

[54] **INTERMITTENT POSITIVE PRESSURE BREATHING MANIFOLD**

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[58] Field of Search **128/194, 195, 196, 185,
128/186, 188, 145.5, 145.6, 145.8; 137/63,
102; 239/338**

[56]

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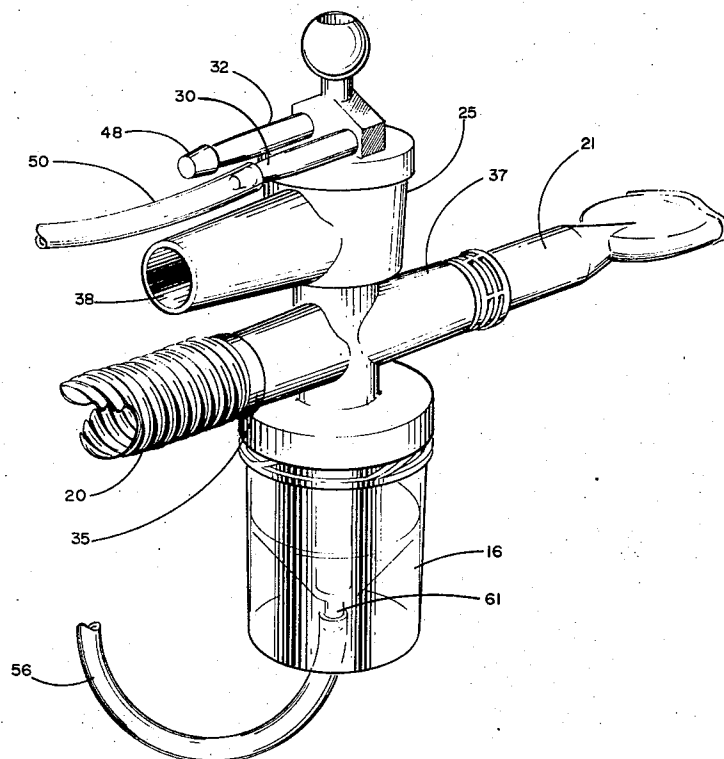
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[57]

ABSTRACT

An improved intermittent positive pressure breathing manifold device comprises a substantially vertical main tube having open upper and lower ends, a diaphragm adjacent the upper main tube opening for intermittent closing thereof and which diaphragm is in sealing engagement with an upper cap portion located above the main tube, an exhalation port adjacent the upper main tube end and in communication with the lower main tube opening, and first and second gas ports along the main tube between the upper and lower main tube ends. A preferred embodiment includes an improved nebulizer incorporating an air nozzle and coaxial aspirator cap each having concentric orifices substantially aligned with the central vertical axis of the main manifold tube.

