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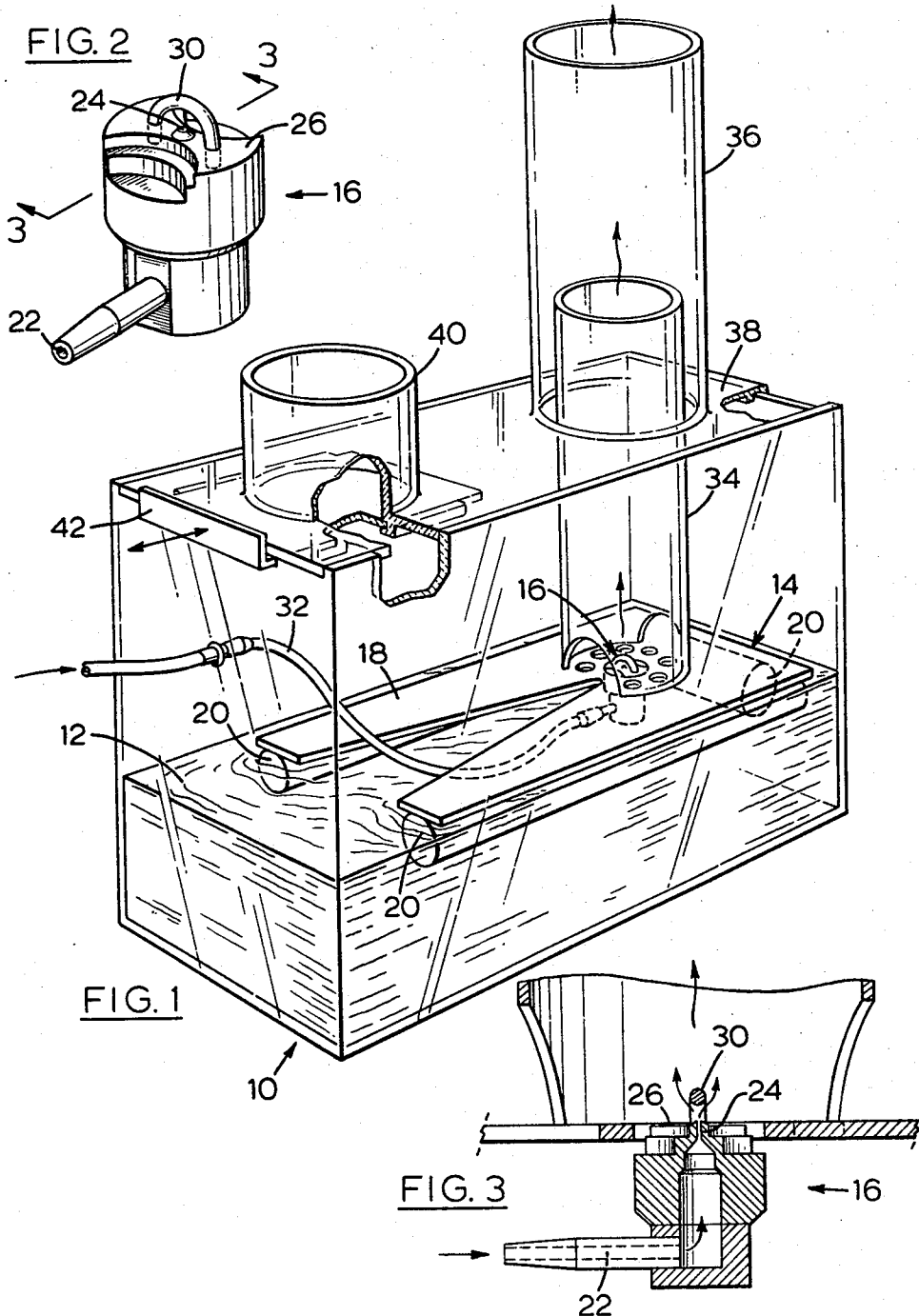
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3,398,897

