Nov. 21, 1967 F. M. BIRD ET AL 3,353,536

NEBULIZER

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Fig. 2

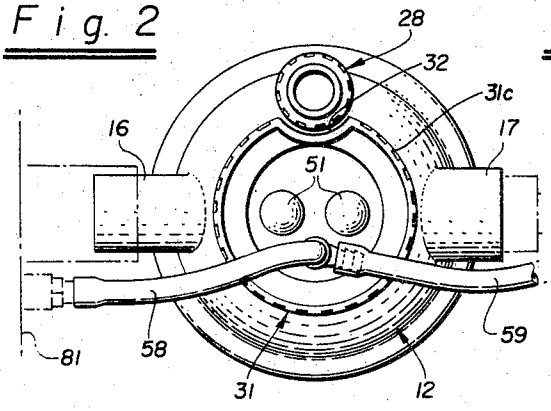
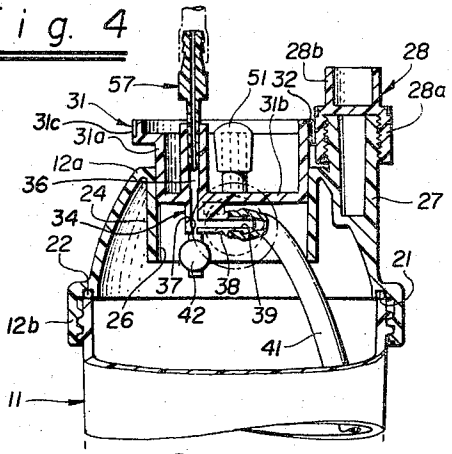


