



US 20130199520A1

(19) **United States**

(12) **Patent Application Publication**
Dhuper et al.

(10) **Pub. No.: US 2013/0199520 A1**

(43) **Pub. Date: Aug. 8, 2013**

(54) **MODULAR PULMONARY TREATMENT SYSTEM**

A61M 16/14 (2006.01)

A61M 16/12 (2006.01)

A61M 16/10 (2006.01)

A61M 11/04 (2006.01)

(71) Applicant: **Aeon Research and Technology, LLC**,
Hewlett, NY (US)

(52) **U.S. Cl.**

CPC *A61M 16/06* (2013.01); *A61M 16/1045*

(2013.01); *A61M 16/0057* (2013.01); *A61M*

16/20 (2013.01); *A61M 11/04* (2013.01); *A61M*

15/0065 (2013.01); *A61M 16/14* (2013.01);

A61M 16/12 (2013.01); *A61M 15/0086*

(2013.01); *A61M 16/0875* (2013.01)

USPC **128/200.23**; 128/201.13; 128/205.24;

128/204.25; 128/203.12

(72) Inventors: **Sunil Kumar Dhuper**, Old Westbury,
NY (US); **Greg Marler**, Rockford, IL
(US)

(73) Assignee: **Aeon Research and Technology, LLC**,
Hewlett, NY (US)

(21) Appl. No.: **13/747,095**

(22) Filed: **Jan. 22, 2013**

(57)

ABSTRACT

Related U.S. Application Data

(60) Provisional application No. 61/589,671, filed on Jan. 23, 2012, provisional application No. 61/610,828, filed on Mar. 14, 2012, provisional application No. 61/694,020, filed on Aug. 28, 2012.

A patient interface system for delivering a gas to a patient includes a patient interface device that includes at least one inhalation valve and at least one exhalation valve. The system also includes a venturi device that has at least one port for connection to a gas source. The venturi device has at least one primary air entrainment window and at least one secondary air entrainment window which is downstream of the at least one primary air entrainment window. The inhalation valve is disposed between: (1) the main body and (2) the primary and secondary air entrainment windows of the venturi device. At least one of the primary air entrainment window and secondary air entrainment window includes a means for closing the respective window, thereby changing a degree at which the respective window is open and changing a flow rate of the air flowing through the respective window.

Publication Classification

(51) **Int. Cl.**

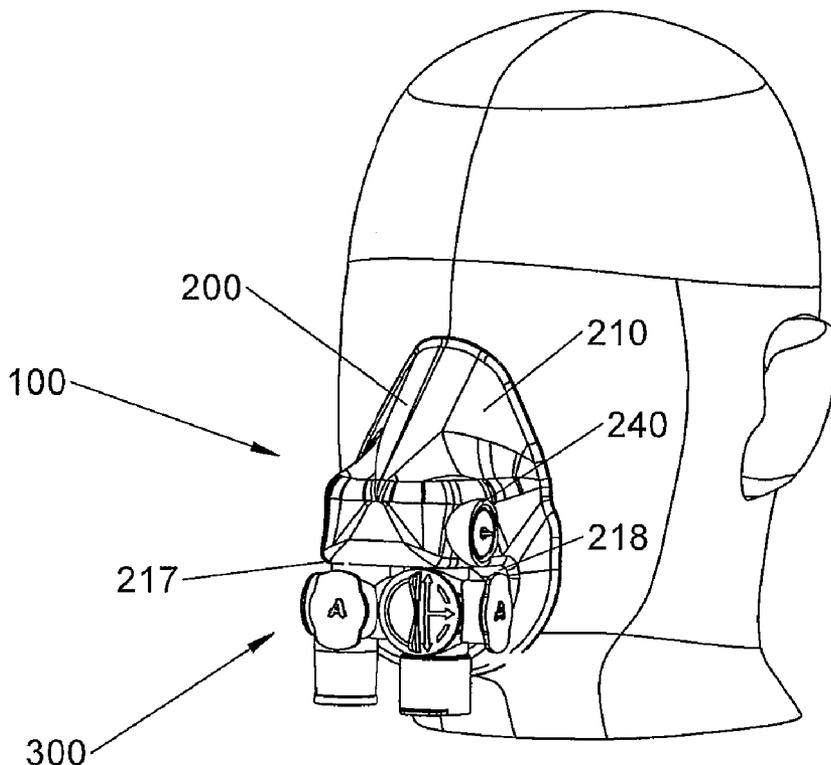
A61M 16/06 (2006.01)

A61M 16/00 (2006.01)

A61M 16/20 (2006.01)

A61M 16/08 (2006.01)

A61M 15/00 (2006.01)



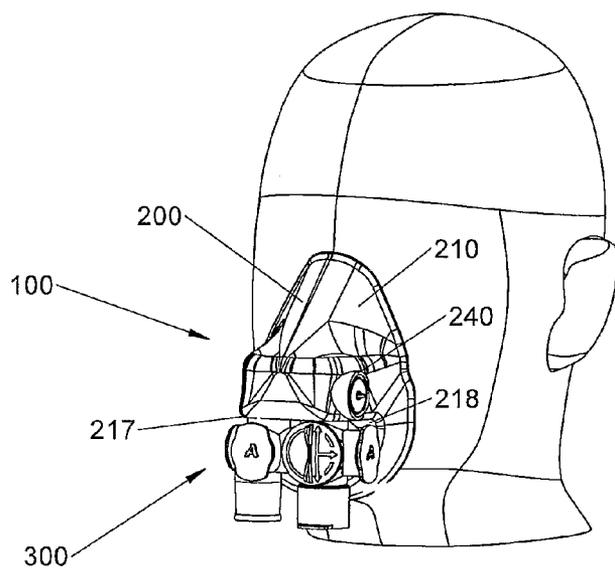


FIG. 1

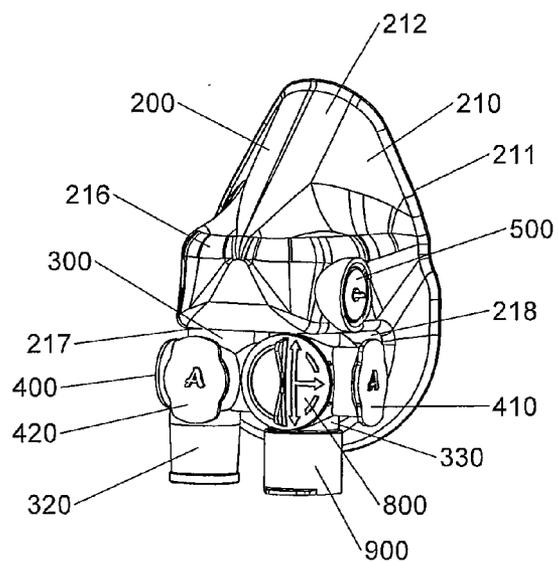


FIG. 2

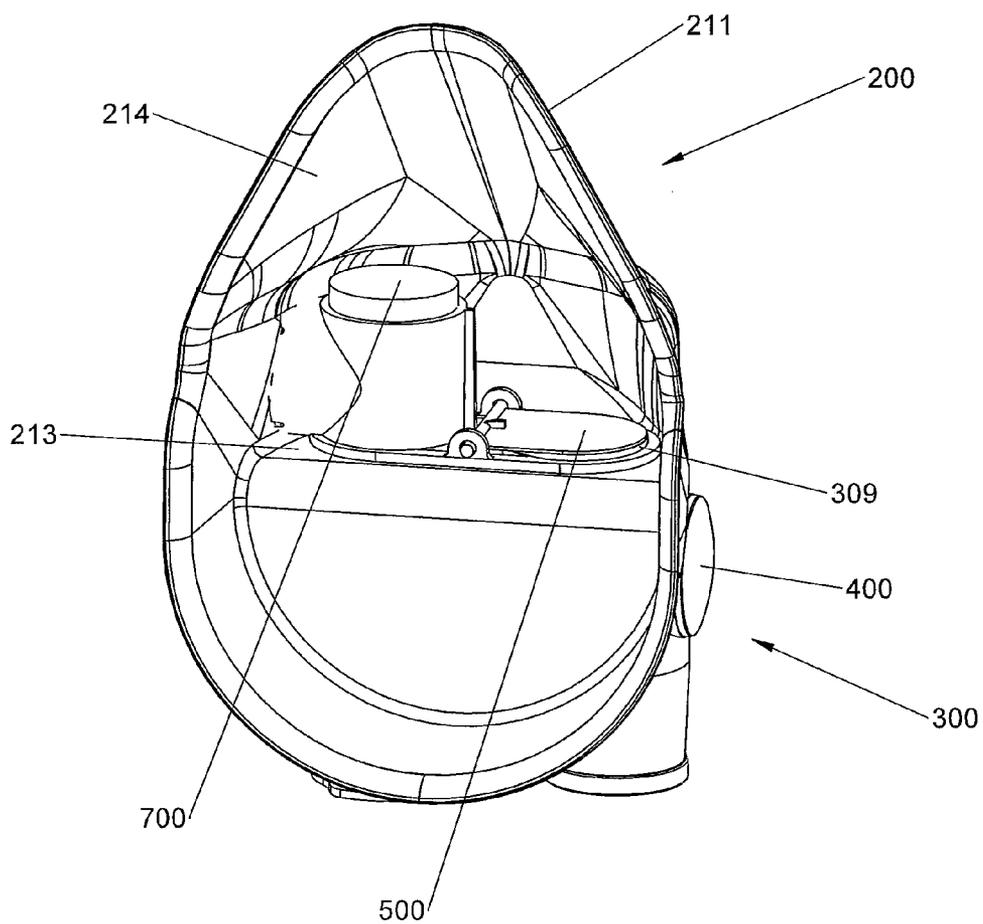
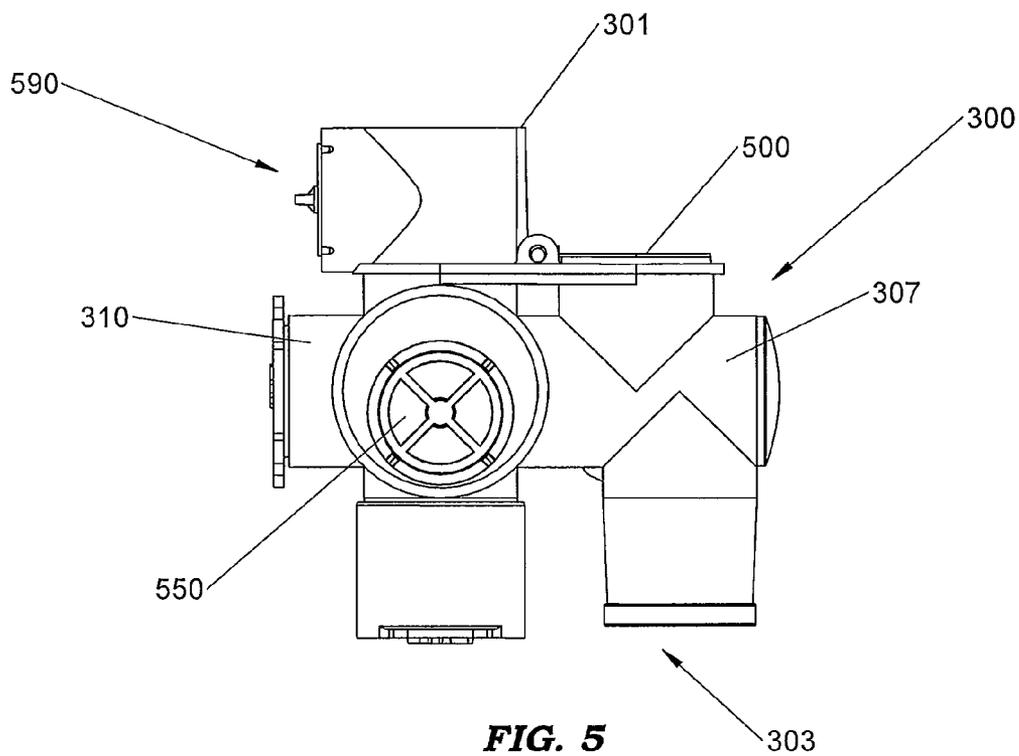
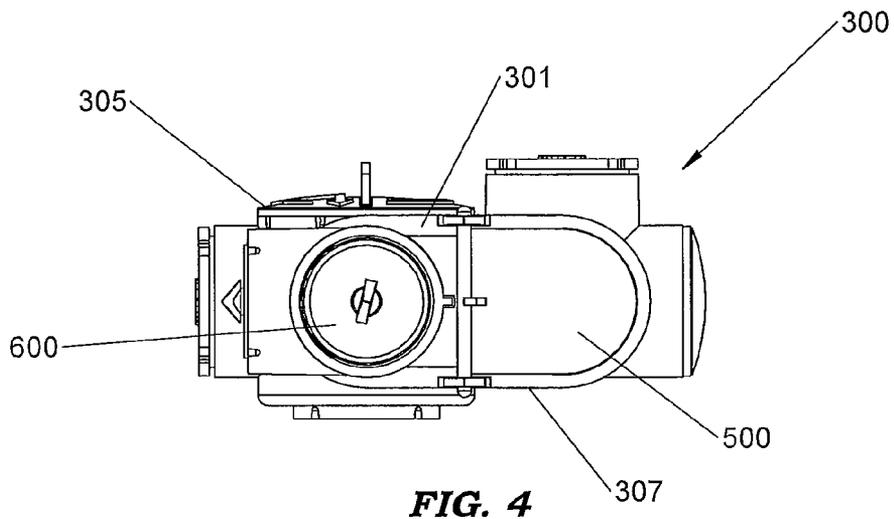


FIG. 3



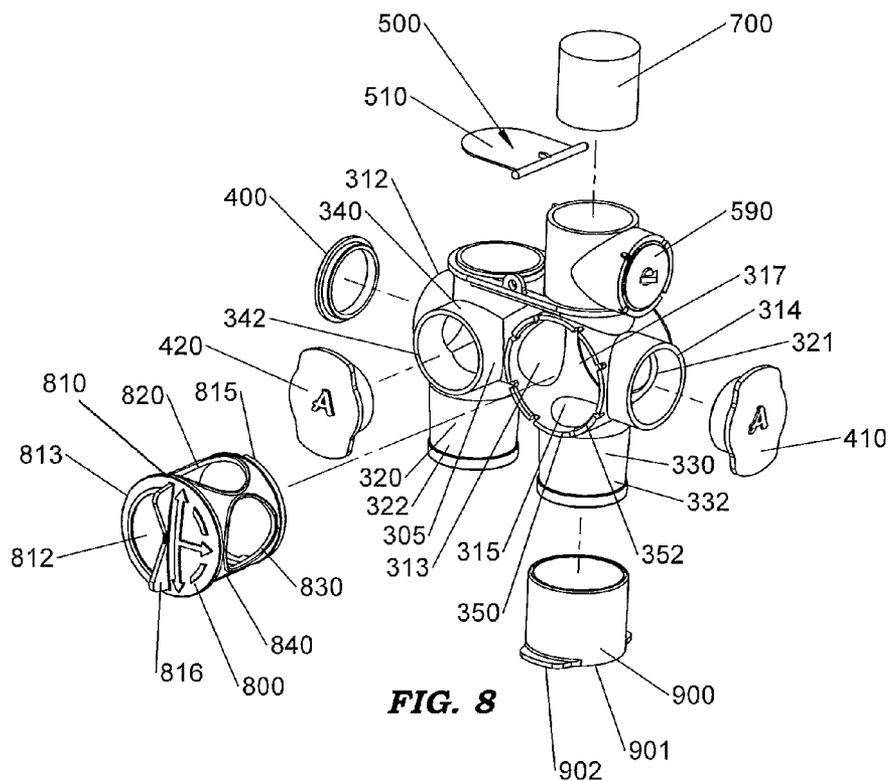


FIG. 8

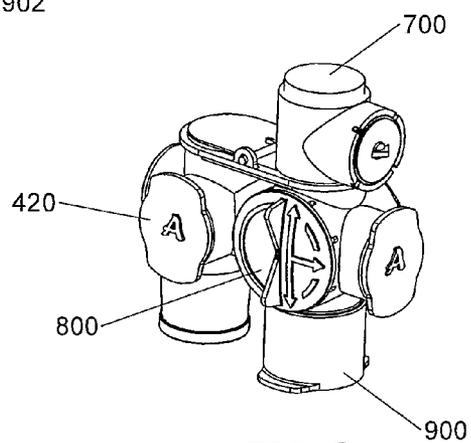
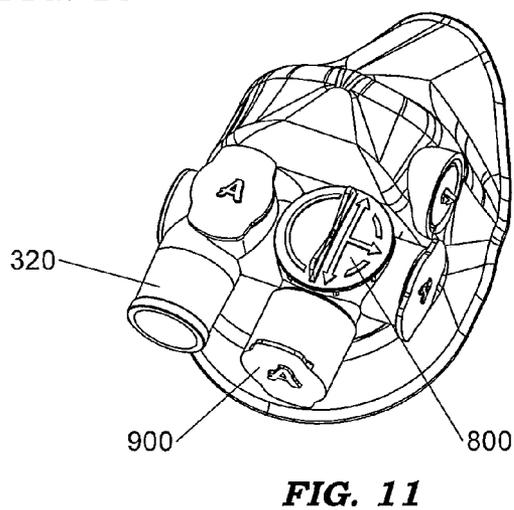
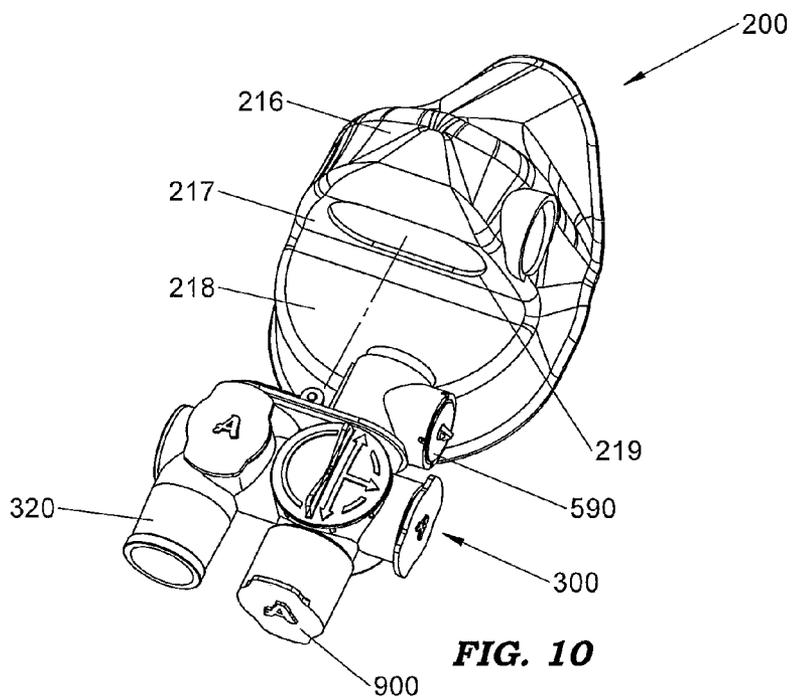