NEBULIZER

Filed Sept. 26, 1966

2 Sheets-Sheet 1



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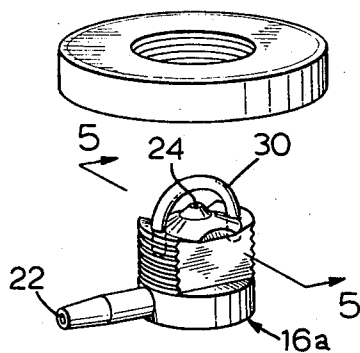


FIG. 4

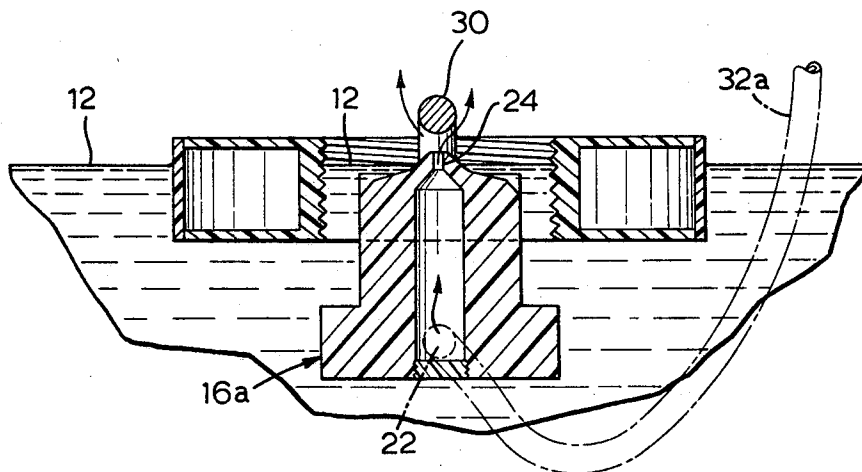


FIG. 5

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NEBULIZER
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ABSTRACT OF THE DISCLOSURE

The invention described consists of a nebulizer operating on a principle of nebulization which amounts to passing a carrier gas upwardly through a small aperture in the top surface of a body member on which is formed a thin film of liquid to be nebulized. Nebulization is assisted through the provision of a baffle positioned above and spaced from the aperture to create additional turbulence in the carrier gas. In particular, the nebulizer provides an arrangement for feeding a liquid to be nebulized to the top surface of the body member which essentially consists of a float for carrying the body member within a body of the liquid to be nebulized and including adjustment means for varying the relative position of the body member in the float so that the top surface of the body member may be positioned relative to the top surface of the body of liquid for optimum nebulization.

This invention relates to nebulizers and is particularly concerned with a nebulizer characterized by a nebulizing device which actually floats in a bath of the liquid to be nebulized.

A nebulizer is an apparatus for forming a fine mist of a liquid carrying a medicant. Such devices are commonly used in sick rooms to create a beneficial atmosphere to be breathed by a patient and are actually used as a means of administering medicants to the patient. The common method of nebulizing has been to pass a carrier gas, which is commonly air, through a venturi throat whereby the vacuum so created draws the liquid to be nebulized upwardly through a capillary tube so that it is introduced into the carrier gas at the venturi throat. Due to the use of the small diameter capillary tube, such devices easily become clogged as the medicant often precipitates within the tube and eventually blocks it off.

A recent basic development in nebulizing devices has provided a nebulizing principle which avoids the usual venturi throat and capillary tube. By this recently introduced principle, the carrier gas is passed upwardly through a small aperture in a plate or the like on which is created a thin film of the liquid to be nebulized. As a preferred expedient, a small baffle is positioned above the aperture to create additional turbulence whereby to assist in the pick-up of the liquid from the plate by the carrier gas emerging from the aperture. These recently introduced nebulizers are used in conjunction with some means for creating the thin film of liquid on the top surface of the plate such as a burette type device for dropping liquid on to the plate at a controlled rate.

The nebulizer of the present invention employs the above mentioned recently introduced nebulizing principle but improves on the devices introduced heretofore through use of a novel method for creating the thin film of liquid on the plate surface. To this end the nebulizer of the present invention is characterized by a float supporting the plate in a bath of the liquid to be nebulized. As a preferred expedient whereby to provide means for using the same nebulizer to nebulize liquids of different density, there is further provided means for adjusting the height of the plate relative to the float so that the plate can be held at the most efficient level relative to the top surface of the bath of the liquid concerned.

