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HUMIDIFIER

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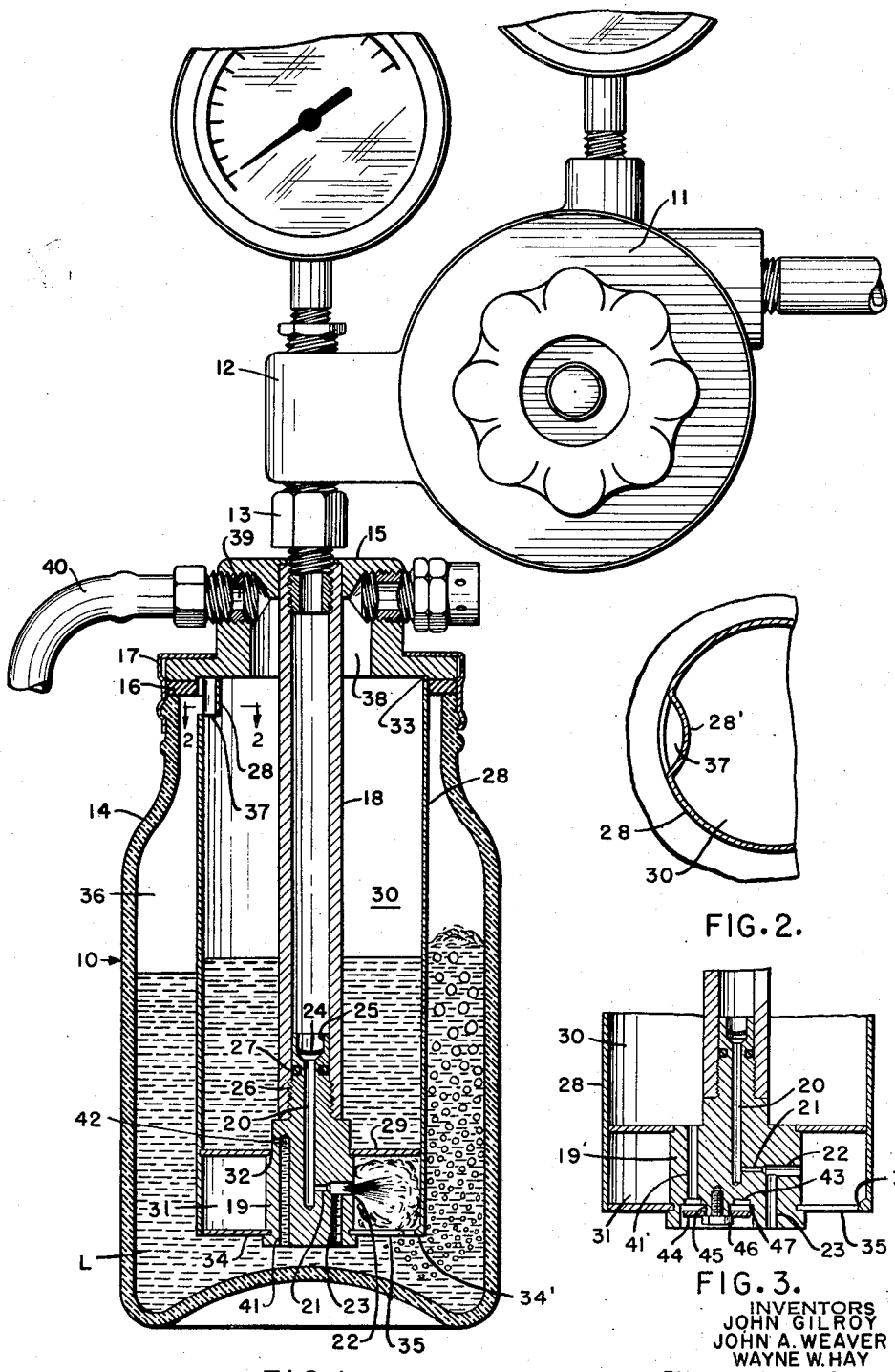

FIG. 1.

