United States Patent

Deaton

[15] **3,682,168**

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[54] **STERILE LIQUID ENTRAINING SYSTEM**

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[21] Appl. No.: **44,929**

[52] **U.S. Cl.**.....**128/194**, 261/122

[51] **Int. Cl.**.....**A61m 15/00**

[58] **Field of Search**.....239/327, 338; 128/194, DIG. 24, 128/188, 185, 186, 193, 272; 222/92, 81; 261/2, 119, 76, 122

[56] **References Cited**

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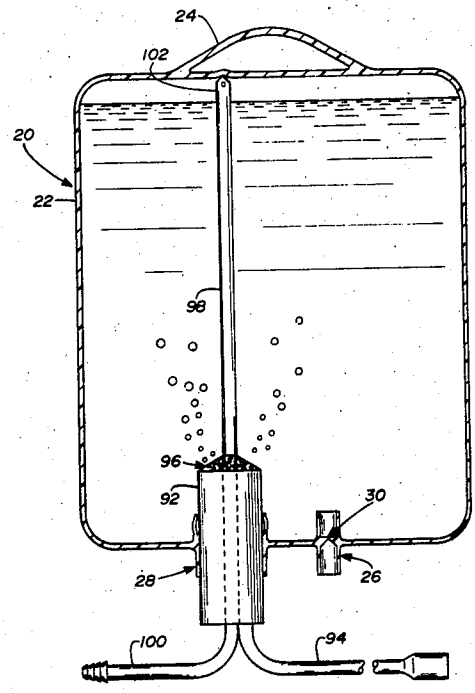
[57] **ABSTRACT**

In a sterile liquid entraining system, a liquid is fed to a vapor generator from a collapsible liquid container. Initially, the container is sterilized and is filled with a sterile liquid. Then, a vapor generator, which may comprise either a humidifier or a nebulizer, is connected to the container through one of two normally sealed ports secured to the bottom of the container. As the liquid flows from the container to the vapor generator, the container gradually collapses. This prevents contact between the interior of the container and the atmosphere, and thereby prevents contamination of the sterile liquid in the container by microorganisms in the atmosphere.