FIG. 9



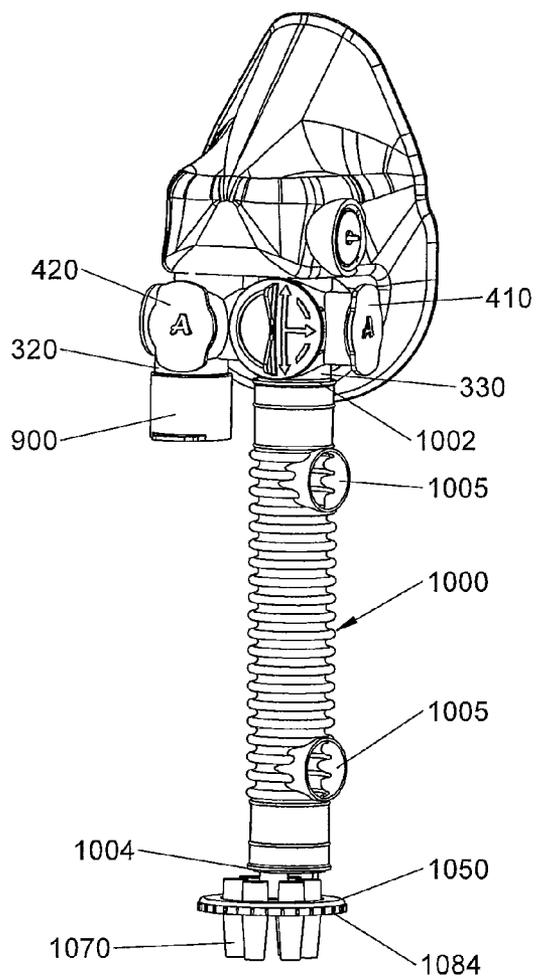


FIG. 12

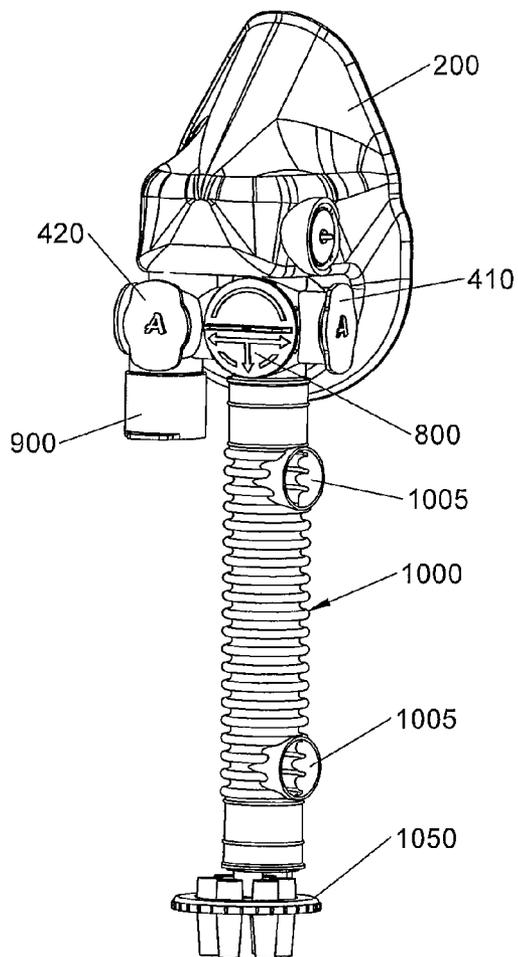


FIG. 13

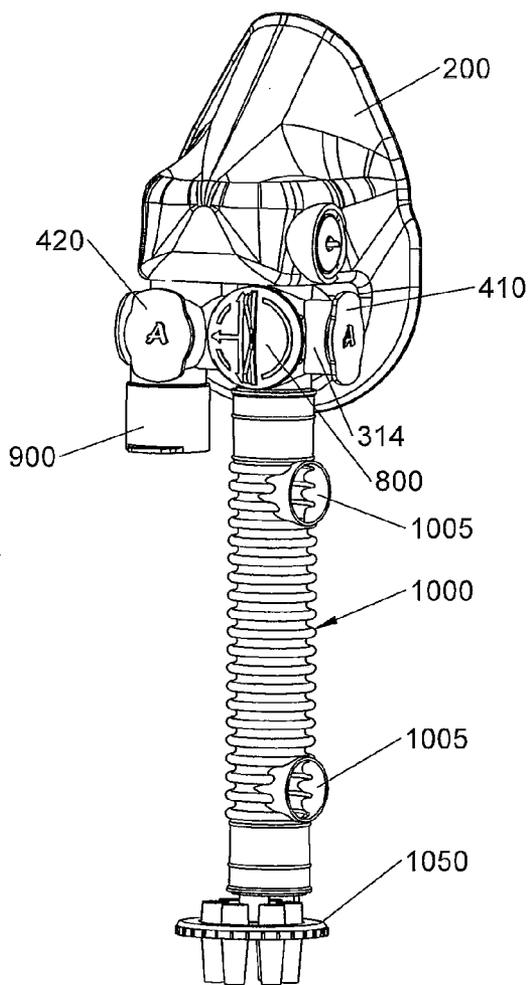


FIG. 14

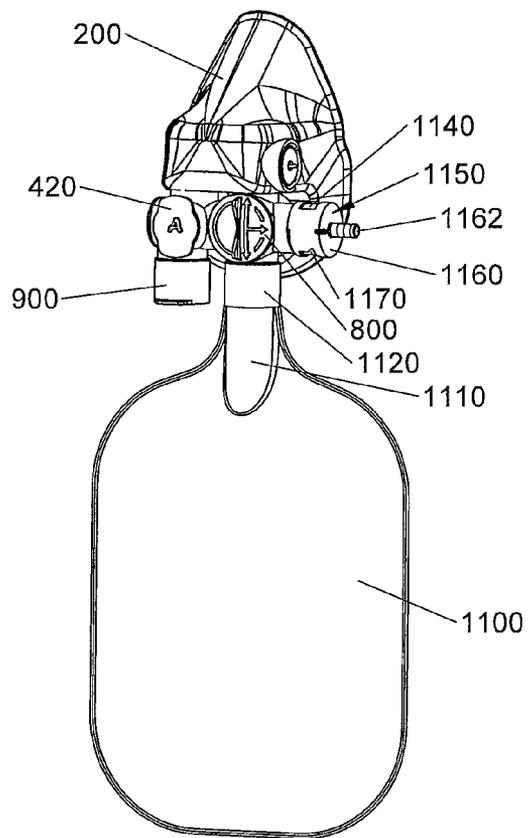


FIG. 15

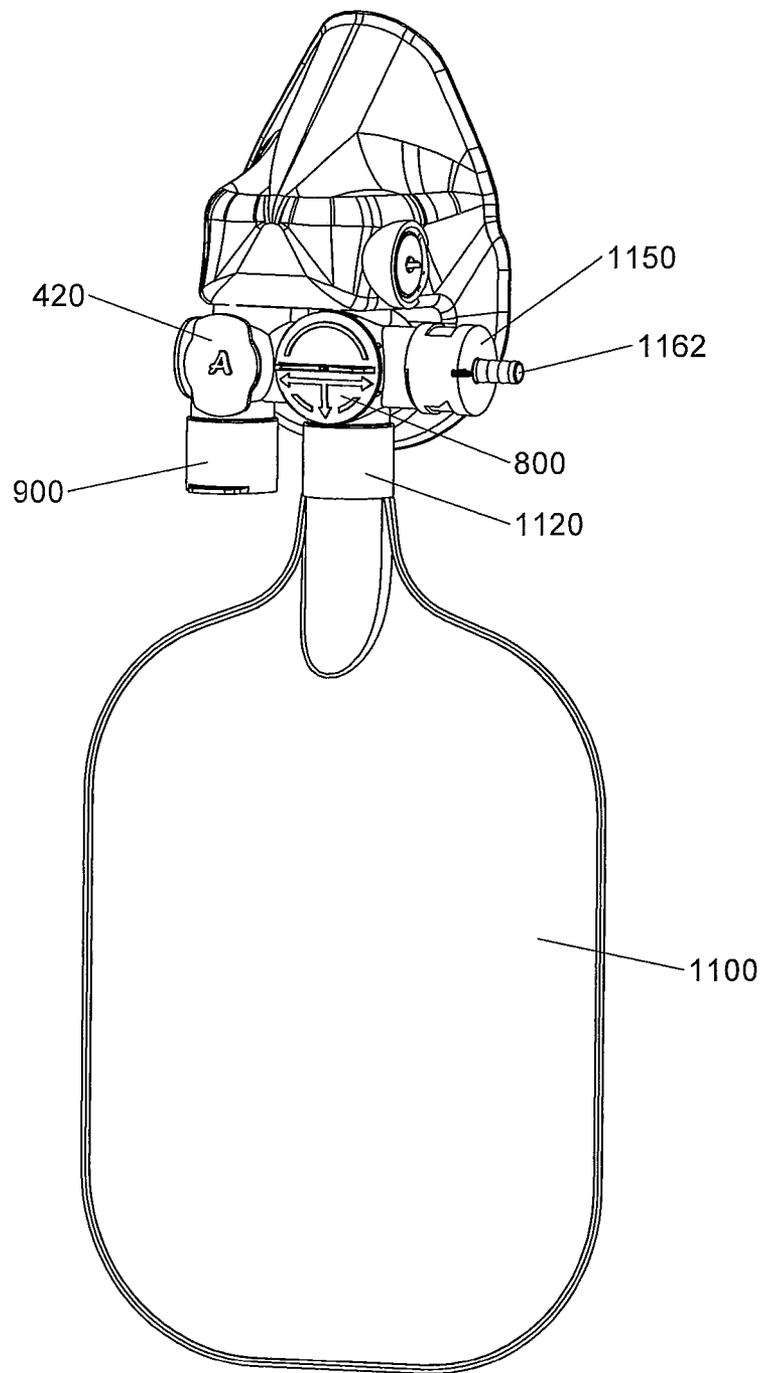


FIG. 16

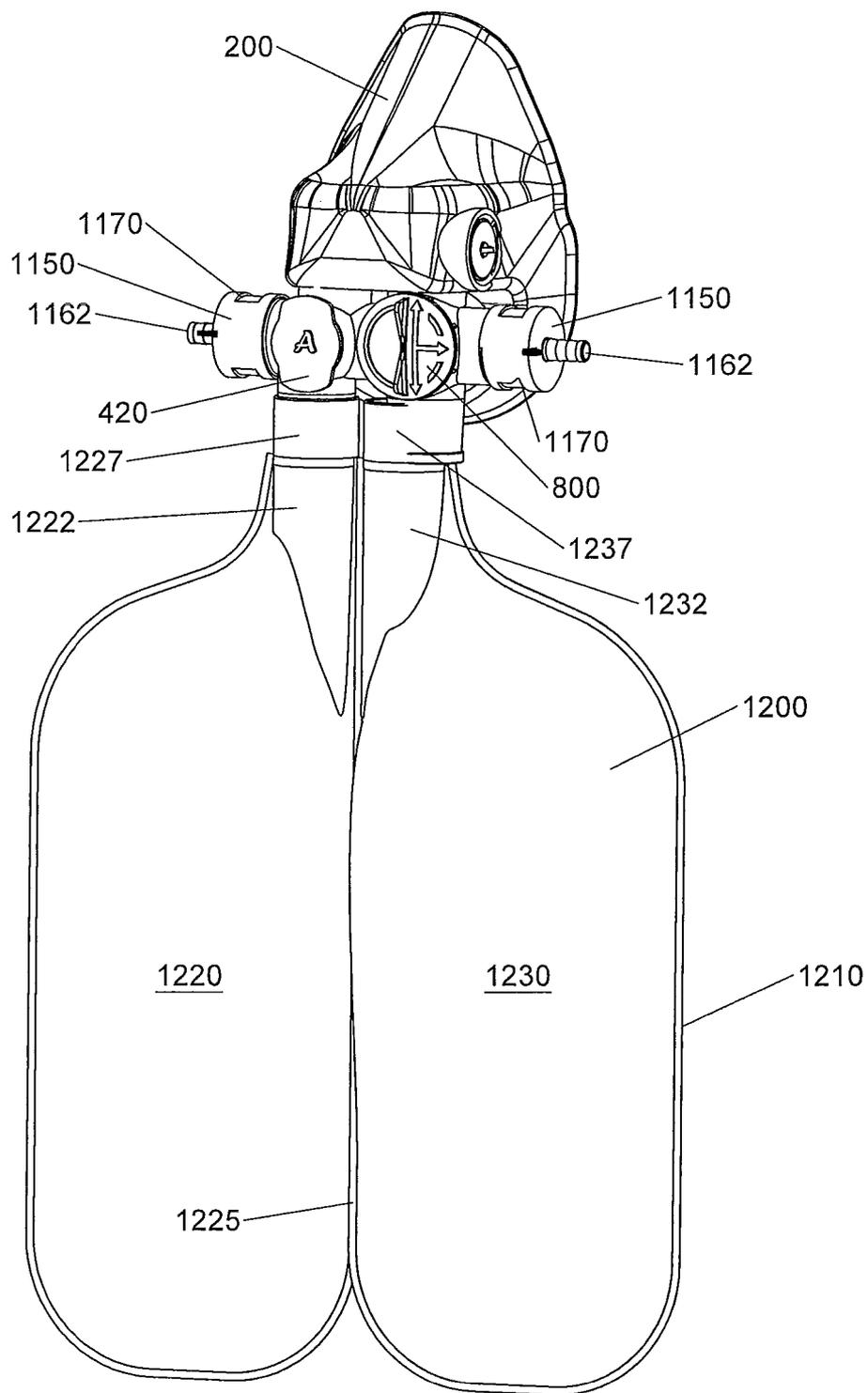


FIG. 17

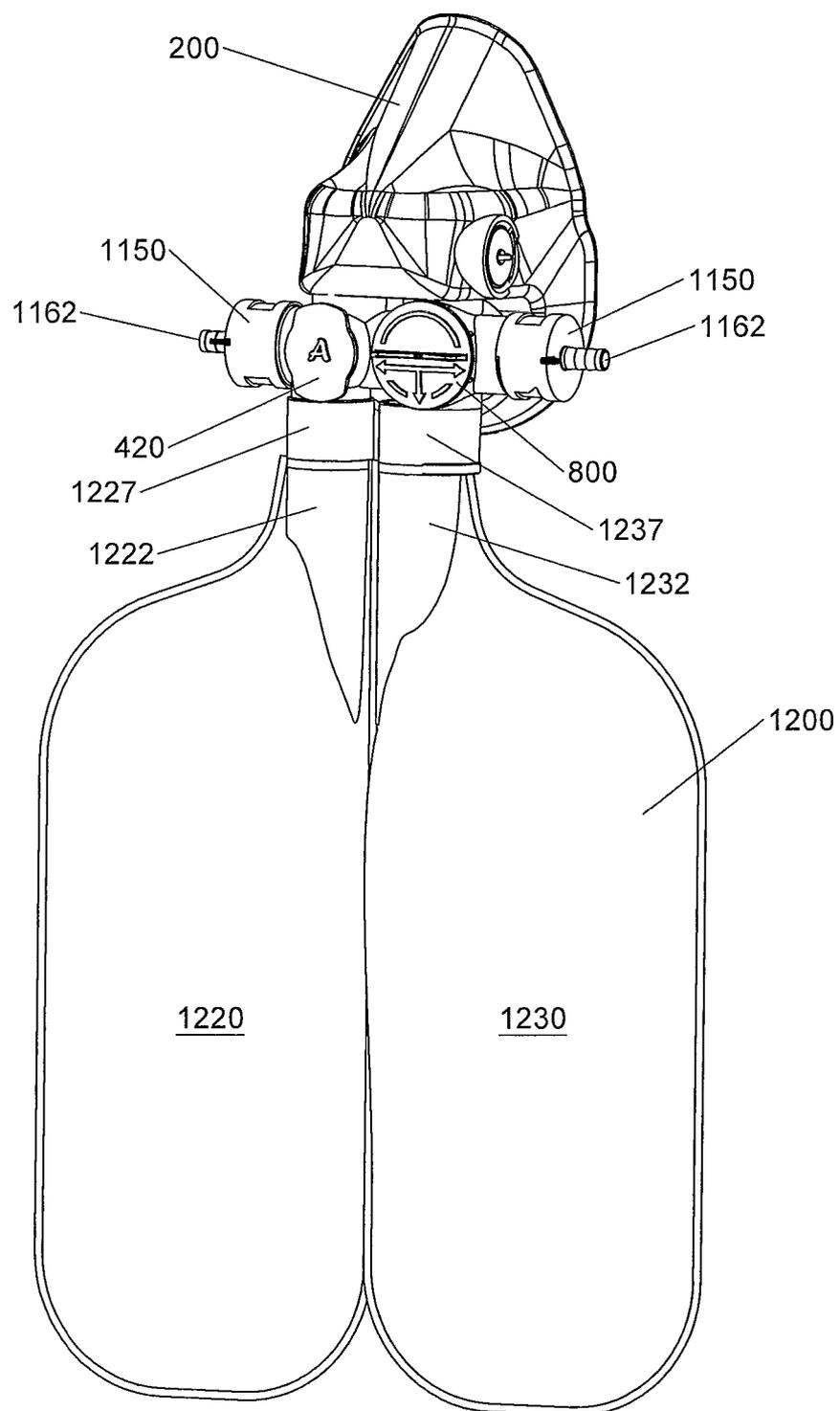


FIG. 18

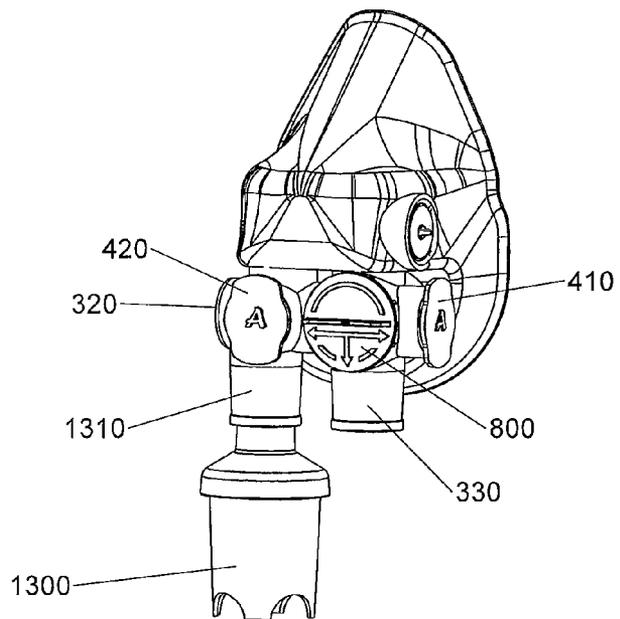


FIG. 19

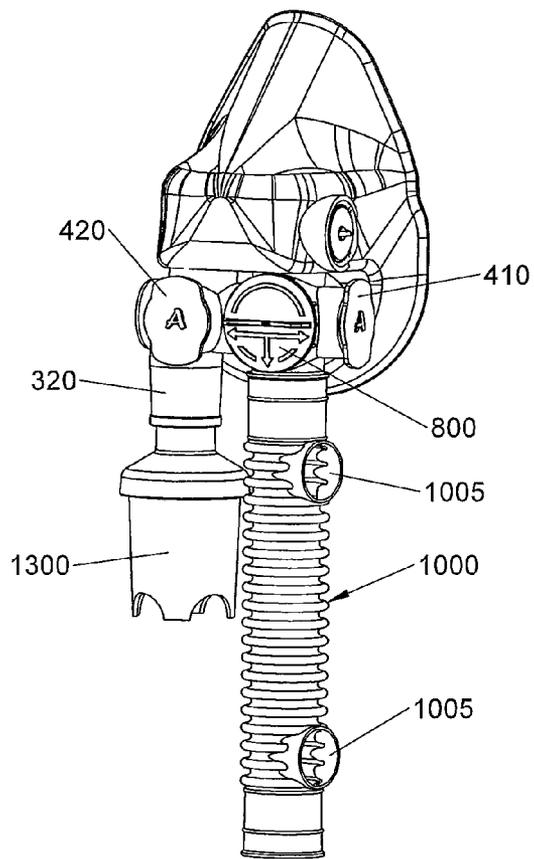


FIG. 20

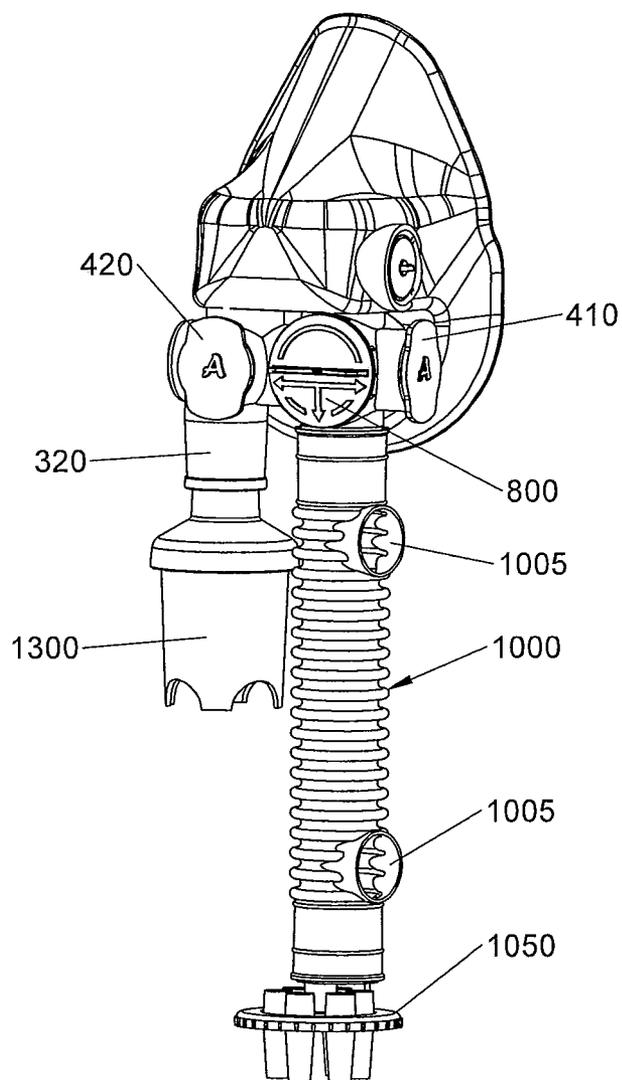


FIG. 21

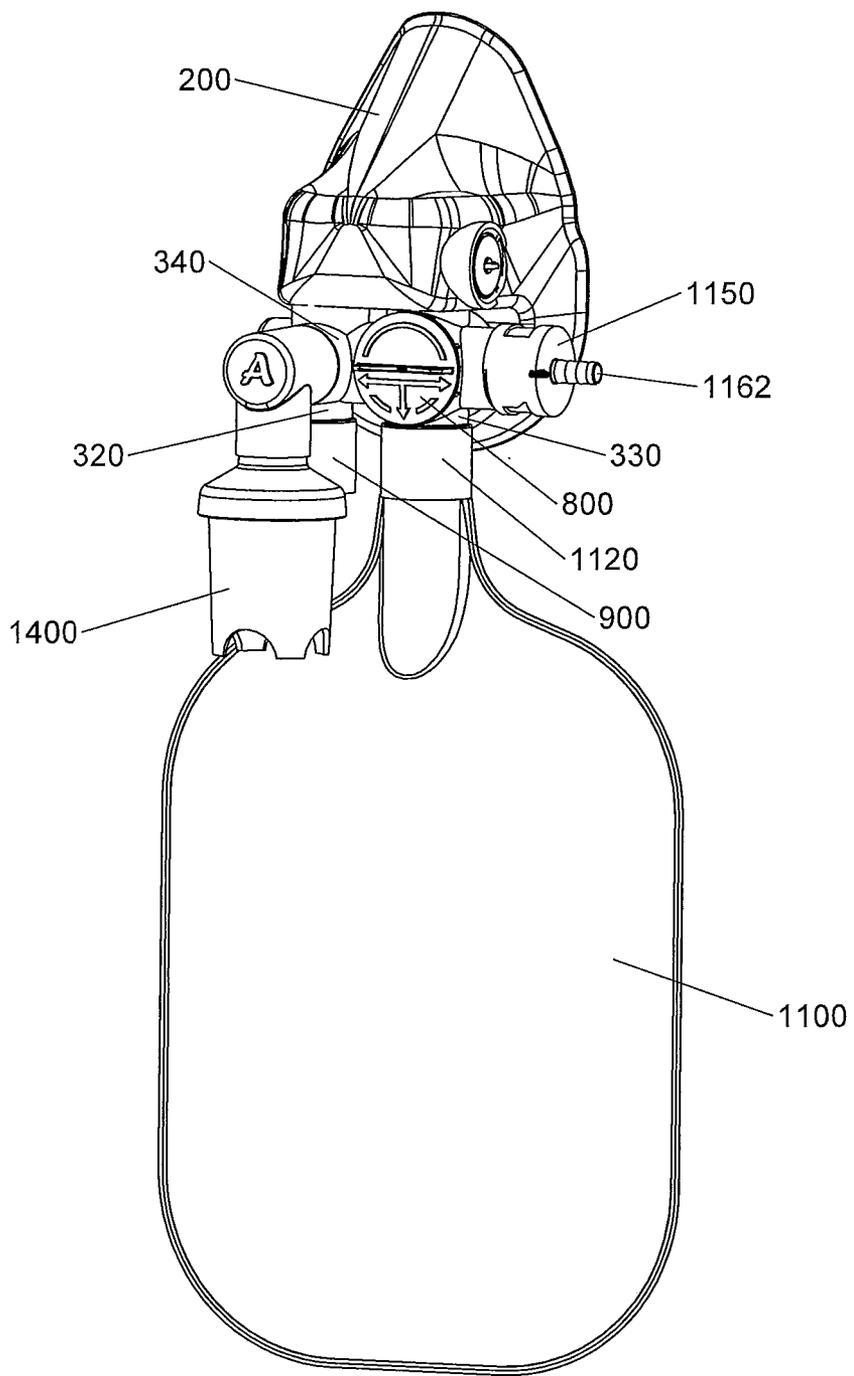


FIG. 22

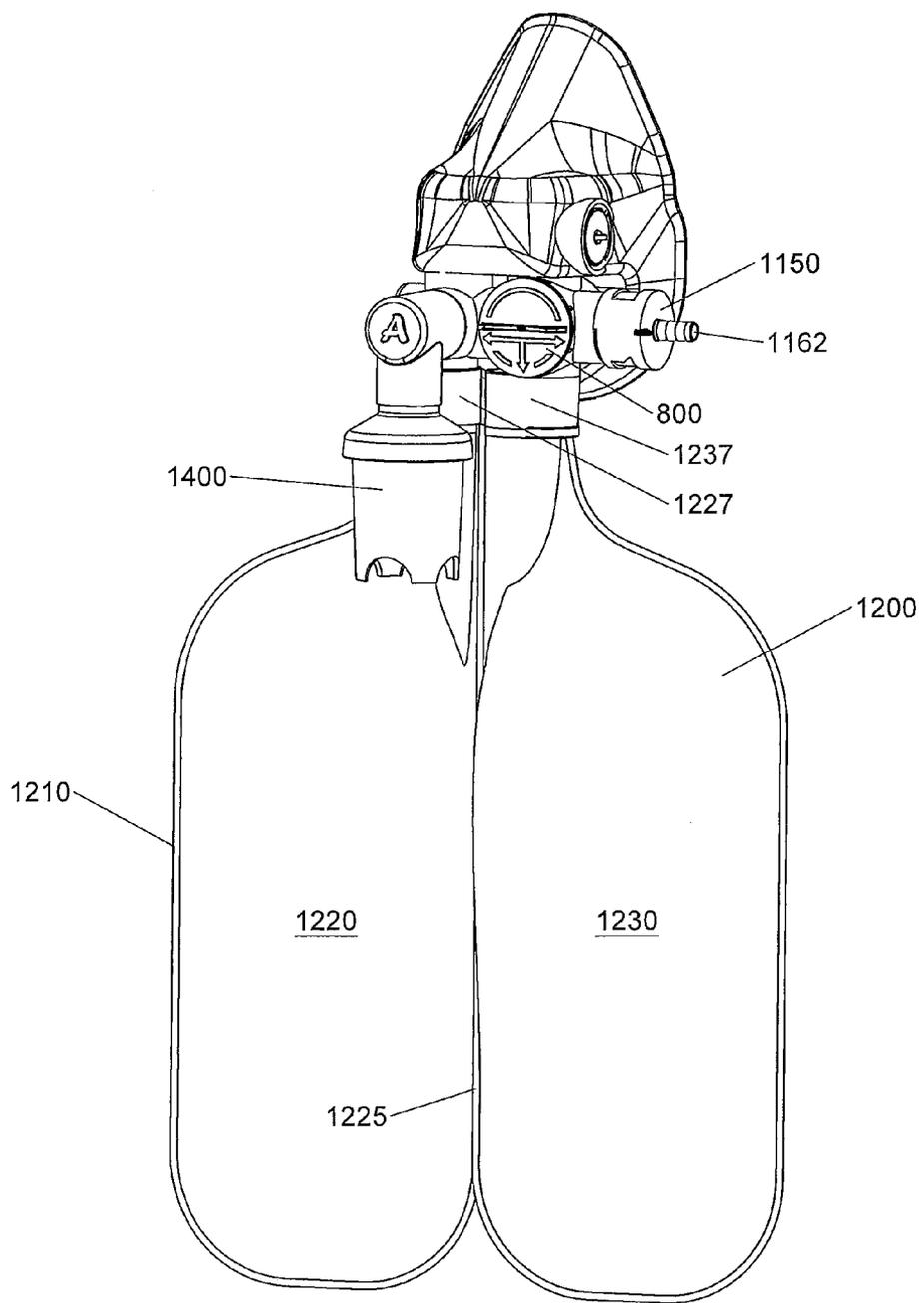


FIG. 23

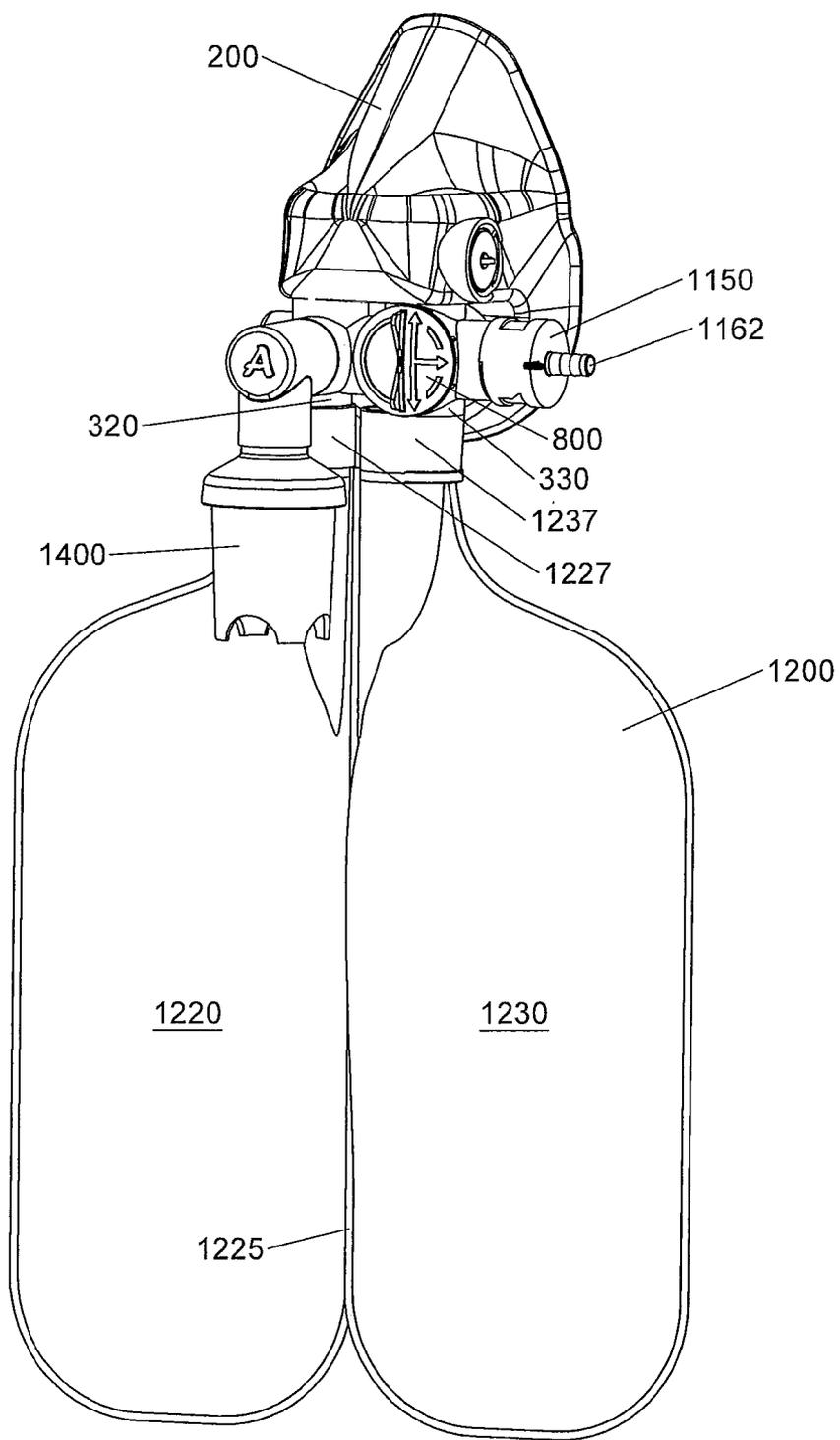


FIG. 24

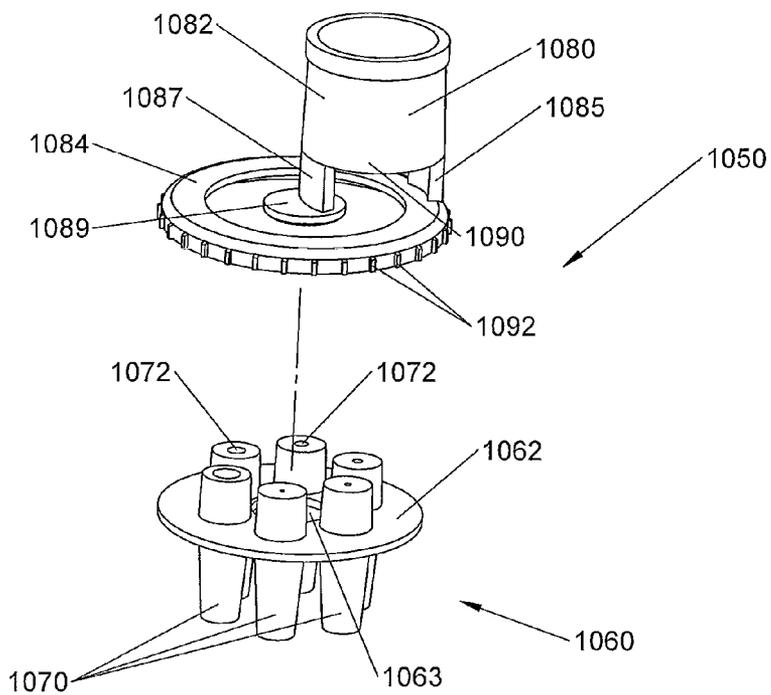


FIG. 25A

