice.

3. A nebulizer as defined in claim 1, in which:

- (f) the gas inlet includes a passageway that converges into a substantially parallel constricted throat portion

6

passageway and thence into a divergent entrance orifice leading into the mixing chamber, and

- (g) the gas and liquid outlet includes a substantially parallel outlet passageway terminating in an exit orifice in substantial axial alignment with the entrance orifice, the outlet passageway having an area at least twice the area of the constricted throat passageway.

4. A nebulizer as defined in claim 1, in which:

- (f) the liquid chamber has an annular configuration,
- (g) the gas inlet includes an entrance orifice leading into the mixing chamber,
- (h) the gas and liquid mixture outlet includes an exit orifice in substantial axial alignment with said entrance orifice, and
- (i) the gap peripheral to the mixing chamber discharges liquid into the mixing chamber in a direction toward said axis of alignment, yet generally in a direction away from said entrance orifice.

5. A nebulizer as defined in claim 1, in which:

- (f) at least one of the adjacent shaped faces of the first and second body portions forming the gap includes a conical face disposed transversely about the axis alignment of the gas inlet and the gas and liquid outlet, and the gap is between 0.010 inch and 0.012 inch wide.

6. A nebulizer as defined in claim 5, in which:

- (g) the other adjacent shaped face forming the gap has a compatible conical face providing a gap having substantially parallel faces, and
- (h) the gap has a conical annular configuration.

7. A nebulizer as defined in claim 1, in which:

- (f) the first and second body portions are threadedly interconnected, one of said portions forming a plug having an obtuse angle, frusto-conical tip, the other of said portions forming a socket receiving the plug and including a coaxial, obtuse angle frusto-conical tip, the other of said portions forming a socket receiving the plug and including a coaxial, obtuse angle frusto-conical portion spaced from the tip to form at least part of the communicating aperture.

8. A nebulizer as defined in claim 1, in which:

- (f) the first and second body portions are threadedly interconnected, one of said portions forming a plug and the other of said portions forming a socket receiving the plug,
- (g) the plug includes a tip providing one of said adjacent shaped faces, the tip including a substantially circular margin at the remote end, and
- (h) the socket includes a conical bottom wall forming at least a portion of the other of said adjacent shaped faces, the circular margin and the conical bottom wall cooperating to form the peripheral gap substantially symmetrically disposed about the axis of alignment of the gas inlet and the gas and liquid outlet.

9. A nebulizer as defined in claim 1, in which:

- (f) the gas and liquid outlet includes an exit orifice, and
- (g) the peripheral gap has a discharge area into the mixing chamber at least twice the area of the exit orifice.

10. A nebulizer as defined in claim 1, in which:

- (f) the first and second body portions are threadedly interconnected, one of said portions forming a plug and the other of said portions forming a socket receiving the plug,
- (g) the plug includes a tip providing one of said adjacent shaped faces, the tip including a frusto-conical face and a base, the base partially defining the mixing chamber,
- (h) the socket includes a conical bottom wall, the wall having a portion cooperating with the frusto-conical face to form the peripheral gap into a circular configuration substantially symmetrically disposed about

7

- the axis of alignment of the gas inlet and the gas and liquid outlet, and the wall having a portion partially defining the mixing chamber,
- (i) the gas inlet includes a passageway which converges into a constricted throat portion and thence diverges into an entrance orifice leading into the mixing chamber, and
- (j) the gas and liquid outlet includes an exit orifice in substantial axial alignment with the entrance orifice.
11. A nebulizer as defined in claim 1, in which:
- (f) the gas inlet includes a passageway terminating in a divergent orifice leading into the mixing chamber, the contained angle of divergency being obtuse.

5

10

8

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U.S. Cl. X.R.

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