10 Claims, 12 Drawing Figures



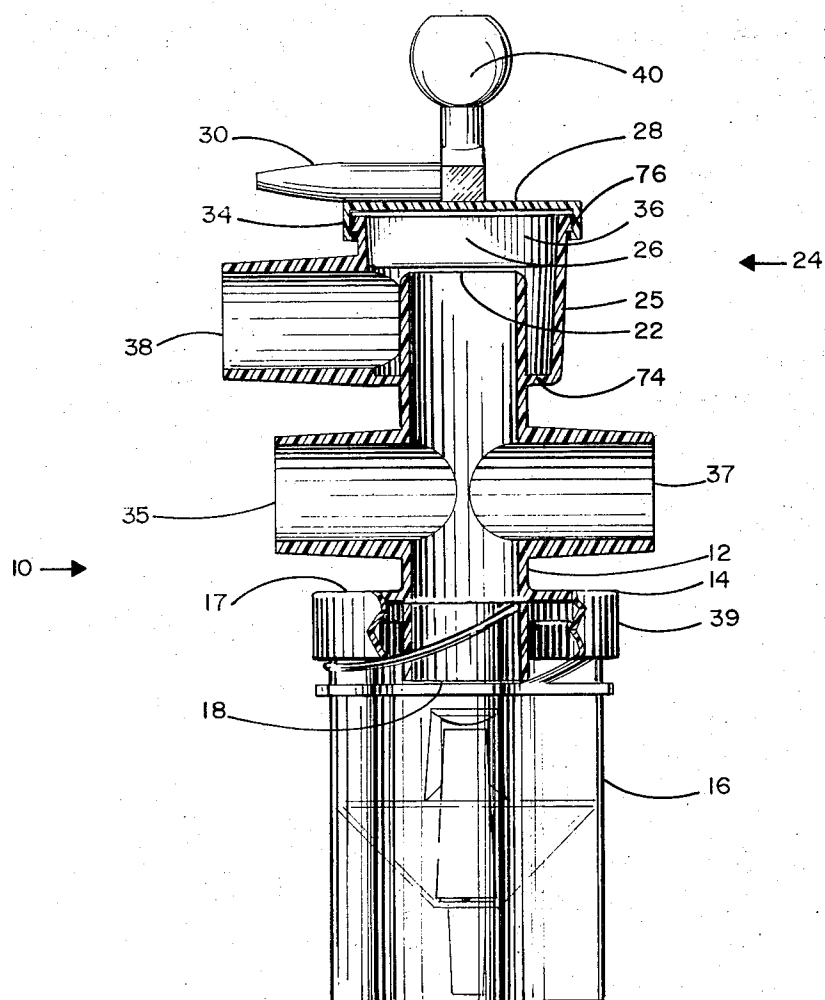


FIG. 1

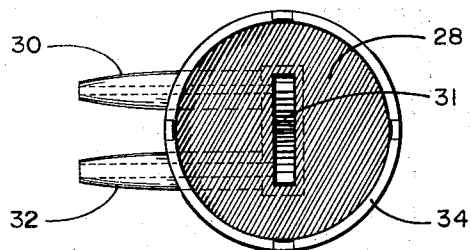


FIG. 2

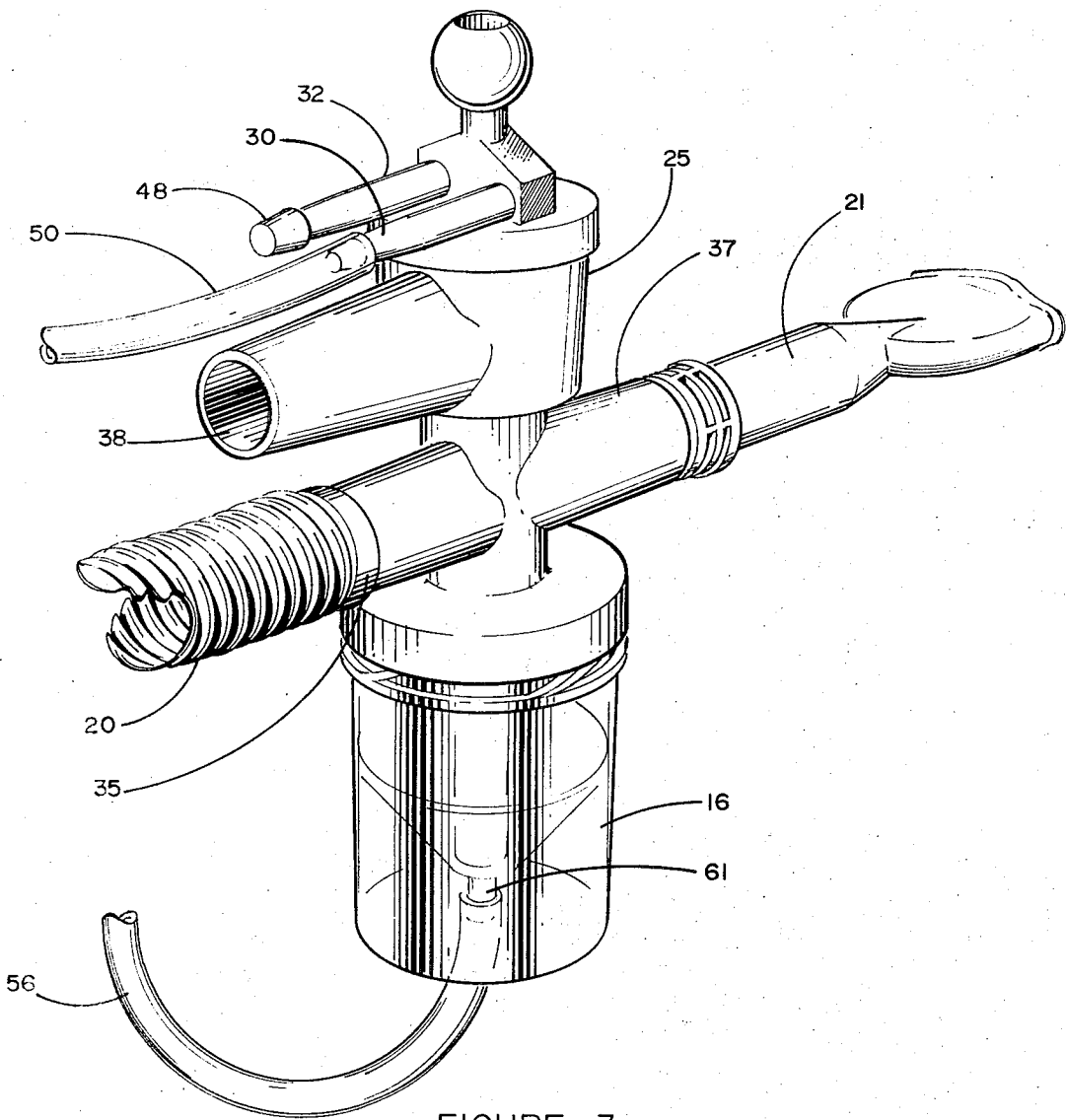
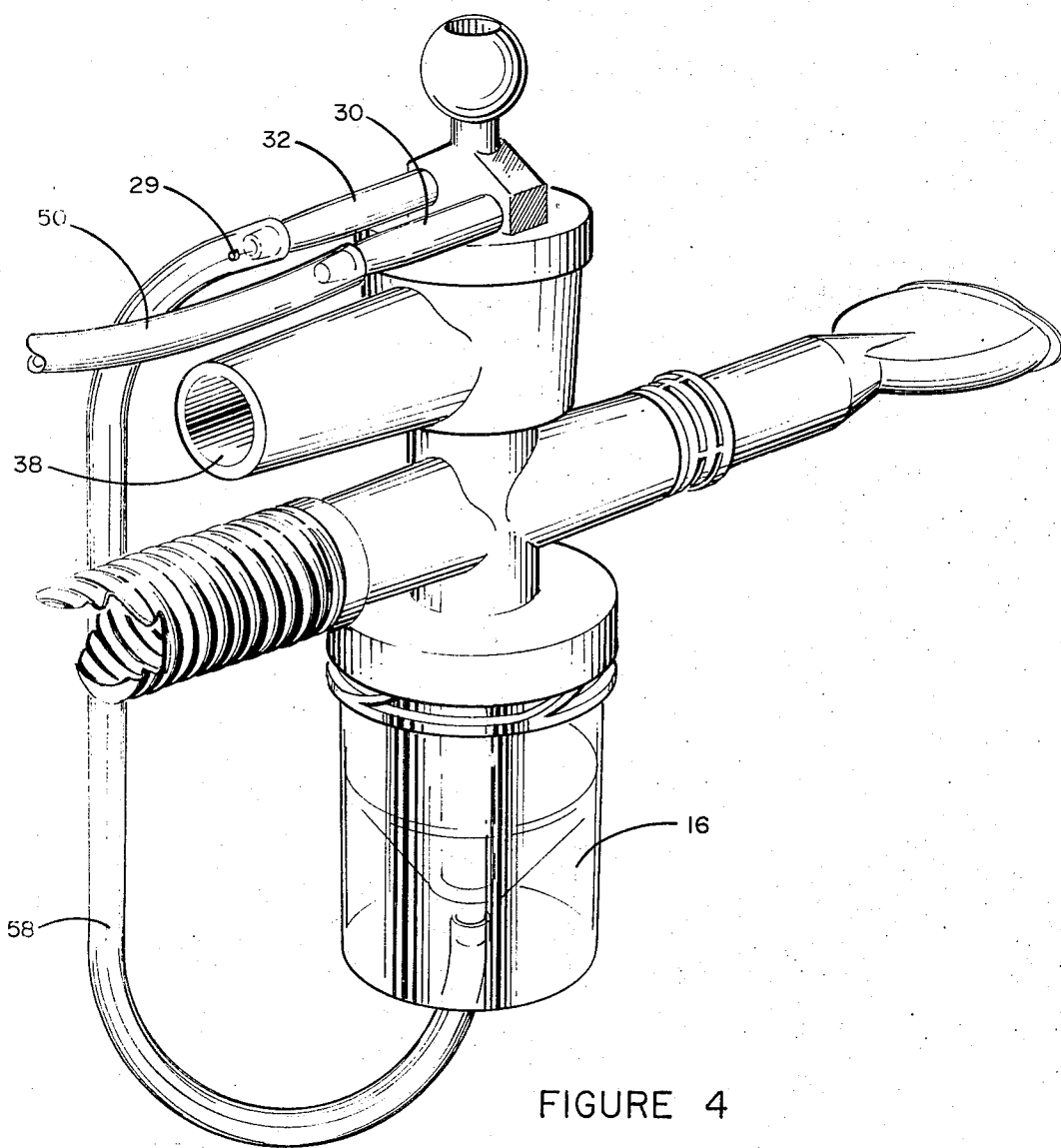
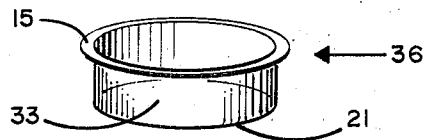
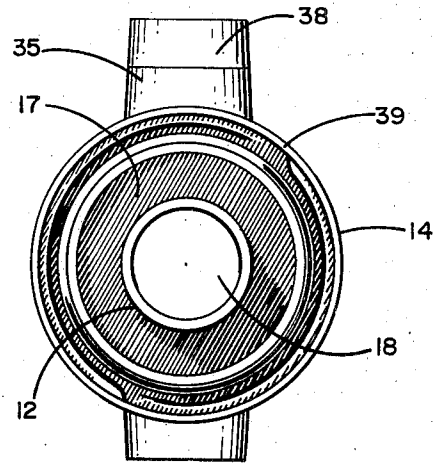
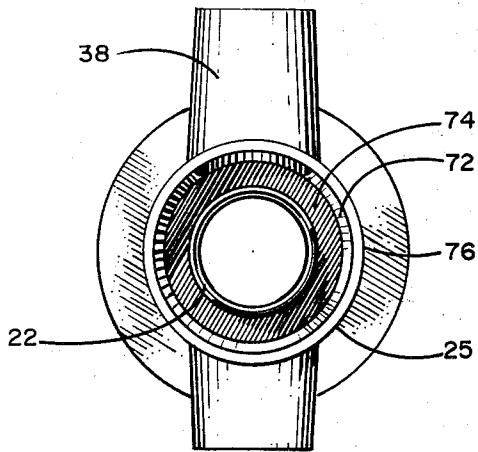
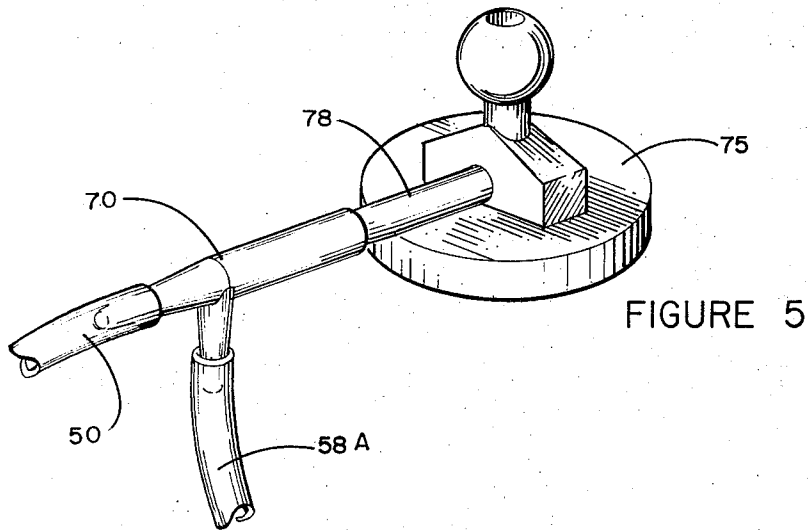


