

- [54] **HUMIDIFIER AND HEATER FOR DELIVERED GASES**
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[51] Int. Cl. **F22b 1/28**
[58] Field of Search..... 219/271, 272, 275,
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121 R, 142, DIG. 65; 55/255-256

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[57] **ABSTRACT**
A humidifier to moisten and heat delivered gases from a source such as a respiratory machine. In a preferred form, the humidifier is a disposable assembly unit formed from a thermoplastic material in which the heating means is part of the assembly unit, removable or fixed. The structure of the humidifier further provides an improved handling of the delivered gas for moistening and heating in that gas is delivered through an inlet and tube means to a rebound chamber in a lower portion of the container where the gas is moved upwardly through a dispersion plate for bubbling through a body of water prior to discharge through an outlet.

17 Claims, 8 Drawing Figures

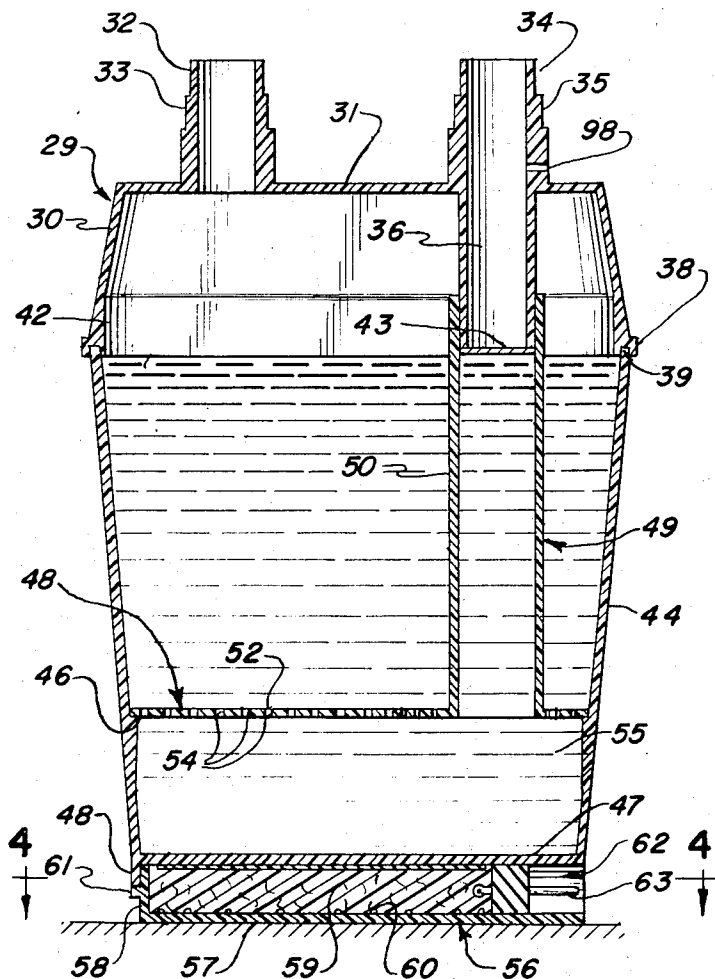


FIG. 1

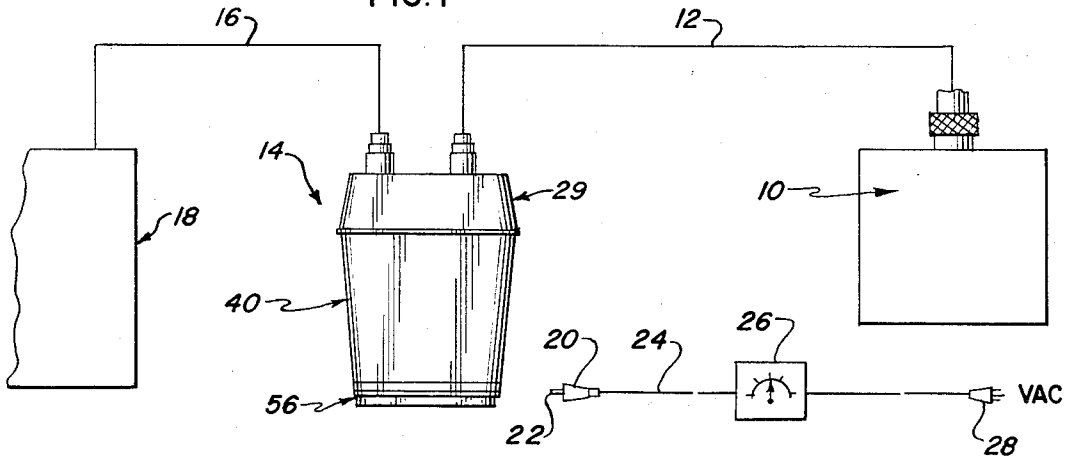


FIG. 2

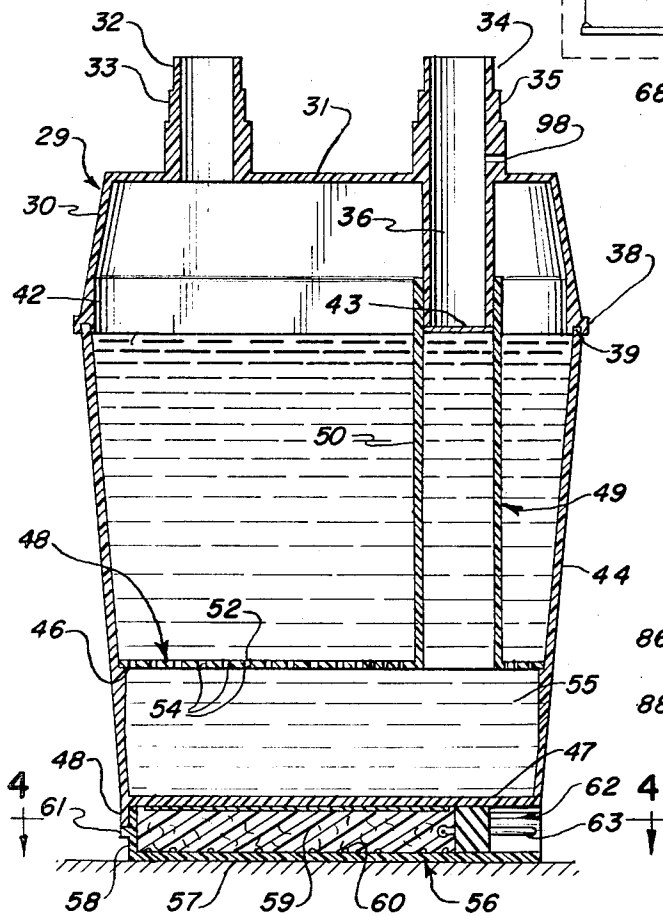


FIG. 3

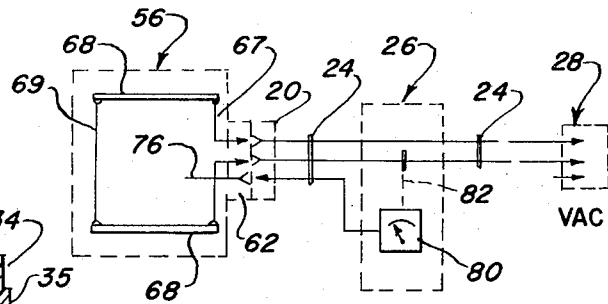