FIG. 2.

FIG. 3.

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HUMIDIFIER

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This invention relates to gas humidifiers and particularly to apparatus for increasing the relative humidity of gases such as oxygen for therapeutic and other uses. It is applicable to the humidification of other gases and to the addition thereto of the vapors of other liquids having viscosities relatively equivalent to that of water.

Gases such as oxygen which are used for therapeutic purposes are often supplied to patients through the medium of a nasal catheter whereby the gas is delivered to the pharynx for inhalation. It has been found that this means of administering therapeutic gas often causes a drying of the mucous membranes and a resultant irritation to the patient unless the gas is first satisfactorily humidified.

Many types of humidifier apparatus have been in use, but few of those devices have been capable of affording the desired degree of saturation, particularly for therapeutic purposes. In the administering of therapeutic oxygen, for instance, the flow of gas through the humidifier may vary over a wide range depending upon the needs of the patient. Prior apparatus, generally, have not been capable of effective humidification of the gas at all rates of consumption. Another difficulty has been the ineffectiveness of such apparatus in preventing the entrainment of water particles in the humidified gas. While substantially complete saturation is desired, the presence of water droplets in therapeutic gas administered by means of nasal catheters and the like is objectionable.

It is, therefore, one object of the present invention to provide an improved apparatus capable of increasing the relative humidity of a gas substantially to saturation.

It is another object of the invention to provide apparatus which is effective over a wide range of gas consumption for producing substantially complete saturation of the gas.

A further object is to provide such apparatus in which the humidified gas is substantially free of water in the liquid phase.

A still further object of the invention is to provide such an improved humidifier capable of the above desirable manner of operation which is housed in a single container.

According to the invention, a gas, such as oxygen, of relatively low moisture content is delivered to a humidifier apparatus of improved construction wherein the gas is humidified substantially to saturation and discharged therefrom substantially free of water in the liquid phase. The improved humidifier includes a container for holding a supply of the liquid to be evaporated, a removable cover for the container, an aspirator therein for atomizing a portion of the liquid supply into a stream of the gas, a chamber that receives the aspirated liquid and gas having an outlet normally submerged in the liquid supply, a collection chamber in a space above the level of the liquid in the container, a gas outlet in communication therewith, and baffle means for removing liquid droplets from the humidified gas. A displacement member is associated with the removable cover which is effective when the cover and container are assembled to prevent the storage of more than a maximum desirable amount of liquid in the container and to provide a space above the level of the liquid in the container.

The latter feature is particularly advantageous in facilitating the operation of such apparatus and in insuring its proper use. Heretofore, great care has been required in replenishing the liquid supplies of ordinary humidifiers to avoid over-filling the containers. In these humidifiers, a part of the liquid supply in excess of the supply intended for the apparatus could be forced or carried into the humidified gas discharge outlet. It is essential that this condition be avoided due to the hazard to patients where the liquid is carried into a nasal catheter or other inhalation device. Such occurrence, however, is obviated by the present invention wherein the displacement member removes the excess liquid from the container when the unit is reassembled after filling and provides a space above the level of the liquid in the container. Thus, the operation is simplified because the container may be filled without regard to the amount of liquid which is introduced into the container. When the unit is assembled, the liquid is automatically limited to a maximum safe level.

Other objects and advantages of the present invention will become apparent as it is better understood by reference to the following description and accompanying drawing in which:

Fig. 1 is an elevation view, in vertical section, of a humidifier device, embodying the invention; and,

Fig. 2 is a partial cross-section view through the humidifier shown in Fig. 1, taken along the line 2—2 and,

Fig. 3 illustrates an alternative construction of a portion of the humidifier shown in Figs. 1 and 2.