Fig. 4



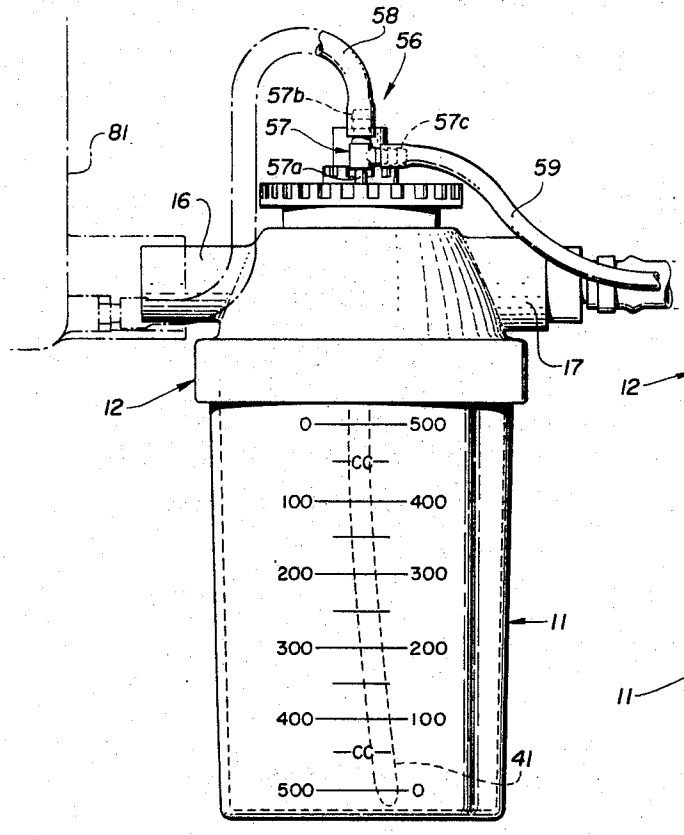


Fig. 1

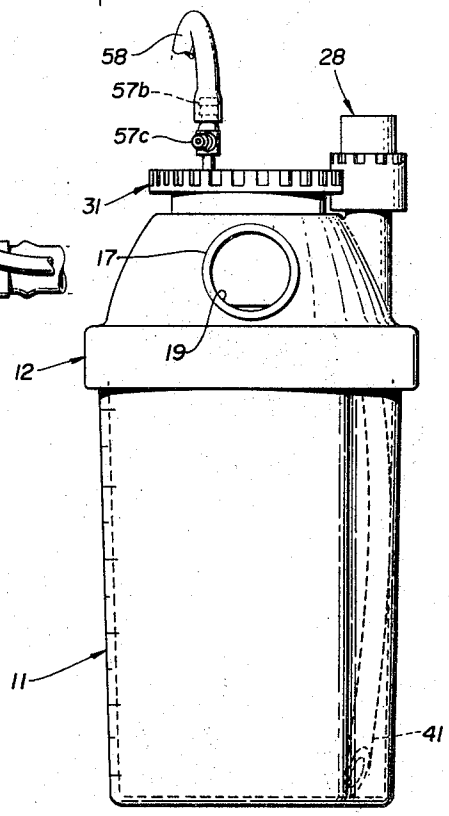


Fig. 3

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Fig. 5

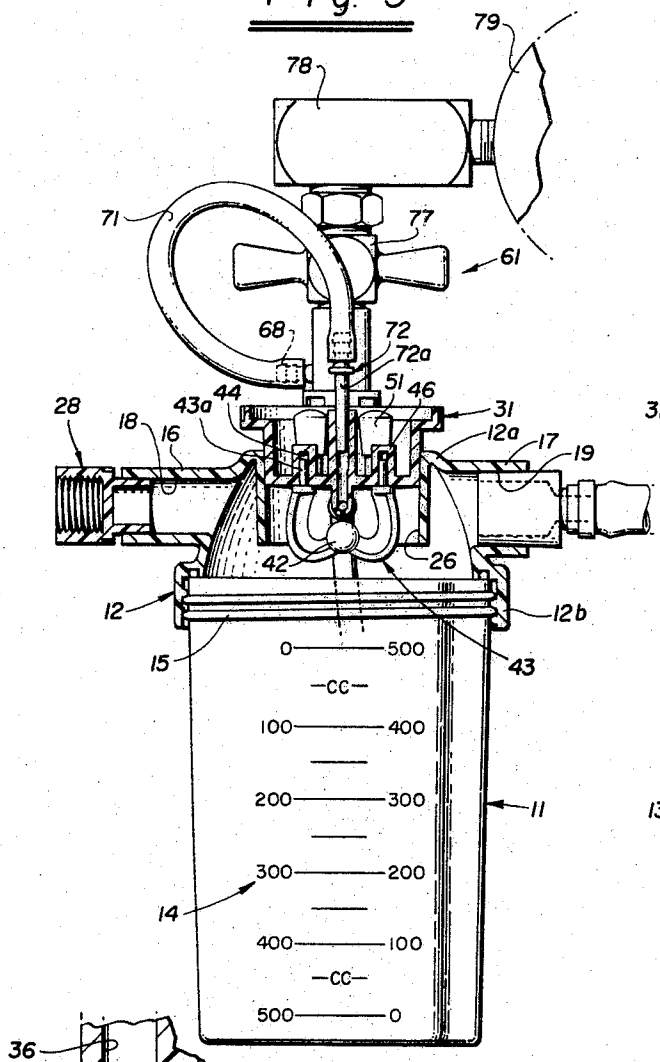
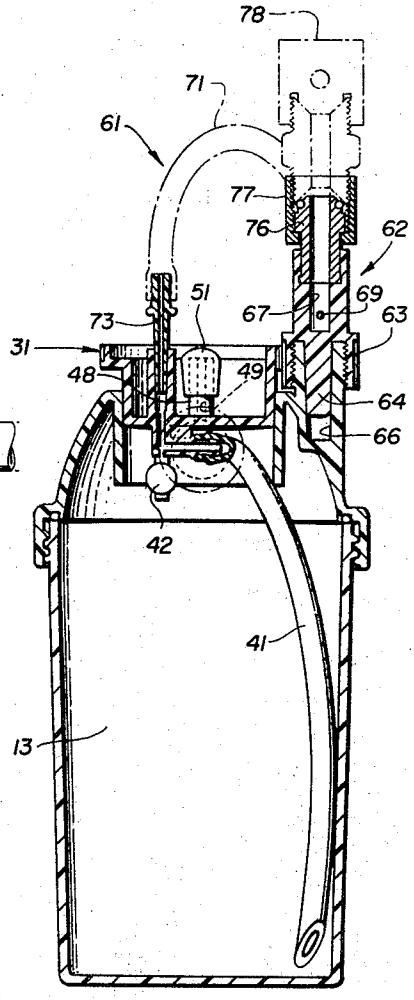


Fig. 6



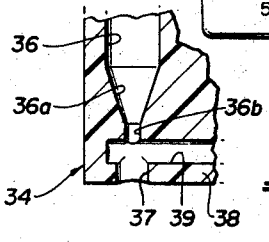


Fig. 7

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NEBULIZER

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ABSTRACT OF THE DISCLOSURE

Nebilizer having a container and a cover removably mounted on the container and in which the cover is formed with an inlet passage and outlet passage and with a skirt which is disposed in front of the inlet passage and the outlet passage, the cover having a nozzle mounted thereon for taking fluid from the container and nebulizing the same at a point which is above the lower extremity of the skirt.