FIGURE 3





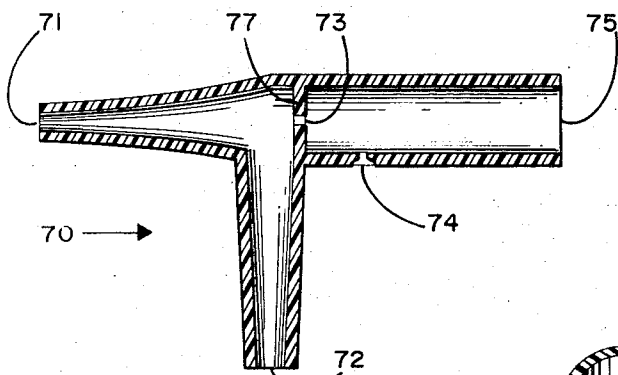


FIG. 9

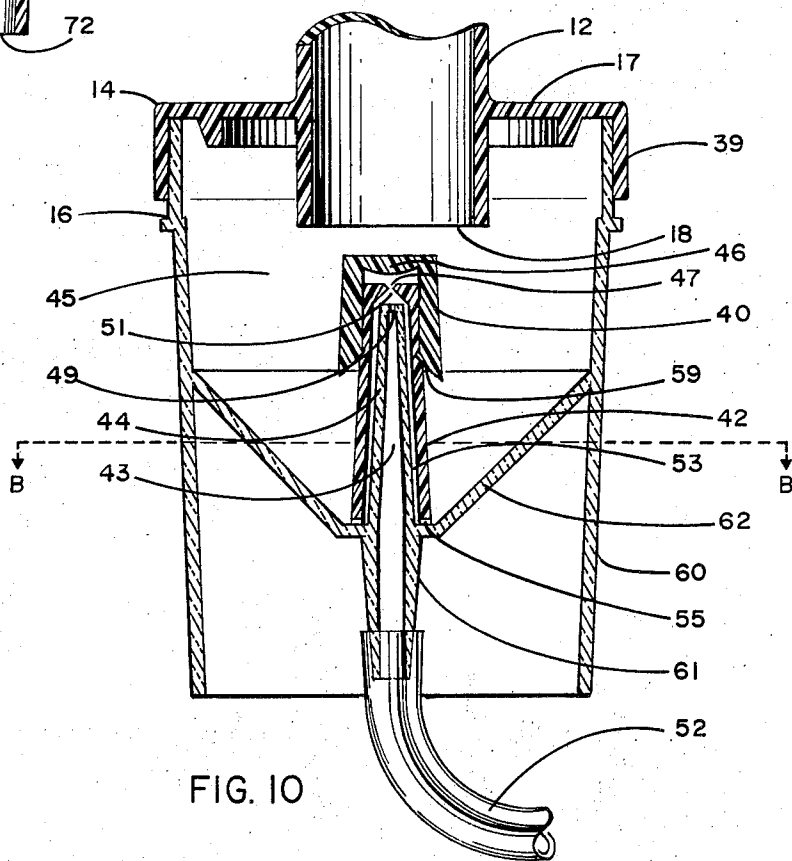


FIG. 10

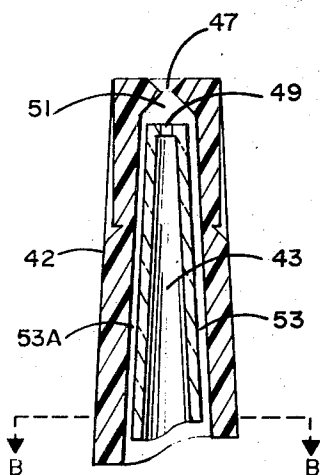


FIG. 11

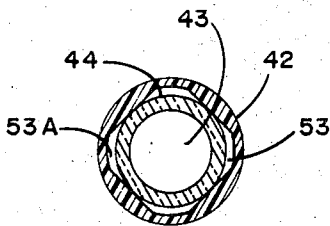


FIG. 12

INTERMITTENT POSITIVE PRESSURE BREATHING MANIFOLD

BACKGROUND OF THE INVENTION

Intermittent positive pressure breathing devices, commonly referred to as IPPB devices have been utilized for some time. The most commonly known devices are the Bird and Bennett IPPB units and incorporate various valves and pressure regulating means as generally described, for example, in U.S. Pat. Nos. 3,234,932 and 3,265,061, respectively. These units deliver oxygen or oxygen enriched gas mixture to a patient under pressure upon inspiration. As the patient's lungs become filled, the gas flow is automatically terminated by flow sensing means and the patient may exhale normally during the breathing cycle. The devices are also sometimes referred to as respirators, ventilators or respiration control units. Again, these and similar devices supply the air or oxygen enriched gases to a patient under pressure during the inhalation breathing phase and, through the various valves and flow sensing means terminate the oxygen or air flow once the lungs have been filled to the desired capacity.