A preferred embodiment of the invention is shown in the drawings in which a humidifier device is designated generally at **10**. Gas is supplied from a suitable source through a gas regulator device **11** having an outlet fixture **12** to which a connection fitting **13** of the humidifier is attached. The gas may be supplied from a high pressure source, such as a gas cylinder, whence it is expanded in the regulator and delivered to the humidifier at some lower pressure as desired. It is also possible to supply the gas from a reduced pressure source such as a gas piping system in which case a simple needle valve or other similar device will be equally satisfactory for controlling the gas flow. The humidifier may be connected to the regulator or valve by means of a hose or pipe and thus be remotely located.

The humidifier **10** consists of a jar container **14** having a cover **15** which may be held against a gasket **16** on the top of the jar by means of a ring **17** or other suitable means. The ring **17** has a threaded engagement with the top of the jar **14** which facilitates the removal of the jar and thereby makes it simple to refill or clean the container.

The cover **15** receives the gas inlet **13** and is thus attached to outlet fixture **12** of the regulator **11**. A pipe **18** depends from the inside of the cover **15** and carries an atomizer head **19** at its lower end. A passage **20** communicates with the pipe **18**, and a nozzle passage **21** extends from the passage **20** to an enlarged recess **22**. The recess **22** has access to the liquid supply through a vertical drilling **23** which opens into the lower face of the atomizer head **19** in direct contact with the liquid supply L in jar **14**. A screen filter **24** is disposed in a recess **25** at the upper portion of passage **20** to prevent the entrance of foreign particles into the atomizer head with the gas. The atomizer head **19** has a threaded stud projection **26** by which it is secured in pipe **18**. An O-ring gasket **27** carried thereon provides an effective gas tight seal between the members.

A hollow tubular member **28** which is held against the cover **15** in substantially concentric relation to the pipe **18** forms an inner receptable depending from the cover into the container **14**. The tubular member **28** has a partition **29** recessed from its lower end which effectively divides the interior into an upper chamber **30** and a lower chamber **31**. The partition **29** is engaged by a shoulder **32** on the atomizer head which holds the tubular member **28** in seated engagement with the cover **15** in a recess **33**. Thus, the pipe **18**, atomizer **19**, and tubular member **28** form a rigid assembly with the cover **15** which is withdrawn from the container **14** when the container is removed from cover **15** for refilling or cleaning. A lower plate **34** carried on the atomizer head **19** closes off the bottom of tubular member **28** and separates chamber **31** from the liquid supply L. The plate **34** has an opening **35** to permit escape of the gas ejected into chamber **31** from recess **22**. A lip **34'** formed on the lower edge of tubular member **28** prevents accommodation of the plate **34** in the bottom opening of chamber **31** unless the

opening 35 in plate 34 registers therewith. The lip 34' therefore orients the opening 35 in the desired position as will be more clearly seen hereinafter.

A gas collection space 36 is provided above the level of the liquid supply L in the chamber surrounding the tubular member 28. Gas from space 36 passes into chamber 30 through an opening 37 formed in the upper end of the tubular member 28 at a position diametrically opposite opening 35. The chamber 30 communicates with a space 38 in the cover 15 from whence the gas is discharged through outlet 39. A hose 40 is connected to the outlet 39 and to an instrument for utilizing the humidified gas, such as a nasal catheter, which is not shown.