This invention relates to a nebulizer and more particularly to a nebulizer which can be utilized for long-term therapy.

Nebulizers heretofore available have either been relatively small in size requiring frequent re-filling, or have been very expensive for the larger sizes. There is, therefore, a need for a new and improved low price nebulizer which can be utilized for long-term therapy.

In general, it is an object of the present invention to provide a nebulizer which can be utilized for long-term therapy for all applications where oxygen or air is administered to a patient.

Another object of the invention is to provide a nebulizer of the above character which is relatively inexpensive.

Another object of the invention is to provide a nebulizer of the above character which can be used on many different types of respirators.

Another object of the invention is to provide a nebulizer of the above character which can be readily filled and refilled.

Another object of the invention is to provide a nebulizer of the above character which can be readily maintained.

Another object of the invention is to provide a nebulizer of the above character which can be readily cleaned.

Another object of the invention is to provide a nebulizer of the above character in which the critical parts are always in alignment.

Additional objects and features of the invention will appear from the following description in which the preferred embodiment is set forth in detail in conjunction with the accompanying drawings.

Referring to the drawings:

FIGURE 1 is a side elevational view of a neubulizer incorporating the present invention.

FIGURE 2 is a top plan view of the nebulizer shown in FIGURE 1.

FIGURE 3 is a front elevational view of the nebulizer shown in FIGURE 1.

FIGURE 4 is a side elevational view partially in cross-section of a portion of the nebulizer shown in FIGURE 1.

FIGURE 5 is a side elevational view similar to that shown in FIGURE 1 showing another way of using the nebulizer and showing the cap in cross-section.

FIGURE 6 is a cross-sectional view of the nebulizer shown in FIGURE 5.

FIGURE 7 is an enlarged fragmentary view of a portion of the nebulizer shown in FIGURE 6.

In general, the nebulizer is utilized for supplying small liquid particles in a mainstream of gases supplied to a patient. The nebulizer consists of a container defining

a chamber which is adapted to contain a liquid. A cover is removably mounted on the container and is formed with inlet and outlet passages having relatively large cross-sectional areas for carrying the mainstream of gases for the patient. A nozzle is mounted on the cover and has a passage therein for supplying additional gases into the chamber and mixing with the mainstream gases. A nipple is formed on the nozzle and has a passage opening into the passage in the nozzle. A tube is connected to the nipple and is adapted to extend into the liquid in the container so that as gases pass through the nozzle, the liquid is drawn upwardly and entrained in the gases passing through the nozzle. Means is mounted in the cover and provides a surface disposed in front of the nozzle to break up the liquid particles entrained in the gases passing from the nozzle. A skirt is mounted in the cover and surrounds the nozzle and has its lower extremity extending beyond the point at which the liquid particles impinge upon the surface whereby the larger particles engage the skirt and fall back into the liquid in the reservoir and the smaller particles are picked up by the mainstream of gases passing from the inlet passage and into the outlet passage.

As shown in the drawing, the nebulizer consists of a container **11** with a castellated cover **12** removably mounted thereon. The container **11** can be formed in any suitable shape as, for example, cylindrically, as shown in the drawings, and can be formed of any suitable material such as a transparent plastic. The container can be of any suitable size but preferably should be relatively large in order to provide a relatively large chamber **13** for long-term therapy as hereinafter described. Thus, the container can be of a size such as to contain 500 cc. of liquid. If desired, as shown particularly in FIGURE 1, the container **11** can be provided with vertical calibrations **14** so that the amount of liquid in the chamber can be readily determined by visually examining the level of the liquid in the chamber or reservoir.

The container **11** is open at the top and is provided with threads **15** on its upper extremity. The cover **12** can also be formed of a suitable material such as an opaque plastic and can be of any suitable shape. For example, as shown in the drawings, it can have a dome-shaped portion **12***a* and a cylindrical portion **12***b*. The cylindrical portion **12***b* is provided with threads which are adapted to cooperate with the threads **15** to form a threaded connection between the cover **12** and the container **11**.

The cover **12** is provided with extensions **16** and **17** which have axially aligned inlet and outlet passages **18** and **19** formed therein having relatively large cross-sectional areas for carrying the mainstream gases for the patient. As shown in the drawing, the outlet passage **19** is slightly larger than the inlet passage **18**. However, it should be pointed out that the functions of the two passages can be reversed.