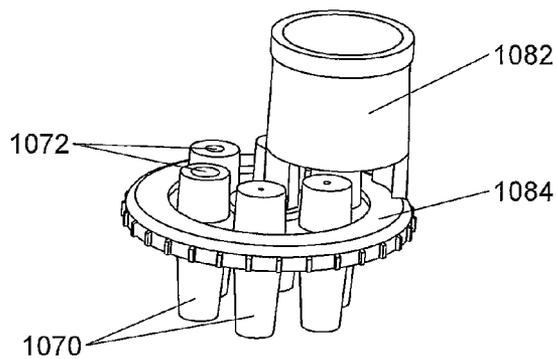


FIG. 25B

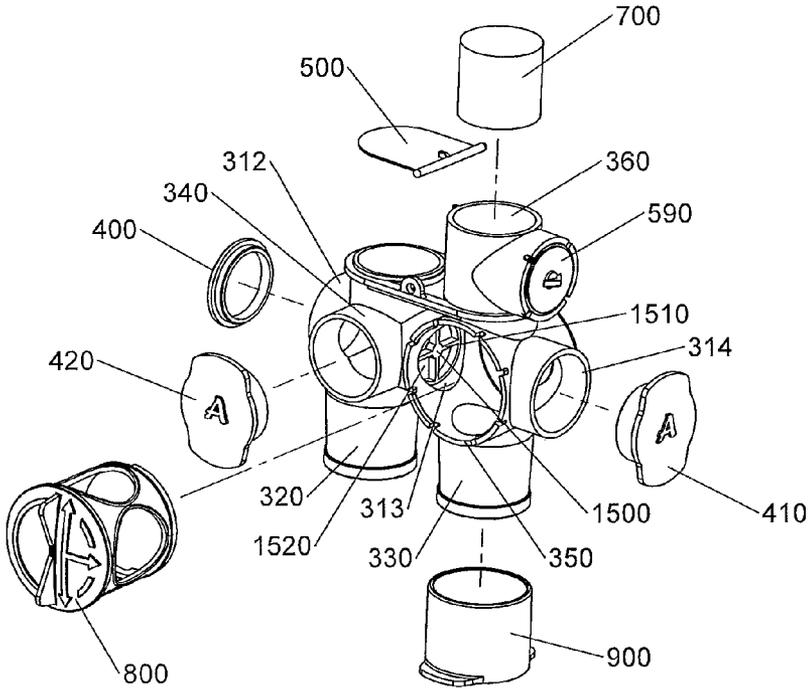


FIG. 26

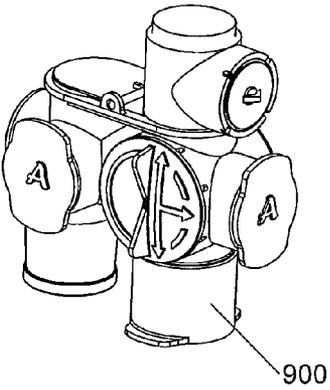


FIG. 27

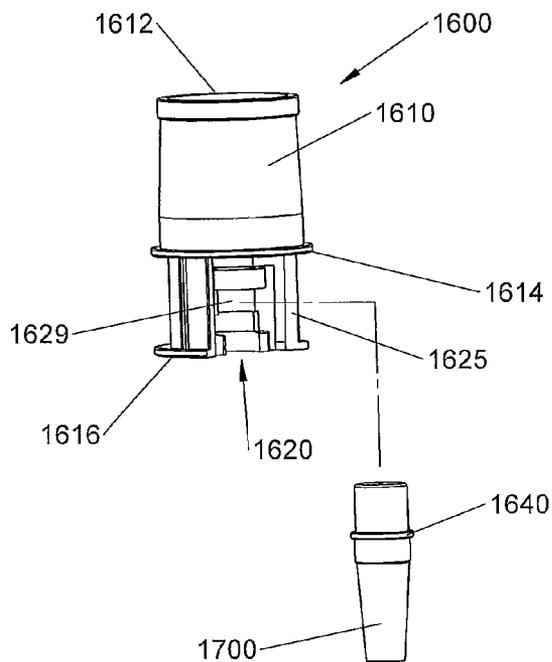


FIG. 28

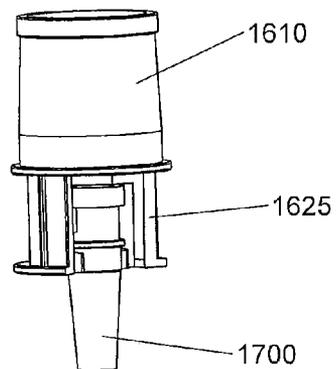


FIG. 29

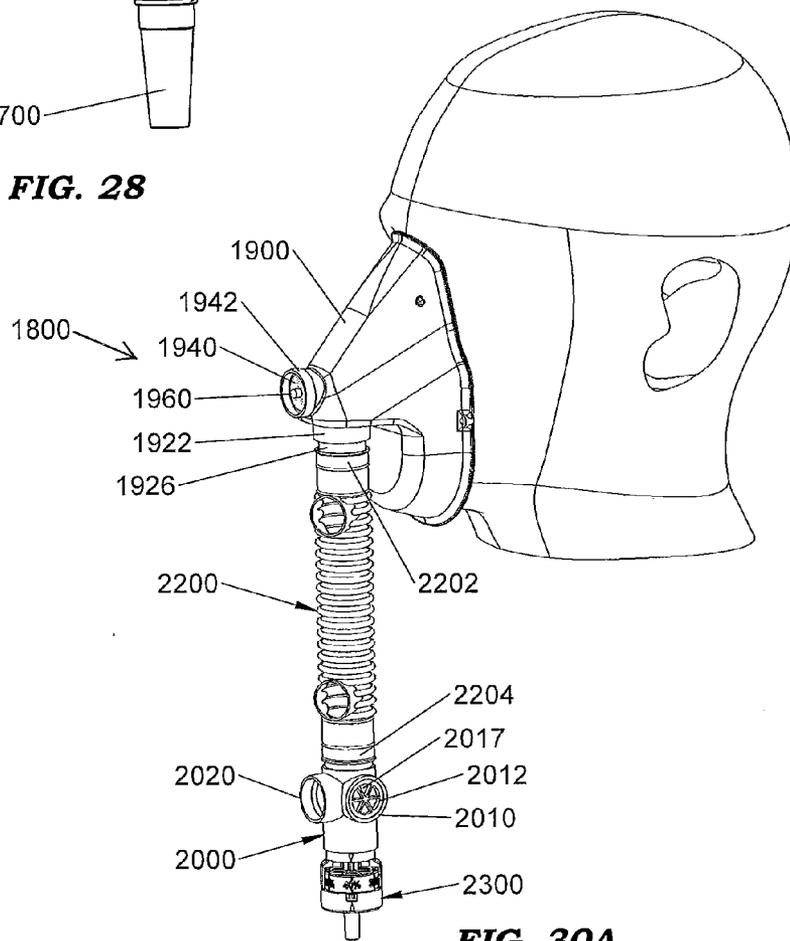


FIG. 30A

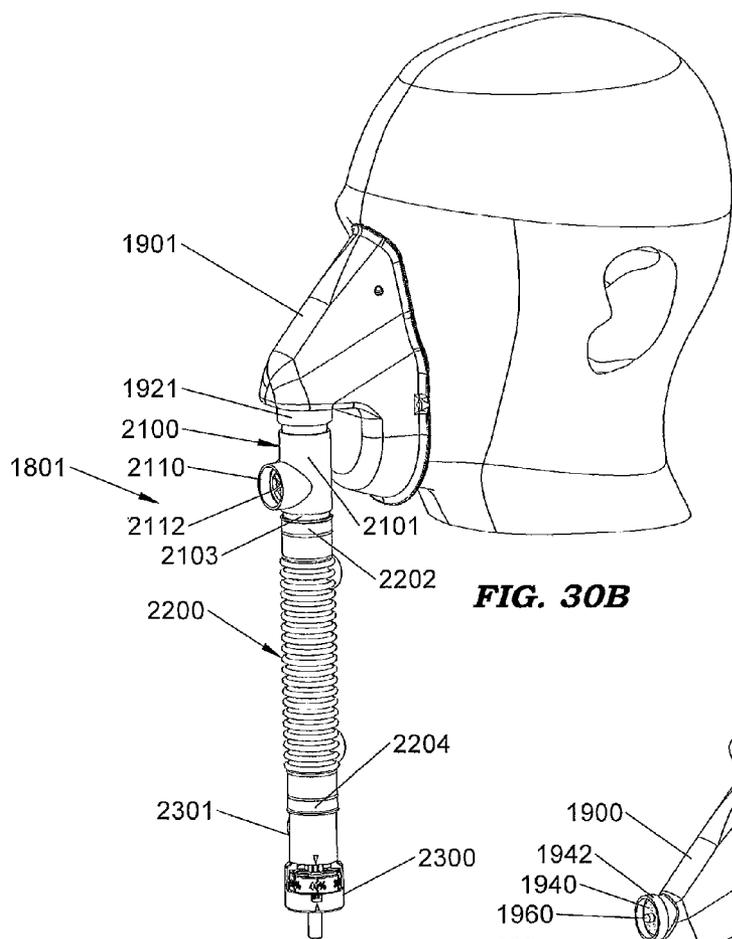


FIG. 30B

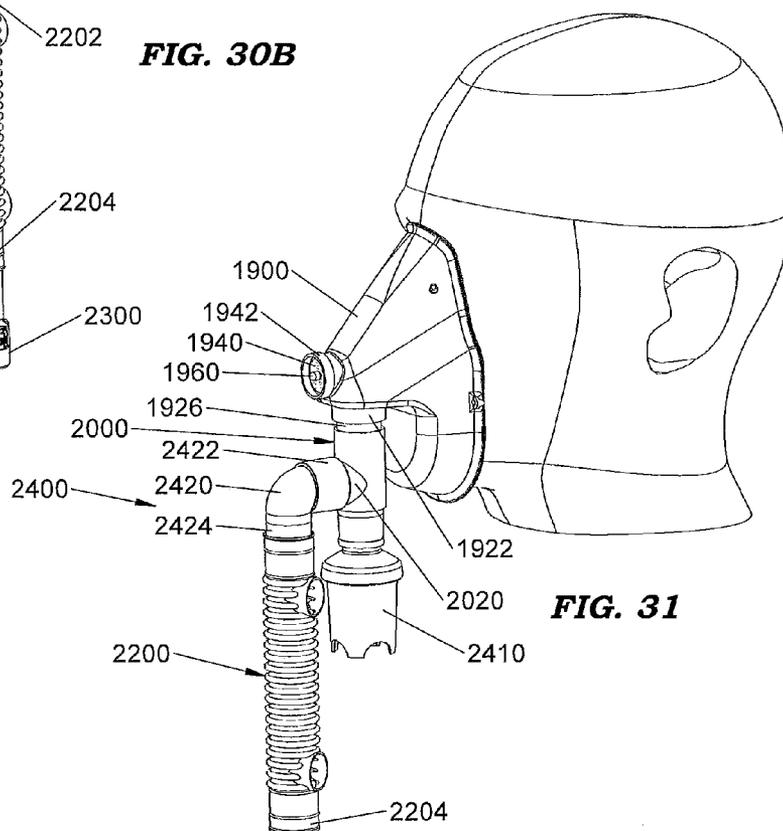


FIG. 31

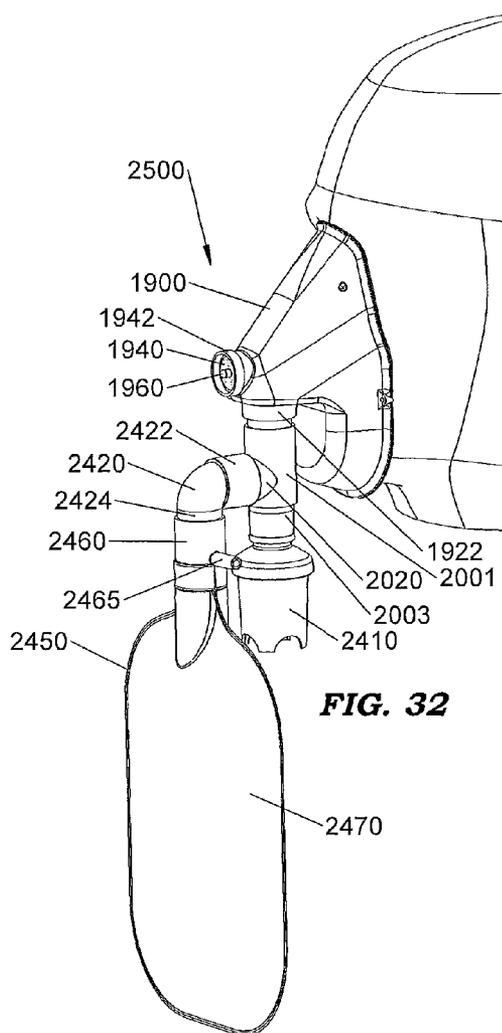


FIG. 32

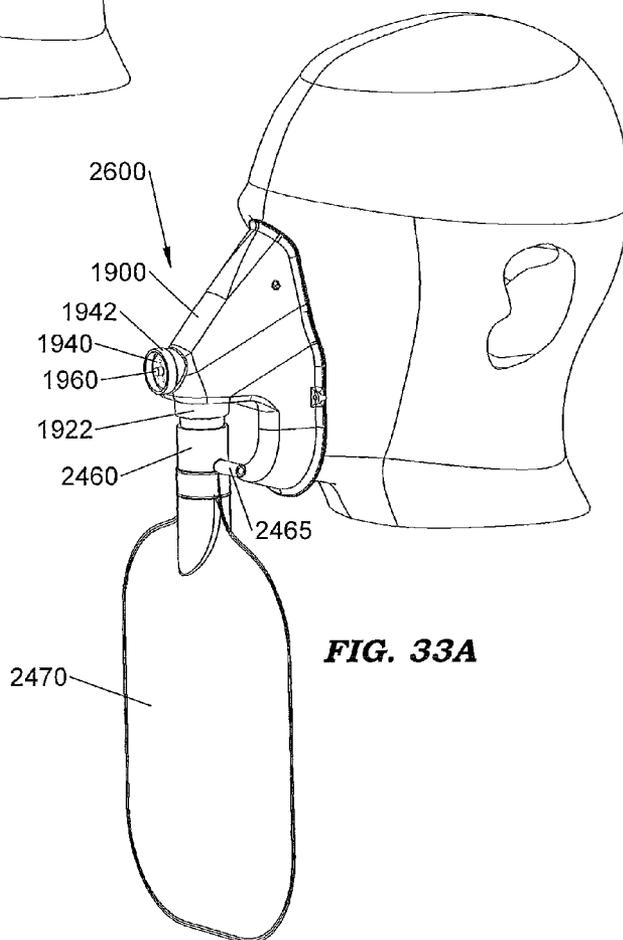


FIG. 33A

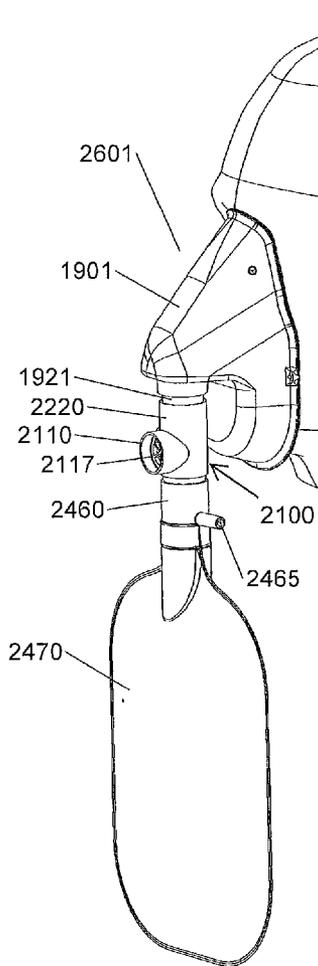


FIG. 33B

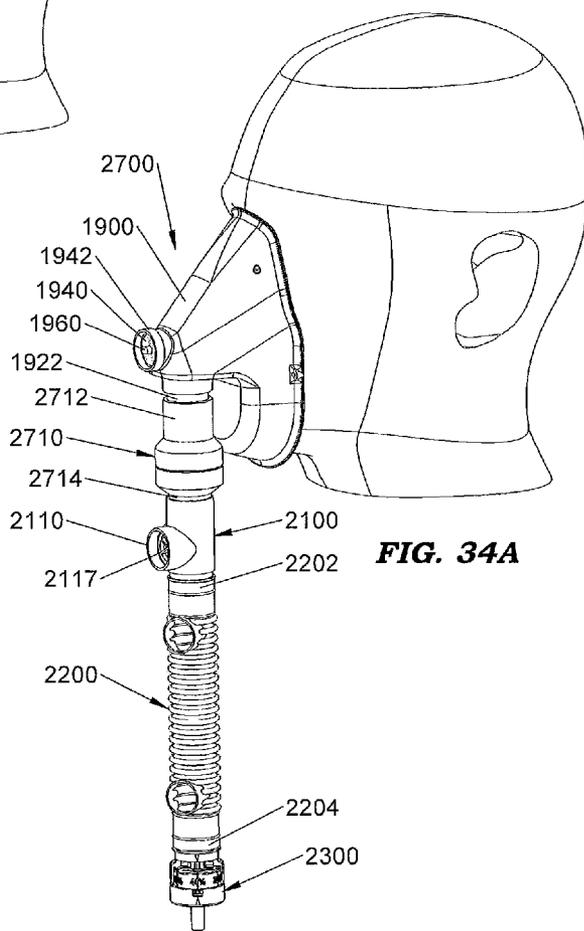


FIG. 34A

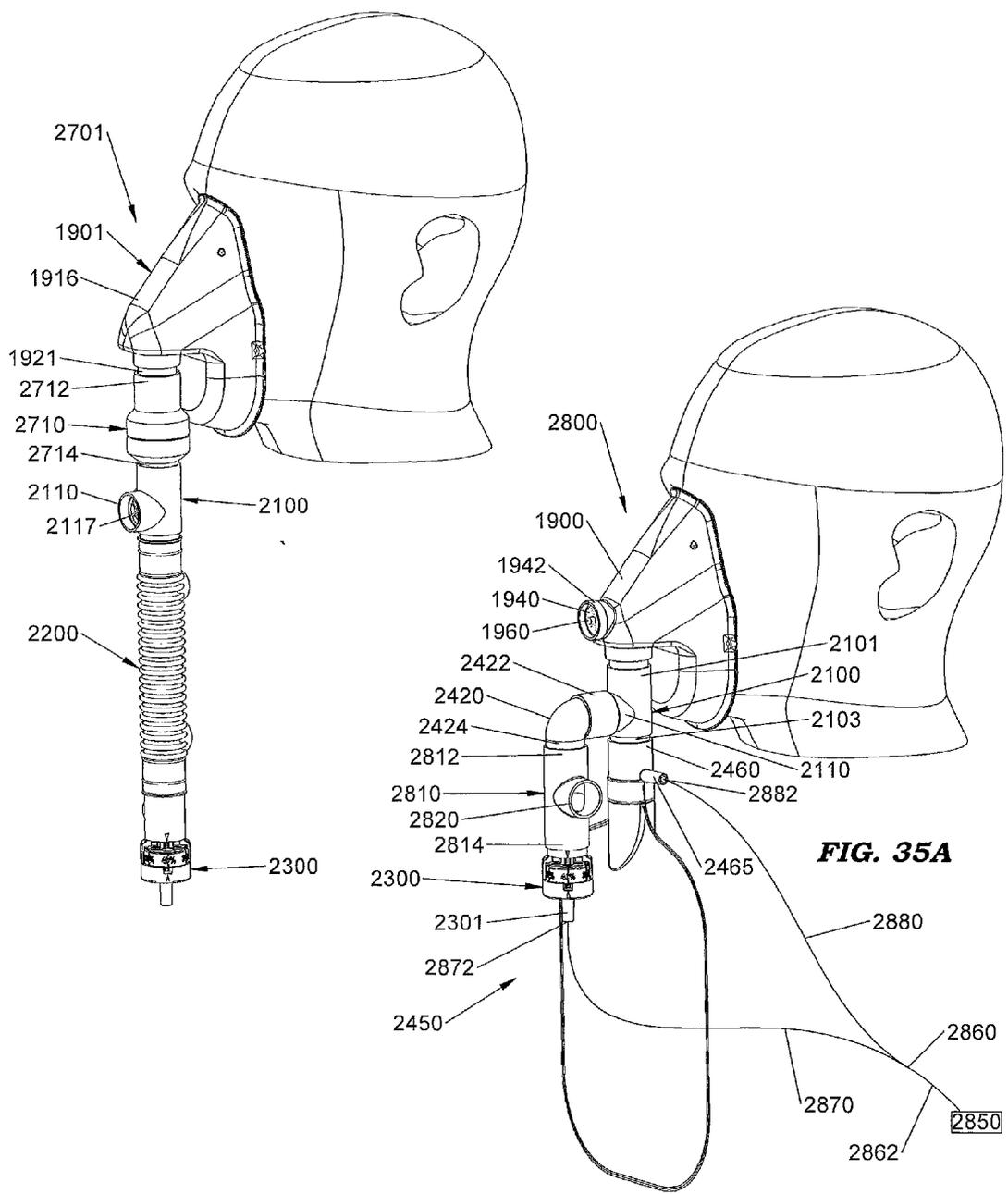
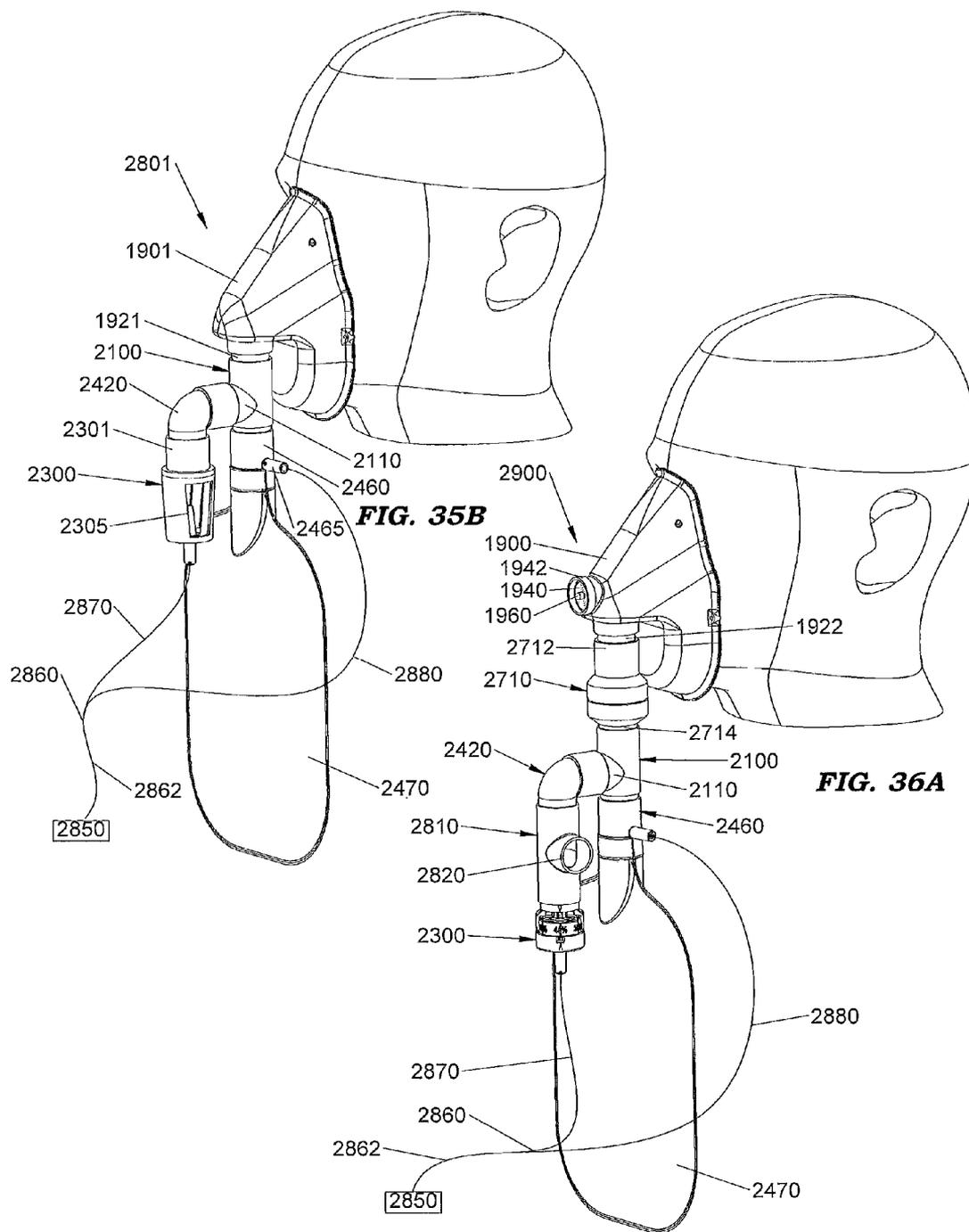
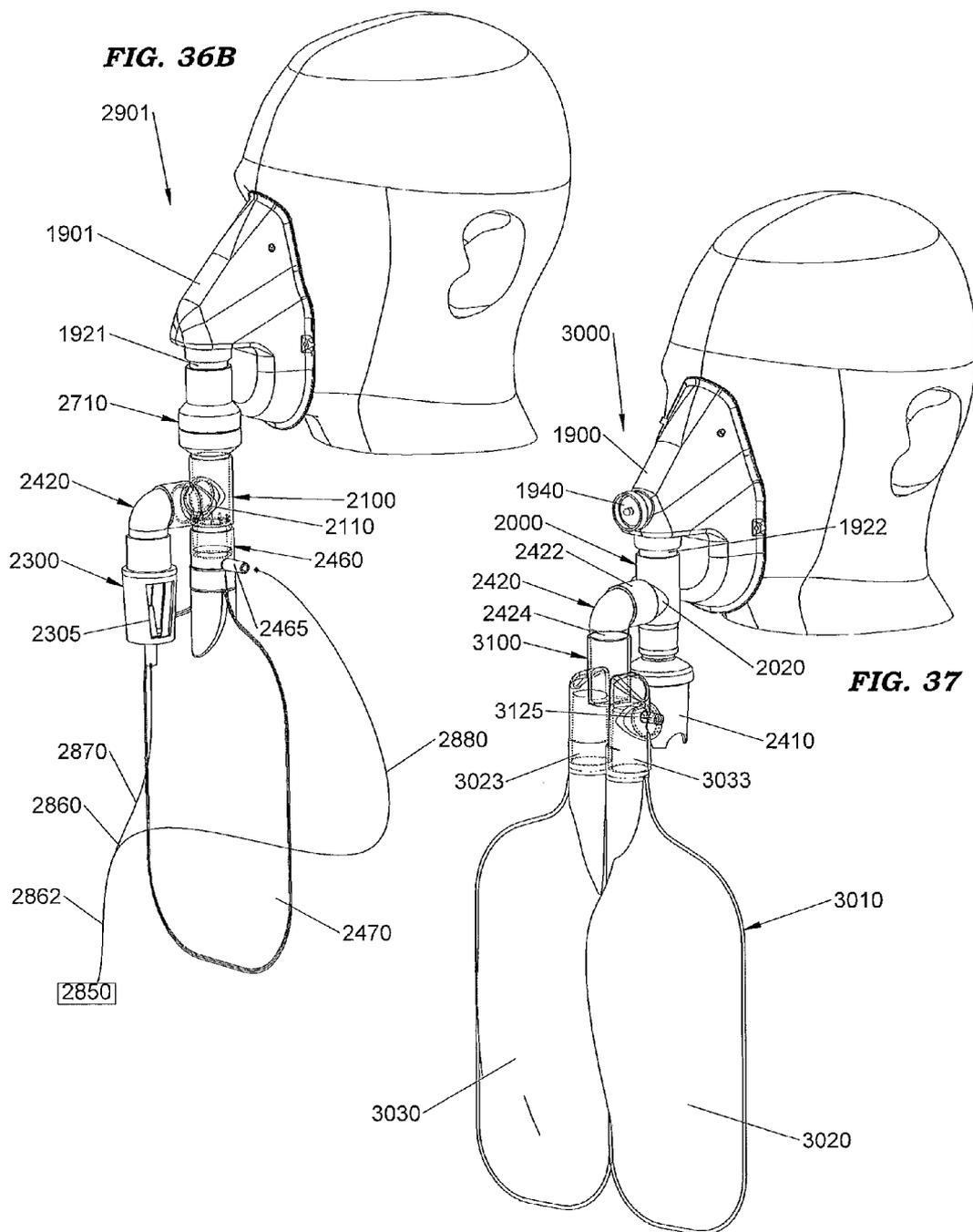