7 Claims, 10 Drawing Figures



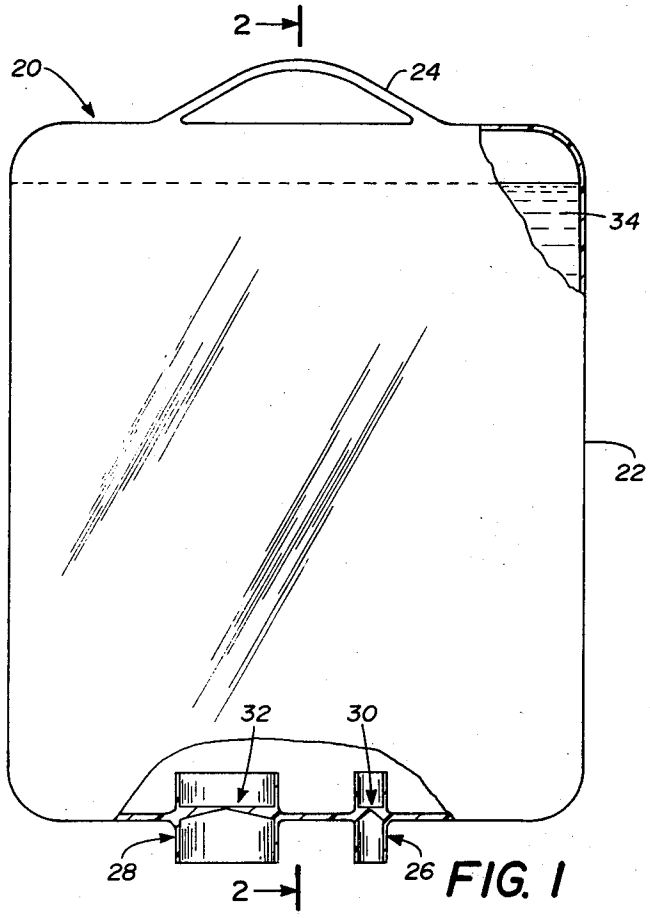


FIG. 1

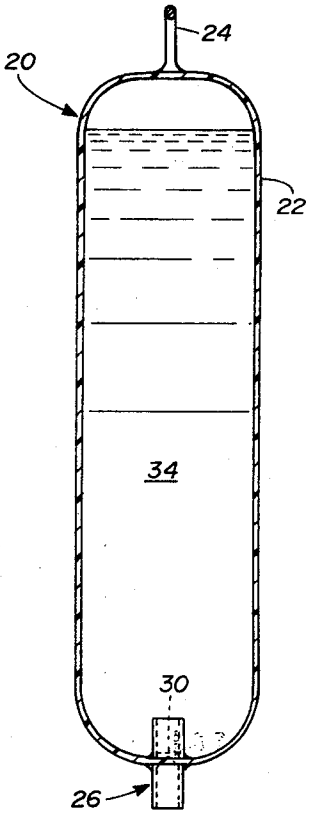


FIG. 2

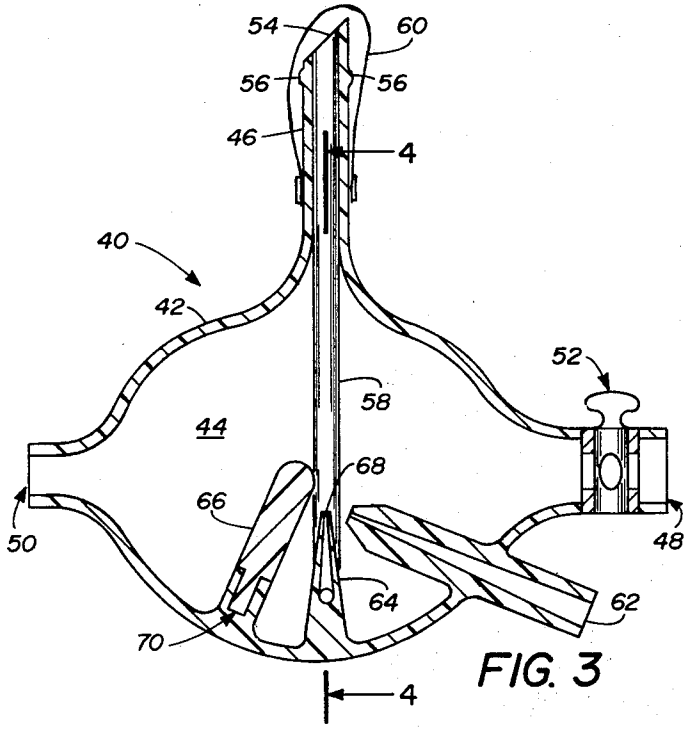


FIG. 3

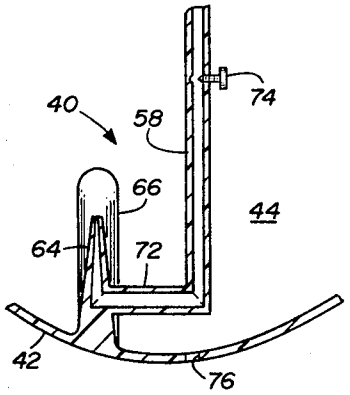


FIG. 4

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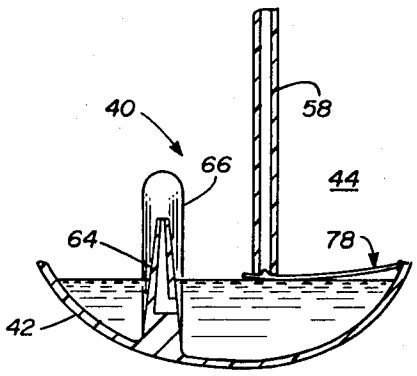