The cover **12** is provided with an annular recess **21** which carries an O-ring **22** which is adapted to engage the top edge of the reservoir **11** to form a tight seal between the cover **12** and the reservoir **11** as shown particularly in FIGURE 4.

The upper portion of the cover is provided with a frustoconical depending skirt **24** which extends downwardly into the cover **12** for a substantial distance and which has its lowermost extremity substantially below the lower portions of the inlet and outlet passages **18** and **19** for a purpose hereinafter described. The skirt **24** is provided with a slight inward taper in a downward direction and forms a large opening **26** in the top of the cover **12**. The cover **12** is also provided with a vertically extending threaded boss **27** which has a mantle **28** threadedly mounted thereon. The mantle **28** is provided with large and small plug-like male portions **28***a* and **28***b*.

The male portion **28***a* is of a size so that it can be inserted in the outlet passage **19** to plug the same, whereas the portion **28***b* is of such a size that it can be inserted in the inlet passage **18** to plug that passage when desired.

The large opening **26** provided in the cover **12** is normally closed by a large plug or crown **31**. The plug is provided with a frustoconical portion **31***a* and a planar bottom wall portion **31***b* which adjoins the frustoconical portion **31***a*. The plug is also provided with an outwardly extending lip **31***c*. An arcuate recess **32** is formed in the lip portion **31***c* to accommodate the mantle or cap **28**. As can be seen from FIGURE 4, the plug **31** forms a relatively tight fit in the skirt **24** and normally seals the opening **26**.

A nozzle **34** is mounted in the plug **31** and is formed as an integral part thereof and extends through the bottom wall portion **31***b*. The nozzle **34** is provided with a vertically extending passage **36** which has a tapered portion **36***a* and a capillary-like portion **36***b* which are in communication with a port or orifice **37** disposed below the bottom wall portion **31***b* to provide a downwardly directed jet of air. The nozzle is provided with a nipple **38** which has a passage **39** which communicates with the passage **36**. The nozzle **34** and the nipple **38** are cast as integral parts so that they cannot become misaligned. This assures maximum efficiency of the nozzle at all times. A flexible tube **41** of a suitable material such as plastic is mounted on the nipple **38** and is adapted to extend downwardly into the chamber **13** and into the liquid carried in the container **11**. As hereinafter described, the nozzle **34** is adapted to carry gases and through conventional aspirator action, is able to draw liquid from the chamber **13** and to cause liquid particles to be entrained in the gases as they pass through the nozzle **37**.

By way of example, one nozzle **34** and nipple **38** had the following dimensions. The passage **36** had a diameter of .025 inch; the passage **39** had a diameter of .045 inch; and the port or orifice **37** had a diameter of .047 inch. The tapered portion **36***a* of the passage **36** had an included angle of 8°. The portion **36***b* had a length of 1/16 of an inch and the orifice or port **37** had a length of .067 inch. Thus, in this example, the ratio of the size of the portion **36***b* of the passage **36** and the orifice **37** is .025:.047, and the ratio of the area was 1:3.54.

Means is provided on the plug **31** which forms a surface disposed in front of the nozzle for breaking up the liquid particles entrained in the gases passing from the port **37**. This means consists of a ball **42** which is formed as an integral part of a substantially U-shaped pendant **43**. The pendant **43** is provided with upper tapered portions **43***a* which are adapted to fit relatively tightly in holes **44** provided in bosses **46** formed integral with the planar bottom wall portion **31***b*. The pendant **43** is so positioned so that the spherical surface provided by the ball **44** is disposed slightly below the port **37** for the nozzle **34**. It also will be noted that the port **37** and the ball **42** are positioned so that the gases carrying the liquid particles impinge upon the ball at a point which is above the lower extremity of the skirt **24** or, in other words, the skirt **24** extends beyond the point at which the liquid particles impinge upon the ball **42**.

The plug **31** is also provided with a pair of risers **48** which have passages **49** extending therethrough. Caps **51** of a suitable material, such as rubber, are mounted over the risers and close the upper ends of the passages **49**.

Suitable additional fittings are provided for use with the nebulizer. For example, as shown in FIGURES 1, 2, 3 and 4, a fitting assembly **56** is provided which consists of a T-shaped fitting **57**. The fitting **57** has one leg **57***a* which is tapered and adapted to seat within the passage **36** provided in the nozzle **34**. The fitting is also provided with nipples **57***b* and **57***c* which are stepped as shown and which are connected to tubes **58** and **59**. Tube **58** is adapted to be connected to a source of gas under pressure so that the gas is supplied to the nozzle **34**. The tube **59** is adapted to be connected to other accessories as, for example, an exhalation valve of a breathing assembly provided as a part of a respirator.