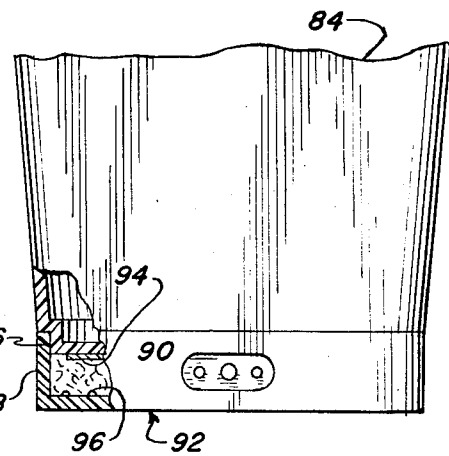
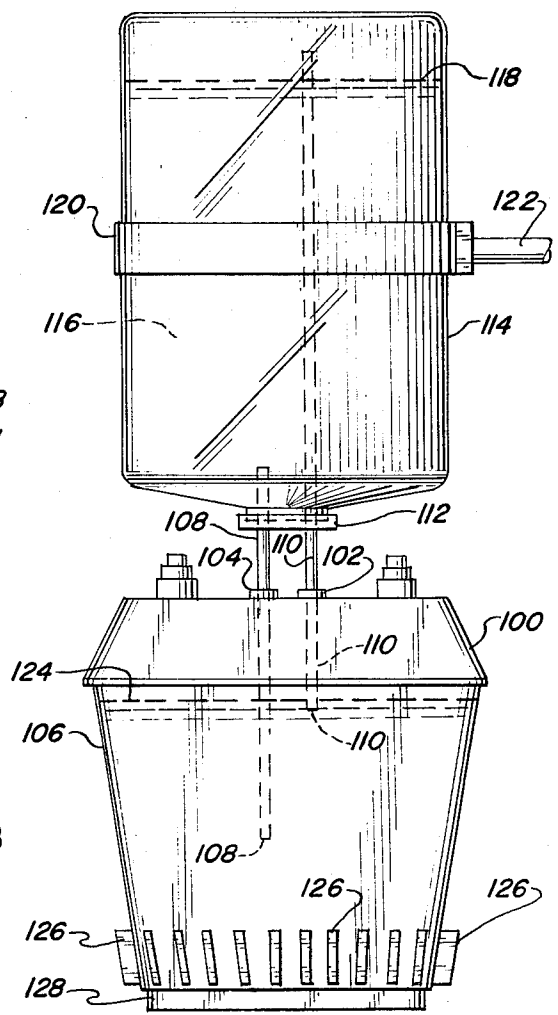
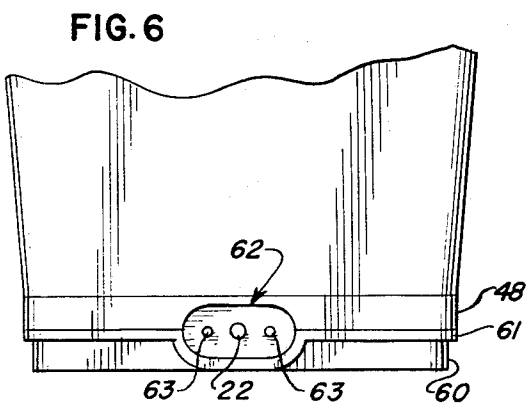
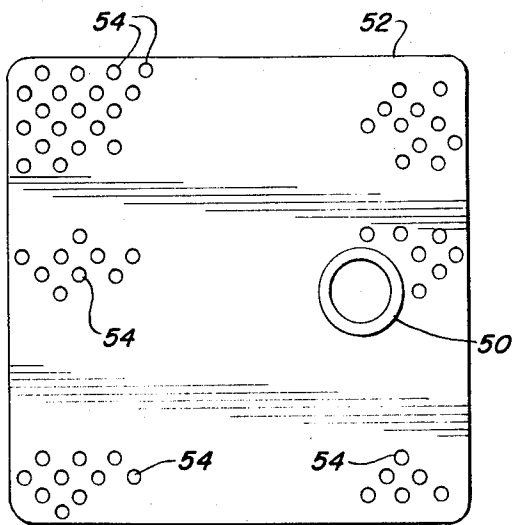
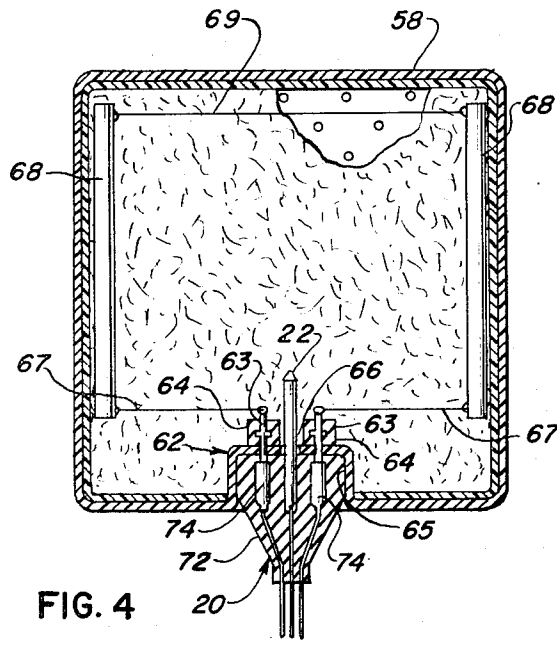


FIG. 7





HUMIDIFIER AND HEATER FOR DELIVERED GASES

This invention relates to an improved humidifier for delivered gases, such as from a respiratory machine. The invention particularly relates to a humidifier which can be produced at a low cost per unit so that it may be disposable, even though means are provided for electrically heating the water in the container to predetermined temperatures.