FIG. 5

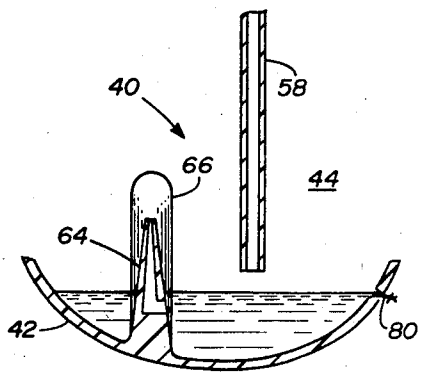

FIG. 6

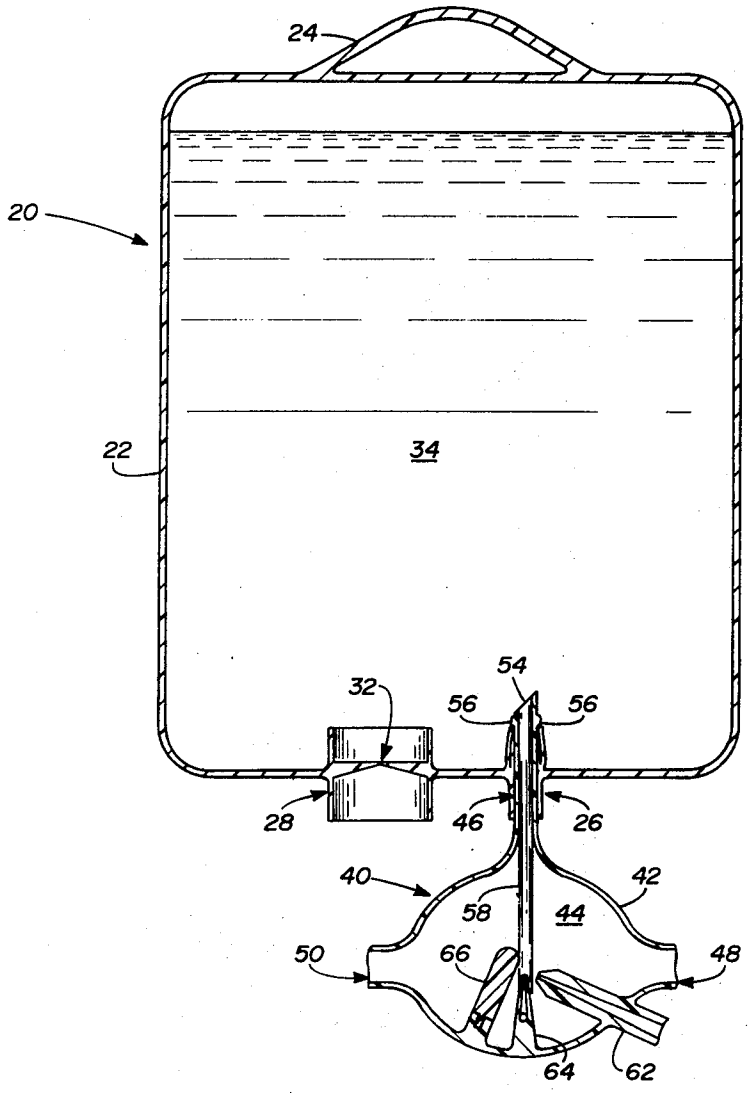

FIG. 7

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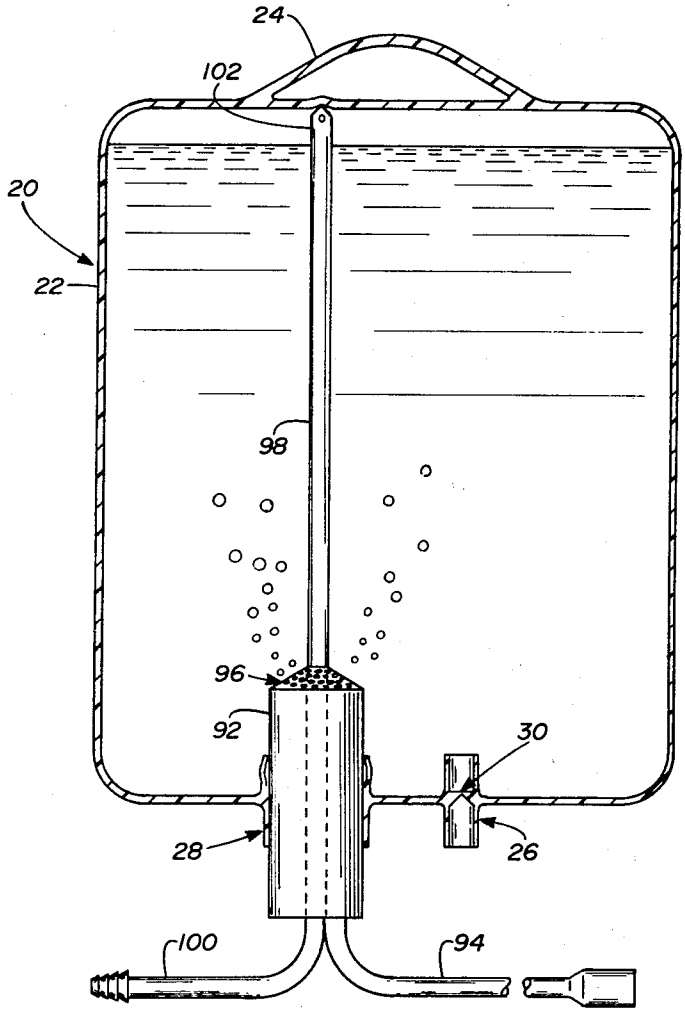

FIG. 10

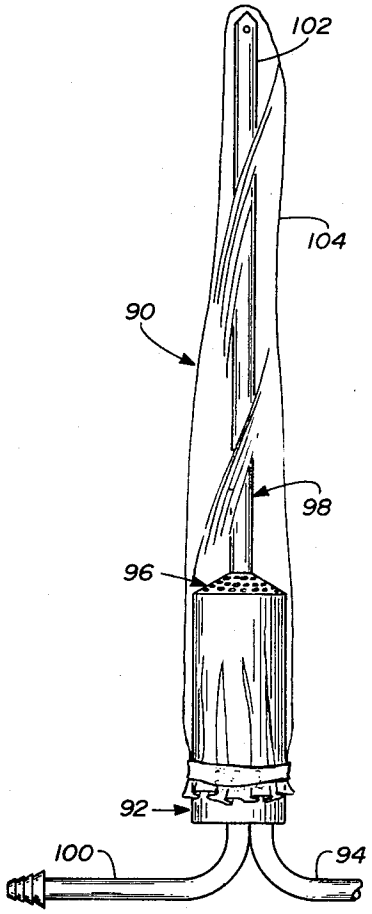

FIG. 8

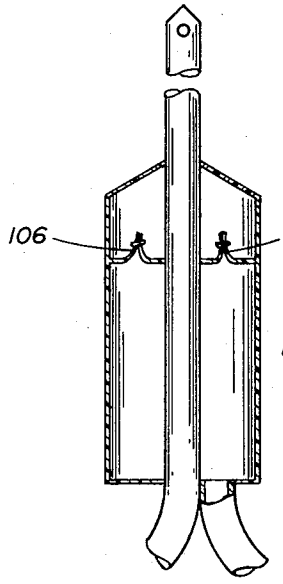

FIG. 9

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STERILE LIQUID ENTRAINING SYSTEM

BACKGROUND OF THE INVENTION

In the practice of the healing arts, the remedies that are prescribed for a wide variety of ailments include the use of various gases, including oxygen, oxygen enriched air, etc. Although these gases are usually supplied in a high pressure, moisture-free state, the inhalation of a completely dry gas is generally considered to be injurious. For this reason, it is now common to employ liquid entraining systems in conjunction with the administration of medicinal gases.