In FIGURES 5 and 6, another fitting assembly **61** is provided which consists of an extension member **62** which is provided with a cap **63** which is adapted to be threaded onto the threaded boss **27** and a tapered element **64** which is adapted to seat within a tapered recess **66** provided in the boss **27**. The extension member **62** can be formed of any suitable material such as plastic. It is provided with a vertically extending passage **67**. It also is provided with an integral fitting **68** which has a passage **69** therein opening into the passage **67**. A tube **71** is mounted on the fitting **68**. An adapter **72** is mounted on the other end of the tube **71** and is provided with a tapered portion **72***a* adapted to fit within the passage **36** provided in the nozzle **34**. The adapter is provided with a passage **73** which opens into the tube **71**. A metal fitting **76** is mounted on the upper end of the extension member **72** and has a swivel **77** of a conventional type mounted thereon which is adapted to be connected to an outlet assembly **78** of a conventional type that is connected to a source of gas **79** under pressure.

Operation and use of the nebulizer may now be briefly described as follows. Let it be assumed that the inlet extension **16** is connected to means for supplying mainstream gases to a patient, as, for example, a respirator **81** such as disclosed in Patent No. 3,068,856, and that the outlet extension **17** is connected to a suitable patient adapter such as a breathing assembly and that the fitting assembly **56** has its tube **58** connected to a suitable supply of gas under pressure such as supplied from the respirator. Let it also be assumed that the container **11** has been filled to a suitable level with a liquid with which it is desired to supply to the patient as, for example, water.

In operation, the gases passing through the tube **58** enter the passage **36** and the nozzle **34** and discharge at relatively high velocity through the port **37**. During the travel of the gases through the passage **36**, liquid from the container **11** is siphoned through the tube **41** and is entrained in liquid particles in the gases passing through the passage **36** by conventional aspiratory action and the liquid particles are discharged with the jet of gases emerging from the port **37** and impinge upon the spherical surface provided by the ball **42** which breaks the entrained particles of liquid into many smaller particles as, for example, particles having a size of .5 to 4 microns. These particles, with the jet of air, are dispersed downwardly within the skirt **24**. Certain of the larger normally undesirable particles collect on the skirt, whereas the smaller particles enter the mainstream of gases passing through the nebulizer from the inlet passage **18** and around the skirt **24** out the outlet passage to the patient. Since the mainstream does not take a direct route across the point at which the gas jet emerging from the port **37** strikes the ball **42** because of the protection afforded by the skirt **24**, the mainstream of gases passing around the skirt **24** will only pick up or capture those smaller particles which readily travel with the gases, whereas the larger particles will be collected by the skirt **24** and will drain down into the container **11**. The smaller particles captured by the main air stream passing through the nebulizer are delivered to the patient so that the patient is supplied with properly moistened gases.

The integral one-piece construction of the nozzle **34** and nipple **38**, which alternatively can be called a one-piece air jet capillary and discharge port assembly, is relatively important. This is because the amount of liquid delivered to the pendant ball **42** through the metering orifice **37** is determined by its size relationship with respect to the size of the passage **36***a* and the length of the passage **39** that must be bridged by the jet of gases which passes from the passage **36** through the orifice **37**. Thus, the area of the passage **36***b*, the length of the free gas jet travel across the passage **39** to the inlet of the larger orifice **37** and the relationship of the large orifice **37** to the passage **36***b*

controls the amount of liquid placed in the jet stream and which is slammed against the ball **42** and thus, in a great measure, determining the availability of the volume of liquid to be suspended in the mechanical airway to the patient. The element efficiency of the jet capillary construction depends greatly on the registration or concentricity of the jet orifice **36***b* and the discharge orifice **37** which emits the mixed gas and liquid. The present construction precludes misalignment of the parts. The size of the ball **42** determines the particulate size.