FIG. 35A





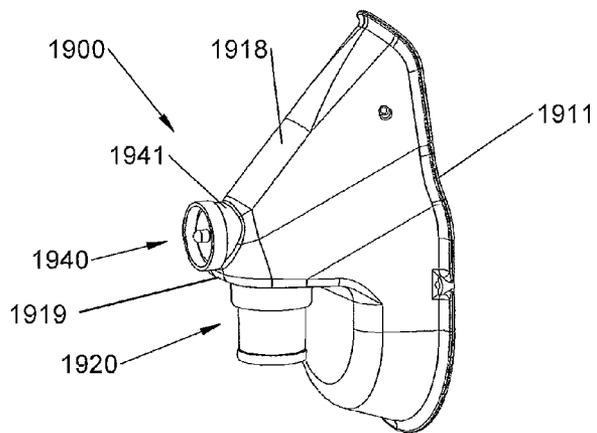


FIG. 38B

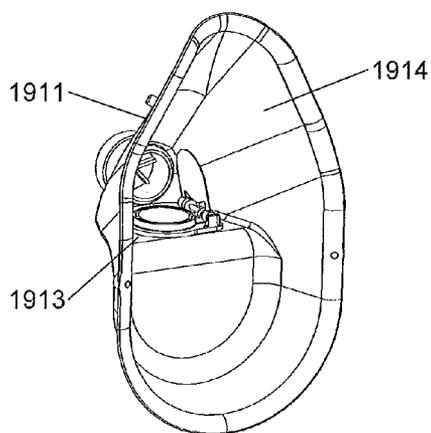


FIG. 38C

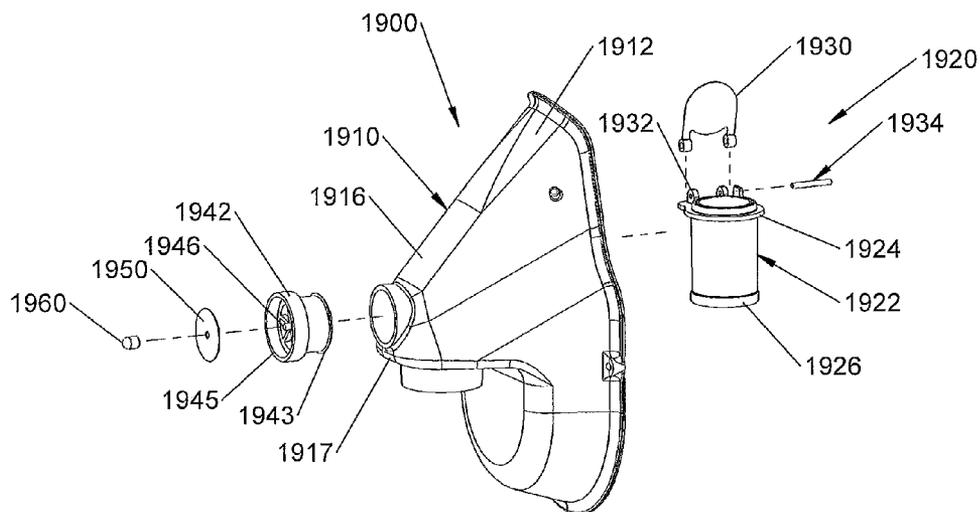


FIG. 38A

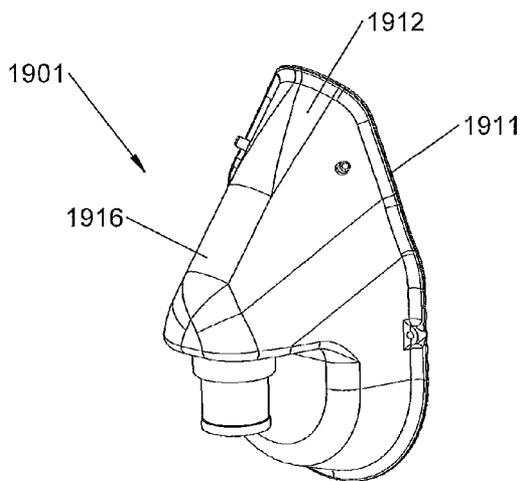


FIG. 38E

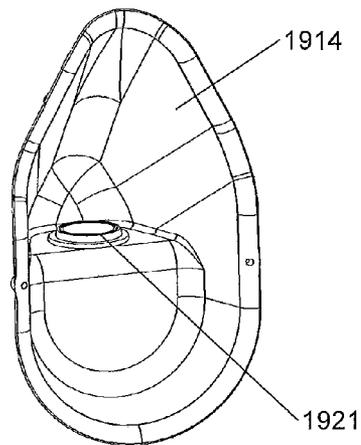


FIG. 38F

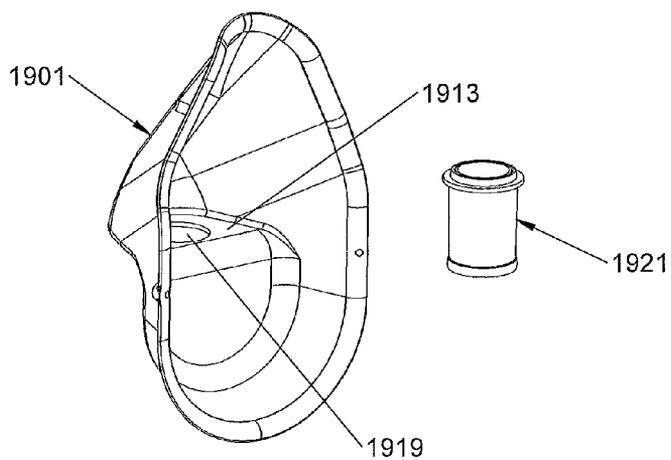


FIG. 38D

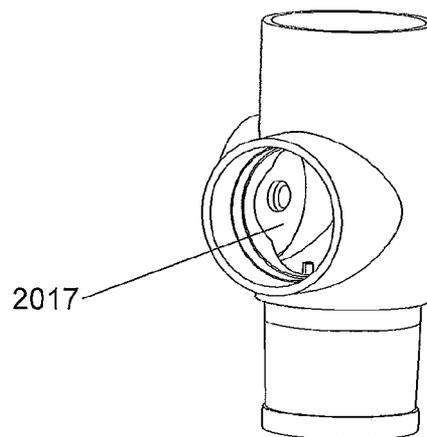


FIG. 39B

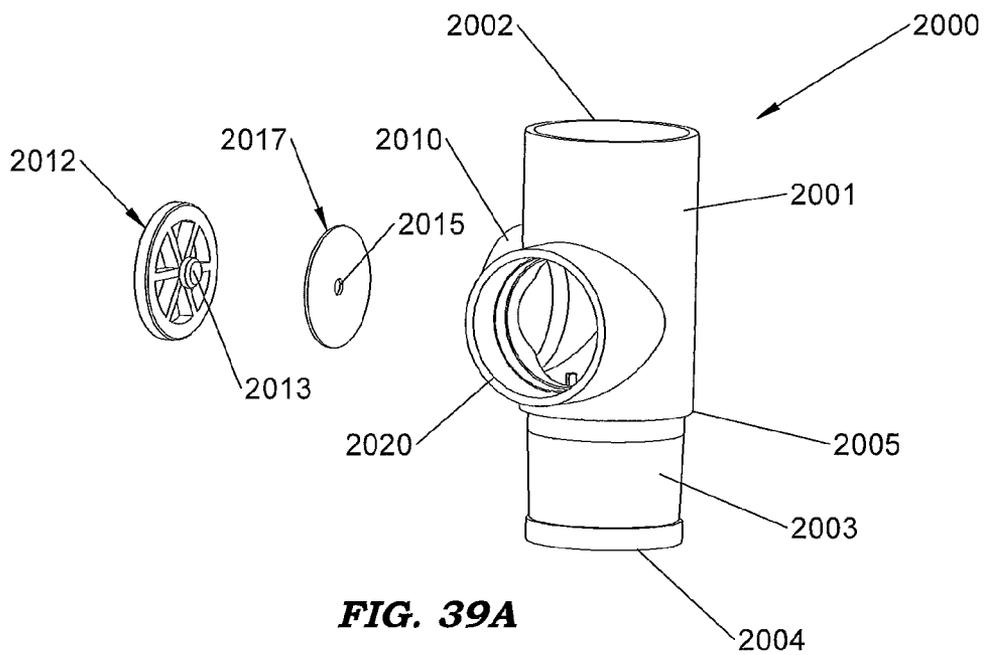


FIG. 39A

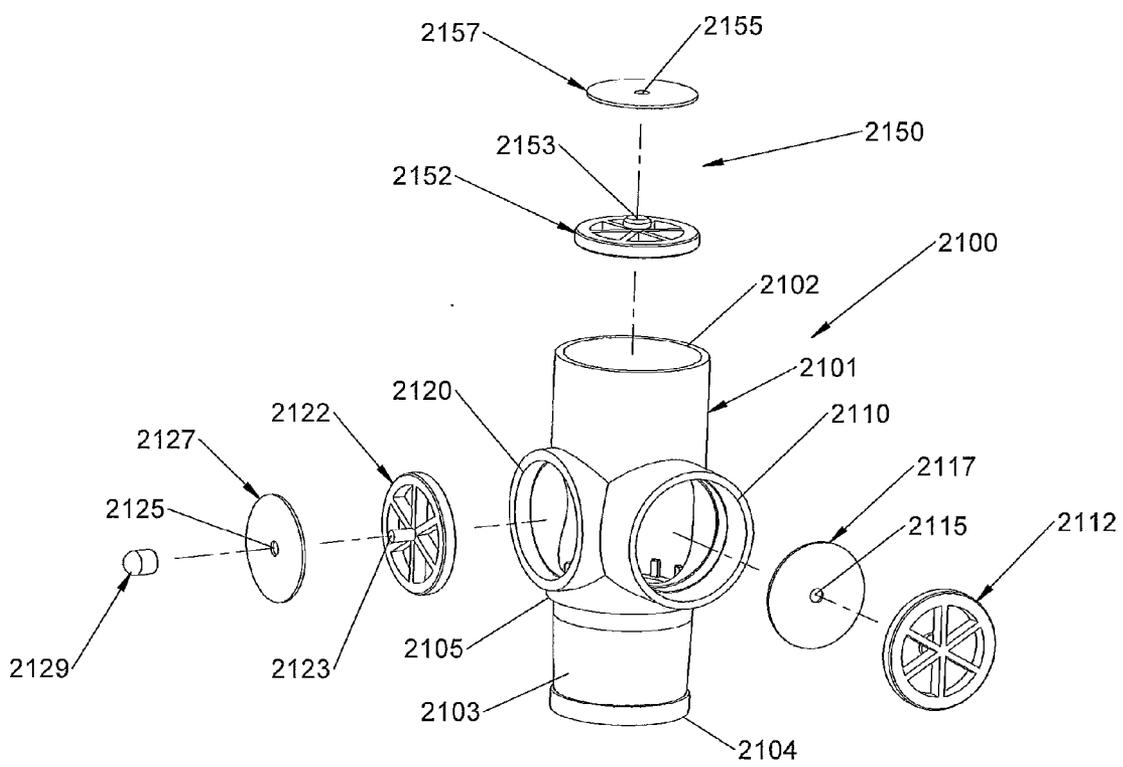


FIG. 40

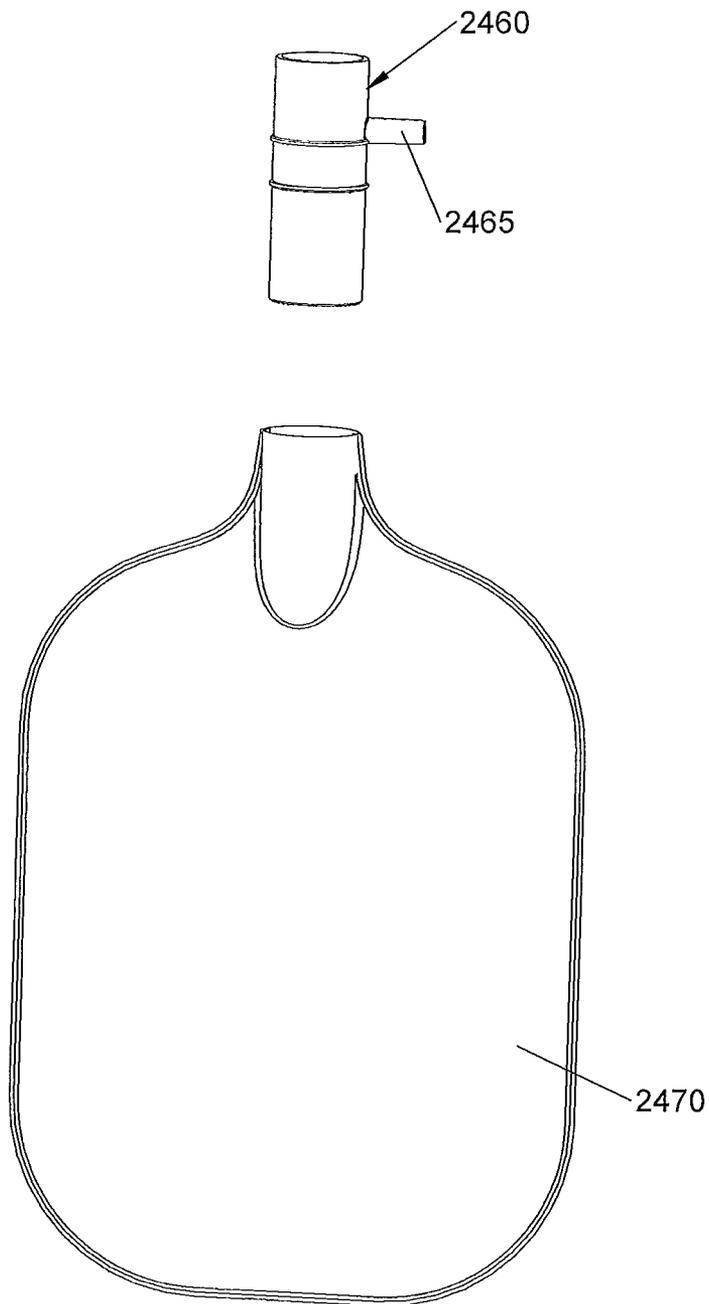


FIG. 41

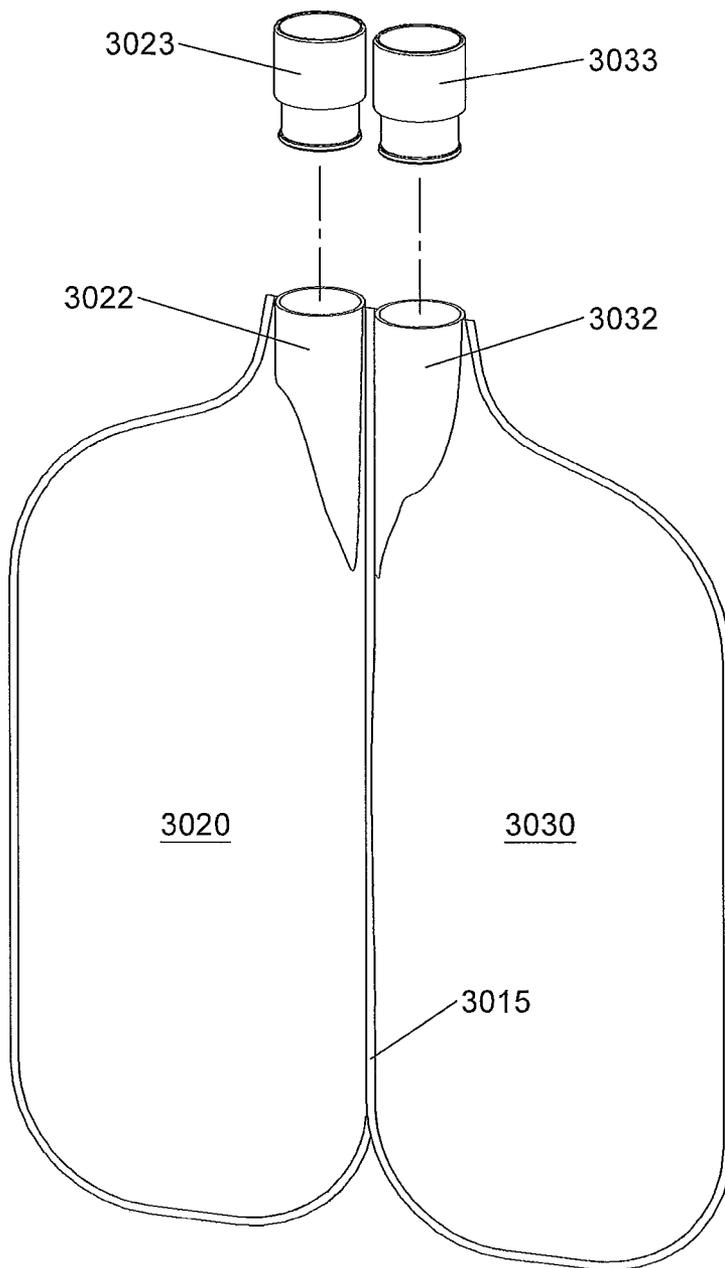


FIG. 42

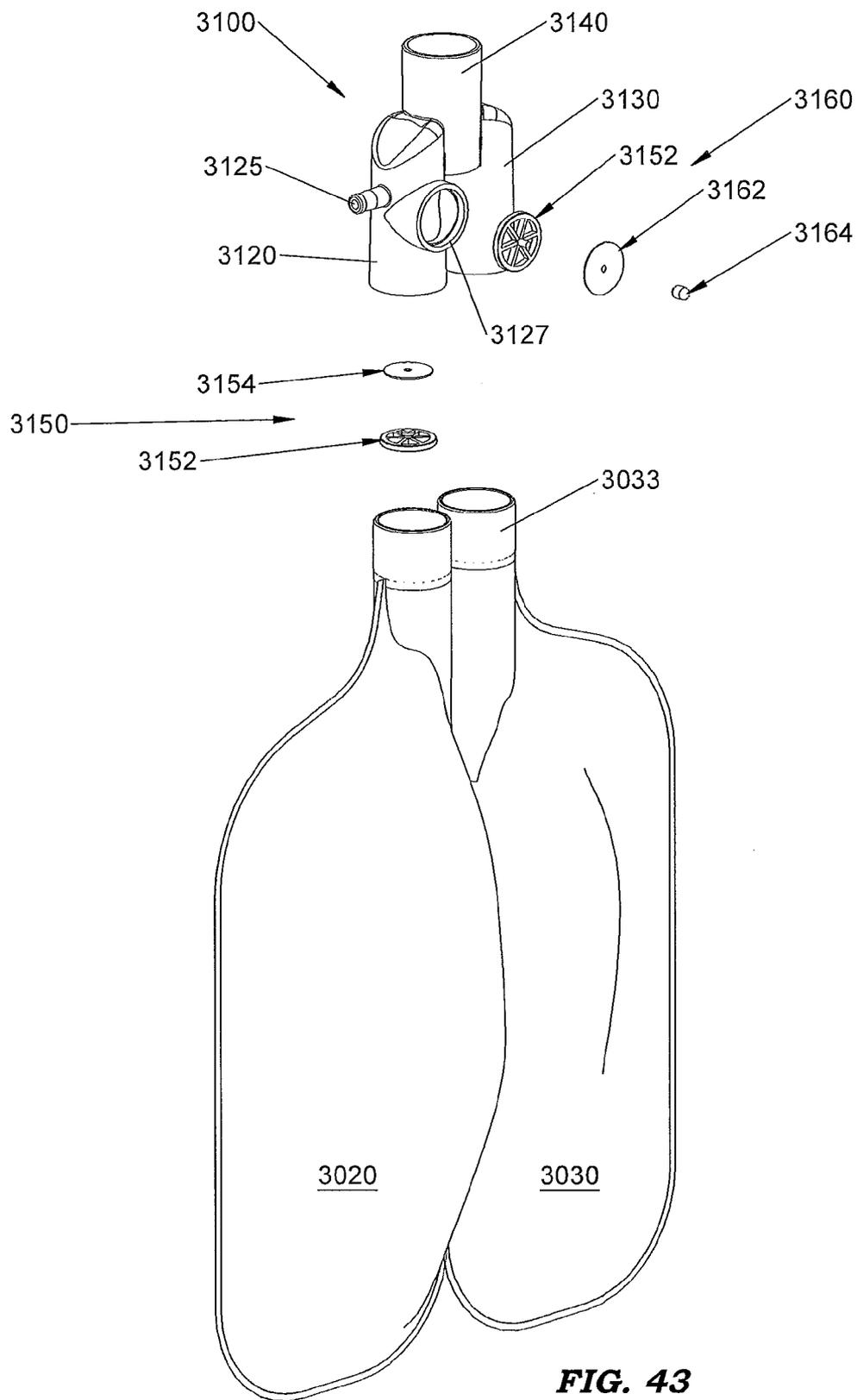
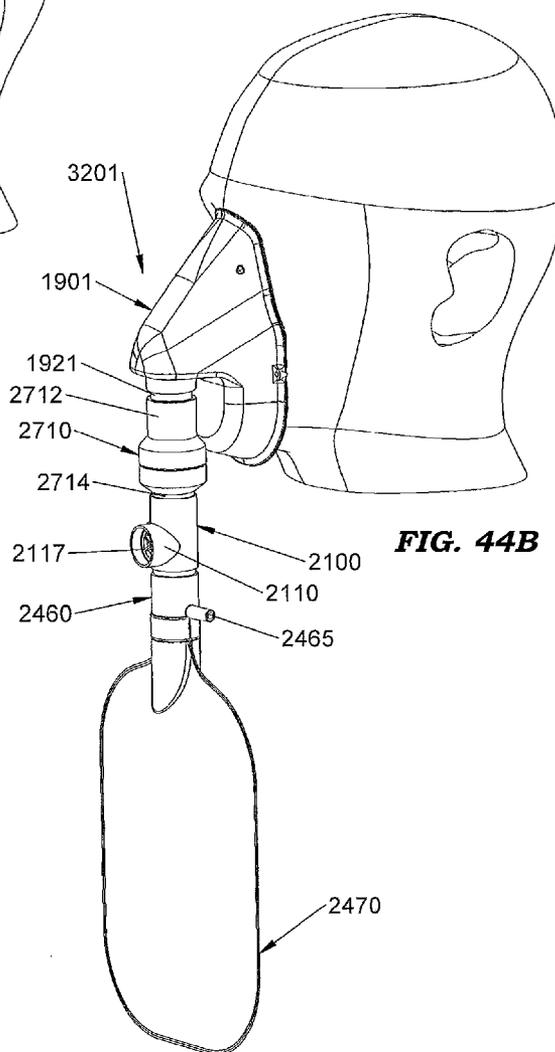
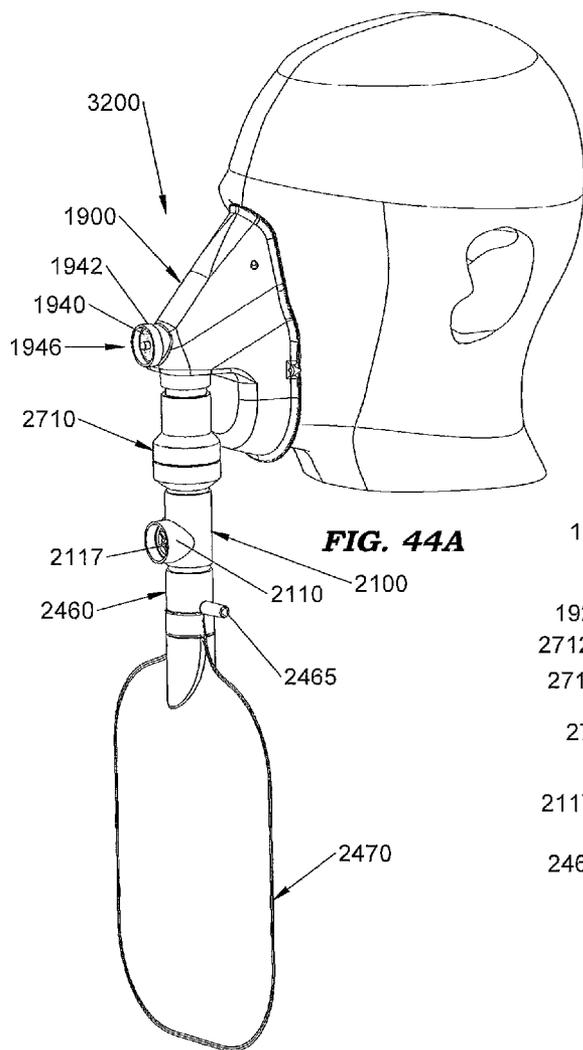
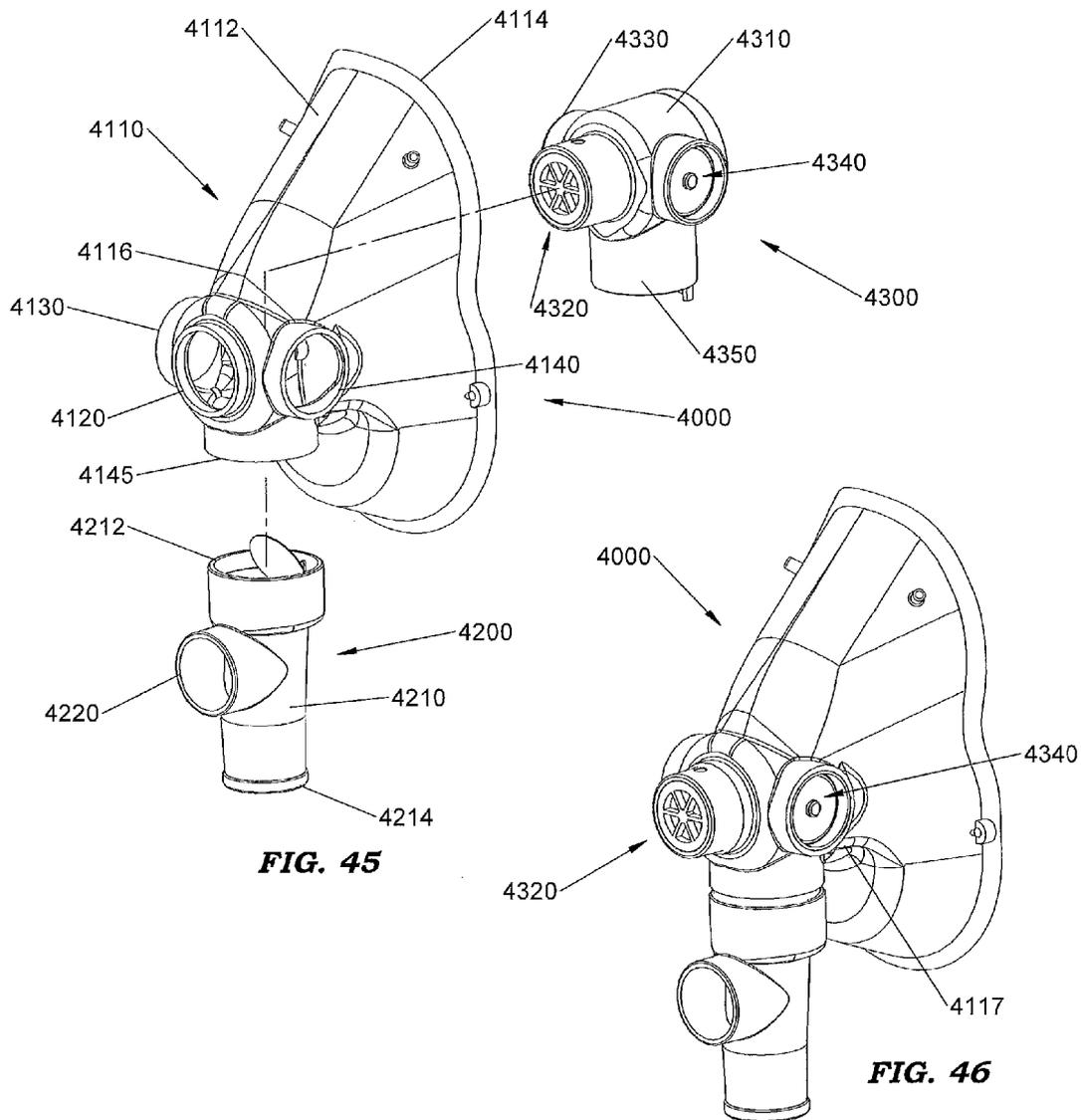