In the atomizer head 19 a vertical drilling 41 extends upwardly from the lower face of the atomizer to a cross passage 42 which opens through the side of the atomizer head into chamber 30. These passages provide a drain for the liquid accumulated in chamber 30. The cross passage 42 is of small aperture so that when the cover 15 and the container 14 are assembled, the flow of the liquid into the chamber 30 from the container 14 is retarded. The level of the liquid in the chamber 30 rises slowly after the humidifier is assembled until it is in equilibrium with the liquid in the container. However, when gas to be humidified is passed through the apparatus, the balance of the water level becomes disrupted as in Fig. 1. An alternate arrangement for providing a drainage from chamber 30 is shown in Fig. 3. Referring to this figure, vertical drilling 41' in the atomizer head 19' opens at its upper end into the chamber 30 of the tubular member 28. At its lower end, the passage 41' registers with an annular recess 43. The flow of the liquid in the container into chamber 30 upon assembling the humidifier, in the form shown in Fig. 3, is retarded by a check valve 44 which is adapted to be closed against the valve seat surrounding recess 43 by the liquid pressure in container 14. The check valve comprises a metal disc slidably mounted on a cylindrical boss 45 projecting downwardly from the underside of atomizer head 19. A screw having an enlarged head 46 retains the valve disc on the boss, for movement toward and away from the valve seat 47 in response to reversals in the pressure differential between container 14 and chamber 30.

In the operation of the apparatus described, the container 14 is removed from cover 15 and may be completely filled with a liquid such as water. When the container is raised toward the cover 15, the immersion of tubular element 28 causes an overflow from the jar of the water that is in excess of the volume for storage provided in the space between the hollow displacing member 28 and the wall of container 14. Water remaining above the level of the opening 37 in member 28 flows through this opening into the chamber 30, but this volume is not so large as to enable the liquid to fill the chamber 30. Thus, there is assured a collection space in the container 14 above the level of the liquid at the opening 37, and a water-free opening between the outer container and the chamber 30. Hence, the passage of the gas to the outlet opening of the humidifier cannot be blocked by the liquid supply regardless of the amount of liquid placed in the container. After the container has been remounted in the cover, the liquid level will recede slowly as a part of the supply in the annular storage space is metered through drilling 41 and restricted passage 42 into the chamber 30 within the tubular member 28. By such recession of the liquid level in container 14, the space for collection of the gas above the level of the liquid will be enlarged as shown in Fig. 1. This is desirable inasmuch as liquid splashes caused by agitation of the gas passing through the liquid are less likely to be carried through the opening 37 when the liquid level is lower in the container.

It will be apparent that in spite of the flow restricting means provided in the drainage passage 41, a small amount of liquid may rise into the chamber 30 while the container 14 is being replaced in cover 15. However, the flow restriction passage 42 is sufficient to limit the flow of liquid to a negligible amount in the time that is normally necessary to affect this operation. In the alternate form of the apparatus shown in Fig. 3, the pressure of the liquid in the container 14 acts against valve disc 44, when the container is assembled with the cover 15, causing the valve disc to move against valve seat 47. The liquid held in the container is thus substantially prevented from flowing into the chamber 30 while the humidifier is being assembled. However, the valve disc does not effect a complete seal with the valve seat 47 and a small amount of liquid seeps through the passage 41' into chamber 30. Eventually, the pressure of the liquid head acting against valve disc 44 is sufficiently reduced that the weight of the valve member causes it to move away from the valve seat. It should be noted that with either the flow restricting means provided in the apparatus of Fig. 1, or the valve device of the alternate device shown in Fig. 3, more than mere inadvertence is necessary to cause an undesirable amount of liquid to flow into the chamber 30 before the container 14 has been secured in cover 15. With the latter apparatus, the level of the liquid in the container will recede more slowly. The liquid accumulated in the chamber 30 is drained through the drilling 41 of the apparatus in Fig. 1, and through the drilling 41' of the apparatus in Fig. 3, when the liquid level in the container recedes below that of the liquid in the chamber 30.