At the present time two types of liquid entraining systems are in use. These include humidifiers, which traditionally generate a vapor comprising the gaseous state of a liquid, and nebulizers, which generate a vapor comprising very small liquid droplets. In the operation of both humidifiers and nebulizers, a liquid from a reservoir is transformed into a vapor, and the vapor is entrained in a medicinal gas as the gas is administered.

The reservoirs that are employed in conjunction with presently available liquid entraining systems comprise refillable plastic or glass jars. Liquid entraining system reservoirs of this type are unsatisfactory for a number of reasons. For example, hospital personnel often fail to sterilize the jars between uses. Even if a jar is sterilized, there is no guarantee that the liquid that is used to fill the jars is sterile. And, at the present time, the liquid that is withdrawn from a liquid entraining system reservoir is replaced with unfiltered room air. Microorganisms carried into a reservoir with the air can contaminate the interior of the reservoir, even though the interior was initially sterile.

Regardless of the manner in which microorganisms are introduced into a liquid entraining system reservoir, there is ample time for the microorganisms to multiply within the reservoir. This is because modern liquid entraining systems are capable of operating for as long as eight hours before it is necessary to refill the reservoir. During the latter stages of the operation of such a liquid entraining system, microorganisms that have multiplied within the reservoir are carried out of the reservoir with the liquid, and are entrained in a medicinal gas along with the vapor that is generated from the liquid.

Obviously, the introduction of microorganisms into medicinal gases is a dangerous practice. Thus, a need exists for a liquid entraining system in which the interior of the reservoir is maintained sterile throughout the use of the system. The present invention fulfills this need, in that is comprises a liquid entraining system in which the reservoir is sterilized and filled with a sterile liquid prior to use, and in which contact between the liquid and unfiltered air is prevented during use.

SUMMARY OF THE INVENTION

In accordance with the preferred embodiment of the invention, a sterile liquid entraining system includes a vapor generator and a collapsible liquid container for supplying liquid to the vapor generator. Initially, the collapsible liquid container is sterilized and is filled with a sterile liquid. During the use of the invention, the container is collapsed as the liquid is fed from the container into the vapor generator so that the interior of the container does not come into contact with the atmosphere. Preferably, the container is discarded when it is empty.

DESCRIPTION OF THE DRAWINGS

A more complete understanding of the invention may be had by referring to the following Detailed Description when taken in conjunction with the drawings, wherein:

FIG. **1** is a front view of a collapsible liquid container in which certain portions have been broken away more clearly to illustrate certain features of the invention;

FIG. **2** is a sectional view taken along the lines **2—2** in FIG. **1** in the direction of the arrows;

FIG. **3** is a sectional view of a nebulizer assembly;

FIG. **4** is a sectional view taken along the line **4—4** in FIG. **3** in the direction of the arrows;

FIG. **5** is a sectional view similar to FIG. **4** showing an alternative construction of the nebulizer assembly shown in FIG. **3**,

FIG. **6** is a sectional view similar to FIG. **4** showing another alternative construction of the nebulizer assembly shown in FIG. **3**;

FIG. **7** is an illustration of the use of the nebulizer assembly shown in FIG. **3** in conjunction with the collapsible liquid container shown in FIG. **1**;

FIG. **8** is an illustration of a humidifier assembly;

FIG. **9** is an illustration of an alternative embodiment of the humidifier assembly shown in FIG. **8**, and

FIG. **10** is an illustration of the use of the humidifier assembly shown in FIG. **8** in conjunction with the collapsible liquid container shown in FIG. **1**.

DETAILED DESCRIPTION

Referring now to the drawings, a sterile liquid entraining system employing the present invention is shown. Referring particularly to FIGS. **1** and **2**, there is shown a collapsible liquid container **20** useful in the practice of the invention. The container **20** is formed from a sterilizable, microorganism impervious substance, for example, a poly-l-olefin, such a polyethylene, polypropylene, etc., a polyamid such as nylon, etc. The container **20** is preferably formed from flexible sheets that are joined into a flexible bag by conventional bonding techniques, such as heat sealing.