FIG. 43





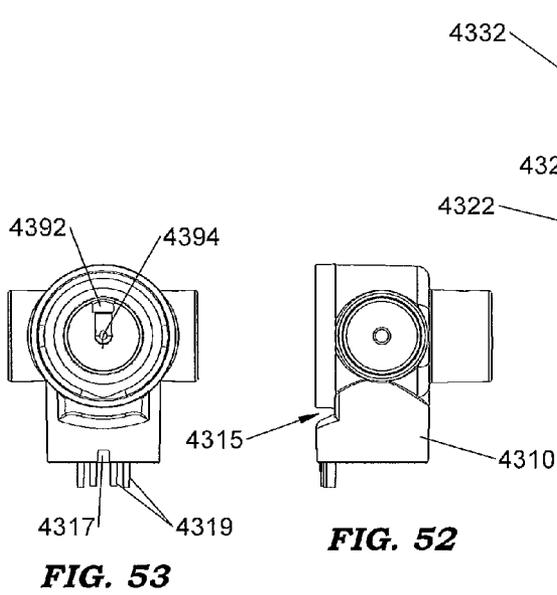


FIG. 51

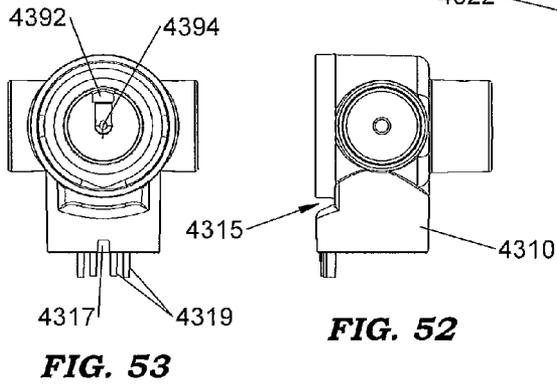


FIG. 52

FIG. 53

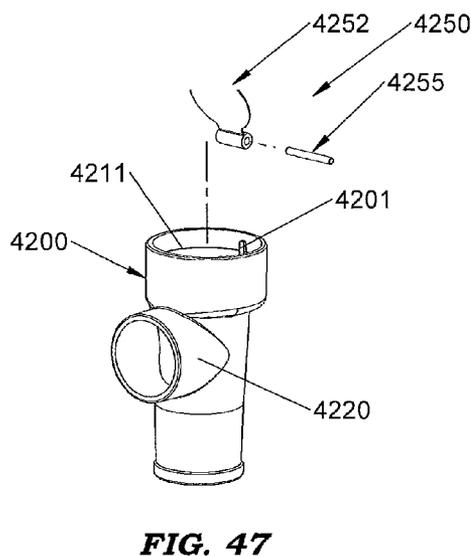


FIG. 47

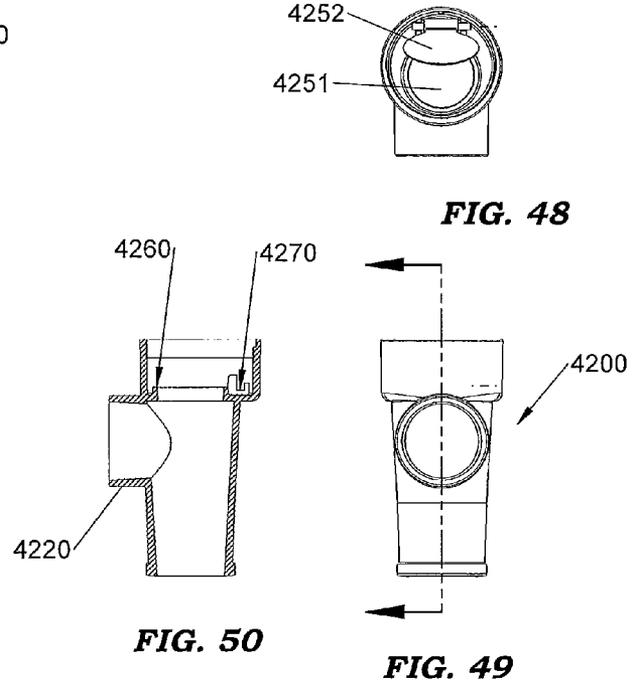


FIG. 48

FIG. 50

FIG. 49

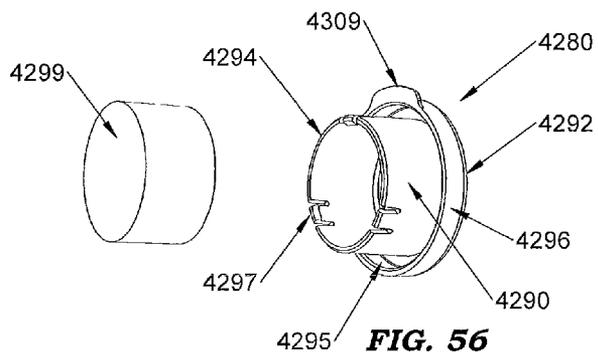


FIG. 56

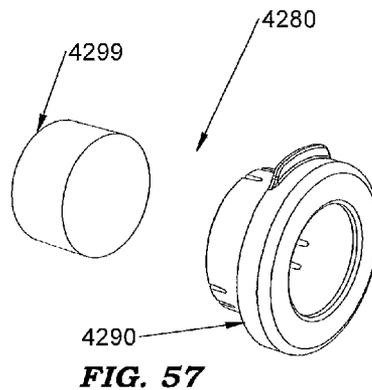


FIG. 57

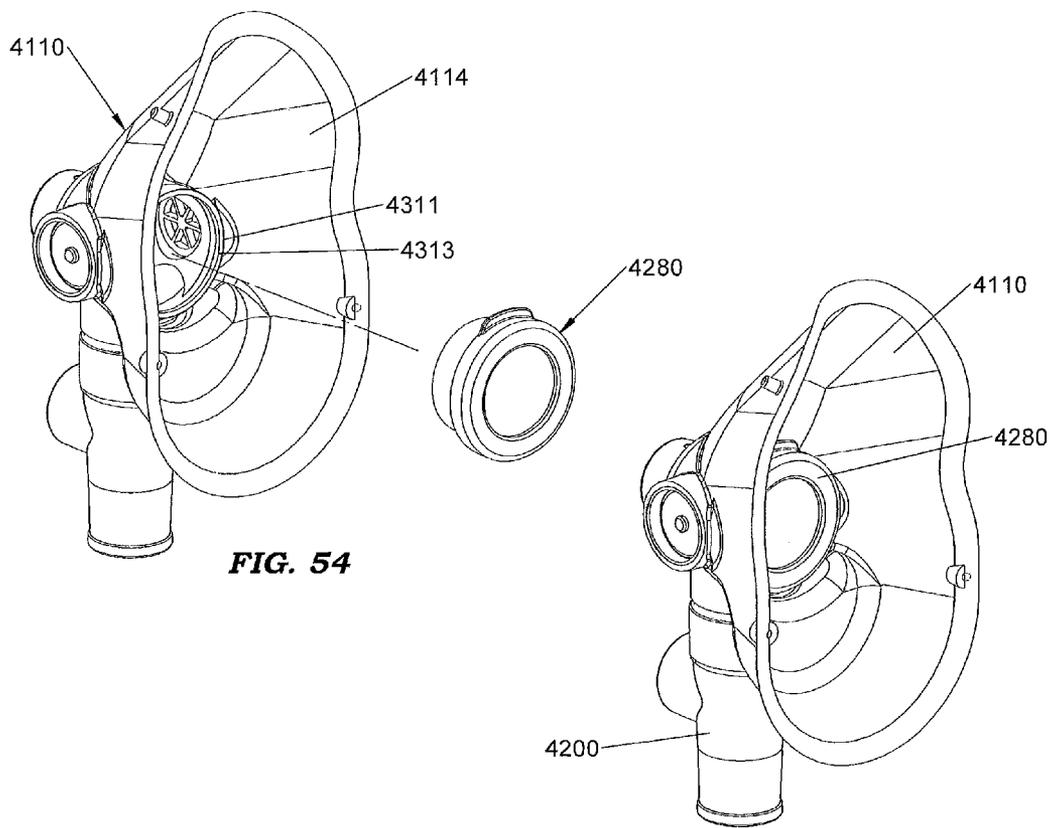


FIG. 54

FIG. 55

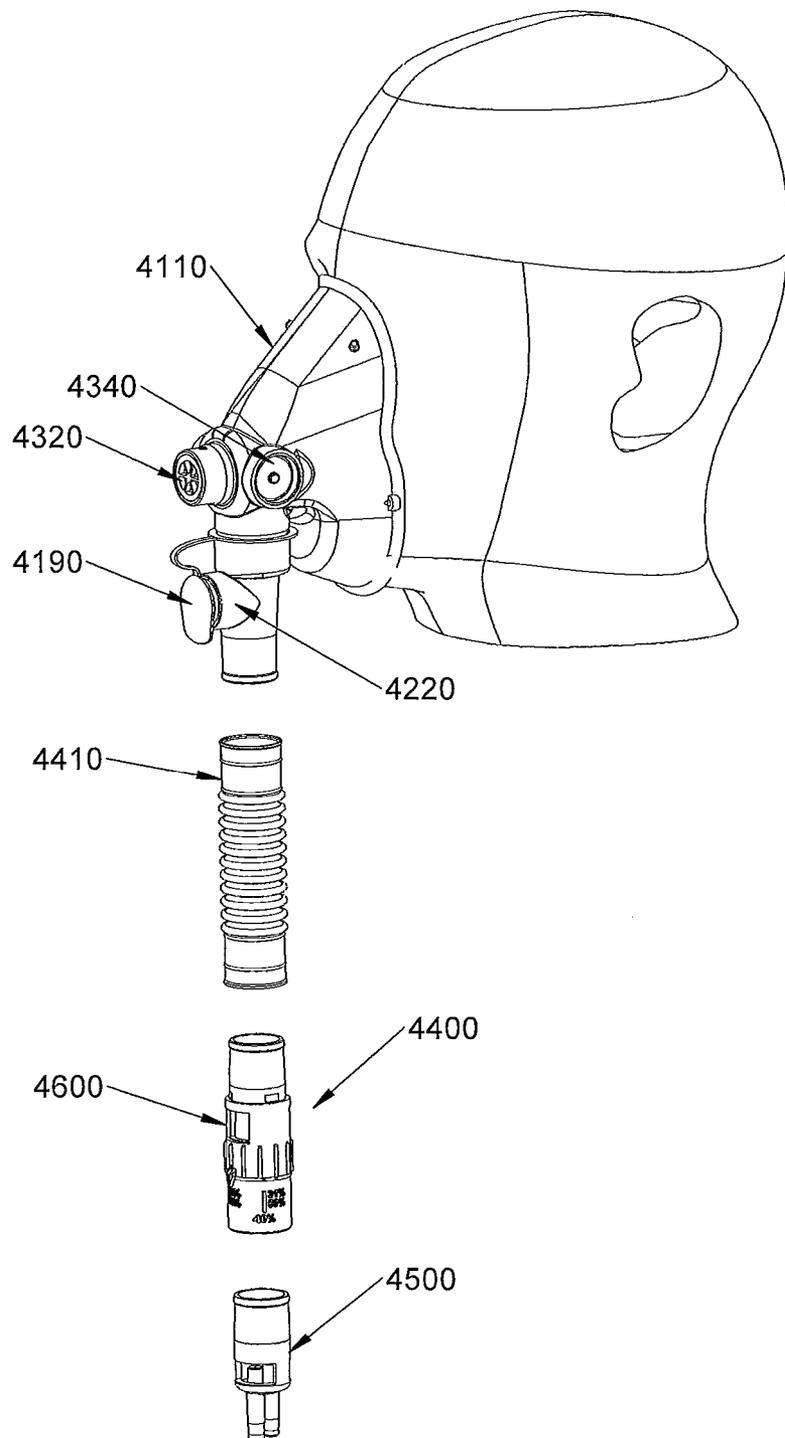


FIG. 58

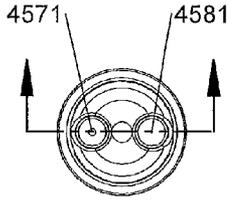


FIG. 61

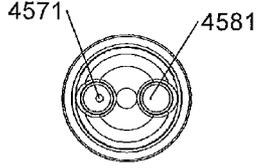


FIG. 64

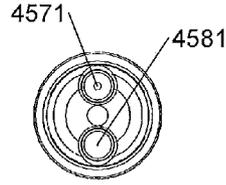


FIG. 66

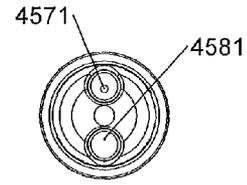


FIG. 68

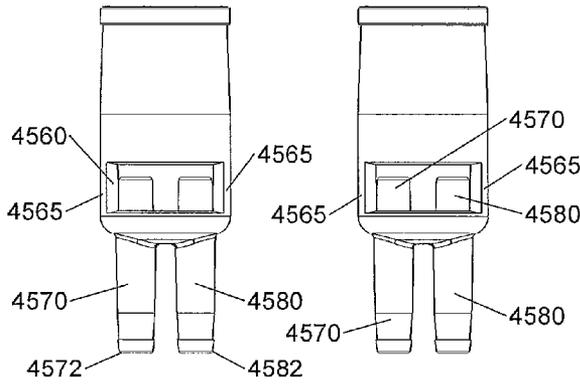


FIG. 60

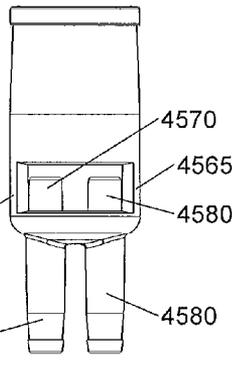


FIG. 63

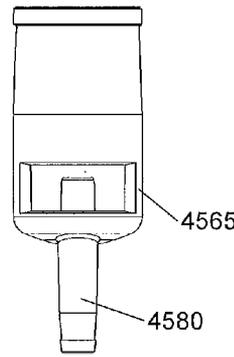


FIG. 65

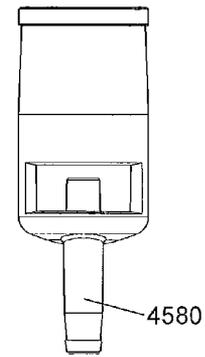


FIG. 67

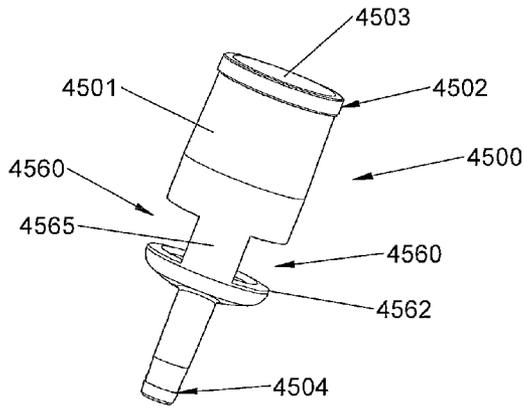


FIG. 59

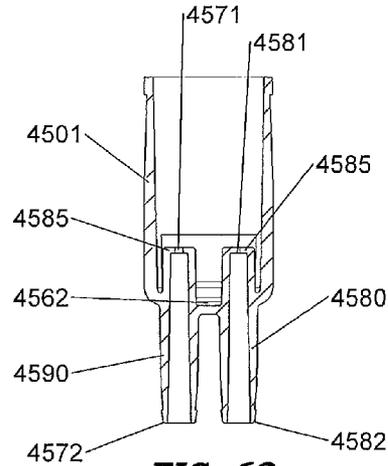


FIG. 62

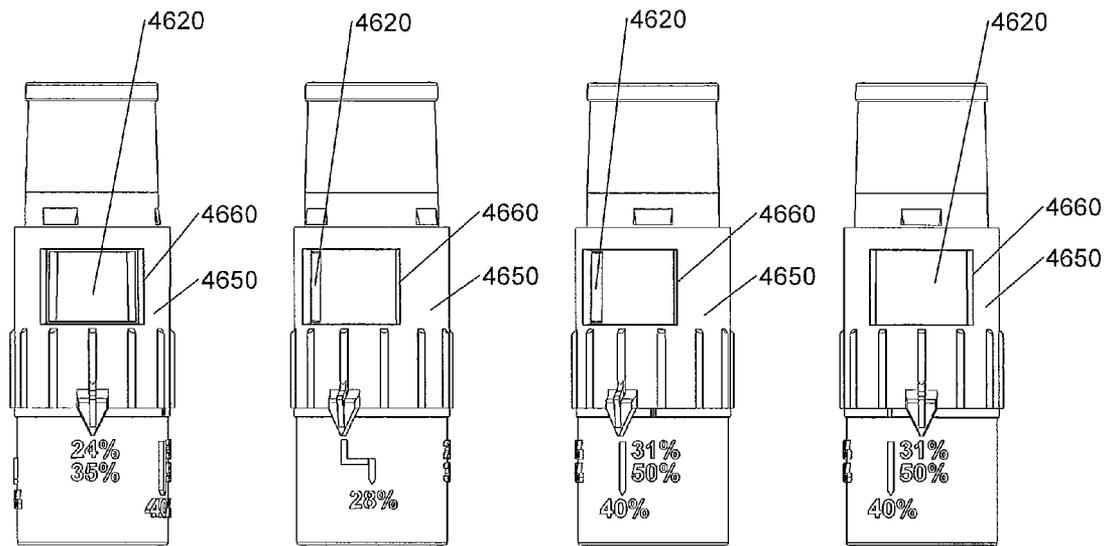


FIG. 70A

FIG. 70B

FIG. 70C

FIG. 70D

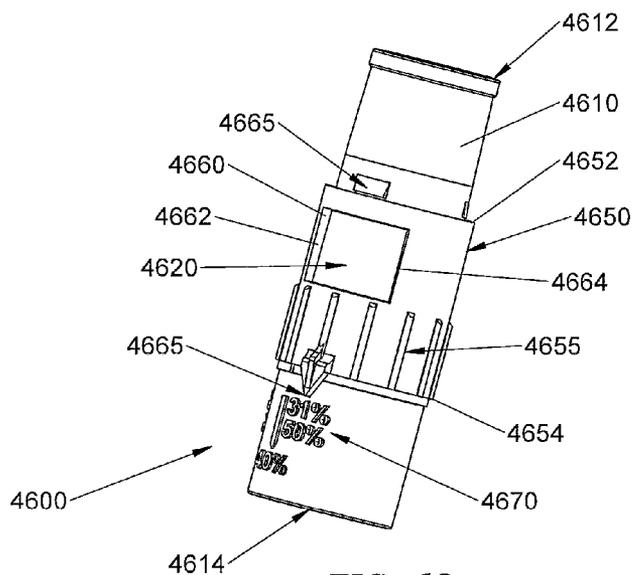


FIG. 69

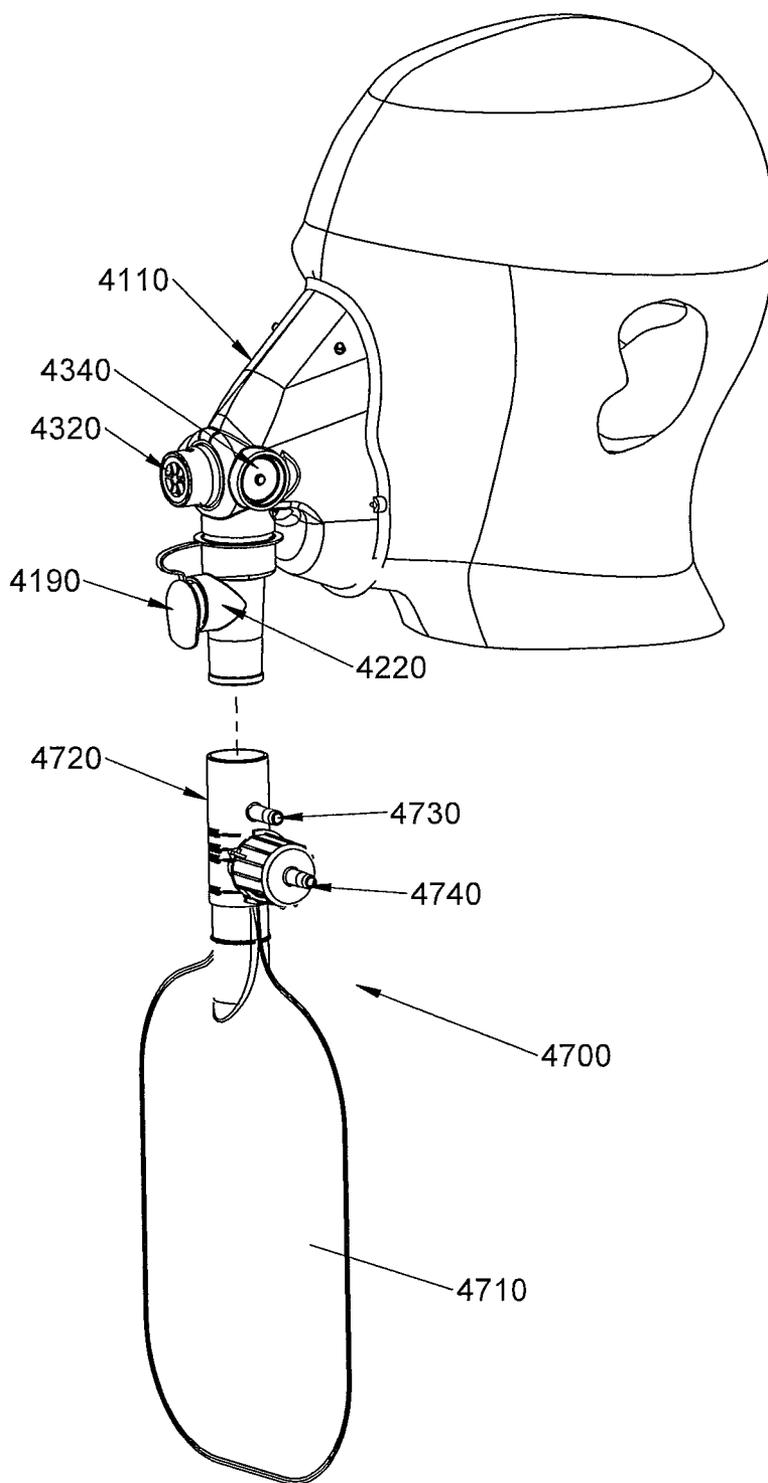
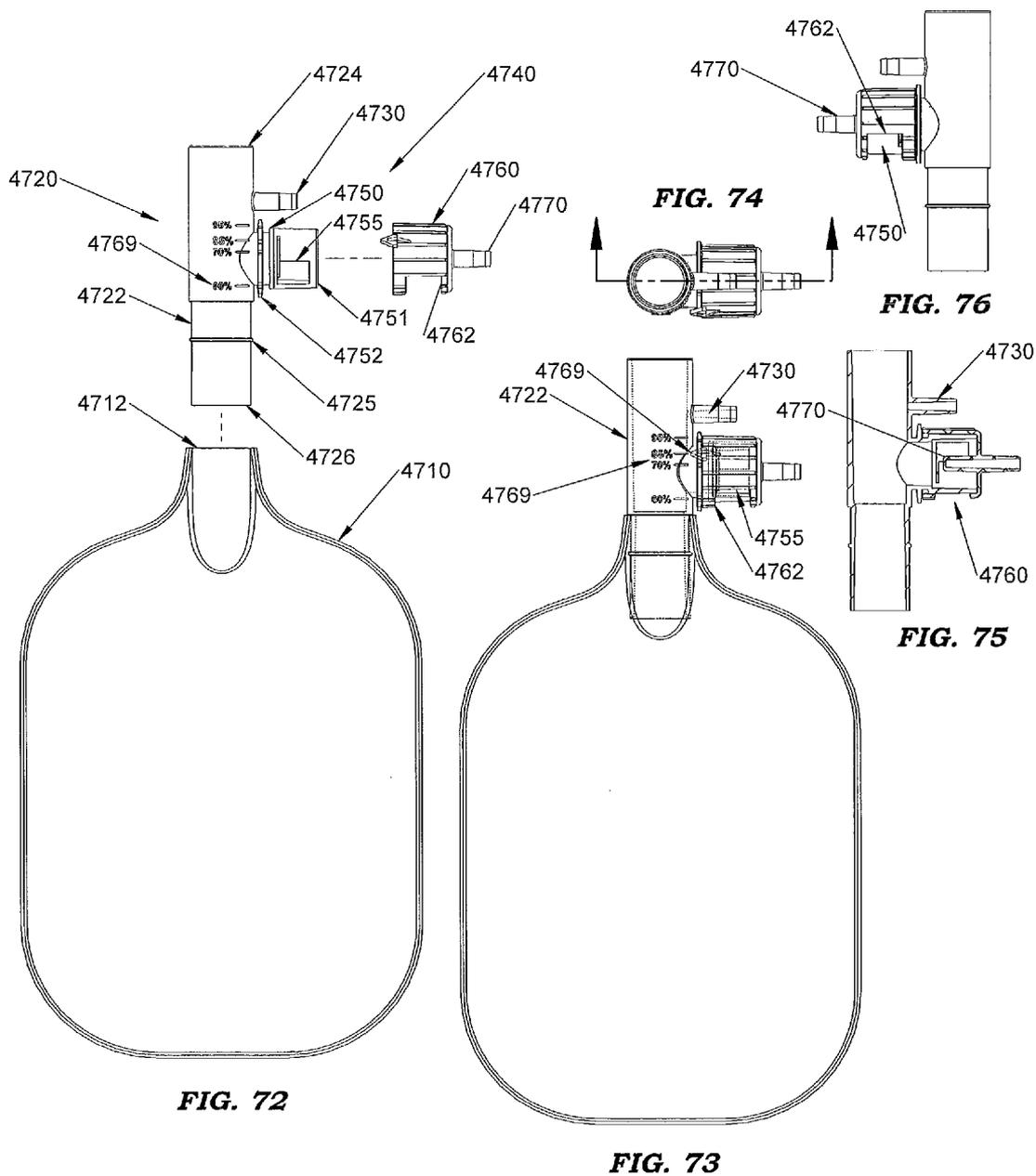