The above-described devices, hereinafter referred to as control units, are used in combination with a gas delivery assembly of the type described in U.S. Pat. No. 3,265,061 or breather head assembly disclosed in U.S. Pat. No. 3,234,932 or control and exhaust valve assembly such as disclosed in U.S. Pat. No. 3,584,621. Such assemblies are often referred to as IPPB manifold assembly devices and accordingly, the term "manifold" will be used to so designate hereinafter. The manifold is attached to the gas supply tube or tubes which deliver pressurized oxygen or oxygen containing gas from the control unit. The manifold works in cooperation with the control unit to provide for intermittent gas delivery to the patient and to allow for unobstructed expiration of the gas.

As evidenced by the devices disclosed in the afore-said patents, prior art manifolds incorporate a number of individual parts and are thus rather complex in construction as well as having other disadvantages. Disadvantages in producing the device having a number of individual parts or components which must be fitted and interlocked together during manufacture and assembly are self evident. Especially, from a manufacturing standpoint, the various parts must be individually molded or stamped requiring a variety of dies. These individual parts then must be hand or machine assembled thereby further increasing their costs.

Not only are such manifolds undesirable from a manufacturing or production standpoint but because of the rather complex construction including plurality of fitting parts gas leakage may occur with concomitant reduction in efficiency unless the fittings are made correctly and the components properly secured. Such a plurality of component parts also lends to instances of improper assembly which, of course, requires time consuming inspection and quality control thereby increasing product costs. Moreover, because of the design of interior passageways of most prior art manifolds, pockets or crevices are present in which foreign material or bacteria may lodge. Even though the devices are made of plastic and are intended for single patient use and thereafter disposed, certain bacteria or virus may grow rapidly in a relatively short period of time. The elimina-

tion of such disadvantages is especially important when the manifolds are used to treat patients having lung or respiratory ailments. Moreover, where gases are required to flow through or between offset or angled passageways, air flow may be somewhat impeded and undesirable turbulence created.

Manifolds are often used in combination with a nebulizer when it is desirable to humidify the oxygen or oxygen containing gases administered to the patient or to create a mist or vapor of fine particles of water or medicament in the treatment of certain respiratory disorders. Certain prior art manifolds require the nebulizer to be offset from the normal gas flow. Such devices also usually create a slip-stream or internally baffled main stream gas flow in order to induce pick-up of the mist generated by the nebulizer. Such techniques do not utilize maximum nebulizer advantages and create inefficiencies because of the manner in which the nebulized particles must travel within the device prior to reaching the main oxygen flow to the patient.

Finally, there is a need for a simply designed and uniformly constructed manifold which can be easily adapted to use for either Bird or Bennett respiration control units. It is to the elimination of the above-noted disadvantages and for the production of a manifold and nebulizer assembly which can be inexpensively produced and yet be adaptable to either of the types of respiratory control devices as noted that the present invention is directed.

SUMMARY OF THE INVENTION

The manifold device of the present invention is intended to obviate the disadvantages noted hereinabove. The device, excluding the nebulizer portion incorporates a minimum number of components whereby the necessity of fitting or snapping together a number of individually molded parts is not required. Thus, the cost of manufacture, assembly and inspection is significantly reduced as well as substantially eliminating possible dangers of improper assembly, leakage around fitted parts, joints and the like.

The device comprises an elongated substantially vertical main tube portion having a pair of oppositely disposed tubular ports extending substantially normal to the main tube axis. The first of said ports is for attaching a gas supply conduit from an IPPB control unit and thus receives air or oxygen enriched air from the control unit during patient inspiration. The second, and oppositely disposed port is for attaching a mouthpiece or conduit directed to a mouthpiece, mask or similar device by which a patient may receive air or oxygen enriched air during inspiration. This second port also receives expired gases from the patient which are then directed into the manifold and expelled as will be explained further hereinafter.

Disposed adjacent the upper end of the main tube is an exhalation valve assembly including an exhalation port through which expired gases are directed, and a diaphragm disposed across the upper main tube opening for intermittently opening and closing the opening in response to pressure in a diaphragm chamber. The diaphragm is in sealed engagement with an exhalation valve cap and therebetween is defined the diaphragm chamber. Extending from the exhalation valve cap are a pair of hollow pipes which communicate with the diaphragm chamber through orifices in the valve cap. Alternatively one pipe may be used in combination with

a gas flow restricting member as will be more fully explained hereinafter.

A further embodiment includes an improved nebulizer secured to the lower end of the main manifold tube. The manifold device, in addition to having relatively few parts including the nebulizer portion extends generally along the vertical axis of the main manifold tube. Thus, the exhalation valve assembly is located directly above and substantially coaxial to the main manifold tube while the nebulizer portion, also coaxial with the main tube is located at the lower tube end. Accordingly, the device, having only tubes and ports extending therefrom is balanced, with the center of the balance or gravity extending substantially along the main manifold tube vertical axis. This feature is important in utilizing the nebulizer whereby the medication or water level therein will be substantially normal to the main tube vertical axis. Other advantages as well as the operational features of the device will be more fully explained hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevational view of the manifold device of the invention partially in section to expose the interior thereof;

FIG. 2 is a bottom plan view of the exhalation valve cap;

FIG. 3 is a perspective view of the device showing tube attachments used with a Bennett IPPB unit;

FIG. 4 is a perspective view of the device showing tube attachments for use with a Bird IPPB unit;

FIG. 5 is a perspective view of an alternative exhalation valve cap and gas flow restrictor as used for a Bird IPPB unit;

FIG. 6 is a top plan view of the manifold device with the exhalation valve cap removed;

FIG. 7 is a bottom plan view of the manifold device with the nebulizer assembly removed;

FIG. 8 is a perspective view of the diaphragm;

FIG. 9 is a side sectional elevation of a gas flow restrictor;

FIG. 10 illustrates the lower portion of the manifold device including a side sectional elevation of the nebulizer assembly;

FIG. 11 is an enlarged sectional elevational view of the air nozzle and aspirator cap portion of the nebulizer assembly; and

FIG. 12 is a sectional view taken along line B—B of FIG. 11.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to FIG. 1, the manifold device 10 comprises an elongated vertical main tube 12 which terminates at an upper end 22 and lower end 18. The tube is substantially hollow along its entire length with openings at the respective upper and lower ends 22 and 18. The main tube interior is preferably of a substantial uniform diameter between the ends. Adjacent the lower main tube end is a nebulizer cap 14 which cap is secured to the main tube and preferably integral therewith. The lower portion of main tube 12 extends through nebulizer cap 14 and into the cavity of nebulizer jar 16 when the latter is attached to the cap. The cap is also preferably provided with threads for threadedly engaging the nebulizer jar.