When the nebulizer is connected as shown in FIGURES 1–4, an in-line connection is provided for the mainstream gases and all of the mainstream gases as, for example, all of the inspired gases during pressure breathing, can be caused to flow directly through the nebulizer to make possible maximum transport of the liquid particles to the patient. Additional liquids for giving the necessary therapy to the patient, such as anaesthetic agents, drugs and bronchodialators, can be introduced by way of hypodermic needles through the caps **51** and through the passage **49** provided in the risers **48**. The chamber or reservoir **13** can be refilled during the expiratory phase merely by removing the cover **12** and filling the reservoir without disconnecting the various fittings. Alternatively, if desired, the container **11** can be unscrewed from the cover **12**, filled with liquid and then screwed back into the cover.

The operation is substantially identical with the use of the fitting assembly **61** provided in FIGURES 5 and 6. However, in this arrangement, the mantle **28** closes the inlet passage **18** and the only gas which passes through the nebulizer and out the outlet passage **19** is the gas supplied through the nozzle **34**. Such an arrangement is used where the patient is being supplied with oxygen through a nasal catheter, etc. Since the oxygen passes through the nebulizer, it is properly moistened for the patient's use.

The crown **31** can act as a relief valve which will automatically pop out of the cover **12** when excessive high pressure gases accumulate in the mechanical airway to the patient.

From the foregoing, it can be seen that the nebulizer may be used in combination with any metered oxygen supply to provide a suspension of water particles to resolve any humidity deficit in the gases being supplied to the patient. Thus, the nebulizer may also be called a humidifier. The container **11** is of sufficient size so that continuous therapy can be provided for the patient. The inlet and outlets are in line and can be reversed. The nebulizer humidifier can be applied without alternation on free flow oxygen inhalation therapy or pulmonary therapy.

We claim:

1. In a nebulizer for supplying small liquid particles in a mainstream of gases supplied to a patient, a container forming a chamber adapted to contain a liquid, a cover mounted on said container, the cover being formed with an inlet opening and an outlet opening for carrying mainstream gases to the patient, a nozzle mounted on said cover and having a passage therein for supplying gases into the chamber, an additional passage formed in said nozzle and communicating with said first named passage, means connecting said additional passage to the fluid in the reservoir, means mounted in the cover providing a surface disposed in front of the nozzle for breaking up liquid particles entrained in the gases passing from the nozzle, and a skirt disposed in the cover and surrounding the nozzle and having its lower extremity extending below said inlet and outlet openings and below the point at which the liquid particles impinge upon said surface, said skirt being disposed in front of said inlet opening and said outlet opening and in said mainstream gases so that the mainstream gases have a tendency to flow around the skirt.

2. A nebulizer as in claim **1** wherein said cover has a large opening formed therein, a plug removably mounted in said cover and closing said opening and wherein said nozzle and said means providing a surface are mounted on said plug.

3. A nebulizer as in claim **1** wherein the inlet and outlet passages are in alignment and wherein the nozzle is disposed so that the gases jetting therefrom are substantially at right angles to the aligned inlet and outlet passages.

4. In a nebulizer for supplying small liquid particles in a mainstream of gases supplied to a patient, a container forming a chamber adapted to contain a liquid, a cover removably mounted on said reservoir and being formed with axially aligned inlet and outlet passages having relatively large cross-sectional areas for carrying the mainstream of gases for the patient, a cylindrical skirt formed in the cover and defining a relatively large opening extending downwardly at right angles to and below the axially aligned inlet and outlet passages, the skirt being disposed in front of the inlet and outlet passages in the main airstream so that the mainstream gases have a tendency to flow around the skirt, a plug removably mounted in said large opening in the cover and serving to close the same, a nozzle mounted in said plug and having a downwardly disposed port so that gases jetting therefrom pass in a direction which is substantially at right angles to the direction of flow of the mainstream gases through the nebulizer, said nozzle being formed with an additional passage, means connecting said additional passage to the liquid in the container so that as gases pass through the nozzle, liquid is siphoned from the container and entrained in the gases, and means mounted on the cover supporting a substantially spherical surface disposed in front of the nozzle for breaking up the liquid particles entrained in the gases passing from the port into smaller particles.

5. A nebulizer as in claim **4** together with a boss mounted on said cover and a mantle removably mounted on said boss, said mantle having portions thereof adapted to be inserted in either said inlet passage or said outlet passage to close either said inlet passage or said outlet passage.

6. A nebulizer as in claim **4** wherein said means supporting said substantially spherical surface consists of a substantially U-shaped member removably mounted in said plug.

7. A nebulizer as in claim **4** together with at least one riser mounted on said plug, a passage in said riser, and a resilient cap mounted on said riser and closing said passage.

8. A nebulizer as in claim **4** wherein said substantially spherical surface is positioned so that it is above the lower extremity of the skirt.

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