FIG. 71



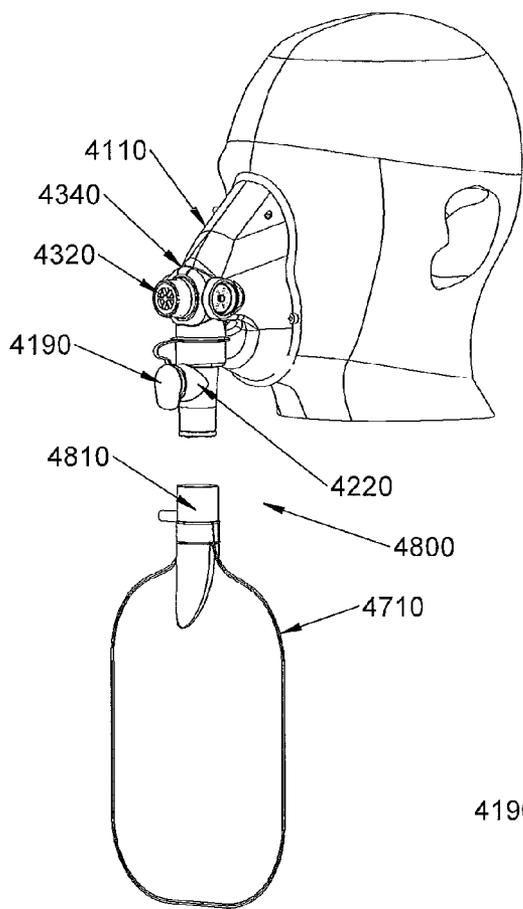


FIG. 77

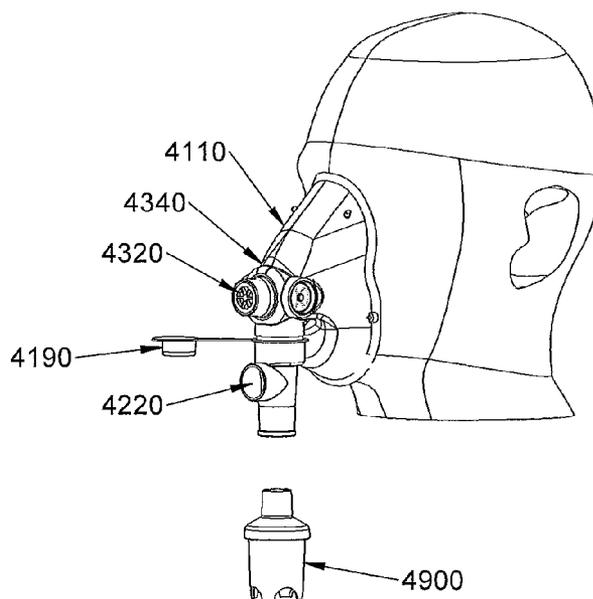


FIG. 78

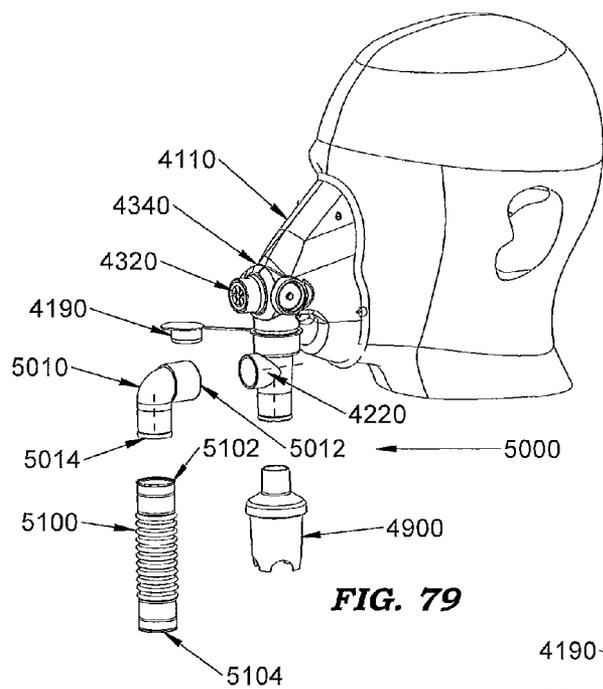


FIG. 79

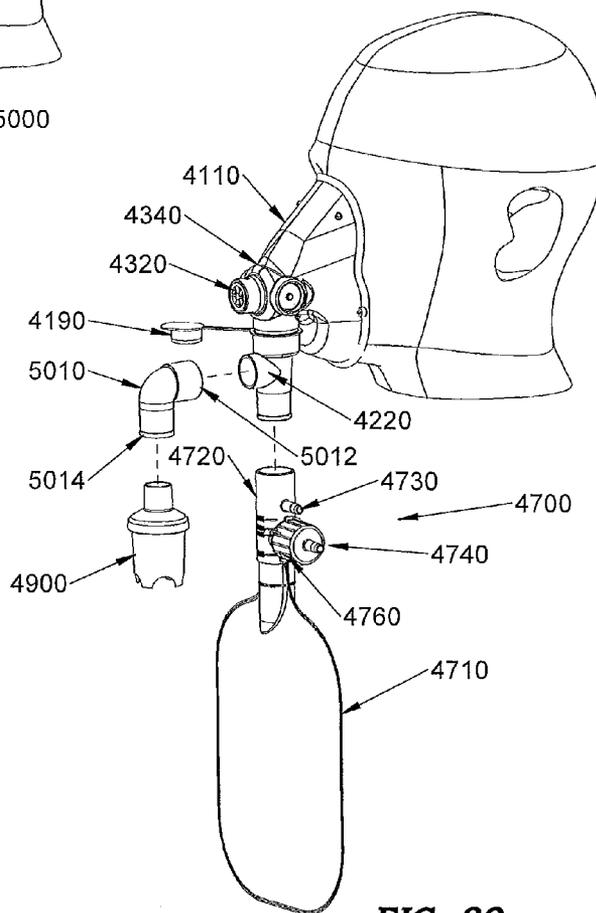


FIG. 80

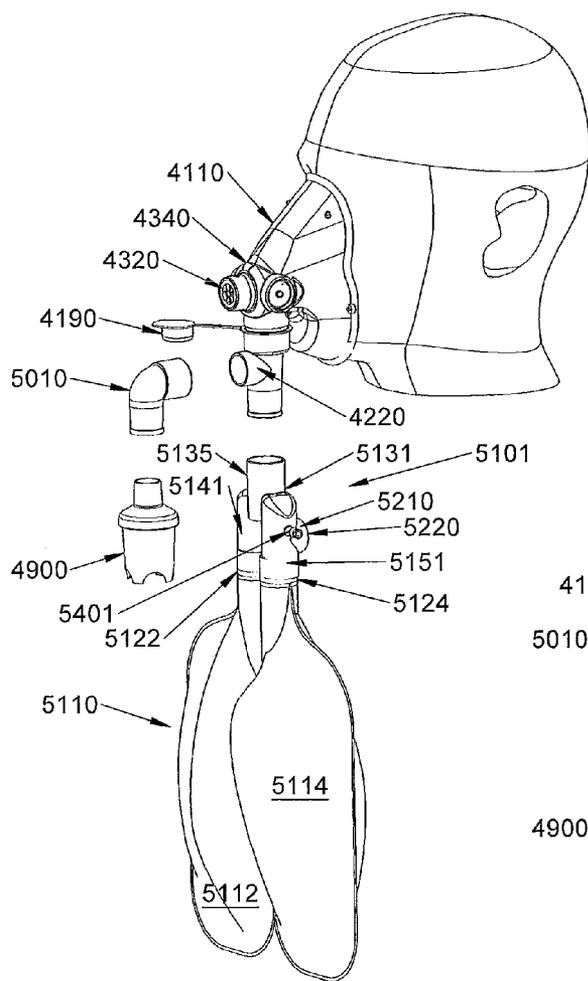


FIG. 81

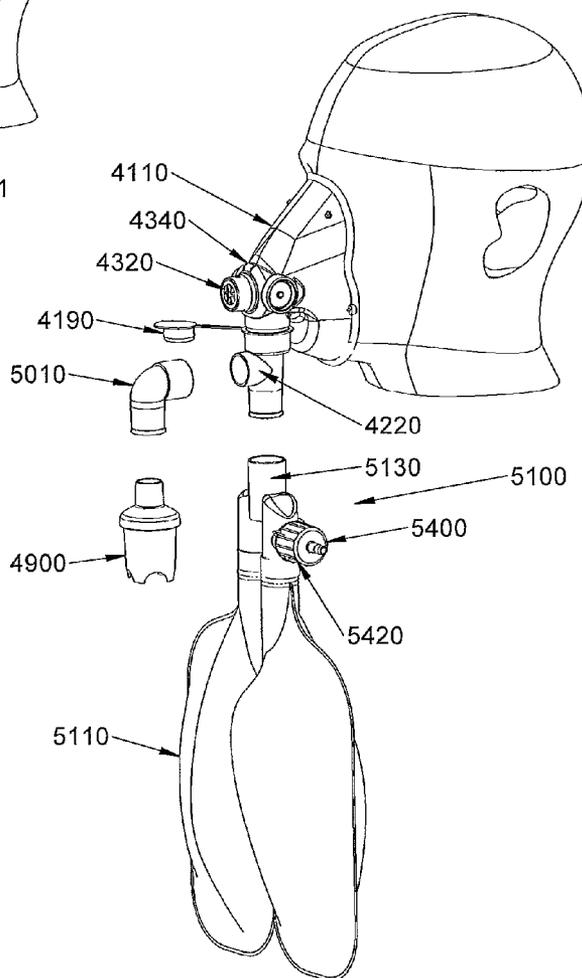


FIG. 82

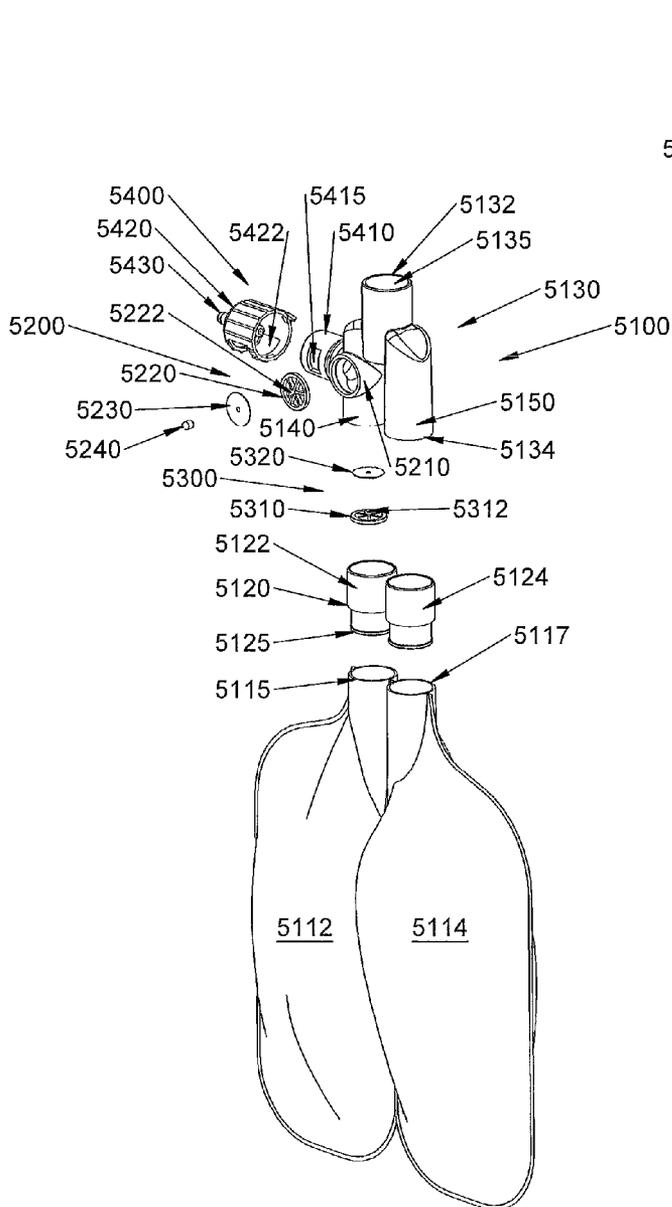


FIG. 83

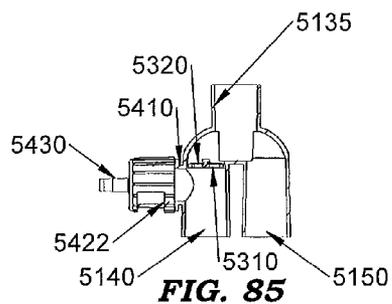


FIG. 85

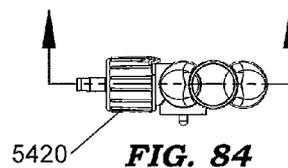


FIG. 84

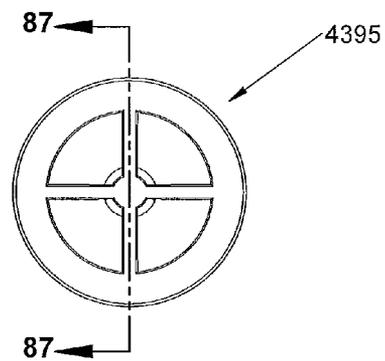


FIG. 86

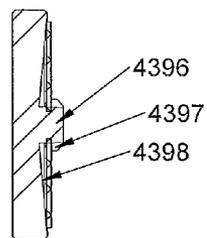


FIG. 87

MODULAR PULMONARY TREATMENT SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application claims the benefit of: U.S. patent application Ser. No. 61/589,671, filed on Jan. 23, 2012; U.S. patent application No. 61/610,828, filed Mar. 14, 2012 and U.S. patent application No. 61/694,020, filed Aug. 28, 2012, each of which is hereby incorporated by reference in its entirety.

TECHNICAL FIELD

[0002] The present invention relates to pulmonary treatment equipment and more particularly, relates to a modular pulmonary treatment system that includes a number of interchangeable parts that allow the system to have a number of different operating modes including but not limited to delivery of a gas to a patient; delivery of an aerosolized medication (drug) to a patient; and a combination thereof.

BACKGROUND

[0003] Respiratory care devices are commonly used as a means to deliver gases and medication in an aerosolized form to a patient. Aerosolized medication is typically used to treat patients with respiratory conditions, such as reactive airways disease, asthma, bronchitis, emphysema, or chronic obstructive pulmonary disease (COPD), bronchiectasis, cystic fibrosis, etc.

[0004] It is generally accepted that effective administration of aerosolized medication depends on the delivery system and its position in relation to the patient. Aerosol particle deposition is influenced by particle size, ventilatory pattern, and airway architecture, and effective medication response is influenced by the dose of the medication used.

[0005] An aerosol delivery system includes three principal elements, namely a generator, a power source, and an interface. Generators include small volume nebulizers (SVN), large volume nebulizers (LVN), metered dose inhalers (MDI), and dry powder inhalers (DPI). The power source is the mechanism by which the generator operates or is actuated and includes compressed gas for SVN and LVN and self-contained propellants for MDI. The interface is the conduit between the generator and the patient and includes spacer devices/accessory devices with mouthpieces or face masks. Depending on the patient's age (ability) and coordination, various interfaces are used in conjunction with SVN and MDI in order to optimize drug delivery.

[0006] The three primary means for delivering aerosolized medication to treat a medical condition is an MDI, a DPI, or a nebulizer. MDI medication (drug) canisters are typically sold by manufacturers with a boot that includes a nozzle, an actuator, and a mouthpiece. Patients can self-administer the MDI medication using the boot alone but the majority of patients have difficulty synchronizing the actuation of the MDI canister with inhalation causing oropharyngeal drug deposition, decreased drug delivery and therefore effectiveness, and causes other adverse effects.

[0007] A dry powder inhaler (DPI) is a device that delivers medication to the lungs in the form of a dry powder. DPIs are an alternative to the aerosol based inhalers commonly called metered-dose inhaler (or MDI). The DPIs may require some procedure to allow a measured dose of powder to be ready for

the patient to take. The medication is commonly held either in a capsule for manual loading or a proprietary form from inside the inhaler. Once loaded or actuated, the operator puts the mouthpiece of the inhaler into their mouth and takes a deep inhalation, holding their breath for 5-10 seconds. There are a variety of such devices. The dose that can be delivered is typically less than a few tens of milligrams in a single breath since larger powder doses may lead to provocation of cough. Most DPIs rely on the force of patient inhalation to entrain powder from the device and subsequently break-up the powder into particles that are small enough to reach the lungs. For this reason, insufficient patient inhalation flow rates may lead to reduced dose delivery and incomplete deaggregation of the powder, leading to unsatisfactory device performance. Thus, most DPIs have a minimum inspiratory effort that is needed for proper use and it is for this reason that such DPIs are normally used only in older children and adults.

[0008] Small volume nebulizers (SVN) and large volume nebulizers (LVN) have been used to overcome difficulties encountered with MDI and DPI during acute exacerbation of obstructive airways disease but even these devices are fraught with problems especially significant waste of medication and not adequately reaching the target airways.

[0009] Problems with prior art devices include that the devices are inefficient and significantly waste medication, they provide a non-uniform concentration of delivered medication, they are expensive, and they are difficult to use. In addition, multiple pieces of equipment are needed to treat a plurality of different conditions.

[0010] The modular pulmonary treatment system of the present invention overcomes these deficiencies and provides a system that includes a number of interchangeable parts that allow the system to have a number of different operating modes including but not limited to delivery of a gas to a patient; delivery of an aerosolized medication (drug) to a patient; and a combination thereof.

SUMMARY

[0011] According to one embodiment, a patient interface device for delivering a gas to a patient includes a main body for placement against a face of the patient for delivering the gas to the patient. The main body includes a conduit portion that is open at a first end to a hollow interior of the main body and a free second end for attachment to another object in a sealed manner. The device also includes: (1) at least one exhalation valve assembly that is disposed within a first port formed in the main body and includes an exhalation valve member that is configured to vent exhaled air when open; (2) a primary inhalation valve assembly that is disposed within the conduit portion and includes a primary valve member that moves between open and closed positions; and (3) a secondary inhalation valve assembly that is disposed within a second port formed in the main body and includes a secondary valve member that moves between open and closed positions.

[0012] The body includes an HME (heat moisture exchange) seat for receiving an HME unit and being located in relationship to the least one primary inhalation valve assembly and the at least one exhalation valve assembly to: (1) allow passage of inhaled gas, that flows through the primary inhalation valve assembly, through the HME seat before flowing into the hollow interior of the main body and to the patient and (2) allow passage of exhaled gas from the patient through the HME seat before exiting to atmosphere through the at least one exhalation valve assembly. The HME seat is at

least partially defined by a wall that is integral to the main body and defines a hollow space for receiving the HME unit, the wall being constructed for mating with the HME unit for the secure, yet releasable, attachment of the HME unit to the HME seat.

[0013] According to another embodiment, a patient interface system for delivering a gas to a patient includes a patient interface device that includes a main body for placement against a face of the patient for delivering the gas. The patient interface device includes at least one inhalation valve and at least one exhalation valve. The system also includes a venturi device that is fluidly connected to the free second end of the conduit portion. The venturi device has at least one port for connection to a gas source. The venturi device has at least one primary air entrainment window and at least one secondary air entrainment window which is downstream of the at least one primary air entrainment window and thus closer to the main body of the patient interface device. The at least one inhalation valve is disposed between: (1) the main body and (2) the primary and secondary air entrainment windows of the venturi device. At least one of the primary air entrainment window and secondary air entrainment window includes a means for closing the respective window, thereby changing a degree at which the respective window is open and changing a flow rate of the air flowing through the respective window.

[0014] In another embodiment, a patient interface system for delivering a gas to a patient includes a patient interface device for delivering a gas to a patient. The patient interface device includes a main body for placement against a face of the patient. The main body includes a conduit portion that is open at a first end to a hollow interior of the main body and a free second end for attachment to another object in a sealed manner. The patient interface delivery device also includes: (1) at least one exhalation valve assembly that is disposed within a first port formed in the main body and includes an exhalation valve member that is configured to vent exhaled air when open; (2) a primary inhalation valve assembly that is disposed within the conduit portion and includes a primary valve member that moves between open and closed positions; and (3) a secondary inhalation valve assembly that is disposed within a second port formed in the main body and includes a secondary valve member that moves between open and closed positions. The system also includes a first accessory that is fluidly attached to the conduit portion.

[0015] The primary inhalation valve assembly has a first flow resistance associated therewith and the second inhalation valve assembly has a second flow resistance associated therewith which is greater than the primary inhalation valve assembly and as a result, the secondary inhalation valve assembly acts as an emergency inhalation valve.

[0016] The first accessory can be any number of different pieces of equipment including but not limited to a reservoir member, a device for delivering gas and/or aerosolized medication, etc.

BRIEF DESCRIPTION OF THE DRAWING FIGURES

[0017] FIG. 1 is a front and side perspective view of a patient interface system/modular pulmonary treatment system according to one embodiment and configured for delivery of gases to a patient including aerosolized medication;

[0018] FIG. 2 is a close-up perspective view of the patient interface system/modular pulmonary treatment system of FIG. 1;

[0019] FIG. 3 is a rear perspective view of the patient interface system/modular pulmonary treatment system of FIG. 1;

[0020] FIG. 4 is a top plan view of a patient interphase valve assembly according to one embodiment for use with a face-mask as shown in FIG. 1;

[0021] FIG. 5 is a rear elevation view of the patient interphase valve assembly of FIG. 4;

[0022] FIG. 6 is a partially exploded view of the patient interphase valve assembly;

[0023] FIG. 7 is a perspective view of the patient interphase valve assembly of FIG. 6 in an assembled state;

[0024] FIG. 8 is a partially exploded view of the patient interphase valve assembly illustrating a directional valve according to the present invention;

[0025] FIG. 9 is a perspective view of the patient interphase valve assembly of FIG. 8 in an assembled state;

[0026] FIG. 10 is a front and bottom perspective view of the system of FIG. 1 prior to mating the primary treatment module valve assembly with the patient interphase system;

[0027] FIG. 11 is a front and bottom perspective view of the system of FIG. 10 in the assembled position;

[0028] FIG. 12 is a front perspective view of the patient interface system of FIG. 1 attached to an expandable conduit for delivering gas in accordance with a first operating mode;

[0029] FIG. 13 is a front perspective view of the patient interface system of FIG. 12 shown in accordance with a second operating mode;

[0030] FIG. 14 is a front perspective view of the patient interface system of FIG. 12 shown in accordance with a third operating mode;

[0031] FIG. 15 is a front perspective view of the patient interface system of FIG. 1 attached to a gas reservoir assembly and venturi mechanism for delivering gas in accordance with a first operating mode;

[0032] FIG. 16 is a front perspective view of the patient interface system of FIG. 15 shown in accordance with a second operating mode;

[0033] FIG. 17 is a front perspective view of the patient interface system of FIG. 1 attached to a dual gas reservoir assembly and two venturi mechanism shown in accordance with a first operating mode;

[0034] FIG. 18 is a front perspective view of patient interface system of FIG. 17 shown in accordance with a second operating mode;

[0035] FIG. 19 is a front perspective view of the patient interface system of FIG. 1 attached to a nebulizer for aerosol drug delivery;

[0036] FIG. 20 is a front perspective view of the patient interface system of FIG. 19 in further combination with an expandable conduit for aerosol drug delivery;

[0037] FIG. 21 is a front perspective view of the system of FIG. 20 in further combination with a multi-port low concentration venturi for aerosol drug and controlled low concentration gas delivery;

[0038] FIG. 22 is a front perspective view of the patient interface system of FIG. 1 in further combination with a nebulizer and a gas reservoir assembly for aerosol drug and controlled high concentration gas delivery;

[0039] FIG. 23 is a front perspective view of the patient interface system of FIG. 1 in further combination with a nebulizer and a dual gas reservoir assembly shown in accordance with a second operating mode;

[0040] FIG. 24 is a front perspective view of the patient interface system of FIG. 23 shown in accordance with a third operating mode;

[0041] FIG. 25A is an exploded perspective view of a multi-port, variable concentration, gas delivery venturi connector;

[0042] FIG. 25B is a perspective view of the multi-port, variable concentration, gas delivery venturi connector in an assembled position;

[0043] FIG. 26 is an exploded perspective view of a patient interface system/modular pulmonary treatment system according to another embodiment and configured for delivery of gases to a patient including aerosolized medication;

[0044] FIG. 27 is a perspective view of the system of FIG. 26 in an assembled state;

[0045] FIG. 28 is an exploded perspective view of cassette style venturi connector according to one embodiment;

[0046] FIG. 29 is a perspective view of the cassette style venturi connector assembly in the assembled state;

[0047] FIG. 30A is a side perspective view of a patient interface system according to another embodiment for low concentration gas delivery;

[0048] FIG. 30B is a side perspective view of a patient interface system according to another embodiment for low concentration gas delivery;

[0049] FIG. 31 is a side perspective view of a patient interface system according to another embodiment for standard dose aerosol drug delivery;

[0050] FIG. 32 is a side perspective view of a patient interface system according to another embodiment for high dose aerosol drug delivery;

[0051] FIG. 33A is a side perspective view of a patient interface system according to another embodiment for 100% non-rebreather gas (oxygen) delivery;

[0052] FIG. 33B is a side perspective view of a patient interface system according to another embodiment for 100% non-rebreather gas (oxygen) delivery;

[0053] FIG. 34A is a side perspective view of a patient interface system according to another embodiment for low concentration gas (oxygen) delivery with heat and moisture exchange;

[0054] FIG. 34B is a side perspective view of a patient interface system according to another embodiment for low concentration gas (oxygen) delivery with heat and moisture exchange;

[0055] FIG. 35A is a side perspective view of a patient interface system according to another embodiment for high concentration gas (oxygen) delivery;

[0056] FIG. 35B is a side perspective view of a patient interface system according to another embodiment for high concentration gas (oxygen) delivery;

[0057] FIG. 36A is a side perspective view of a patient interface system according to another embodiment for high concentration gas (oxygen) delivery with heat and moisture exchange;

[0058] FIG. 36B is a side perspective view of a patient interface system according to another embodiment for high concentration gas (oxygen) delivery with heat and moisture exchange;

[0059] FIG. 37 is a side perspective view of a patient interface system according to another embodiment for high dose drug delivery with 100% oxygen or other premixed gas like heliox delivery;

[0060] FIG. 38A is an exploded perspective view of a patient interface mask system with valves for use in some of the systems of FIGS. 30-37;

[0061] FIG. 38B is a perspective view of the system of FIG. 38A in the assembled condition;

[0062] FIG. 38C is a rear perspective view of the system of FIG. 38A;

[0063] FIG. 38D is an exploded perspective view of a patient interface mask system without valves for use in some of the systems of FIGS. 30-37;

[0064] FIG. 38E is a front view of the system of FIG. 38D in the assembled condition;

[0065] FIG. 38F is a rear perspective view of the system of FIG. 38D;

[0066] FIG. 39A is an exploded perspective view of a first multi-port valve connector for use in some of the systems of FIGS. 30-37;

[0067] FIG. 39B is perspective view of the connector of FIG. 39A in an assembled condition;

[0068] FIG. 40 is an exploded perspective view of a second multi-port valve connector for use in some of the systems of FIGS. 30-37;

[0069] FIG. 41 shows both exploded and assembled perspective views of a single bag reservoir assembly;

[0070] FIG. 42 shows both exploded and assembled perspective views of a dual bag reservoir assembly;

[0071] FIG. 43 shows both exploded and assembled perspective views of a dual bag reservoir system used in embodiment 37 for high dose drug delivery with 100% gas (oxygen) delivery system;

[0072] FIG. 44A is a 100% non-rebreather gas (oxygen) delivery with heat and moisture exchange; and

[0073] FIG. 44B shows another embodiment for 100% non-rebreather gas (oxygen) delivery with heat and moisture exchange;

[0074] FIG. 45 is a side and front perspective view of a patient interface system according to a different embodiment and showing a mask valve assembly and a primary gas valve assembly exploded therefrom;

[0075] FIG. 46 is a side and front perspective of the assembled patient interface system of FIG. 45;

[0076] FIG. 47 is a perspective view of the primary gas valve assembly with a valve member shown exploded therefrom;

[0077] FIG. 48 is a top plane view of the primary gas valve assembly;

[0078] FIG. 49 is a side elevation view of the primary gas valve assembly;

[0079] FIG. 50 is a cross-sectional view of the primary gas valve assembly taken along the lines 50-50 of FIG. 49;

[0080] FIG. 51 is an exploded perspective view of the patient interface-mask valve assembly;

[0081] FIG. 52 is a side elevation view of the patient interface-mask valve assembly;

[0082] FIG. 53 is a front elevation view of the patient interface-mask valve assembly;

[0083] FIG. 54 is a rear perspective view of the patient interface system showing an HME assembly exploded therefrom;

[0084] FIG. 55 is a rear perspective view of the patient interface system with the HME assembly installed therein;

[0085] FIG. 56 is an exploded perspective view of the HME assembly;

[0086] FIG. 57 is also an exploded perspective view of the HME assembly;

[0087] FIG. 58 is an exploded perspective view of a respiratory treatment system for low concentration gas (oxygen) delivery;

[0088] FIG. 59 is a side perspective view of a multi-port venturi member that is part of the venturi assembly of FIG. 58;

[0089] FIG. 60 is a side elevation view of the multi-port venturi member of FIG. 59 and according to a first embodiment;

[0090] FIG. 61 is a top plan view of the multi-port venturi member of FIG. 60;

[0091] FIG. 62 is a cross-sectional view of the multi-port venturi member taken along the lines 62-62 of FIG. 61;

[0092] FIG. 63 is a side elevation view of the multi-port venturi member according to a second embodiment;

[0093] FIG. 64 is a top plan view of a multi-port venturi member of FIG. 63;

[0094] FIG. 65 is a side elevation view of the multi-port venturi member according to a third embodiment;

[0095] FIG. 66 is a top plan view of a multi-port venturi member of FIG. 65;

[0096] FIG. 67 is a side elevation view of the multi-port venturi member according to a fourth embodiment;

[0097] FIG. 68 is a top plan view of a multi-port venturi member of FIG. 67;

[0098] FIG. 69 is a side perspective view of a secondary gas entrainment valve member that is part of the assembly of FIG. 58;

[0099] FIG. 70A is a side elevation showing the secondary gas entrainment valve member in a fully open position;

[0100] FIG. 70B is a side elevation showing the secondary gas entrainment valve member in a partially open position;

[0101] FIG. 70C is a side elevation showing the secondary gas entrainment valve member in a partially open position;

[0102] FIG. 70D is a side elevation showing the secondary gas entrainment valve member in a fully closed position;

[0103] FIG. 71 is an exploded perspective view of a respiratory treatment system for high concentration gas (oxygen) delivery;

[0104] FIG. 72 is an exploded elevation view of a device of the system of FIG. 71;

[0105] FIG. 73 is an elevation view of the device of FIG. 72 in an assembled condition;

[0106] FIG. 74 is a top plan view of the device of FIG. 73;

[0107] FIG. 75 is a cross-sectional view taken along the line 75-75 of FIG. 74;

[0108] FIG. 76 is a rear elevation view thereof;

[0109] FIG. 77 is an exploded perspective view of a respiratory treatment system for a 100% non-breather gas delivery;

[0110] FIG. 78 is an exploded perspective view of a respiratory treatment system for standard dose aerosol drug delivery;

[0111] FIG. 79 is an exploded perspective view of a respiratory treatment system for enhanced dose aerosol drug delivery;

[0112] FIG. 80 is an exploded perspective view of a respiratory treatment system for high dose aerosol drug delivery with gas delivery with single bag reservoir system;

[0113] FIG. 81 is an exploded perspective view of a respiratory treatment system for high dose aerosol drug delivery with gas delivery with dual bag reservoir system;

[0114] FIG. 82 is an exploded perspective view of a respiratory treatment system for high dose aerosol drug delivery with controlled concentration gas delivery with dual reservoir bag system;

[0115] FIG. 83 is an exploded perspective view of the high dose aerosol drug delivery/gas delivery mechanism of FIG. 82;

[0116] FIG. 84 is a top plan view of the system of FIG. 83;

[0117] FIG. 85 is a cross-sectional view taken along the line 85-85 of FIG. 84;

[0118] FIG. 86 is a top plan view of a valve seat in accordance with a different embodiment of the present invention; and

[0119] FIG. 87 is a cross-sectional view taken along the lines 87-87 in FIG. 86.