At the upper end of main tube 12 is an exhalation valve assembly 24 which includes annular exhalation

valve housing 25 (note FIG. 6), diaphragm 36, exhalation valve cap 28, exhalation port 38 and pipes 30 and 32 (note FIG. 2). Referring also to FIG. 6, valve housing 25 includes annular sidewall 72 extending upwardly from valve housing base 74. A normally extending flange 76 is preferably formed around at the upper end of sidewall 72, the upper surface of which flange provides a seat for seating engagement with a diaphragm as will be pointed out hereinafter. It will be noted that an upper portion of the manifold main tube extends into a valve housing cavity defined within the valve housing which cavity has a greater diameter than the main tube. However, the shape and size of the exhalation valve housing is not critical so long as it accommodates the upper portion of the main manifold tube, the diaphragm and valve cap. A tubular exhalation port 38 is also secured to and extends from valve housing 25 so that the exhalation port communicates with the valve housing cavity through wall 72. Valve housing 25 including sidewall 72, base 74 and exhalation port 38 are also preferably integrally molded with the main tube.

Referring also to FIG. 2, exhalation valve cap 28, provides a closure for the exhalation valve assembly. The valve cap includes a pair of hollow pipes 30 and 32 which communicate with channel or groove 31 formed in the cap which in turn is exposed to a diaphragm chamber. The valve cap also includes an annular skirt 34 which is designed to fit over and engage flange 76 at the upper circumferential end of valve housing sidewall 72. At the top of valve cap 28 is a ball member 40 used to suspend the manifold device from a socket or clamp of supporting apparatus.

Referring also to FIG. 8, diaphragm 36 comprises a cup-shaped flexible gas impermeable membrane having a substantially flat base surface 21, sidewall 33 and an upper annular flange 15 which rests on annular flange 76 of the exhalation valve housing. Thus, when cap 28 is secured to flange 76 it forces diaphragm flange 15 into sealed engagement therebetween. Diaphragm chamber 26 is defined within the diaphragm cup and exhalation valve cap and communicates with pipes 30 and 32. The diaphragm chamber is alternately pressurized by introducing gas via the pipes whereby the diaphragm expands and because of its close proximity to upper main tube end 22, flat base 21 is forced downwardly sealing off the upper main tube opening. When the diaphragm is not in an expanded state its base may rest lightly on the upper main tube end or be only slightly separated therefrom so that expired gases may pass therebetween.

Extending from exhalation valve assembly 25 is exhalation port 38. The exhalation port is in communication with the interior cavity defined by valve housing 25 so that when diaphragm 36 is not expanded, expired gas from a patient passing into the main tube may pass through upper main tube opening and exit through exhalation port 38.

Downwardly from the exhalation valve assembly along main tube 12 and extending therefrom are a pair of tubular ports 35 and 37. These ports may be conveniently located approximately midway between the upper and lower main tube ends. First port 35 directs air or oxygen enriched air into main tube 12 and second port 37 directs the gas to a patient from main tube 12 and receives expired patient gases. Because of these functions, ports 35 and 37 are preferably oppositely

disposed on the main tube and extend normal to vertical main tube axis as shown.

Attached to the lower portion of main tube 12 is a nebulizer assembly including a nebulizer cap 14 and jar 16. The nebulizer assembly, which will be described in more detail hereinafter is for the purpose of creating and directing a mist or aerosol of finely nebulized water or medicament particles into main tube 12 through lower tube end 18 during patient inspiration. The aerosol is forced upwardly along the lower portion of the main tube where it mixes with air or oxygen enriched air flowing across the main tube interior from port 35 to port 37 and to the patient.

Noting FIGS. 1 and 10, nebulizer cap 14 includes a flat top portion 17 extending radially from a lower portion of main manifold tube 12 whereby the latter projects downwardly for a distance past the plane of intersection and into the nebulizer jar cavity. An annular skirt 39 extends circumferentially from flat top portion 17 and the inner skirt surface is preferably provided with threads for theadedly engaging nebulizer jar 16. The nebulizer cap is preferably integrally molded to main tube 12.

Basically, and referring especially to FIG. 1, the principal of operation of the manifold device of the invention is as follows;

On patient inspiration, air or oxygen enriched air is passed from a respirator or IPPB control unit into first port 35, across the central interior of main tube 12 and through second port 37 which is connected by a suitable gas directing conduit such as a flexible hose and mask or mouthpiece to a patient. At the same time, gas is forced into the nebulizer through a separate conduit creating an aerosol which is directed upwardly through lower main tube opening 18 and main tube 12 where it combines with the flow of gas passing across the main tube from port 35 to port 37. Concurrently, diaphragm chamber 26 is pressurized by gas supplied through exhalation valve cap pipe 30 expanding diaphragm 36 and sealing the upper end 22 of main tube 12. Thus, the diaphragm seal at the upper main tube end prevents air or oxygen within main tube 12 from leaking during patient inspiration.

As the patient's lungs become filled with the gas and inspiration is terminated, a flow sensing means in an IPPB control unit shuts off the air flow to port 35, diaphragm chamber 26 and to the nebulizer. The pressure in the diaphragm chamber is then dumped whereby diaphragm 36 returns to an unexpanded position. As this occurs, the seal at upper main tube opening 22 is relieved and the patient exhales, expired gases are directed through port 37, upwardly through the upper portion of the main tube 12, out through upper main tube opening 22 and exhalation port 38. Expired air is normally not allowed to pass into the nebulizer jar either when the nebulizer is connected for nebulization or when it is sealed off. However, expired patient gases normally may not pass back through port 35 or into the nebulizer through the main tube because of static pressures.

Referring now to FIGS. 3 and 4, there are shown two different means for connecting the manifold device of the invention, FIG. 3 illustrating the manner for connecting the unit to a Bennett IPPB control unit, and FIG. 4 for connection to a Bird unit. Referring first to FIGS. 1 and 3, line 50 is connected between a Bennett IPPB unit (not shown) and exhalation valve pipe 30. It

will be noted that second pipe 32 is sealed off by cap 48 so that only one of the pipes is utilized in the Bennett mode. Nebulizer supply line 56 is attached via hose connector 61 between nebulizer 16 and to a nebulizer gas pressure outlet on the Bennett unit. A larger flexible supply conduit 20 is attached between the Bennett device and main oxygen inlet port 35. The second port 37 is attached to mouthpiece 23 for delivery of the oxygen enriched gas to a patient.