It is recognized that a humidifier is essential for moistening delivered gases such as oxygen or a mixture of air and oxygen from a respiratory machine prior to inhalation by a subject. It has also become the accepted practice to heat the humidifier so that the water therein reaches temperature levels which are closer to that of body temperature. The subject therefore inhales gas and water vapor which is warmed so there is no serious challenge to respiratory tissues during inhalation. Such humidifiers can be prefilled, or can be filled with water when being prepared for connection to the respiratory machine and used by the subject. Sterility of the water is not an important criterium because microorganisms are not carried by gases for all practical purposes. The expense of the original humidifier is a consideration, as well as the time and expense involved in disassembling a unit for cleaning, removing mineral formations from heating elements, and the like.

It is accordingly one important object to provide an improved humidifier for delivering gases in which electrical heating elements are made a part of the unit assembly, but separated from the container portion in which water is placed. It is a particular advantage to attain such a unit assembly at very low cost per unit assembly by forming the assembly from thermoplastic material, thereby permitting disposal of the unit without seriously adverse economies.

It is yet another important object of the present invention to provide an improved humidifier for moistening and heating delivered gases whereby such gases are moved in an improved way through a delivery tube into a rebound chamber in the container wherein said gas is dispersed by rebounding from the floor portion, or otherwise, followed by upward flow through a dispersion plate which assures widely distributed contact with a body of heated water above the plate prior to discharge for delivery to a subject.

A still yet another important object of the invention is the improved humidifier and heater in which a heating housing is secured in different ways to a water container, said heating housing having economically manufactured heating elements sensed by a temperature probe and controlled by a thermostat separate from the unit assembly.

A still further object of the present invention is to provide an improved humidifier and heater having four components, each of which is economically molded from plastics, such components being a removable cap with gas inlets and outlet; a dispersion plate and gas conveying tube means; a water container; and a heating housing with heating elements and electrical connector; and all of the foregoing components forming a unit assembly which can be disposed after use without economic burden.

Still yet another object of the present invention is to provide an improved humidifier and heater unit assembly with improved means for directing a delivered gas

through a body of water inside a container to the bottom of a container wherein such gas is rebounded or otherwise dispersed upwardly so that widely distributed gas particles are desirably moistened in a body of water which is further heated to desired temperature levels, all of said desired features being accomplished by thermoplastic parts, one of said parts additionally having electric heating elements and means associated therewith.

These and still other objects are now attained by the present invention which is shown in the following disclosure, including drawings wherein:

FIG. 1 is a somewhat schematic side elevational view showing the humidifier and heater as part of a connected line between a gas source and a receiving station;

FIG. 2 is a side elevational view in section on an enlarged scale, of the humidifier and heater;

FIG. 3 is a schematic view, on a reduced scale, of the electric circuits for the heater provided in the unit assembly;

FIG. 4 is a plan view partly in section and with parts removed, of the heating housing, on a scale similar to that of FIG. 2;

FIG. 5 is a plan view of the gas dispersion member which is a component in the unit assembly;

FIG. 6 is a portional side elevational view showing the heating housing and electrical connector in the humidifier;

FIG. 7 is a view similar to that of FIG. 6 but representing an alternative embodiment wherein the container is removably mounted on a heater housing, and

FIG. 8 is a side elevational view of an alternative embodiment showing a water reservoir mounted on a humidifier provided with heat dissipating.

Referring now to the drawings, the view of FIG. 1 schematically indicates a gas supply 10 such as a respiratory machine. An oxygen mixture is delivered along a line 12 to a humidifier and heater shown generally as 14. Moistened and heated gas moves out of the humidifier and heater through a line 16 to a human subject 18, or to a receiving station prior to ultimate delivery to a subject. The humidifier and heater 14 is provided with heating means to which is connected female plug 20 having a temperature probe 22. An electric cord 24 joins plug 20 to a thermostat control 26, and a male plug 28 is provided for connection to a 110 volt alternating current source. The thermostat control 26 presets a small range of moderate temperature levels, say 70° F., 90° F., 98° F. and 105° F.