DETAILED DESCRIPTION OF CERTAIN EMBODIMENTS

[0120] FIGS. 1-7 illustrate a patient interface/modular pulmonary treatment system 100 in accordance with one embodiment of the present invention. The system 100 is formed of a number of components that mate together to form the assembled system 100 and in particular, the patient interface system 100 includes a face mask 200 and a primary treatment module valve assembly 300 that intimately mates with the face mask 200.

[0121] The illustrated face mask 200 is merely exemplary in nature and it will therefore be understood that any number of different face mask geometries/constructions can be utilized. The face mask 200 includes a face mask body 210 that has a front surface or face 212 and an opposite rear surface or face 214. The face mask body 210 includes a nose portion 216 that is defined by a planar underside 217 and a front planar portion 218. The planar underside 217 and the front planar portion 218 generally are formed at a right angle. The face mask body 210 has a peripheral edge 211 that seats and seals against the face of a user.

[0122] As shown in FIG. 3, a hollow interior 211 of the face mask body 210 has a landing or planar floor 213 that is part of the nose portion 216.

[0123] The face mask body 210 can be formed of any number of different materials including but not limited to polymeric materials.

[0124] The primary treatment module valve assembly (main module) 300 intimately mates with the face mask body 210 to form a complete assembly. In one embodiment, the main module 300 is integrally attached to the face mask body 210 so as to provide a single disposable structure. In other words, the main module 300 is not meant to be detached from the face mask body 210. However, the present invention is not limited to such a construction and covers, as well, an arrangement where the main module 300 is detachable.

[0125] In the illustrated embodiment as best shown in FIGS. 10 and 11, the module 300 can be received into an opening 219 formed in the underside wall 217 of the face-mask 200. Any number of different types of coupling can be used between the module 300 and the face mask 200. In the illustrated embodiment, the module 300 can include a lip 309 that seats above the edge of the underside wall 217 that defines the opening 219. The lip 309 thus prevents the module 300 from moving downward within the opening 219.

[0126] The main module 300 includes a number of interconnected conduits that provide various flow paths for gas(es) as described herein. In particular, the main module 300 has a

top **301**, a bottom **303**, a front **305**, and a rear **307**. The main module **300** also includes a main body **310** that is in the form of a hollow structure (e.g., tubular structure) that is open at a first end **312** and a second end **314**. In the illustrated embodiment, the main body **310** is a hollow tubular structure that has a generally circular shape.

[0127] The main module **300** also includes a first conduit **320** that fluidly communicates with the hollow interior of the main body **310**. The first conduit **320** is a hollow structure that represents a leg that extends downwardly from the main body **310** and is open at a bottom end **322** thereof. In the illustrated embodiment, the first conduit **320** is in the form of a hollow tubular structure, such as a hollow circular tube. Similarly, the main module **300** includes a second conduit **330** that fluidly communicates with the hollow interior of the main body **310**. The second conduit **330** is similar or identical to the first conduit **330** in that it is hollow structure that represents a leg that extends downwardly from the main body **310** and is open at a bottom end **332** thereof. In the illustrated embodiment, the second conduit **330** is in the form of a hollow tubular structure, such as a hollow circular tube. The first conduit **320** is near the first end **312** of the main body **310**, while the second conduit **330** is located near the second end **314** of the main body **310**.

[0128] Along the front **305**, there is a first port **340** that fluidly communicates with and forms an entrance into the hollow main body **310** above the first conduit **320** at the first end **312** of the main body **310**. As shown, the first port **340** and the first conduit **320** are formed at a right angle relative to one another. Along the front **305**, there is also a second port **350** that fluidly communicates with and forms an entrance into the hollow main body **310** above the second conduit **330**. As shown, the second port **350** and the second conduit **330** are formed at a right angle relative to one another. The first port **340** has an open end **342** that faces forwardly and the second port **350** has an open end **352** that faces forwardly.

[0129] Along the rear **307**, a safety port **315** is provided and defines an opening into the hollow interior of the main body **310**. The safety port **315** is axially parallel with the second port **350** and is generally located across therefrom.

[0130] The main module **300** also includes a third conduit **360** that extends upwardly from the main body **310** and is in fluid communication with and forms an entrance into the hollow main body **310**. Like the other conduits, the third conduit **360** can be in the form of a tubular structure that has an open free end **362**. The third conduit **360** also includes a side port **370** that extends outwardly from a side of the third conduit **360**. The side port **370** is open at a free end **372** thereof. The third conduit **360** and the side port **370** can be tubular structures.

[0131] The third conduit **360** is located generally above the second conduit **330** and communicates with the open interior of the hollow main body **310**. At this end of the main body **310**, there is an interior portion at which six (6) openings or ports intersect.

[0132] Along the top of the main body **310** there is also another port or opening **380** that opens into the hollow interior of the main body **310**. The opening **380** provides one of the primary flow paths in addition to the third conduit **360** as described herein. The opening **380** is located next to the third conduit **360**.

[0133] In accordance with the present invention, a number of accessories mate with the main body **310** to provide a modular and easily reconfigurable assembly. For example, a

first closure **400** can be provided and disposed within the open first end **312** to close off and seal the first end **312** of the main body **310**. The first closure **400** can be in the form of a plug or cap. A second closure **410** can be provided and disposed within the open second end **314** to close off and seal the second end **314** of the main body **310**. The second closure **410** can be in the form of a plug or cap. The first and second closures **400**, **410** have a lip or flange portion that allows the user to easily grasp and pull the closure out to remove it and open up the respective end of the main body **310** and also to insert the closure into the main body **310** so as to seal the main body **310**. The first and second closures **400**, **410** can be the same or different (as shown) structures.

[0134] In addition, a third closure **420** can be provided and disposed within the first port **340**. As with the other closures **400**, **410**, the third closure **420** can be in the form of a plug or cap. The third closure **420** has a lip or flange portion that allows the user to easily grasp and pull the closure **420** out of the main body **310** and conversely, insert the closure **420** into the first port **340**.

[0135] Within or on top of the opening **380**, a first inhalation valve assembly **500** is provided, which can be in the form of a swing (pivot) or flapper or any other form of one-way valve mechanism. The first inhalation valve assembly **500** can be in the form of a one-way inhalation valve that opens upon inhalation. More specifically, the first inhalation valve assembly **500** includes an inhalation valve member **510**, which opens when the patient inhales. In the illustrated embodiment, the inhalation valve member **510** has a main body **512** and a coupling member **514** that serve to couple (in a pivotal manner) the main body **512** to a portion of the main body **310** of the device. The coupling member **514** can be in the form of an axle or a hinge pin or the like that has free ends that are received within a structure **515** that is part of the main body **310** and is in the form of a pair of mounts or brackets that include openings for receiving the free ends of the coupling member **514**. The valve member **510** pivots open by rotating within the opposing mounts that form the structure **515**.

[0136] The mating between the coupling member **514** and the structure **515** serves to securely hold the valve member **510** in place and permit it to open upon patient inhalation since as described herein, inhalation by the patient causes air flow in an upward direction through opening **380**, thereby causing a lifting of the valve member **510** from the main body **310** (the valve seat defined therein).

[0137] Within the safety port **315**, an emergency valve assembly **550** is provided and in the illustrated embodiment is in the form of an emergency air valve that opens when a patient needs additional air flow for breathing. The emergency air valve can be in the form of a flapper or swing (pivot) style valve or any other form of one-way valve mechanism. The emergency valve assembly **550** includes a valve seat **552** and a valve member **554** that mates with the valve seat **552**. The valve assembly **550** is of a type commonly referred to as a one-way valve in that the valve opens in one direction to allow flow in only one direction. The valve member **554** can be a flapper type valve that mates with the valve seat **552** which can be in the form of a body (i.e., spoke structure) that receives the valve member **554** which covers the openings in the seat when closed and lifts from the seat **552** when opened. The emergency valve assembly **550** is thus located along the rear of the module and faces the wall **218** of the face mask **200**. There is a space/gap between the module **300** and the wall **218** through which air flows and can enter the emergency

valve assembly 550. Air entering through the valve assembly 500 is routed to the hollow interior of the main body 310 where it flows accordingly as described herein.

[0138] The system 100 also includes an exhalation valve assembly 590 that is designed to exhaust (vent) gas from the patient to the exterior (atmosphere). The exhalation valve assembly 590 is a one way valve assembly that is designed to only open during exhalation and only allows flow of gas in one way, namely, out of the system 100 and into the atmosphere. The exhalation valve assembly 590 is disposed within the side port 370 and in particular, at the free end 372 thereof. The exhalation valve assembly 590 can be any number of different types of one way valve assemblies including the one illustrated herein. The exhalation valve assembly 590 can be in the form of a valve seat 592 that supports a valve member 596. The valve seat 592 includes a plurality of openings 594 formed therein to allow gas to flow therethrough. In the illustrated embodiment, the valve seat 592 is a spoked structure and has a central mounting structure that is received through a center opening of the valve member 596 to attach the valve member 596 to the valve seat 592.

[0139] The exhalation valve assembly 590 is thus located above the main body 310 and gas reaches the exhalation valve assembly 590 by flowing through the third conduit 360 (which is open to the interior of the mask body 210 as described herein) and then the side port 370.

[0140] The system 100 also includes a supplemental gas valve assembly 600 that serves to allow a flow of supplemental gas to the patient. The valve assembly 600 is disposed at or near the interface between the main conduit body 310 and the conduit 360 and below the exhalation valve assembly 590. The supplemental gas valve assembly 600 is thus located at the entrance to the third conduit 360 from the main body 310 and thus, the supplemental gas valve assembly 600 allows gas flow between the main body 310 and the third conduit 360 when it is open and conversely, when the valve assembly 600 is closed, gas flow is prevented between these two conduit structures.

[0141] The supplemental gas valve assembly 600 is a one way valve assembly that is designed to only open during inhalation and only allows flow of gas in one way, namely, from the main conduit body 310 and into the third conduit 360. The supplemental gas valve assembly 600 can be any number of different types of one way valve assemblies including the one illustrated herein. The supplemental gas valve assembly 600 can be in the form of a valve seat 610 that supports a valve member 620. The valve seat 610 includes a plurality of openings 612 formed therein to allow gas to flow therethrough. In the illustrated embodiment, the valve seat 610 is a spoked structure and has a central mounting structure that is received through a center opening of the valve member 620 to attach the valve member 620 to the valve seat 610.

[0142] The third conduit 360 not only receives the supplemental gas valve assembly 600 but it can also include HME (heat and moisture exchange) media 700. As is known, HME media is constructed to heat and humidify inhaled gas and in the present system 100, the HME media 700 is disposed within the third conduit 360 above the supplemental gas valve assembly 600. The HME media 700 is thus in fluid communication with both the gas that flows through the main body 310 and into the third conduit 360 for inhalation by the patient and also exhaled gas that flows from the patient to the side port 370 where it flows out of the exhalation valve assembly 590. Thus, inhaled air flowing through the third conduit 360

to the patient and exhaled gas from the patient both are required to flow through the HME media 700. In this manner, the naturally warm and moist exhaled gas serves to treat the HME media 700 by adding heat and moisture thereto which is then transferred to the inhaled gas that flows through the HME media 700, thereby resulting in the inhaled gas being heated and humidified.

[0143] The shape and size of the HME media 700 are thus selected in part by the shape and size of the third conduit 360. In the illustrated embodiment, the HME media 700 is in the form of a cylindrical shaped body that snugly (sealingly) fits within the hollow tubular structure of the third conduit 360. The HME media 700 can be inserted and removed from the open top end 362 of the conduit 360. It is understood that the HME media can be designed alternatively in a non-cylindrical shape to conform to the shape of conduit 360 which could also be shaped non-cylindrical.

[0144] It will be appreciated that the HME media 700 is positioned such that it does not interfere with the normal operating movement of the supplemental gas valve assembly 600. In other words, the supplemental gas valve assembly 600 can freely open and close without interfering with the HME media 700.

[0145] In accordance with the present invention, the present invention includes a directional valve 800 that allows the gas flow paths within the system 100 to be defined and varied. The directional valve 800 thus opens up and closes off certain flow paths within the main body 310 and the related conduits and ports connected thereto so as to allow the user to define how the gas flows within the system 100. This allows the system 100 to have a significant number of different operating modes as described herein.

[0146] As shown, the illustrated directional valve 800 has a valve body 810 that includes a number of strategically placed openings. In particular, the valve body 810 is shaped and sized so that it is received into the second port 350 and can rotate therein to allow the position of the valve 800 to be varied. The valve body 810 can be a cylindrical shaped body as shown and includes a closed outer face 812 that is at a first end 813 of the body 810. The closed outer face 812 is exposed and accessible to the user and represents the portion of the valve body 810 that is manipulated by the user to change the position of the valve body 810 within the main body 310. The closed outer face 812 includes a protrusion or tab 816 that allows the user to manipulate the valve body 810 and more specifically, provides a contact surface from which the user can rotate the valve body 810.

[0147] An opposite second end 815 is an open end and in the case of a cylindrical valve body 810, the second end 815 is an open circular end.

[0148] The openings formed in the valve body 810 are spaced about the body at specific locations. In particular, a first side opening 820 is formed in the valve body 810 along the side wall of the valve body 810 that extends between the first end 813 and the second end 815. A second side opening 830 is formed in the valve body 810 along the side wall and at a location such that the axis of the opening 820 and the axis of the opening 830 are generally about 90 degrees disposed to one another. The valve body 810 also includes a third side opening 840 formed therein along the side wall and at a location such that the axis of the opening 840 and the axis of the first side opening 820 are about 180 degrees disposed to one another and the axis of the opening 840 and the axis of the third side opening 830 are about 90 degrees disposed to one

another. In the illustrated embodiment, the first side opening **820** is located in the 12 o'clock position, the second side opening **830** is located in the 3 o'clock position and the third side opening **840** is located in the 6 o'clock position. When the valve body **810** is placed in this orientation, the 9 o'clock position does not include an opening and instead represents a closed end.

[0149] The closed outer face **812** includes indicia that indicate the direction of the openings **820**, **830**, **840**. In particular, as illustrated, the closed outer face **812** includes arrows that point toward the open regions of the valve body, through which fluid (gas) can flow, in that the arrows point toward the three openings **820**, **830**, **840**. The region of the valve body that does not include an opening does not include an arrow indicator since fluid (gas) cannot flow in this direction through the valve body **810**. The indicia on the closed outer face **812** also include a solid semi-circular line that indicates that fluid cannot flow in this direction.

[0150] When inserted into the second port **350**, the valve body **810** extends into the hollow interior of the main body **310** and is adjacent the entrances to the other ports and conduits, such as the third conduit **360**, the second conduit **330**, and the safety port **315**. The openings **820**, **830**, **840** are sized and shaped in view of the openings that are defined between the main body **310** and the various legs (conduits) that extend therefrom. As shown in FIG. 8, the main body **310** has a first internal opening **313**, at the 9 o'clock position, that is within the main body **310** between the ports **320/340** on one side and **330/350** on the other; a second internal opening **319**, at the 6 o'clock position, that is between the main body **310** and the leg port **330**; a third internal opening **321**, at the 3 o'clock position that is between the main body **310** and leg port **314**; a fourth internal opening **323**, at the 12 o'clock position that is between the main body **310** and leg port, **360**; and a fifth internal opening **317** that is between the main body **310** and the rear conduit in which the safety (emergency) port **315** is located. It will therefore be appreciated that the location in which the directional valve **800** is disposed is defined by the intersection of five openings or conduits which define fluid flow paths. In particular, as shown in FIG. 8, a first flow path is in the direction of end **312**; a second flow path is in the direction of end **314**; a third flow path is in the direction of conduit **360**; a fourth flow path is in the direction of the safety port **315**; and a fifth flow path is in the direction of conduit **330**.

[0151] When the directional valve body **810** is rotated within the main body **310**, the openings **820**, **830**, **840** are placed in registration with the various internal openings, with the degree of registration being variable depending upon the positioning between the openings **820**, **830**, **840** and the internal openings defining the conduits.

[0152] It will therefore be understood that the directional valve body **810** is constructed to allow simultaneous flow along three flow paths that can be along three directions.

[0153] The system **100** also includes other accessories that mate with various openings/conduits thereof. In particular, a port cap **900** can be provided for mating with the open end **332** of the conduit **330**. The port cap **900** has a closed end **901** that effectively seals off the conduit **330** so as to prevent fluid flow from the conduit **330**. The port cap **900** has a tab **902** that assists the user in removing the port cap **900**. The port cap **900** is thus used when use of the conduit **330** is neither desired nor necessary and the cap **900** thus effectively dead ends the conduit **330**.

[0154] FIGS. 12-24 show different operating modes for the system **100** of the present invention.

[0155] FIG. 12 shows a venturi style, low concentration oxygen delivery with humidification. In this operating mode, an expandable external conduit **1000** fluidly mates with the module **300** as described below. The expandable external conduit **1000** has a first end **1002** and an opposing second end **1004**. The expandable external conduit **1000** is expandable along its length (i.e., it can be elongated and subsequently contracted). In the illustrated embodiment, the conduit **1000** is in the form of a collapsible corrugated tube. The conduit **1000** includes one or more air entrainment ports **1005** that are located along the length of the conduit **1000**. An air entrainment port **1005** is an opening or hole formed along the conduit **1000** that freely allows air to flow into the hollow interior of the conduit **1000**. The air entrainment port **1005** is a complete hole formed in the side wall of the conduit **1000** to allow free flow of air into the conduit **1000**. The air entrainment port **1005** can be located at any location along the conduit **1000** and there can be 1 or more ports **1005** formed in the conduit **1000**.

[0156] The first end **1002** of the conduit **1000** sealingly mates with the open end **332** of conduit **330** so as to allow the gas (such as air) flowing through the conduit to enter into the conduit **330**. Any number of different types of fits or couplings between the two parts can be achieved; including but not limited to a mechanical fit, such as a frictional fit, snap-fit, etc.

[0157] A multi-port low concentration venturi **1050** is also provided for mating with the second end **1004** of the conduit **1000**. FIGS. 25A-B illustrate the venturi **1050** in greater detail. The venturi **1050** can include a first connector **1060** that includes a plurality of venturi tubes **1070** that are attached to and pass through a first connector body **1062** which can be in the form of a plate or disk that has a center hole **1063** formed therein. The venturi tubes **1070** are elongated tubular structures having a center bore and distal orifice **1072** formed therein. As shown, the tubes **1070** can have different diameter orifices **1072**. It will be understood that the flow rate through the tubes **1070** differs depending upon the diameter of the orifice **1072** and therefore, the tubes with smaller diameter orifices have lower flow rates than the tubes with larger diameter orifices.

[0158] The venturi **1050** also includes a second connector **1080** that mates with the first connector **1060**. The second connector **1080** includes a first part that is in the part of a tubular structure **1082** that is open at both ends and includes a second part in the form of an annular shaped base ring **1084** that has a center opening. The first part **1082** is connected to the ring **1084** by means of a first leg **1085** that is attached to a peripheral edge of the ring **1084**. A second leg **1087** also extends downwardly from the tubular structure **1082**. The second leg **1087** terminates in a small disk **1089** that is disposed within the center of the opening that is defined within the center of the ring **1084**. The disk **1089** and annular base ring **1084** thus define an annular shaped opening or track **1090**.

[0159] An outer peripheral side edge of the ring **1084** includes ribs **1092** to assist in positioning the axes of the venturi tubes **1070** to the axis of the tubular structure **1082**.

[0160] It will be appreciated from FIGS. 25A-B that a portion of the annular shaped opening/track **1090** extends underneath the hollow tubular structure **1082** and thus the

hollow interior (bore) of the structure **1082** intersects the arcuate shaped portion of the opening **1090**.

[0161] The first and second connectors **1060**, **1080** mate together by inserting the small disk **1089** into the hole **1063** of the connector body **1062**, thereby allowing the first connector **1060** to rotate within the annular shaped opening or track **1090**. As shown, the tubular structure **1082** is constructed such that only one of the venturi tubes **1070** and in particular the center bore **1072** thereof is centrally located within the bore of the tubular structure **1082**.

[0162] In accordance with the present invention, the first connector **1060** can rotate relative to the second connector **1080** and within the annular shaped opening/track **1090** to vary which venturi tube **1070** is centrally located within the bore of the tubular structure **1082**. Thus, the user can vary the flow rate of the fluid being discharged from the venturi tube **1070** into the bore of the tubular structure **1082** by selecting the desired venturi tube **1070** which is centrally located within the tubular structure **1082**. To change the characteristics of the fluid flowing into the bore of the tubular structure **1082** and thus into the conduit **1000**, the user simply rotates the first connector **1060** within the track **1090** such that the venturi tubes **1070** rotate about the disk **1089** until the desired venturi tube **1070** is properly located underneath the bore of the tubular structure **1082**.

[0163] The present invention thus allows the user to easily alter how the venturi functions and how the gas is delivered to the patient.

[0164] FIG. 12 shows an operating mode in which humidification is provided to the gas (e.g., oxygen) being injected into the module **300**. In particular, the directional valve **800** is positioned such that the openings **820**, **830**, **840** are in registration with the internal opening **319** and the openings leading to the conduit **360** and the conduit portion to the end **314**. In other words, the direction valve **800** is positioned such that the conduit **330**, the conduit **360** and the main body **310** toward the end **314** are open and fluid can flow therein. However, the second end **314** is closed off with the cap **410** and thus gas cannot exit or flow into the second end **314**. In addition, the internal opening **313** is closed and thus gas cannot flow toward the first end **312** within the main body **310**.

[0165] In this position of the directional valve **800**, fluid can only flow through the conduit **330** into the main body **310** and into the conduit **360** and thus, when the patient inhales and the supplemental gas valve assembly **600** opens (under the patient inhalation), gas flowing through the conduit **1000** flows into the conduit **330** and through the open valve assembly **600** into contact with the HME media **700** which acts to heat and humidify the inhaled gas.

[0166] When the patient exhales, the exhaled gas flows through conduit **360** and the HME media **700** located within the conduit **360** thereby capturing the heat and moisture from the patients exhaled gas and is vented through the valve assembly **590**. Note that during exhalation, swing valve **500** is closed, valve **620** is also closed, both the nebulizer port and the first end **312** are capped, and hence exhaled air can only exit via HME **700** and then through the exhaled valve **590**.

[0167] FIG. 12 thus shows a venturi style, low concentration oxygen delivery (by means of the conduit **1000**) with humidification.

[0168] FIG. 13 illustrates an operating mode that is similar to the operating mode that shown in FIG. 12 with the exception that the gas (oxygen) is delivered to the patient without

humidification. The directional valve **800** is rotated in the operating mode such that the conduit **360** is closed off and thus gas does not flow into the conduit **360** and thus does not flow into contact with the HME media **700**. Instead, the gas flowing through the conduit **1000** enters the conduit **330** and can flow in the main body **310** towards both the first end **312** and the second end **314**. Since the second end **314** is closed off with the cap **410** and other conduits are closed off as shown, the gas entering the main body **310** through the conduit **1000** flows toward the first end **312**. Upon patient inhalation, the main inhalation valve assembly **500** opens and thus the gas flowing within the main body **310** enters the interior of the patient interface **200** by flowing through the valve assembly **500** and thereby reaches the patient.

[0169] When the patient exhales, the exhaled gas can only flow through the HME media **700** within conduit **360** and exits through the side port **370** through the exhalation valve assembly **590** to atmosphere.

[0170] FIG. 14 illustrates a different operating mode and in particular, shows a venturi style, low concentration oxygen delivery with reduced humidification/resistance. In this operating mode, the directional valve **800** is positioned such that the conduit **330**, the conduit **360** and the internal opening **313** are open to flow, while the main body **310** toward the second end **314** is closed off (as shown by the indicator arrows). The conduit **320** is closed off with the cap **900**.

[0171] It will be appreciated that in this embodiment, the gas (e.g., oxygen) flowing through the conduit **1000** enters the main body **310** and flows both (1) into the conduit **360** and (2) flows through the internal opening **313** toward the first end **312**. Upon patient inhalation, the main inhalation valve assembly **500** opens and gas flows into the face mask **200** to the patient and also flows through the open supplemental gas valve assembly **600** (inhalation valve **620**) and through the HME media **700** to the patient. Thus, gas flows along two flow paths to the patient during inhalation, with one path being a path that humidifies the gas. It will also be appreciated that in all of the operating modes, the amount of gas flowing into a conduit through the directional valve can be varied by rotating the directional valve to cause less registration between the openings **820**, **830**, **840** and the respective conduits. This arrangement though allows intermediate level of heated and moist gas to be inhaled, it has the advantage of overall reduced resistance during inhalation.

[0172] FIG. 15 shows another operating mode in which an accessory module in the form of a gas reservoir assembly **1100** and the venturi mechanism via venture connector **1150** are used to deliver variable concentration of oxygen. The gas reservoir assembly **1100** is in the form an expandable bag that includes a neck portion **1110**. The neck portion **1110** includes a connector **1120** that allows the bag **1100** to be sealingly attached to the module **300**. The connector **1120** attaches to the conduit **330** to permit the conduit **330** to be in free communication with the interior of the bag **1100**. The cap **900** is placed on the conduit **320** to close off this conduit **320**.

[0173] The second end **314** of the main body **310** is an active port in this embodiment and a venturi connector **1150** mates with the second end **314** to allow gas to be delivered thereto. The venturi connector **1150** includes an outer part **1160** that includes a tubing connector (nipple) **1162** that protrudes outwardly therefrom and provides an entrance into the hollow interior of the connector **1150**. The outer part **1160** also includes one or more and preferably a plurality of openings or windows **1170** that are located circumferentially about

the side wall of the outer part **1160**. The venturi connector **1150** also includes an inner part that is a tubular structure and likewise includes one or more openings or windows that are located circumferentially about the side wall of the inner part **1140**. Registration between the windows **1170** of the outer part **1160** and the openings of the inner part **1140** can be achieved by moving the outer part **1160** relative to the inner part **1140** or vice versa. It will be appreciated that air enters through the overlying window **1170** and the inner opening **1140** and into the interior of the tubular structure of the inner part that is in fluid communication with the hollow interior of the body part **310**.

[0174] As gas, such as oxygen flows through the connector **1162** and into the hollow interior of the inner part, air is entrained into the flow stream through the inner and outer openings or windows **1140** and **1170** parts. The amount of air entrained can be varied by increasing or decreasing the relative size of the openings formed by the relationship of the outer part **1150** and the inner part **1140** by rotating the outer part windows with respect to the stationary inner part windows.

[0175] The cap **900** closes off the conduit **320** and the first end **312** is also closed off.

[0176] The directional valve **800** is positioned such that the conduits **330**, **360** are open along with the second end **314** of the main body **310**. Since the conduit **330** is open, the gas reservoir assembly (bag) **1100** is freely open to the main body **310** and gas can both flow into and flow out of the bag **1100** relative to the main body **310**.

[0177] Gas, such as oxygen, flowing into the main body **310** can flow directly into the bag **1100** and thus, the bag **1100** serves a structure that stores excess gas (that enters through the venturi connector **1150**) that is not immediately needed by the patient. However, since the inside of the bag **1100** is in communication with the conduit **360** when the supplemental gas valve assembly **600** opens, the gas within the bag **1100** can be inhaled by the patient during inhalation since the valve member **620** is an inhalation valve.

[0178] In this embodiment, all of the gas inhaled by the patient passes through valve assembly **600** and thus passes through the HME media **700** resulting in heat exchange and humidification thereof. The exhaled air exists through the HME media **700** and the exhalation valve assembly **590**.

[0179] FIG. **16** shows an operating mode that is very similar to the operating mode shown in FIG. **15** with the exception that the inhaled air is provided without humidification. In this embodiment, the directional valve **800** is rotated such that the conduit **360** is closed off and instead, the internal opening **313** is open to allow gas that enters through the venturi connector **1150** at the second end **314** and additional gas, if needed, from the bag **1100** to flow toward the first end **312** which is closed off with a cap. As a result, when the patient inhales, the main inhalation valve **500** opens and the gas flows therethrough into the face mask **200**. When the main inhalation valve **500** is closed as during exhalation, the gas flowing into the main body **310** from the venturi connector **1150** can flow into the bag **1100** for storage. As a result, the only inhalation flow path is through the main inhalation valve assembly **500** and thus, the inhaled air is not heated or humidified since no inhaled air flows through the HME media **700**.