In operation, during patient inspiration the Bennett unit will supply air or oxygen enriched air to the nebulizer through supply line 56, at a constant pressure, usually between about 40 psi and about 60 psi during inspiration. At the same time, the Bennett unit supplies gas under pressure via control line 50 to pipe 30 and into diaphragm chamber 26 thereby expanding diaphragm 36 to seal off upper main tube end 22 of the manifold. Oxygen or oxygen enriched gas to be inhaled by the patient is supplied by conduit 20 via ports 35 and 37. Again, it will be appreciated that during patient inspiration as the pressure is continuously being supplied to the nebulizer via line 56, fine medicament or water particles in the form of an aerosol are combined and mixed with gas in main tube 12 and directed to the patient.

As the patient's lungs become filled and he begins to exhale the pressure change will be sensed by the Bennett unit and gas flow is terminated. Gas pressure in the diaphragm chamber is "dumped" by the control unit via pipe 30 and control line 50 and oxygen supplied to the nebulizer and port 35 ceases. As pressure within the diaphragm chamber is relieved the diaphragm no longer seals the opening at upper end 22 of main tube 12. Accordingly, expired gases will pass through tube 21, port 37, into main tube 12, upwardly through main tube 12 and out through end 22 and exhalation port 38.

FIG. 4 illustrates the manifold device as it is used with a Bird IPPB unit. It will be noted that pipe 32 is not capped but instead communicates with nebulizer 16 via supply line 58. Because a Bird respirator is a single line-type, it does not have a separate nebulizer gas pressure supply line. Thus, when using a Bird unit gas to the nebulizer is supplied through the diaphragm chamber. Referring also to FIG. 1, gas from the unit (not shown) is directed via supply line 50 and pipe 30 into diaphragm chamber 26. Again, this causes the diaphragm to expand and seal off upper end 22 of main manifold tube 12. Gas supplied by the Bird unit to the diaphragm chamber via supply line 50, during patient inspiration, will normally be constant, for example, about 50 psi. Since that amount of pressure is in excess of that required to maintain the diaphragm seal, the excess gas is directed to the nebulizer via pipe 32 and conduit 58. Moreover, the diameter of pipe 32 is preferably larger than pipe 30 so as to ensure sufficient venting of gas from the diaphragm chamber to the nebulizer and preventing undue diaphragm chamber pressure which could rupture the diaphragm.

Upon termination of patient inspiration and during expiration, the flow of gas into the diaphragm chamber via line 50 is terminated thereby allowing pressure in the chamber to be dumped. For this purpose, an orifice 29 of suitable diameter is present in conduit 58 through which diaphragm chamber pressure will be dumped once the gas flow in supply line 50 is terminated. The size or diameter of orifice 29 will be large enough to permit rapid pressure dumping and yet small enough to allow sufficient gas to be directed to the nebulizer

through the supply line during patient inspiration. It will also be understood that once the diaphragm pressure is dumped through the orifice, gas flow to the nebulizer is then also terminated. Otherwise, the manifold assembly as shown in FIG. 4 operates similar to that as shown in FIG. 3.

Observing again FIG. 3, in the Bennett mode of operation, cap 48 is provided to seal pipe 32 which is not used. Where the pipes are of different sizes, both internally and externally, cap 48 will fit only pipe 32 which reduces the chances of an operator inadvertently sealing off pipe 30. Such a feature is thus convenient and will reduce the possibility of an inexperienced operator incorrectly making the attachments when used in the Bennett mode.

An alternative embodiment of the exhalation valve cap described hereinabove is shown in FIG. 5 utilizing valve cap 75 having a single pipe 78 corresponding to pipe 30 previously described and which pipe communicates with the diaphragm chamber. Thus, in the Bennett mode in which only one pipe is utilized, this embodiment will be used and functions substantially as described according to FIG. 3 but eliminating the requirement of capping a second pipe.

Where the single pipe embodiment is to be used with a Bird unit it will be necessary to attach a gas flow restricting and splitting member 70 which will be referred to as a "T"-adapter hereinafter. Referring also to FIG. 9, the T-adapter provides a triple function required for adapting the unit for Bird mode operation. The T adapter includes three gas directing ports. Port 71 is attached to control line 50 which directs gas flow from the Bird unit. Port 75 is secured directly to pipe 30 for directing the flow of gas into the diaphragm chamber while port 72 is secured to nebulizer supply line 58 which does not have an orifice as does supply line 58. T-adapter 70 also incorporates restrictor wall 77 having an orifice 73 therein for reducing the gas pressure supplied into the manifold diaphragm chamber. Thus, orifice 73 will allow a majority of gas supplied to flow through port 72 to operate the nebulizer and yet sufficient gas to enter the diaphragm chamber and expand the diaphragm for sealing the upper end of the main manifold tube during patient inspiration. A dump vent 74 is located on the low pressure side of restrictor wall 77 for venting or relieving gas pressure in the diaphragm chamber when the gas flow from the Bird unit is terminated during patient expiration and for controlled leakage preventing unduly high diaphragm pressure buildup during patient inspiration. Thus, dump vent 74 functionally corresponds to orifice 29 in nebulizer supply line 58 in the embodiment shown in FIG. 4.

For normal Bird unit operation where pressure supplied through control line 50 is about 50 psi, suitable diameters of orifice 73 are between about 0.015 and about 0.025 inch and vent 74 between about 0.030 and about 0.035 inch and more preferably about 0.019 and about 0.031, respectively.

Alternatively, the T-adapter may be used with the two pipe embodiment shown in FIG. 4 for the Bird mode. However, only one pipe will be used with the other pipe closed off or capped and eliminating the need for supply line 58 having orifice 29. Thus, the attachments used will correspond to those shown in FIG. 5 with T-adapter 70 attached to pipe 30 while pipe 32 will be capped (see FIG. 3).

In still a further embodiment to be used with the Bird unit and referring to FIG. 4, orifice 29 in supply line 58 may be eliminated and instead a dump port may be provided on the exhalation valve cap. However, in order to further restrict unduly great pressure in the diaphragm chamber a separator disc may be placed between the valve cap and diaphragm which disc is provided with a restricting orifice. Thus, the combined orifices and separator disc will achieve the same function of the T-adapter previously described it being understood that such functions are required for use in the Bird mode.

Referring again to FIG. 1, it will be noted that the manifold of the invention is quite symmetrical since all of the ports as well as the exhalation valve assembly and nebulizer components are not substantially displaced or offset from the longitudinal axis of main tube 12. This construction offers advantages over previous manifold devices. For example, because of the symmetry of the manifold and its components, when the device is attached to a holding arm which fits around ball member 40, because of its center of gravity along the vertical axis the manifold will remain substantially upright rather than at an angle relative to vertical. Such a feature will insure that the water or medicament level within the nebulizer will be at least nearly normal to the vertical manifold axis since the nebulizer jar will not be tipped which, if the water or medicament level was low, could cause nebulizer inefficiency or malfunction. In addition, as a mist is generated by the nebulizer it will be forced upwardly directly into the main manifold tube 12 without passing through any offset chambers or angled ports prior to being mixed with oxygen which passes across the flow of mist and is directly mixed with the aerosol. That feature is also designed to optimize the functions of the device thereby achieving maximum efficiency. Such features, combined with the relative simplicity of construction of the device including minimum number of parts provides not only reduced construction and assembly costs but the other advantages as noted hereinabove over prior art devices as will be appreciated by those skilled in the art.