Gas is delivered to the humidifier apparatus from the regulator 11. The gas is conducted through pipe 18 and passage 20 in the atomizer head 19 to the discharge nozzle 21 from whence it is ejected into recess 22 at a relatively high velocity. The jet of gas produces an aspirating effect causing the water to be drawn upwardly in drilling 23. Water is aspirated into the gas stream in the form of minute globules which are carried into the aspirating chamber 31 with the gas. For the most part, the globules are of small size and evaporate readily. Some of the larger droplets which may resist evaporation are broken into smaller sizes upon impingement against the wall of the chamber 31 and are thus more easily vaporized. Other large droplets adhere to the wall of the chamber; coalesce; flow to the bottom of the wall; and are removed from the gas in this manner. The aspirated liquid and gas leave chamber 31 via opening 35 and bubble upwardly through the liquid supply L to the collection space 36. It will now be seen that the positioning of opening 35, diametrically opposite opening 37 in the tubular member 28, places the agitating action created by passage of the gas bubbles through the liquid supply at a remote location from the opening 37. Thus, droplets or splashes of liquid caused by the agitating action are not as apt to pass into the chamber 30.

The mechanism for humidification of the gas will be seen to comprise two successive stages: the first, by aspiration of the liquid into the gas stream; and the second, by direct passage of the gas through the liquid. Humidification can be accomplished in either manner separately. However, it has been found that in humidifier devices, good humidification is not accomplished satisfactorily by aspiration of the liquid into the gas when the gas velocity is low due to small consumption. Also, it is difficult to increase the relative humidity of the gas to a sufficient extent by passing the gas directly through the liquid supply when the gas flow is high. Therefore, the device herein described affords an efficient humidification of the gas over a greater range of rate of flow of the gas than is normally possible.

It has also been found that liquid droplets are extremely difficult to remove from a gas humidified only by aspiration of liquid into a stream of such gas, even when numerous baffle elements are provided to trap and remove such droplets. However, when the aspirated liquid and gas are passed or allowed to bubble through the liquid, the droplets are effectively removed.

As the liquid supply is depleted by evaporation, the level of the liquid in the container 14 will be lowered. The desirable effect of passing the aspirated liquid and gas through the liquid stored in the container is apparent even after substantially most of the liquid has been consumed. However, the liquid is preferably replenished while a quantity of liquid yet remains so that gas from the aspirating chamber 31 will bubble upwardly through at least a small depth of the supply. Aspiration and humidification can be accomplished without adding more liquid at this time until the liquid level falls below the bottom of the head 19 and does not respond to the suction in vertical drilling 23 whence it is drawn into the gas stream.

Efficient baffle means are provided in the path of the gas entering chamber 30 from collection space 36, through opening 37. This opening is disposed in a horizontal plane by warrant of the special construction shown in the plan view of Fig. 2. A section 28' of the tubular member is depressed inwardly leaving the opening 37 in substantially a horizontal plane. The section 28' acts

as a baffle causing the gas and the moisture carried from space **36** to be diverted downwardly in order to enter opening **37**. Referring again to Fig. 1, the gas must thereafter rise in chamber **30** and space **38** to the gas outlet **39**. The change in direction of the gas flow assists in removing droplets that might be entrained in the gas. In addition, the chamber **30** provides a further interval during which evaporation of minute water particles may occur, and also affords additional surface area to which such droplets may adhere and be separated from the gas. Thus, several impediments are provided in the present apparatus to effectively prevent the carrying of water in the liquid phase into the outlet **39** with the humidified gas.

The apparatus described is an efficient device for humidification of gases such as oxygen and particularly for gases that are used for therapeutic purposes. The water or other liquid supply in the container is sufficient for humidification of a gas used in normal treatment and provision may be made for a larger supply. The facility with which the container may be removed makes it relatively easy to replace the supply when necessary.

Although only the preferred embodiments are shown and described herein, it will be understood that this application is intended to cover such changes or modifications as come within the spirit or scope of the invention as defined by the following claims.

We claim:

1. In a humidifier apparatus comprising a receptacle for holding a supply of liquid to be evaporated, and a removable cover therefor, means effective upon assembling the receptacle and cover for displacing a portion of the liquid supply in the receptacle causing excess liquid to overflow the receptacle, and gravity overflow means for receiving a portion of the displaced liquid above a predetermined level in the receptacle to permit recession of the liquid level and thereby provide a liquid free space in the receptacle.