The collapsible liquid container **20** includes a main portion **22** having a support bail **24** secured to its upper end and having a nebulizer receiving port **26** and a humidifier receiving port **28** secured in its lower end. The ports **26** and **28** comprise tubes mounted between the sheets comprising the liquid container **20**. In accordance with the preferred embodiment of the invention, the ports **26** and **28** are normally sealed by conventional penetrable seals **30** and **32**, respectively. Other sealing mechanisms, such as tear open strips, can be used in place of the penetrable seals **30** and **32** to close the ports **26** and **28**, if desired.

In the use of the collapsible liquid container **20**, the interior of the main portion **22** is initially sterilized. A medically sterile liquid **34** is then fed into the main portion **22** of the container **20**. The sterile liquid **34** may comprise water or any other liquid, and may include dissolved medicaments, if desired. After a predetermined amount of the liquid **34** has been fed into the container **20**, the container is sealed, so that the liquid **34** remains sterile during the transportation and/or storage of the container **20**.

Referring now to FIG. **3**, there is shown a nebulizer **40** useful in conjunction with the collapsible liquid con-

tainer 20 in the practice of the present invention. The nebulizer 40 includes a housing 42 which defines a nebulizing chamber 44. The housing 42 has a plurality of ports formed in it, including a liquid inlet port 46, a gas inlet port 48 and a vapor outlet port 50. The gas inlet port 48 has a valve 52 mounted in it which may be opened to facilitate use of the nebulizer 40 in a main stream application, or closed to facilitate use of the nebulizer 40 in a side stream application, or may entrain air to mix with the gas entering port 62. The liquid inlet port 46 has a sharp tip 54 and retaining barbs 56, and includes a liquid supply tube 58 which extends through the port 46 to the bottom of the nebulizer chamber 44. When the nebulizer 40 is not in use, the exterior of the liquid port 46 is maintained in a sterile condition by a cover 60.

The operating portions of the nebulizer 40 comprise a pressurized gas inlet tube 62, a liquid delivery tube 64 and a target 66. The liquid delivery tube 64 receives liquid from the liquid supply tube 58, and directs the liquid to a liquid delivery orifice 68. The gas inlet tube 62 directs a high velocity jet of oxygen, air, or the like across the orifice 68, whereupon liquid is drawn out of the orifice and liquid droplets are entrained in the gas jet.

The target 66 is supported on the housing 42 of the nebulizer 40 by a pin and hole connection 70. When the target 66 is removed, the jet flowing from the tube 62 and the liquid droplets entrained therein are directed out of the nebulizer 40 through the vapor outlet port 50. When the target 66 is positioned in the manner shown in FIG. 3, the liquid droplets entrained in the jet are directed into engagement with the target 66. The engagement of the droplets with the target 66 breaks the droplets into very small droplets having diameters ranging down to about 5 microns. The very small droplets are then directed out of the nebulizer 40 through the vapor outlet port 50. At the same time, a portion of the liquid comprising the droplets that engage the target 66 flows down the target 66 into the bottom of the nebulizing chamber 44. A more complete description of the operation of nebulizers of the type shown in FIG. 3 is contained in U.S. Pat. No. 3,172,406.

Referring now to FIG. 4, the connection between the liquid supply tube 58 and the liquid delivery tube 64 is shown. In accordance with the preferred embodiment of the invention, the tube 58 is connected directly to the tube 64 through a crossover tube 72. A needle valve 74 is positioned in the tube 58 to control the rate of flow of liquid to the liquid delivery orifice 68, and to thereby control the quantity of liquid flowing out of the nebulizer 40 through the port 50. A flow meter, such as the flow meter disclosed in U. S. Pat. No. 3,034,504, may also be employed in the tube 58 if desired. When the nebulizer 40 is constructed as shown in FIG. 4, a hole 76 is preferably formed through the housing 42 to permit liquid flowing down the target 66 to pass out of the nebulizing chamber 44.