Considering the humidifier and heater in detail, there is provided a removable top cap 29 which is formed with a continuous inclined sidewall 30 and a flat, top portion 31. The cap is integrally formed with a gas outlet 32 having a stepped annular sidewall 33; and with a gas inlet 34 having a similar stepped sidewall 35. The center axis of the passageways of the outlets is disposed in normal relationship to the flat, top portion 31. The stepped annular sidewalls of the inlet and outlet anchor a close fitting, resilient and flexible tubing for carrying delivered gas to the humidifier and heater; and for carrying the moistened and heated gas out of the humidifier and ventilator, such tubes not shown.

The delivered gas is conveyed into the containers through tube means which includes a downwardly extending tube 36 which forms a continuous passageway with inlet 34, such passageway being coaxial with re-

spect to the inlet and downwardly extending tube. The cap is provided with a continuous bead 38 at its lower edge, and a continuous groove 39 is formed within the bead.

The removable cap is shown mounted on a container shown generally as 40, and the body of water is within such container its level being indicated at 42. The downwardly extending tube 36 is provided with a one-way flap valve 43 at its ends, and such flap valve is designed to prevent water vapor and condensation from entering a line leading to the gas supply 10.

The container has a continuous sidewall 44. The illustrated embodiment shows the continuous sidewalls as being four sided in a somewhat rectangular pattern, but it should be understood that the continuous sidewalls may be another configuration, including curvilinear. The humidifier and heater, illustrated as having four sidewalls, is provided with shoulders or flats 46 on the inside of each of its sidewalls, two of such flats being shown in the view of FIG. 2. Such flats are positioned substantially closer to the floor portion 47 of the container than to the top edge of the container which is seated in groove 39 of bead 38. The bottom edge of the continuous sidewall 44 is shown as a continuous skirt portion 48 to serve a purpose which will be later described.

An integrally formed gas dispersion member shown generally as 49 is seated on the flats 46. Such a gas dispersion member has an upwardly extending gas conveying tube 50 having a diameter slightly oversized relative to the diameter of downwardly extending tube 36 to allow a telescoping connection, as shown. The tube 50 extends upwardly from a substantially planar gas dispersion plate 52 having a plurality of gas transmitting holes such as 54. In the illustrated embodiment the plate 52 is four sided with holes 54 randomly distributed over substantially its entire planar area. When the gas dispersion member is seated on the shoulders, a gas rebound chamber 55 is defined between such dispersion plate 52 and the floor portion 47 of the container. The rebound chamber forms a minor volume of the container marked by the continuous top edge of the continuous sidewall 44.

The delivered gas moves through inlet 34, downwardly extending tube 36, upwardly extending tube 50, and through the water present therein. Such gas is then dispersed in rebound chamber where at least some of the gas is rebounded from the floor portion 47 through the holes 54 and dispersion plate 52. When reference is made to "rebound chamber" or "rebounding gas," it should be understood that such term generally refers to the gas below the dispersion plate and its eventual upward movement through the dispersion plate. Some or all of the gas may actually not rebound from the floor portion, although it is preferred to deliver the gas at pressure levels which are expected to cause such rebound from the floor portion.

An electrical heating chamber or heating housing shown generally at 56 is mounted relative to floor portion 47 of the container. The heating housing is formed with a bottom portion 57 and a continuous sidewall portion 58. The heating chamber is substantially filled with insulating material 59 which may be in the form of a pad made of fiberglass. The fibrous material is preferably packed to a density of about three pounds, and such fibrous material is also preferably held in place by a plurality of integrally formed buttons 60

mounted on the bottom portion 57 inside the heating housing or chamber. The continuous sidewall 58 of the heating housing is shown provided with a continuous flange support 61 to form a supporting overlapping joint between skirt portion 48 and upper portions of the sidewalls 58. The overlapping relationship between the skirt portion and upper portions of the sidewalls 58 of the heating housing allow the heating housing to be securely fitted to the bottom of the container. This may be a close frictional fit to allow removal of the heating housing for subsequent use, or such heating housing may be disposed with the container, cap and dispersion member of the unit assembly. If desired, the heating housing may be bonded to the skirt portion by bonding material, sonic bonding, or by other means.

The heating means provided in the heating housing include a male plug shown generally as 62, one of the Ark-Less pin connectors being shown at 63. Plug blocks 64 support the pin connectors, such blocks being mounted to inset portion 65 of continuous sidewalls 58. A temperature sensor passageway 66 is provided in the inset wall portions 65 of the plug assembly. Conductors 67 join the pin connectors to electroheating elements 68. Another conductor 69 completes the circuit between the heating elements 68.