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The invention will be more thoroughly understood from the following descriptions of two preferred embodiments thereof as read in conjunction with the accompanying drawings.

5 In the drawings which illustrate these preferred embodiments of the invention,

FIG. 1 is a perspective view, partly broken away, of a nebulizer in accord with one embodiment of the invention;

FIG. 2 is an enlarged perspective view of a part of the nebulizer of FIG. 1;

FIG. 3 is a vertical cross-sectional view taken generally along the line 3—3 of FIG. 2 but showing the part illustrated in FIG. 2 just below its normal operative position;

FIG. 4 is an exploded perspective view of a part of a second embodiment of the invention; and

FIG. 5 is a vertical cross-sectional view taken generally along the line 4—4 of FIG. 4 but showing the part illustrated in FIG. 4 as assembled and in its operative position.

Referring to FIG. 1 the nebulizer illustrated essentially consists of a receptacle 10 for holding a quantity of the liquid 12 to be nebulized and a float unit 14 carrying a nebulizing device 16.

The particular receptacle illustrated is a rectangular fluid-tight box formed of a suitable hard and transparent plastic. Having in mind the intended use of the nebulizer in sick rooms, the receptacle and the other parts of the nebulizer are formed of materials which can be readily cleaned and sterilized. It is further preferred that the nebulizer be formed of transparent materials to better observe the operation of the device and to reveal any impurities in the liquid or inadvertently fixed to any of the parts of the device.

The float unit 14 is formed of a platform 18 having a number of hollow closed tubular members 20 fixed to its under surface. Again, and as a preferred expedient, the various components of the float are made of a suitable hard and transparent plastic. The size of the floats are selected to cause sufficient buoyancy in the float which will cause the top surface of the platform to lie just slightly above the top surface of the liquid to be nebulized although it will be appreciated that the height at which the float rests in the liquid bath depends also on the density of the liquid. As will be explained hereinafter, if it is intended that any particular nebulizer will be used only to nebulize one particular liquid, the size of the floats will be selected to cause the top surface of the platform to lie at the most advantageous level relative to the surface of the liquid. However, if it is intended that the nebulizer might be used at different times to nebulize liquids of different density, it is provided with means for adjusting the position of the nebulizing device relative to the platform, as is explained below.

The nebulizing device 16 can best be seen in FIG. 3. This device essentially consists of a hollow plug-like body having a carrier gas inlet 22 and an outlet orifice 24 in its top surface 26. The latter surface constitutes the plate on which is formed a thin film of the liquid to be nebulized. This plate need not be of any particular minimum size and can even be constituted by the end surface of a small nozzle. Thus, it should be understood that where this specification refers to a "plate" about the carrier gas outlet orifice, this is a reference to a normally horizontal surface adjacent the orifice on which a thin film of the liquid being nebulized may be formed and from which the carrier gas may pick up liquid as it emerges from the orifice.

As a preferred expedient, a small baffle 30 is positioned directly above the orifice to create additional turbulence in the carrier gas emerging from the orifice. The device 16 is press-fitted in a hole in platform 18 and is capable of

adjustment relative to the plate 18. This adjustment is desirable, as previously mentioned, where the nebulizer of the invention might be used at different times to nebulize liquids of different density. Thus, this adjustment permits accurate positioning of the top surface 26 of the nebulizing device relative to the liquid being nebulized. The most efficient nebulization occurs when the surface 26 is just slightly above the surface of the liquid so that only a very thin film of liquid is formed on the surface 26 by an action that can be best described as a "slopping over" of the liquid onto the surface. The formation of the film is also aided by surface tension effects and by the vacuum created at the orifice by the emerging air. The selection of the most efficient height of the surface 26 above the surface of the liquid is governed by several factors including the area of surface 26, the size of the orifice (which has an effect on the vacuum created above the orifice), and the viscosity of the liquid being nebulized. A further factor is the pressure exerted on the carrier gas. An increase in pressure has the effect of forcing the platform deeper into the bath of liquid, i.e., lowers surface 26 relative to the surface of the liquid. Thus, the height of surface 26 above the surface of the liquid which gains the most efficient nebulization is most easily determined empirically with every change of liquid and pressure of carrier gas. Some degree of nebulization will occur even with surface 26 slightly under the liquid surface or up to $\frac{1}{16}$ " above the liquid surface. But for the best nebulization it should be above the liquid surface only a few thousandths of an inch and the absolute optimum conditions are best found by experimentation.