Expired gases passing from exhalation port 38 may be directed to a gas analyzer or similar device for measuring the amount or composition of the expired gas as desired. Thus, if carbon dioxide concentration, vital capacity or other tests are desired, a suitable conduit may be attached to exhalation port 38 for directing the gases to the analyzing equipment. Otherwise, the expired gas will simply be directed to the room atmosphere. Further an exhalation retard cap for adjusting exhalation rates may be attached to the exhalation port.

Referring now to FIGS. 10-12, the improved nebulizer of the invention is situated directly below the main tube 12 along its vertical axis. Nebulizer jar 16 is attached to cap 14 which is affixed to the lower end of main tube 12 as shown. The method of attachment of the jar to the cap is not critical and it may be snapped into place or the interior of skirt 39 and the top exterior side of the jar may be provided threads for threadedly engaging the two parts as shown in FIG. 1. The shape of the jar is not particularly critical but it is preferred that it has a bowl-shaped bottom 62 for improved efficiency as will be explained hereinafter.

Extending upwardly from bottom 62 and integral therewith is an air nozzle 44. Preferably, the air nozzle

and bowl-shaped bottom are molded as a portion of the nebulizer jar. It will be noted that nozzle 44 is elongated and has an interior nozzle cavity 43 through which gas is upwardly directed. The nozzle terminates at its apex in a nozzle orifice 49 located along the central vertical axis of the nozzle. The sides of nozzle 44 are also preferably inclined or slanted inwardly from the bottom to top so that the diameter of both the interior and exterior nozzle surface decreases from bottom to top. A hose connector 61 integral with air nozzle 44 extends below bottom 62 for attaching a supply line 52. However, the design of the exterior bottom portion of the nebulizer jar is not critical and may be as shown or otherwise modified, so long as means for providing air to the air nozzle is present to achieve the desired purpose.

An aspirator cap 42 is disposed coaxially on the air nozzle as shown and substantially covers the air nozzle. Bottom edge 55 of aspirator 42 does not rest on the bottom surface 62 of jar 16 but instead is elevated therefrom somewhat to provide a passageway for water or medicament within the nebulizer chamber defined within the nebulizer jar. Alternatively, the aspirator cap end may rest on or be secured to the bowl surface with passageways formed through and along its lower end. At the upper end of aspirator cap 42 is an orifice 47 which is disposed directly in line above orifice 49 of air nozzle 44. The top surface of both the air nozzle and aspirator cap may be flattened in the form of a flange having the respective orifices therein as shown for the air nozzle or one or both may be formed like that of the aspirator cap (see FIG. 11).

Observing particularly FIG. 12, there is illustrated the relationship of aspirator cap 42 and air nozzle 44 whereby the interior sides of the aspirator cap are cut so that a portion of the interior sides rest against the exterior side surface of the air nozzle. It will be noted that the interior sides of aspirator cap 42 are beveled to provide a plurality of channels 53 between the exterior air nozzle surface and interior aspirator cap surface. Alternatively the interior aspirator cap surface may be circumferential and the exterior air nozzle surface beveled to provide the channels. The channels are in communication with the space between bottom edge 55 of aspirator cap 42 and bottom 62 of the nebulizer jar, so that water or medicament can flow into the aforesaid space and is drawn up through the channels to mixing chamber 51 (see FIG. 11). Mixing chamber 51 is defined as the space between air nozzle orifice 49 and aspirator cap orifice 47 as shown in FIG. 11.

In operation, with water or medicament placed in the nebulizer jar 16, air or oxygen enriched air is supplied via supply line 52 into the interior of nozzle 44 where it is forced out of nozzle orifice 49. Depending on the liquid surface tension, water or medicament will usually rise within channels 53 by capillary action thereby pre-priming the system and improving its response time to inspiratory gas flow. Because of the lower pressure provided in mixing chamber 51 by the jet's stream of air escaping from nozzle 49, through the mixing chamber and out through aspirator cap orifice 47, liquid within channels 53 will be drawn upwardly therealong mixing chamber 51. The liquid is drawn into the mixing chamber due to the partial vacuum created therein by the gas being forced therethrough which partial pressure is lower than the pressure on the surface of the liquid within the nebulizer jar and is often referred to as

the Venturi principle as will be appreciated by those skilled in the art. Further, as the gas escaping from nozzle orifice 49 contacts and mixes with the liquid within mixing chamber 51, because of the gas velocity, small droplets of the water or medicament will be formed in the form of an aerosol or mist which will pass through restricted aspirator cap orifice 47. Thereafter, observing further FIG. 10, the mist will impinge on the lower surface of baffle 46 located directly above aspirator cap orifice 47 and spaced therefrom and then be deflected out into the interior chamber 45 of the nebulizer.

It will be noted that the liquid level within jar 16 should be maintained below the horizontal plane of air nozzle orifice 49. Should the liquid level be too high, the liquid level within the channels would spill over the top of nozzle orifice 49, drain into the interior of the air nozzle and into the oxygen or gas directing tube 52 which is undesirable. For this purpose, a visible maximum liquid level line or indicia may be scribed or molded on jar 16 for observation by an operator to prevent filling the jar with too much water or medicament. Further, since the manifold device of the invention including the nebulizer jar are maintained along a substantially vertical plane, even when in operation because of the devices symmetry, the liquid level can be readily observed by an operator whereas in other devices which are unbalanced and tilted with respect to vertical, the liquid surface level may not be so correctly observed relative to the scribed line on the nebulizer jar.

Although a baffle 46 is optional, it will be preferred since it assists further nebulization of the liquid particles impinging thereon. Moreover, it will prevent unduly large particles from entering main tube 12 of the manifold. Generally for most patients receiving inhalation therapy requiring a mist or aerosol composed of fine droplets of water or medicament in an air or oxygen enriched air stream, particle sizes between about 2 and about 5 microns are preferred. Thus, by using a baffle in cooperation with the spray orifice, larger particles will be further broken up as they impinge against the baffle surface or will collect there. Such particles or drops are then forced outwardly from the surface by the forced gas and fall into the body of water or medicament within the jar.

As shown, baffle 46 comprises a main body having extending downwardly therefrom a plurality of arms 40 which are flanged on the bottom. The flanged portion 59 extends inwardly and is connected or attached to the exterior side of aspirator cap 42. However, such construction is not particularly critical and other means of employing a baffle and attaching it within the nebulizer chamber may be used. However, again, the baffle is preferably located so that the surface on which the nebulized mist is forced from aspirator cap orifice 47 will impinge is located directly above but separated from that orifice.

Observing again FIG. 12, aspirator cap 42 is shown as having its interior side cut to provide four flattened surfaces which rest against the circumferential exterior surface of air nozzle 44. However, any number of such flattened surfaces may be formed on the interior surface of the aspirator cap 42 to achieve the same purpose and provide a like number of passageways for flow of the medicament or liquid.