FIGS. 5 and 6 comprise illustrations of alternative constructions of the nebulizer 40 in which the liquid supply tube 58 conveys liquid to, and in which the liquid delivery tube 64 receives liquid from, the bottom of the nebulizing chamber 44. In the construction shown in FIG. 5, the nebulizer 40 includes a floating valve 78 which blocks the outlet of the tube 58 when liquid in the bottom of the nebulizing chamber 44 reaches a predetermined depth. In the construction shown in FIG. 6, a check valve 80 maintains the liquid in the bottom of the nebulizing chamber 44 at a predetermined level by draining excess liquid from the housing 42. In both constructions, liquid flowing down the target 66 returns to the quantity of liquid in the bottom of the nebulizing chamber 44.

The use of the nebulizer 40 in conjunction with the collapsible liquid container 20 is illustrated in FIG. 7. Initially, the cover 60 is removed from the liquid inlet port 46 of the nebulizer 40, and the exterior of the port 46 is sterilized. Then, the pointed tip 54 of the liquid inlet port 46 is forced through the penetrable seal 30 of the nebulizer receiving port 26 until the liquid supply tube 58 of the nebulizer 40 communicates with the interior of the main portion 22 of the collapsible liquid container 20. When the nebulizer 40 is properly positioned relative to the collapsible liquid container 20, the barbs 56 prevent outward movement of the nebulizer 40 relative to the container, and the seal 30 of the port 26 cooperates with the exterior of the port 46 to form a seal between the nebulizer 40 and the collapsible liquid container 20.

After the nebulizer 40 and the collapsible liquid container 20 are interconnected, the pressurized gas inlet tube 62 is connected to a source of pressurized gas, and the vapor outlet port 50 is directed to a patient through suitable hoses, tents, etc. If the nebulizer 40 is to be used in a main stream application, a source of dry gas is connected to the dry gas inlet port 48, or the port 48 is opened to the atmosphere, as required. Then, the nebulizer is operated either with or without the target 66 in place to direct a vapor to the patient through the vapor outlet port 50. When the collapsible container is empty, the nebulizer 40 is disconnected therefrom, and the container is discarded.

During the use of the nebulizer 40, liquid is supplied to the nebulizer from the collapsible container 20. Due to the collapsible nature of the container 20, there is no need to admit air to the interior of the container during the withdrawal of liquid therefrom. Rather, the container 20 simply collapses as liquid is fed to the nebulizer 40. Thus, the interior of the liquid container 20 remains sealed throughout the withdrawal of liquid so that the possibility of contamination of the liquid by micro-organisms in the atmosphere is completely eliminated.

Referring now to FIG. 8, there is shown a humidifier 90 useful in conjunction with the collapsible liquid container 20 in the practice of the present invention. The humidifier 90 comprises a relatively large diameter gas inlet cylinder 92 having a gas supply tube 94 extending to it. The upper portion 96 of the tube 92 is conical in shape and has a plurality of small diameter holes formed through it.

The humidifier 90 further includes a relatively small diameter gas outlet cylinder 98. The cylinder 98 extends axially through the cylinder 92 into communication with gas receiving tube 100, and may be integrally formed with the tube 100, if desired. The upper end 102 of the cylinder 98 is pointed and has a plurality of holes formed through it. When not in use, the gas inlet cylinder 92 and the gas outlet cylinder 98 of the hu-

midifier **90** are maintained in a sterile condition by a cover **104**.

Referring now to FIG. **9**, an alternative construction of the humidifier **90** is shown. The construction shown in FIG. **9** is identical to the construction shown in FIG. **8**, except that the gas inlet cylinder **92** has a plurality of check valves **106** mounted in it. The valves **106** function to permit gas to flow out of the cylinder **92** and to prevent liquid from flowing into the cylinder **92**. When the construction shown in FIG. **9** is used, the holes formed in the upper portion **96** of the cylinder **92** may be of any convenient diameter.