When any particular nebulizer will be used to nebulize liquids of constant density and viscosity, the orifice 24 may be formed directly in the platform 18 provided there are also apertures located in the platform adjacent the orifice to permit liquid to flow over the top surface of the platform so that as the carrier gas emerges from the aperture, there will be a thin film of liquid immediately adjacent the aperture. In this case, therefore, it is actually a portion of the upper surface of platform 18 which constitutes surface 26.

The inlet 22 is connectible to a suitable flexible feeding tube 32 which is connectible with an outside source of carrier gas, commonly air, under pressure. As a preferred expedient, tube 32 is connectible with a nipple which is passed through the wall of the receptacle whereby the tube 32 may be easily removed from the device for cleaning. The tube 32 must be of a length which will permit the float 14 to fall to the bottom of the receptacle as the liquid is gradually nebulized away.

It can be seen from the foregoing that in operation, the liquid to be nebulized is automatically fed over the top surface 26 of the nebulizing device 16 and as the liquid is nebulized and its level in the receptacle gradually falls, the nebulizing device always has the same position relative to the top surface of the liquid. Thus, the nebulizer of the invention is characterized by particularly simple and trouble-free operation. As the carrier gas is always forced through the orifice 24 at high pressure whereby the aperture is automatically kept clear, there is no point at which the device might become clogged and either stop operation altogether or change its rate of nebulization.

As a further expedient, a chimney-like tube 34 is fixed to the top surface of the plate 18 as to guide the nebulized liquid upwardly to an outlet tube 36 carried on the top plate 38 of the receptacle and connectible to a further flexible tube for feeding the nebulized liquid to the area where it is required which is commonly an oxygen tent-like canopy over a patient's bed. The lower end of the tube 34 is apertured whereby to permit the entry of secondary air into the tube. This arrangement permits better upward flow of the mist. It will be appreciated that tubes 34 and 36 are preferred expedients and that in certain applications, these tubes will not be required and the liquid can be nebulized directly into the room.

As a still further expedient, the top plate 38 is provided with an inlet tube 40 which can be connected to a second flexible tube leading from the canopy over the patient's bed whereby to continuously recirculate the medicant carrying air. In this way, much of the medicant which would normally simply condense on the inside of the canopy can be recirculated to the nebulizer for condensation in the receptacle and renebulization. Where it is not desired to use the recirculation technique, a slidable plate 42 can be used to close off the under side of the tube 40. As previously mentioned, it is possible to use the nebulizer just described to nebulize directly into the room, in which case no top plate similar to plate 38 is required but use of such a plate is desirable as a means of preventing inadvertent introduction of impurities into the receptacle.

The embodiment of the invention illustrated in FIGS. 4 and 5 operates on the same principle as the embodiment just described in that there is a nebulizing device supported by a float in a bath of the liquid being nebulized. However, one of the characteristic features of the embodiment of FIGS. 1 to 3 is the use of a large bath of liquid and a large float. The large float stabilizes the nebulizing device relative to the surface of the liquid as it will be appreciated that with the carrier gas being passed through the aperture in a nebulizing device at high pressure, there is a certain amount of vibration in the nebulizing device and the larger the float the more stable the nebulizing device is held.