It has been found that the relationship of the relative sizes of the air nozzle orifice and aspirator cap orifice as well as the distance therebetween is an important feature of the invention to achieve optimum aerosol characteristics. To achieve particles sizes within the preferred range of between about 2 and about 5 microns it has been found that the air nozzle orifice and aspirator cap orifice should have diameters between 0.030 and 0.032 and 0.041 and 0.043 inch respectively. In addition, the distance between the upper edge of the air nozzle orifice and lower edge of the aspirator cap nozzle should be greater than the diameter of either of the orifices and preferably about two times greater than the diameter of the aspirator cap orifice. Although the improved nebulizer is described herein for uses with the manifold it should be appreciated that it may be used to provide an aerosol for other inhalation therapy equipment such as oxygen masks, mouthpieces and the like.

Various types of materials and preferably plastics may be used to prepare the device of the invention. For example, the main manifold tube and exhalation valve assembly may be formed of high impact polystyrene, polyethylene and similar materials where visibility through the parts is not critical. The nebulizer cap may also be prepared of the same material. However, the nebulizer jar should preferably be made of a clear plastic such as crystal styrene.

I claim:

1. An IPPB manifold device for use with an IPPB respirator of either of two types, type (i) providing a main stream of gas and two minor gas streams during patient inspiration and type (ii) providing a main stream of gas and one minor gas stream during patient inspiration, the manifold comprising:

a. a hollow main tube being elongated along a vertical axis and terminating at openings at both the upper and lower tube ends;

b. a nebulizer attached to the lower end of said main tube said nebulizer comprising an air nozzle provided with gas inlet means and having an upper orifice and an aspirator cap provided with liquid inlet means and having an upper orifice said air nozzle and aspirator cap orifices being coaxially aligned with said main tube whereby aerosol emanating from said aspirator cap orifice is directed upwardly toward said lower tube opening and into said main tube;

c. a diaphragm for alternately closing the upper main tube opening and in sealing engagement with an upper cap portion having an air supply conduit means and wherein said cap and diaphragm define a gas pressure chamber therebetween with which chamber the conduit means communicates said conduit means comprising first and second pipes, whereby in use with said type (i) respirator a first gas supply tube is attached between the first pipe and said respirator for delivering one of said minor gas streams to said pressure chamber and said second pipe is stoppered, and a second gas supply tube is attached between said respirator and said nebulizer for delivering the other of said minor gas streams thereto, and in use with said type (ii) respirator a third gas supply tube is attached between the first one of said pipes and said respirator for delivering the minor gas stream to said pressure chamber and a fourth gas supply tube is attached

between said second pipe and said nebulizer for directing a portion of said minor gas stream from said chamber thereto;

d. a walled housing member for receiving said diaphragm having a lower end radially extending from and secured to said main tube adjacent the upper tube end and having and upper rim to which said upper cap is secured;

e. an exhalation port adjacent said upper main tube end and extending through said walled housing member; and

f. a tubular gas inlet port and a tubular gas outlet port oppositely disposed along said main tube and extending normal to the vertical axis thereof between said upper and lower main tube ends wherein a gas supply hose is attached between said respirator and said gas inlet port for delivering said main stream of gas to said device and from said gas outlet port to a patient, whereby said main gas stream flowing from said gas inlet port to said outlet port passes across said main tube where it is combined with said aerosol.

2. The device of claim 1 wherein said diaphragm includes a flange therearound which flange is sealingly engaged between said upper cap and the upper rim of said walled housing member.

3. The device of claim 1 wherein said nebulizer further comprises a jar portion having sides, bottom and top defining a nebulizing chamber, said aspirator cap being coaxially mounted on said air nozzle, said air and aspirator cap orifices being spaced apart to define an aspirating chamber therebetween and wherein the distance between said aspirator cap orifice and said air nozzle orifice is greater than the diameter of either of said orifices.

4. The device of claim 3 wherein the diameter of said air nozzle orifice is smaller than the diameter of said aspirator cap orifice.

5. The nebulizer of claim 4 including a baffle axially disposed adjacent said aspirator cap orifice.

6. An IPPB manifold device for use with an IPPB respirator of either of two types, type (i) providing a main stream of gas and two minor gas streams during patient inspiration and type (ii) providing a main stream of gas and one minor gas stream during patient inspiration, the manifold comprising:

a. a hollow main tube being elongated along a vertical axis and terminating at openings at both the upper and lower tube ends;

b. a nebulizer attached to the lower end of said main tube said nebulizer comprising an air nozzle provided with gas inlet means and having an upper orifice and an aspirator cap provided with liquid inlet means and having an upper orifice said air nozzle and aspirator cap orifices being coaxially aligned with said main tube whereby aerosol emanating from said aspirator cap orifice is directed upwardly toward said lower tube opening and into said main tube;

c. a diaphragm for alternately closing the upper main tube opening and in sealing engagement with an upper cap portion having a single air supply pipe and wherein said cap and diaphragm define a gas pressure chamber therebetween said pipe communicating therewith whereby in use with said type (i) respirator a first gas supply tube is attached between said pipe and said respirator for delivery of

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one of said minor gas streams to said pressure chamber and a second gas supply tube is attached between said respirator and said nebulizer for delivering the other of said minor gas streams thereto, and in use with said type (ii) respirator said device includes a gas flow restricting and splitting member having an air inlet for receiving said minor gas stream from said respirator, and first and second gas outlets, the first outlet being attached to said pipe for supplying a portion of said minor gas stream to said pressure chamber and the second outlet for supplying a portion of said minor gas stream to said nebulizer;

- d. a walled housing member for receiving said diaphragm having a lower end radially extending from and secured to said main tube adjacent the upper tube end and having an upper rim to which said upper cap is secured;
- e. an exhalation port adjacent said upper main tube end and extending through said walled housing member; and
- f. a tubular gas inlet port and a tubular gas outlet port oppositely disposed along said main tube and extending normal to the vertical axis thereof between said upper and lower main tube ends wherein a gas supply hose is attached between said respirator and

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said gas inlet port for delivering said main stream of gas to said device and from said gas outlet port to a patient, whereby said main gas stream flowing from said gas inlet port to said outlet port passes across said main tube where it is combined with said aerosol.

7. The device of claim 6 wherein said diaphragm includes a flange therearound which flange is sealingly engaged between said upper cap and the upper rim of said walled housing member.

8. The device of claim 6 wherein said nebulizer further comprises a jar portion having sides, bottom and top defining a nebulizing chamber, said aspirator cap being coaxially mounted on said air nozzle, said air and aspirator cap orifices being spaced apart to define an aspirating chamber therebetween and wherein the distance between said aspirator cap orifice and said air nozzle orifice is greater than the diameter of either of said orifices.

9. The device of claim 8 wherein the diameter of said air nozzle orifice is smaller than the diameter of said aspirator cap orifice.

10. The nebulizer of claim 9 including a baffle axially disposed adjacent said aspirator cap orifice.

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