The female plug, previously identified generally as 20, is shown with a tapered plug body 72 and pin sockets 74. The previously identified temperature probe 22 extends from the plug body 72. The foregoing electrical connections may be further understood by considering the schematic electrical circuit of FIG. 3. The schematic circuit shows a thermostat 26 as further having a dial set 80 for presetting the temperature. A conventional conductor current cut off 82 is made operational when the predetermined temperature level is reached. Circuit breakers may also be conventionally provided to become operational if predetermined temperature levels are exceeded. As a representative embodiment, a temperature level of, say, 115° F. will still result in temperatures of the delivered moistened gases below about 87° F when using a 48 inch delivery tube from gas outlet to subject.

The view of FIG. 7 is intended to represent an alternative embodiment in which a water container 84 has a bottom shoulder 86 formed by inset bottom portion 88 of the container. The shoulder 86 and inset portion 88 form a complementary seat with sidewall 88 of a reusable heating housing. The water container forms a loose frictional fit on the heating chamber so that it may easily be mounted and removed so that a subsequent water container may be placed on the reusable heating chamber. The insulating material 90 again substantially fills the heating chamber between the continuous sidewall 88, the floor portion 92 and the heating elements, one of which is shown at 94. Buttons 96 are again shown to help anchor the pad of insulating material 90.

The humidifier and ventilator may be delivered to a user, such as hospital personnel, in a form substantially as shown in FIG. 2. The cap 29 may be easily removed and the container may be filled with water substantially to the top edge of the sidewall 44 of the container. The cap is remounted by telescoping downwardly extending tube 36 to upwardly extending tube 50. A line 12 is connected to the gas inlet 34 from the respiratory machine, and the line 16 is connected to the outlet and to the intake device used by the subject. The heating ele-

ments 68 in the heating chamber are positioned adjacent to the floor portion 47 of the container, and the thermostat is preset at the desired temperature following connection of plug 20 to plug 62 of the heating housing. The insulating material will direct substantially all of the heat towards the floor portion 47 of the container to desirably heat the body of water therein. If desired, a communicating vent 98 may be provided in the stepped annular wall 35 of the inlet so that inhalation by the subject will trigger delivery of gas into the inlet. The delivered gas will be emptied into the rebound chamber 55 and will have to be distributed generally throughout the major portion of the body of water located above the dispersion plate 52. Following desired use by the subject, the water may be emptied from the container and the entire humidifier and heater unit assembly may be disposed. On the other hand, the heater housing may be retained by removing the container and disposing only of said container, gas dispersion member and removable cap. In the preferred form, the heating chamber is an open top housing so that the heating element such as 68 may directly adjoin or even abut the bottom or floor portion 47 of the container. The heating housing may be used in conjunction with thermoplastic containers because thermoplastic materials are readily available which are stable at temperature levels of at least about 100° F. In the preferred practice, the body of water within the container will not be heated above about 105° F. since higher temperatures are not desirable for inhalation therapy.

FIG. 8 shows an alternative embodiment wherein a cap 100 is provided with fittings 102, 104 for receiving communicating tubes of an assembly to maintain desired water levels within the container 106. The mountings 102, 104 are in the form of bosses having passageways therein to receive closely fitting tubes 108, 110.

The water and pressure responsive tubes pass through a closure 112 of water reservoir bottle 114. Such a bottle may have volume markings 116 to measure the lowering of the water level 118 of the body of water within such a bottle. The bottle is supported in the inverted vertical position by band 120 which is mounted in the usual way to stand, a bracket arm 122 whereof is only shown.

When the water level 124 in the container 106 falls below the bottom of pressure responsive tube 112, pressure changes in reservoir bottle 114 will cause the water level 118 to drop, and thereby move water through water tube 108 into container 106. Such water movement will continue until water level 124 again closes the bottom of pressure responsive tube 112. This embodiment shows a plurality of heat dissipating fins 126 extending peripherally along the bottom of container 106. Such fins may be provided out of materials which are more quickly heat conductive, they may even be plastic. In any event, the fins facilitate the heat dissipation from any undue buildup of heat in the container. Such fins are shown extending to the bottom of the container 106, short of heating housing 128.

The embodiments shown herein are preferably used by nomagrams so that the practitioner can ascertain desired relative humidity of the delivered gases for a given flow rate of gas through the inlet relative to prescribed temperatures.

The claims of the invention are now presented in terms which may be additionally understood by considering the foregoing disclosure.