Referring now to FIG. **10**, the use of the humidifier assembly **90** in cooperation with the collapsible liquid container **20** is shown. Initially, the cover **104** is removed from the humidifier **90**, and the exteriors of the gas outlet cylinder **98** and the gas inlet cylinder **92** are sterilized. Then, the humidifier **90** is inserted into the collapsible container **20** by forcing the upper end **102** of the gas outlet cylinder **98** through the penetrable seal **32** of the collapsible liquid container **20**. The humidifier **90** is forced through the humidifier receiving port **28** of the collapsible liquid container **20** until the upper end **102** of the outlet tube **98** is positioned above the upper surface of the liquid **34** in the container **20**. This positions the upper portion **96** of the inlet cylinder **92** within the main portion **22** of the container **20**, and the seal **32** of the port **28** and the exterior of the cylinder **92** cooperate to form a seal between the humidifier **90** and the container **20**.

When the humidifier **90** is properly positioned within the collapsible liquid container **20**, the tube **94** is coupled to a source of gas under pressure, and the tube **100** is directed to a patient through suitable hoses, tents, etc. Gas entering the humidifier **90** through the tube **94** flows into the interior of the container **20** through the holes formed in the upper portion **96** of the gas inlet cylinder **92**. As the gas flows through the sterile liquid **34** within the container **20**, the liquid is absorbed into the gas. Then, the gas flows out of the container **20** through the holes in the upper portion **102** of the outlet cylinder **98**, through the outlet cylinder **98**, and through the tube **100**.

Preferably, the gas that is directed to the humidifier **90** is sterilized before it is fed into the tube **94**. In such a case, the interior of the collapsible liquid container **20** remains sterile through out the operation of the humidifier. After all of the liquid within the container has been absorbed by gas flowing through the humidifier **90**, the humidifier **90** is removed from the port **28**, and the collapsible liquid container **20** is discarded.

From the foregoing, it will be understood that the present invention comprises a sterile liquid entraining system including a vapor generator and a collapsible liquid container. In the use of the invention, liquid is supplied to the vapor generator from the container without exposing the liquid to the atmosphere. In this way, contamination of the liquid by microorganisms in the atmosphere is prevented.

Although specific embodiments of the invention are illustrated in the drawings and described herein, it will be understood that the invention is not limited to the embodiments disclosed, but is capable of rearrangement, modification and substitution of parts and elements without departing from the spirit of the invention.

What is claimed is:

1. A sterile liquid entraining humidifier comprising:

a collapsible liquid container constructed from a flexible and sterilizable thin walled plastic bag,

said container when in operation containing an amount of fluid such that an unfilled space exists in the upper portion of said container,

a humidifier assembly mounted through and supported by the walls of said plastic bag in the lower portion thereof and including a pressurized gas inlet member directing pressurized gas through the fluid in said container to the unfilled space therein, said gas entraining fluid while passing through the fluid, and a gas outlet member extending to the unfilled space of the container to convey humidified gas from the unfilled space to the exterior of said container, said container tending to collapse as the fluid is entained in the pressurized gas.

2. The sterile liquid entraining system according to claim **1** further including means forming a seal between the humidifier gas inlet member and the collapsible liquid container.

3. The sterile liquid entraining system according to claim **1** wherein the gas inlet member includes means for permitting gas to flow out of the inlet member and into the container and for preventing liquid from flowing out of the container and into the inlet member.

4. The sterile liquid entraining system according to claim **1** further including a gas inlet tube connected to the gas inlet member for directing a gas thereto, and a gas outlet tube connected to the gas outlet member for receiving the humidified gas therefrom.

5. The sterile vapor entraining system according to claim **1** wherein the collapsible liquid container is entirely sealed except for the point of connection of the humidifier gas inlet member thereto.

6. The sterile vapor entraining system according to claim **1** wherein the collapsible liquid container comprises a flexible bag and contains a medically sterile liquid.

7. The humidifier of claim **1** wherein said humidifier assembly comprises:

a first relatively wide diameter, relatively short gas inlet cylinder having apertures in the end thereof for permitting gas to flow therefrom,

a second relatively small diameter, relatively long gas outlet cylinder extending through said first cylinder.

* * * * *