2. In a humidifier apparatus comprising a receptacle for holding a supply of liquid to be evaporated and a removable cover therefor, a dry gas inlet, an atomizing device, means for delivering dry gas to said atomizing device whereby the liquid in the container may be aspirated into a stream of the dry gas to form a humidified fluid stream, means effective upon assembling said receptacle and said cover for displacing a portion of the liquid supply in the receptacle causing excess liquid to overflow the receptacle, means for receiving a portion of the displaced liquid above a predetermined level in the receptacle to permit recession of the liquid level and thereby provide a liquid free space in the receptacle, means for delivering said humidified fluid stream to said space, and a gas outlet communicating therewith.

3. A gas humidifier comprising an outer receptacle for holding a supply of liquid, a cover therefor, an inner receptacle depending from said cover into said outer receptacle so as to be at least partially immersed in said liquid, the inner receptacle being non-fillable by the liquid in the outer receptacle, a liquid free opening between said inner and outer receptacles, a gas inlet, means for humidifying the inlet gas in said outer receptacle including means for passing said gas in direct contact through the liquid in said outer receptacle, and a gas outlet communicating with said inner receptacle, the humidified gas being conducted to the gas outlet through said liquid free opening.

4. A gas humidifier comprising an outer receptacle for holding a supply of liquid, a cover therefor, an inner receptacle depending from said cover into said outer receptacle so as to be at least partially immersed in said liquid, the inner receptacle being non-fillable by the liquid in the outer receptacle, a gas inlet, means for humidifying the inlet gas in said outer receptacle including means for passing said gas in direct contact through the liquid in said outer receptacle, a liquid free opening between said inner and outer receptacles, a gas outlet communicating with said inner receptacle, the humidified gas being conducted to the gas outlet through said liquid free opening, and a second opening in said inner receptacle adapted to permit flow of liquid accumulated in said inner receptacle to said outer receptacle.

5. A gas humidifier comprising an outer receptacle for holding a supply of liquid, a cover therefor, an inner receptacle depending from said cover into said outer receptacle so as to be at least partially immersed in said liquid, the inner receptacle being non-fillable by the liquid

in the outer receptacle, an atomizer depending from said cover into the outer receptacle, a gas inlet in said cover and means for delivering the dry gas to said atomizer whereby liquid therein is aspirated into a stream of the dry gas, means for passing said aspirated gas and liquid in direct contact through the liquid in said outer receptacle, a liquid free opening between said inner and outer receptacles, and a humidified gas outlet communicating with said inner receptacle, the humidified gas being conducted to the gas outlet through said liquid free opening.

6. A gas humidifier comprising an outer receptacle for holding a supply of liquid, a cover therefor, an inner receptacle depending from said cover, and at least partially immersed in the liquid in said outer receptacle, the inner receptacle being non-fillable by the liquid in the outer receptacle, a gas inlet, an atomizer carried by said inner receptacle adapted to aspirate liquid from said liquid supply into a stream of the dry inlet gas, a chamber, means for delivering the inlet gas to said atomizer and discharging the aspirated liquid and gas to said chamber, an opening in said chamber between the chamber and said outer receptacle below the surface of the liquid, a liquid free opening between said inner and outer receptacles, and a humidified gas outlet communicating with said inner receptacle.

7. A gas humidifier comprising an outer receptacle for holding a supply of liquid, a cover therefor, an inner receptacle depending from said cover, and at least partially immersed in the liquid in said outer receptacle, the inner receptacle being non-fillable by the liquid in the outer receptacle, a gas inlet, an atomizer carried by said inner receptacle adapted to aspirate liquid from said liquid supply into a stream of the dry inlet gas, a chamber, means for delivering the inlet gas to said atomizer and discharging the aspirated liquid and gas to said chamber, an opening in said chamber, between the chamber and said outer receptacle below the surface of the liquid, a liquid free opening between said inner and outer receptacles, a humidified gas outlet communicating with said inner receptacle, and baffle means adapted to divert the path of flow of gas to said outlet to effect removal of water droplets therefrom.