What is claimed is:

1. A humidifier for delivered gases including a water container having a continuous sidewall, a top, and a bottom, an inlet for delivered gas on said container, an outlet for moistened and heated gas on said container

electric heating means mounted to the bottom of the container, including heating elements and a temperature sensor, to warm water placed in the container to preset temperature levels,

a gas dispersion plate mounted within said container closer to the bottom than to the top to define a gas rebound chamber therebelow, and

tube means for conveying delivered gas below the dispersion plate into said rebound chamber, whereby gas moves upwardly through the dispersion plate through water placed in the container and out of said gas outlet.

2. The humidifier for delivered gases which includes the features of claim 1 above, wherein the heating elements of said means are within a heating housing mounted to the bottom of said container, said heating housing further including conductors and a connector plug, said plug having a passageway to receive a temperature probe.

3. A humidifier for delivered gases which includes the features of claim 2 above wherein said heating elements are positioned adjacent the bottom of the container, and which further includes insulation material to substantially fill the heating housing so that heat from said heating element is directed substantially towards the bottom of said container.

4. A humidifier for delivered gases which includes the features of claim 3 above, wherein said heating housing has a continuous sidewall, a floor portion and an open top wherein said heating elements are positioned adjacent the bottom of the container, and wherein said insulating material is positioned between the sidewall, floor and the heating elements.

5. A humidifier for delivered gases which includes the features of claim 4 above, wherein said insulating material is fibrous material, and which further includes a plurality of fixed buttons on the floor of the heating housing inside the heating housing to hold the fibrous material.

6. A humidifier for delivered gases which includes the features of claim 4 above wherein said heating housing is removably secured to the bottom of said container.

7. A humidifier for delivered gases which includes the features of claim 6 above wherein said heating housing is removably secured to the bottom of said container by overlapping respective sidewall portions of said container and said heating housing.

8. A humidifier for delivered gases which includes the features of claim 4 above wherein said heating housing is secured through the bottom of said container, whereby the container and the heating housing may be used and disposed as a unit.

9. A humidifier for delivered gases which includes the features of claim 8 above, wherein the container, the dispersion plate, the tube means, and the heating housing are formed of thermoplastic material which is stable up to at least about 100° F.

10. A humidifier for delivered gases which includes the features of claim 1 above, wherein said container

top is a removable cap, and wherein said gas inlet and outlet are formed on a top, flat portion of said cap.

11. A humidifier for delivered gases which includes the features of claim 10 above wherein said dispersion plate includes an integrally formed and upwardly extending tube, wherein said top cap includes a downwardly extending tube having a passageway coaxial with the gas inlet passageway, and wherein the downwardly extending tube is telescoped within said upwardly extending tube to form a passageway in the gas inlet, the downwardly extending and upwardly extending tubes.

12. A humidifier for delivered gases which includes the features of claim 11 above wherein said dispersion plate and integral upwardly extending tube are removably seated on integrally formed flaps extending upwardly from the continuous sidewall of the container.

13. A humidifier for delivered gases which includes the features of claim 12 above wherein the downwardly extending tube is fitted with a one-way valve above the water level mark in the container to block entry of water vapor into a conduit mounted to the gas inlet tube.

14. A humidifier for delivered gases which includes the features of claim 11 above wherein the entire assembly of caps with integrally formed inlet, outlet and downwardly extending tubes; dispersion plate with in-

tegrally formed upwardly extending tube, container sidewalls, and heating housing is formed of thermoplastic material which is stable at temperatures of at least about 100° F.

15. A humidifier for delivered gases which includes the features of claim 14 above wherein the inlet and outlet extend normally to the top, flat portion of the cap, and wherein said inlet and outlet are formed by annular stepped walls to provide an anchoring grip for flexible, resilient tubing.

16. A humidifier for delivered gases which includes the features of claim 15 wherein the annular, stepped wall of the gas inlet has an aperture communicating the passageway of the inlet with ambient air to aid delivery of a gas for a source such as a respiratory unit.

17. A humidifier for delivered gases which includes the features of claim 1, which further includes means to maintain constant water level within the container, such means including a water reservoir, a water tube connecting a body of water in the reservoir with the body of water in the container, and a pressure responsive tube connecting a pressured head in the reservoir to the pressure head in the container, whereby lowering of the water level in the container induces movement of water from the reservoir to maintain the water level in the container substantially constant.

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