There are, however, certain applications where a certain amount of vibration of the nebulizing device is not serious and for such applications a nebulizer of the type shown in FIGS. 4 and 5 is acceptable and, of course, it can be manufactured at relatively less cost. FIGS. 4 and 5 are also used as a means of illustrating alternative constructions for various components of the nebulizer of the invention, which modifications might also be employed in the construction of the nebulizer of the type in FIGS. 1 to 3. Thus, for example, the float of FIGS. 4 and 5 takes the form of a hollow ring rather than the tubes of FIG. 1. Further, the nebulizing device 16a of FIGS. 4 and 5 is provided with a thread on its outside surface whereby the relative adjustment between the nebulizing device and the float is achieved by rotating the nebulizing device so that it moves up and down through interaction of the male thread carried by the nebulizing device and the female thread carried on the inside surface of the float. This arrangement is used as an alternative to the more simple press fit between the nebulizing device and the float such as is used in the FIG. 1 embodiment. Otherwise the nebulizer of the second embodiment operates in the same manner as the first embodiment. Being a smaller device, it may simply be used with a beaker as the equivalent of receptacle 10 of the FIG. 1 embodiment. In this case, the feeding tube 32a is simply dropped over the side of the beaker rather than passed through the wall of the receptacle as is done in the first described embodiment.

The size of the orifice 24 and the size of the baffle as well as the height at which the baffle is positioned above the orifice do have some effect on the rate and quality of nebulization. For a detailed description of these features, reference may be had to my copending United States patent application No. 465,672, filed June 21, 1965. In any case, the minimum acceptable size of the orifice is 0.0005 inch and it is desirable that the ratio of the minimum lateral dimension of the baffle to the size of the orifice is less than seven to one. A larger baffle size will have the effect of interfering with upward flow of the nebulized liquid. In certain applications it can also be advantageous to provide means whereby the baffle height and size can be adjusted and it will also be recognized that while only one aperture is used in the illustrated embodiments, it is within the scope of the invention to use a plurality of apertures.

What I claim as my invention is:

1. A nebulizer comprising a receptacle for holding a

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quantity of liquid to be nebulized, a nebulizing device comprising a body member having a top surface having at least one aperture therein and means connectible to a source of pressurized carrier gas for forcing carrier gas upwardly through said aperture, said body means carrying tubulence inducing baffle means positioned directly above and vertically spaced from said aperture whereby to create additional turbulence in the carrier gas emerging from said aperture; float means for floating said nebulizing device in a body of liquid held in said receptacle, openings in said float means adjacent said body member to provide access to the top surface of said body member for said liquid, said body member being carried by said float means and being height adjustable relative thereto whereby said body member including said baffle means may be raised and lowered relative to the top surface of said body of liquid so that the top surface of said body member may be positioned close to the top surface of said body of liquid regardless of the density of said liquid and the pressure exerted on the carrier gas.

2. A nebulizer as claimed in claim 1 in which said body member comprises a hollow plug body having an inlet spigot connectible with a flexible tube which is in turn connectible to said source of pressurized carrier gas, said float consisting of a platform having a plurality of hollow float members fixed to its under side, said spigot body being received in an opening in said platform by friction fit whereby the adjustment of the body member relative to the float is achieved by sliding the body member up and down within the opening in the float platform.

3. A nebulizer as claimed in claim 1 in which said body member is a hollow plug body being threaded on its outside surface and in which said float means comprises a hollow

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body having an opening therethrough which is threaded on its inside surface whereby the adjustment of said body member relative to said float is achieved by rotating said plug body in the opening through said float.

4. A nebulizer as claimed in claim 1 including a chimney device carried by said float for guiding the upward flow of the nebulized liquid, said receptacle having a cover having an opening through which said chimney device extends, a tube extending upwardly from the cover at said opening and surrounding the upper end of said chimney, said tube being connectible to a flexible conduit for leading away the nebulized liquid for administration to a patient.

5. A nebulizer as claimed in claim 4 in which said receptacle cover includes a second tube also connectible to a flexible conduit leading from the area in which the nebulized liquid is administered to the patient whereby the nebulized liquid may be recirculated to the nebulizer.

6. A nebulizer as claimed in claim 5 including baffle means positioned in the lower end of said second tube whereby said second tube may be closed off when recirculation is not desired.

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