8. A gas humidifier comprising an outer receptacle for holding a supply of liquid, a cover therefor, an inner receptacle depending from said cover, and at least partially immersed in the liquid in said outer receptacle, the inner receptacle being non-fillable by the liquid in the outer receptacle, a gas inlet, an atomizer carried by said inner receptacle adapted to aspirate liquid from said liquid supply into a stream of the dry inlet gas, a chamber, means for delivering the inlet gas to said atomizer and discharging the aspirated liquid and gas to said chamber, an opening in said chamber between the chamber and said outer receptacle below the surface of the liquid, a liquid free opening between said inner and outer receptacles, said opening comprising an aperture in the wall of said inner receptacle in a horizontal plane whereby the gas must flow substantially in a downward direction to enter therein, and a humidified gas outlet communicating with said inner receptacle.

9. A gas humidifier comprising an outer receptacle for holding a supply of liquid, a cover therefor, an inner receptacle depending from said cover, and at least partially immersed in the liquid in said outer receptacle, the inner receptacle being non-fillable by the liquid in the outer receptacle, a gas inlet, an atomizer carried by said inner receptacle adapted to aspirate liquid from said liquid supply into a stream of the dry inlet gas, a chamber, means for delivering the inlet gas to said atomizer and discharging the aspirated liquid and gas to said chamber, an opening in said chamber between the chamber and said outer receptacle below the surface of the liquid, a liquid free opening between said inner and outer receptacles, a humidified gas outlet communicating with said inner receptacle, and a second opening in said inner receptacle through which liquid accumulated therein may drain to said outer receptacle as the liquid supply in said outer receptacle is consumed.

10. A gas humidifier comprising an outer receptacle for holding a supply of liquid therein, a cover therefor, an inner receptacle depending from said cover, and at least partially immersed in the liquid in said outer receptacle, a chamber in said inner receptacle, an opening in said inner receptacle between said chamber and the outer receptacle whereby liquid above such opening is received

in said chamber, the volume of liquid possible in said outer receptacle above said opening being such that the liquid may not fill said chamber, a dry gas inlet, means for introducing the dry gas to the outer receptacle and humidifying it with the vapor of the liquid therein, an outlet for the humidified gas in communication with the said chamber in said inner receptacle, a second opening in said chamber substantially at the bottom thereof through which liquid accumulated in said chamber may drain downwardly into said outer receptacle as the liquid supply therein is consumed, and flow restricting means associated with said second opening to retard the flow of liquid in said outer receptacle therethrough into said chamber.

11. Humidifier apparatus substantially as set forth in claim 10 above, in which said flow restricting means comprises a flow restricting orifice.

12. Humidifier apparatus substantially as set forth in claim 10 above in which said flow restricting means comprises a check valve element movable against said second opening in response to the pressure of the liquid in said outer receptacle.

13. A humidifier apparatus comprising a receptacle adapted to hold a supply of liquid, a cover for said receptacle, said cover and receptacle being so constructed

and arranged as to provide, when assembled, a space in the closed receptacle above the liquid, a dry gas inlet and a humidified gas outlet in said cover, a humidifier element depending from said cover adapted to be at least partly immersed in said liquid, said element having an aspirator, conduit means connecting said aspirator with said dry gas inlet whereby liquid in said receptacle is aspirated into a stream of the dry gas, a chamber in said humidifier element communicating with said aspirator to receive the aspirated gas and liquid therefrom, said chamber having exit opening means in the portion of said humidifier element submerged in said liquid supply through which all of the aspirated liquid and gas are discharged from said chamber into said liquid supply and means connecting said humidified gas outlet with said space above the liquid in the receptacle.

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