[0180] FIG. **17** shows another operating mode which is similar to the modes shown in FIGS. **15** and **16** except that in this embodiment, a dual gas reservoir assembly **1200** is provided. The operating mode shown in FIG. **17** is a variable

concentration gas (oxygen) delivery with partial heat exchange and humidification. The dual gas reservoir assembly **1200** includes two different storage compartments that are located within the expandable bag structure. In particular, a body **1210** of the assembly **1200** is partitioned into a first compartment **1220** and a second compartment **1230** by an inner dividing wall **1225**. Gas cannot pass through this wall **1225**.

[0181] The body **1210** includes two neck portions, namely a first neck portion **1222** that is associated with the first compartment **1220** and a second neck portion **1232** that is associated with the second compartment **1230**. The first neck portion **1222** includes a first neck connector **1227**, while the second neck portion **1232** includes a second neck connector **1237**. The first neck connector **1227** is sealingly attached to the conduit **320**, while the second neck connector **1237** is sealingly attached to the conduit **330**. Gas can thus flow from the main body **310** into and out of each of the first and second compartments **1220**, **1230**.

[0182] In this embodiment, there is a pair of venturi style variable concentration delivery means **1150**, one at the open first end **312** and the other at the open second end **314**. As described above, each of these venturi style variable concentration delivery means **1150** is constructed to let gas, such as oxygen from an oxygen source, to flow therethrough and the windows **1170** formed therein allow a user to select the amount of air that is also introduced into the venturi connector **1150** to mix with the gas being injected therethrough.

[0183] In FIG. **17**, the directional valve **800** is positioned such that the conduit **360** is open and the conduit **330** is open and the end **314** is open. The internal opening **313** is closed and thus gas cannot flow toward the first end **312** into contact with the main valve assembly **500** from the second end **314** and from the second compartment **1230**. As a result, the inhaled air is humidified since the gas introduced through the connector **1162** and mixed with air through window **1170** flows through the supplemental gas valve assembly **600** (upon patient inhalation) and through the HME media **700** where the inhaled gas is humidified before flowing into the face mask **200** to the patient.

[0184] Gas (oxygen) flowing through the connector **1162** at the first end **312** (along with air introduced through the window **1170**) can flow into the first compartment **1220** and also upon inhalation by the patient, the gas flows through the main inhalation valve **500** into the interior of the face mask **200** to the patient.

[0185] It will be appreciated that the gas introduced at the first end **312** can be the same or a different gas than the gas introduced at the second end **314**. When it is a different gas, the patient thus receives two different gases.

[0186] FIG. **18** shows another operating mode and in particular, it illustrates variable concentration gas (oxygen) delivery without humidification. The main difference between the modes shown in FIG. **17** and FIG. **18** is that the system of FIG. **17** humidifies the inhaled air, while FIG. **18** does not. As a result, the directional valve **800** is positioned such that the conduit **360** is closed off and the internal opening **313** is open as well as the second end **314** of the main body **310** and the conduit **330** is open.

[0187] In this position, the direction valve **800** allows gas that is injected into either the first end **312** and/or the second end **314** to flow to the main inhalation valve assembly **500** and upon inhalation, the gas flows into the face mask **200** as a result of the valve assembly **500** opening. Thus, gas can only

flow into the face mask **200** by means of the opening of the inhalation valve assembly **500**. However, gas that flows into the venturi connector **1150** at the first end **312** can flow both into the first compartment **1220** and the second compartment **1230** since the internal opening **313** is open. Similarly, gas that flows into the venturi connector **1150** at the second end **314** can flow into both the second compartment **1230** and the first compartment **1220**. It will be appreciated that the two gases can thus mix to a degree and flow into the various compartments **1220**, **1230**. However, based on fluid dynamics and flow paths based on the path of least resistance, more of the gas that enters into the first end **312** flows into the first compartment **1220** and similarly, more of the gas that enters into the second end **314** flows into the second compartment. In any event, both gases must flow through the main valve assembly **500** in order to reach the patient.

[0188] FIG. 19 shows the system **100** in a standard aerosol drug delivery mode. In this operating mode, the conduits **320**, **330** are open and conduit **360** is closed. Both ends **312**, **314** of the main body **310** are closed off with plugs and/or caps **400**, **410** and therefore gas only flows into the mask through the conduits **320**, **330**. In this case, a nebulizer **1300** is provided and a neck portion **1310** of the nebulizer **1300** mates with the conduit/port **320** to sealingly attach the nebulizer **1300** to the module **300**.

[0189] In this operating mode, the conduit **330** is open and thus acts as a supplemental gas source as described below. The directional valve **800** is positioned such that the conduit **360** is closed off and thus inhaled air does not pass through the HME media **700**. The aerosolized drug is discharged from the nebulizer **1300** and enters the conduit **320** and flows into the main body **310** in which it is available for delivery to the patient upon inhalation and upon opening of the main inhalation valve assembly **500**. It will be appreciated that excess aerosolized drug can flow through the main body **310** and be vented through the conduit **330** to atmosphere. This is especially the case when the patient is exhaling and the main inhalation valve assembly **500** is closed and thus the aerosolized drug cannot flow to the patient. Conduit **330** also provides a supplemental gas source in addition to the gas being injected into the module **300** by the nebulizer **1300** to meet the inhalation requirements of the patient.

[0190] FIG. 20 shows an operating mode for enhanced aerosol drug delivery. In this operating mode, the only difference compared to the arrangement of FIG. 19 is the inclusion of the conduit **1000** which is attached to the conduit/port **330**. The conduit **1000** is sealingly attached to the conduit/port **330** and is open at the other end to allow venting of gas through the conduit/port **330**. The conduit **1000** serves as at least a partial reservoir for storing aerosolized drug when the patient exhales. In other words, when the patient exhales, gas can flow from the main body **310** into the conduit **1000** where some remains captured therein and when the patient subsequently inhales, the main inhalation valve assembly **500** opens and aerosol drug in the conduit **1000** can flow to the face mask **200** and the patient. The conduit **1000** is adjustable-collapsible and expandable to adjust the length of the reservoir for medication storage during exhalation and thereby enhancing controlled and predictable medication delivery during inhalation

[0191] When the user desires to operate the system in this mode, the conduit **1000** can be selected so as to have no or only a few air entrainment ports **1005**.

[0192] FIG. 21 shows another operating mode that is similar to the one shown in FIG. 20 with the exception that the system in FIG. 21 also includes the multi-port low concentration venturi device **1050**. This operating mode is standard aerosol drug and low concentration oxygen delivery. The venturi device **1050** mates with the free end of the conduit **1000** and allows delivery of a gas (e.g., oxygen). This arrangement allows to control the desired oxygen concentration while simultaneously administering medication.

[0193] Since the venturi device **1050** mates with conduit **1000**, the gas flowing therethrough flows into the conduit **1000** to the patient via the main body **310**.

[0194] FIG. 22 shows another operating mode that is defined as standard aerosol drug and variable concentration oxygen delivery. In this operating mode, the gas reservoir assembly **1100** is sealingly attached to the conduit/port **330**. The conduit/port **320** is closed off by the cap **900**. A nebulizer **1400** is sealingly attached to the nebulizer port **340** for delivery of aerosol drug to the patient by flowing through the main body **310**. Upon inhalation, the main inhalation valve assembly **500** opens and the aerosol drug flows into the face mask **200** to the patient.

[0195] In this operating mode, the conduit **360** is closed off. Gas flowing through the venturi connector **1150** at the second end **314** flows to the main inhalation valve assembly **500** and can mix with the aerosol drug for delivery to the patient. The bag **1100** is open and serves to collect and store both the gas delivered through the venturi connector **1150** and by means of the nebulizer **1400**.

[0196] FIG. 23 shows another operating mode, namely, a high efficiency drug and variable concentration oxygen delivery mode. The dual gas reservoir assembly **1200** is provided and includes the first compartment **1220** and the second compartment **1230** segregated by the inner dividing wall **1225**.

[0197] The directional valve **800** is positioned such that the conduit **360** is closed. The conduits **320**, **330** are open to permit gas to flow into the first and second compartments **1220**, **1230**. Variable concentration of the gas is achieved by manipulating the mechanism **1150** as discussed herein.

[0198] FIG. 24 shows another operating mode, namely, another high efficiency drug and variable concentration oxygen delivery mode. The difference between the operating mode of FIG. 24 and the operating mode of FIG. 23 is the position of the directional valve **800**. In particular, the directional valve **800** is positioned such that the internal opening **313** is closed off, while the conduit **330** and conduit **360** are open, as well as the end **314**. At the second end **314**, the venturi style delivery mechanism **1150** is provided for delivering gas (oxygen) to the main body **310**. Gas from the mechanism **1150** can flow into the second compartment **1230** of the bag **1200** when the patient exhales. The gas from the mechanism **1150** flows to the patient by passing through the supplemental gas valve assembly **600** and through the HME media **700**, thereby heating and humidifying the inhaled gas.

[0199] The aerosolized drug flows from the nebulizer **1400** and enters the main body **310** and can only flow to the patient through the main inhalation valve assembly **500** when it opens since the internal opening **313** is closed and thus the aerosol drug cannot flow to the directional valve **800**.

[0200] This operating mode thus delivers humidified gas (oxygen/air) to the patient along one flow path and the aerosol drug is delivered along another flow path. This arrangement allows preferential flow of medication through path of lower

resistance system and additional gas as needed through a relatively higher resistance system thereby maximizing medication delivery.

[0201] FIGS. 26 and 27 illustrate another embodiment that is very similar to the system shown in the previous figures except for the inclusion of an intermediary valve assembly 1500. The intermediary valve assembly 1500 is disposed within the internal opening 313 between the conduits 320, 330. The intermediary valve assembly 1500 includes a valve body 1510 and a valve member 1520. The intermediary valve assembly 1500 is in the form of a one way valve that opens in one direction to only allow fluid to flow in the direction from the second end 314 to the first end 312. The intermediary valve assembly 1500 is an inhalation valve that opens on inhalation by the patient. Thus, when the patient inhales, gas can flow through the valve assembly 1500.

[0202] FIGS. 28 and 29 show a venturi connector 1600 according to one embodiment for use in the system 100 of the present invention in place of the venturi connector 1150. The venturi connector 1600 includes a connector body 1610 that has a first open end 1612 and an opposite second end 1616. The connector body 1610 has an intermediary lip 1614 with the portion from the lip 1614 to the first end 1612 is a tubular structure with a hollow interior. From the lip 1614 to the end 1616 is a cassette loading port 1620 that is open along the side wall of the connector body 1610. In particular the side wall includes an opening or notch 1625 that permits access to the interior of the body 1610. An inner surface of the side wall of the cassette loading port 1620 includes a locking feature, such as a locking channel 1629 or other structure such as a snap, tab, etc.

[0203] The cassette loading port 1620 receives a venturi port cassette 1700. The cassette 1700 is in the form of an elongated tubular structure that has a center bore formed therein. The size of the bore can vary as discussed above with reference to the tubes 1070. The cassette 1700 includes locking feature, such as a locking flange 1640. The cassette 1700 is received within the notch 1625 and the locking flange 1040 mates with the locking channel 1629, thereby removably locking the cassette 1700 in place. The cassette 1700 is positioned such that the bore thereof is axially aligned with the hollow interior of the body 1610 and therefore, gas flowing through the cassette flows into the top portion of the connector body 1610.

[0204] The main module 300 and the various components and accessories described herein can be formed of any number of different materials including but not limited to a plastic material.

[0205] Now referring to FIGS. 30A and 38-40, a patient interface system (modular pulmonary treatment system) 1800 is shown in accordance with one embodiment of the present invention. The system 1800 is formed of a number of components that mate together to form the assembled system 1800 and in particular, the patient interface system 1800 includes a face mask 1900 and one or more accessories that intimately mate with the face mask 1900.

[0206] The illustrated face mask 1900 is merely exemplary in nature and it will therefore be understood that any number of different face mask constructions can be utilized. The face mask 1900 includes a face mask body 1910 that has a front surface or face 1912 and an opposite rear surface or face 1914. The face mask body 1910 includes a nose portion 1916 that is defined by a planar underside 1917 and a front beveled por-

tion 1918. The face mask body 1910 has a peripheral edge 1911 that seats and seals against the face of a user.

[0207] As shown in FIGS. 38A-C, a hollow interior of the face mask body 1910 can have a landing or planar floor 1913 that is part of the nose portion 1916.

[0208] The face mask body 1910 can be formed of any number of different materials including but not limited to polymeric materials.

[0209] As shown in FIGS. 38A-C, the face mask 1900 includes a number of valve assemblies and in particular, includes a first valve assembly 1920 and a second valve assembly 1940. The first valve assembly 1920 is in the form of an inhalation valve assembled and thus opens only when the patient inhales. The first valve assembly 1920 is defined by a primary valve body 1922 that has a first end 1924 and a second end 1926. The valve body 1922 can be in the form of a tubular body with the first end 1924 defining an annular valve seat and the second end 1926 defining a portion that can be connected to another member including a conduit, such as tubing as described herein. The valve seat at the first end 1924 of the valve body 1922 can be constructed to receive a first valve 1930 which can be in the form of a flapper valve. When in the form of a flapper valve 1930, the first end 1924 includes a coupling means (members) 1932 that receive a pin 1934 that pass through bores that are formed through a pair of fingers 1936 that extend from the valve 1930. A hinge is thus formed and the valve 1930 pivots relative to an axis that extends through the pin 1934. The valve 1930 opens only when the patient inhales.

[0210] The planar underside 1917 of the nose portion 1916 includes an inhalation port or opening 1919 that is formed therein for receiving the first valve assembly 1920 and in particular, the first end 1924 of the first valve assembly 1920 is disposed within the inhalation port 1919 with the valve 1930 being at least partially disposed within the open interior space of the face mask 1900. The valve 1930 thus opens inwardly into the interior space. Any number of different means can be used to attach the first valve assembly 1920 to the face mask body including mechanical means.

[0211] The second valve assembly 1940 is in the form of an exhalation valve and mates with an exhalation port or opening 1941 formed in the nose portion 1916. In the illustrated embodiment, the opening 1941 is a circular shaped opening. The opening 1941 is formed generally perpendicular to the opening 1919 in that a central axis through opening 1919 intersects a central axis through opening 1941 to form a right angle. The opening 1941 is located above the opening 1919.

[0212] The second valve assembly 1940 includes an exhalation valve body 1942 that has a first end 1943 that is inserted into the opening 1941 and a second end 1945 that is located outside of the face mask body 1910. The valve body 1942 includes a central post 1946 that is attached to the inner wall of the body 1942 by a support structure, such as a spoke structure. The second valve assembly 1940 includes an exhalation valve 1950 that has a center hole to allow the exhalation valve 1950 to be received on the central post 1946. A valve retainer 1960 (that acts as a cap) mates with the post 1946 to securely attach and hold the valve 1950 in place. The valve 1950 seats against the support structure (spoke structure) when the valve 1950 is in the closed position. The valve 1950 opens only when the patient exhales to allow exhaled air out of the inside of the face mask 1900.

[0213] The face mask body 1910 itself preferably does not include internal exhalation ports, valves, openings, vents, etc.

[0214] In accordance with the present invention, a multi-port valve body (connector or adapter) **2000**, as shown in FIG. **39**, is provided for use with the patient interface system (modular pulmonary treatment system) **1800**. As described herein, depending upon the precise application, the various components of the system **1800** are configured to achieve the desired treatment objective. The multi-port valve body connector **2000** includes a first end **2002** and an opposing second end **2004**. The connector **2000** is a tubular structure with a hollow center that is open at the ends **2002**, **2004**.

[0215] As shown, the connector **2000** does not have a uniform outer diameter but instead can be defined by two different regions, namely, a first region **2001** being located at the first end **2002** and a second region **2003** being located at the second end **2004**. The second region **2003** can have an outer diameter that is less than the first region **2001**. A shoulder **2005** can be formed between the two regions **2001**, **2003**.

[0216] The connector **2000** also includes a pair of side conduits in the form of a first leg **2010** and a second leg **2020** that extend radially outward from the main body of the connector **2000**. The first and second legs **2010**, **2020** are spaced from one another (e.g., at a 90 degree angle) and can be formed in the same plane. The legs **2010**, **2020** can be circular shaped tubular structures that are in fluid communication with the bore (hollow interior) of the main connector body. It will be understood that the sizes (e.g., diameters) of the legs **2010**, **2020** can be different or can be the same.

[0217] The first leg **2010** is in the form of an inhalation valve assembly and thus includes a valve seat **2012**. The valve seat **2012** is disposed within and secured to the first leg **2010**. The valve seat **2012** includes a body that has air passages formed therein and includes a center post **2013** that is received within a hole **2015** formed in an inhalation valve **2017** for attaching the valve **2017** to the valve seat **2012**. The inhalation valve **2017** opens when the patient inhales.

[0218] The second leg **2020** can be an open leg in that it does not include a valve member but instead is merely a free vent to allow air to flow into and out of the inside of the connector **2000**. The second leg **2020** can thus be completely open.

[0219] The system **1800** also includes another multi-port valve body (connector or adapter) **2100** as shown in FIG. **40**. The multi-port valve body connector **2100** is similar to the connector **2000** and includes a first end **2102** and an opposing second end **2104**. The connector **2100** is a tubular structure with a hollow center and is open at the ends **2102**, **2104**.

[0220] As shown, the connector **2100** does not have a uniform outer diameter but instead can be defined by two different regions, namely, a first region **2101** being located at the first end **2102** and a second region **2103** being located at the second end **2104**. The second region **2103** can have an outer diameter that is less than the first region **2101**. A shoulder **2105** can be formed between the two regions **2101**, **2103**.

[0221] The connector **2100** also includes a pair of side conduits in the form of a first leg **2110** and a second leg **2120** that extend radially outward from the main body of the connector **2100**. The first and second legs **2110**, **2120** are spaced from one another (e.g., at a 90 degree angle) and can be formed in the same plane. The legs **2110**, **2120** can be circular shaped tubular structures that are in fluid communication with the bore (hollow interior) of the main connector body. It will be understood that the sizes (e.g., diameters) of the legs **2110**, **2120** can be different or can be the same.

[0222] The first leg **2110** is in the form of an inhalation valve assembly and thus includes a valve seat **2112**. The valve seat **2112** is disposed within and secured to the first leg **2110**. The valve seat **2112** includes a body that has air passages formed therein and includes a center post **2113** that is received within a hole **2115** formed in an inhalation valve **2117** for attaching the valve **2117** to the valve seat **2112**. The inhalation valve **2117** opens when the patient inhales.

[0223] The second leg **2120** is in the form of an exhalation valve assembly and thus includes a valve seat **2122**. The valve seat **2122** is disposed within and secured to the second leg **2120**. The valve seat **2122** includes a body that has air passages formed therein and includes a center post **2123** that is received within a hole **2125** formed in an exhalation valve **2127** for attaching the valve **2127** to the valve seat **2122**. The exhalation valve **2127** opens when the patient exhales. A valve retainer **2129** is used to couple the valve **2127** to the seat **2122**.

[0224] In addition, the connector **2100** includes a second inhalation valve assembly **2150**. The inhalation valve assembly **2150** includes a valve seat **2152**. The valve seat **2152** is disposed within and secured to the inner wall of the main body of the connector **2100**. In particular, the second inhalation valve assembly **2150** is disposed between the legs **2110**, **2120** and the second end **2104**. The valve seat **2152** includes a body that has air passages formed therein and includes a center post **2153** that is received within a hole **2155** formed in a second inhalation valve **2157**. The second inhalation valve **2157** opens when the patient inhales. The second valve **2157** can be located at the interface between the regions **2101**, **2103** below the first leg **2110** and the second leg **2120**.

[0225] When the patient inhales, the inhalation valves **2117**, **2157** open and air can flow to the patient through the main body of the connector **2100** and through the first leg **2110**.

[0226] Now referring back to FIG. **30A**, the system **1800** includes accessories as mentioned above and in particular, FIG. **30A** shows system **1800** being configured for low concentration gas (oxygen) delivery. The system **1800** includes a main external conduit **2200** that has a first end **2202** and a second end **2204**. The external conduit **2200** is in the form of a tubular structure that permits gas to be delivered from a source to the inside of the face mask and thus be delivered to the patient. The external conduit **2200** can be in the form of a corrugated tube (e.g., 22 mm tube); however, other tube structures and other conduits can be equally used. The length of the external conduit **2200** can be varied (expanded/contracted) as a result of the structure of the conduit **2200**.

[0227] The external conduit **2200** is fluidly connected to the second end **1926** of the valve body **1922** as by a frictional fit or some other suitable attachment means.

[0228] In the embodiment of FIG. **30A**, the multi-port valve body connector **2000** is coupled to the conduit **2200** and a venturi device **2300**. The second end **2004** of the connector **2000** is attached to the conduit **2200** and the first end **2002** of the connector **2000** is attached to the venturi device **2300**. The second region **2003** can be frictionally fit with the conduit **2200** as by being received within the conduit **2200**. Similarly, a connector portion of the venturi device **2300** is mated with the first region **2001** of the connector **2000**.

[0229] In this configuration, the second end **2004** represents a top end of the connector **2000** and the first end **2002** represent a bottom end of the connector. The open second leg **2020** represents a means for entraining air into the external

conduit **2200** for mixing with the gas from the gas source that is controlled (metered) by the venturi device **2300** to thereby deliver the proper concentration of gas to the patient.

[0230] As the patient inhales, the inhalation valve **1930** in the face mask opens to allow a gas mixture (e.g., mixture of air and oxygen flowing in from venturi **2300** and the entrainment port **2020** of connector **2000** at a concentration between about 24% to about 50%) to flow to the inside of the face mask for breathing by the patient. When the patient exhales, the inhalation valve **1930** closes and the exhalation valve **1950** opens to allow exhaled gas to be exhausted from the face mask **1900**.

[0231] It will be appreciated that the venturi device **2300** can be any number of different venturi devices that are configured to meter the flow of gas from the gas source to the external conduit **2200**. The venturi device **2300** can be of the type which delivers a fixed contraction of gas or can be of a type that delivers a variable concentration of gas. In addition, the venturi device **2300** can be of the type that is disclosed in commonly owned, U.S. patent application Ser. No. 61/610, 828, which is hereby incorporated by reference in its entirety.

[0232] In the illustrated embodiment, the venturi device **2300** is of a type that allows the gas concentration (oxygen) to be between about 24% to 50%.

[0233] FIG. 30B shows an alternative system **1801** for low concentration gas (oxygen) delivery (e.g., between about 24% and 50%). The system **1801** is similar system **1800** but includes a different face mask **1901** (FIGS. 38D-F). The face mask **1801** does not include the exhalation valve **1950** and does not include primary inhalation valve **1930** within the valve body **1922**. Instead the mask **1901** includes an elongated port **1921** a tubular structure that does not include any valve structure and is free of such elements. Fluid can freely flow therethrough into the inside of the mask **1901**.

[0234] Instead, the system **1801** includes the connector **2100** disposed between the port **1921** and the upper end **2202** of the external conduit **2200**. The connector **2100** is arranged such that the first region **2101** is attached to the port **1921** and thus the main valve **2157** is disposed below the side ports **2110**, **2120** closer to the external conduit **2200**. When the patient inhales, the main inhalation valve **2157** opens to allow the gas (oxygen and air) to flow through the conduit **2200** to the inside of the mask **1901** to the patient. The inhalation valve **2117** serves as an emergency valve and does not normally open or does not open to the degree main valve **2157** opens and instead opens only when there is no other source of gas for the patient. The exhalation valve **2127** in the second port **2120** serves as the main exhalation valve and exhaled air flows therethrough. During exhalation, the gas from the venturi device **2300** remains in the conduit **2200**.

[0235] An air entrainment port **2301** can be formed in the venturi device **2300** as shown for drawing additional air into the venturi device **2300** and into the conduit **2200** for delivery to the patient.

[0236] As with the system **1800**, the system **1801** can deliver gas concentrations between about 24% to 50%.

[0237] Now referring to FIG. 31 in which a standard dose aerosol drug delivery system **2400** is shown. The system **2400** has many of the components of the system **1800** and therefore, like elements are numbered alike.

[0238] In this embodiment, the connector **2000** is attached to the second end **1926** of the valve body **1922**. The open end **2004** of the connector **2000** is fluidly attached to a drug delivery means **2410** that delivers aerosolized drug. For example, the drug delivery means **2410** can be in the form of

a nebulizer that delivers aerosolized drug. The second leg **2020** of the connector **2000** is connected to a first end **2422** of an elbow shaped connector **2420** while an opposite second end **2424** is connected to one end of the external conduit **2200**.

[0239] The system **2400** is of an open nature in that the opposite end of the external conduit **2200** remains free of any connection and therefore is open to atmosphere. As a result when the main inhalation valve **1930** within the main body of the connector **2100** is closed (as when the patient is exhaling), the aerosolized drug from the means **2410** flows through the connector **2000** and through the open side port **2020** into the conduit **2200** for storage and future use. End **2204** remains open to atmosphere so the aerosolized drug can be vented if needed to atmosphere when the patient is exhaling through the exhalation valve **1940**. The conduit **2200** is adjustable-collapsible and expandable to adjust the length of the reservoir for medication storage during exhalation and thereby enhancing controlled and predictable medication delivery during inhalation.

[0240] Now referring to FIG. 32, a system **2500** is shown in the form of high dose aerosol drug delivery.

[0241] The system **2500** includes connector **2000** attached to the open end **1926** of the valve body **1922** that extends through the port **1919**. In particular, the connector **2000** is oriented such that the first region **2001** attaches to the valve body **1922** (friction fit) and the second region **2003** attaches to the source of aerosolized medication (e.g., nebulizer **2410**) as by a friction fit.

[0242] The connector **2420** (e.g., elbow connector) is attached at its first end **2422** to the second leg **2020** of connector **2000**. The second end **2424** of the connector **2420** is attached to a reservoir **2450** that receives and stores gas (e.g., aerosolized medication from the nebulizer **2410**) under select conditions. The reservoir **2450** can be in the form of a reservoir bag that includes a connector **2460** at an open first end. The connector **2460** is a hollow member and includes a side port **2465** that extends radially outward from one side of the connector **2460**. The other end of the connector **2460** is attached to and in fluid communication with the inside of an expandable reservoir bag **2470**. The reservoir bag **2470** can be in the form of a 1.5 liter bag that holds overflow aerosolized medication from the nebulizer **2410**.

[0243] Gas (aerosolized medication) can flow into the bag **2470** when the patient exhales since the inhalation valve **1930** is closed and the second leg **2020** of connector **2000** is always open leading to the reservoir **2470**. Exhalation is through valve **1940**.

[0244] The side port **2465** can be left open (so as to allow the venting of the contents of the reservoir bag **2470**) or can be closed with a cap or the like so as to close off the bag **2470** and create a closed system. The side port **2465** permits control of the concentration of the dose and in particular, if the side port **2465** is not closed and left open, the concentration of the aerosolized medication that is delivered to the patient is reduced. Conversely, if the side port **2465** is left closed (capped), the aerosolized medication that flows into the bag **2470** remains collected in the bag **2470** and is not mixed with or vented to atmosphere outside of the bag **2470**.

[0245] Now referring to FIG. 33A, a system **2600** is shown and is in the form of a 100% non-rebreather gas (oxygen) delivery system.

[0246] The system **2600** includes reservoir bag **2470** which is connected to the face mask **1900** via the valve body **1922** and in particular, the reservoir bag **2470** is connected to the

connector **2000** which in turn is connected to the valve body **1922**. More specifically, the connector **2000** is connected at region **2001** to the end **1926** of the valve body **1922** and the region **2003** of the connector **2000** is connected to the connector **2460** associated with the reservoir bag **2470**.

[0247] The inhalation valve **2017** of the connector **2000** serves as an emergency inhalation valve to allow air to be delivered to the patient under select conditions.

[0248] The side port **2465** of the connector **2460** is fluidly connected to a gas source, such as oxygen, for delivery to the patient. The connector **2460** does not include an inhalation valve within the main body thereof (unlike the connector **2100**) and therefore, gas flowing through the side port **2465** flows into the connector **2460** and the reservoir bag **2470** and into the valve body **1922** such that when the patient inhales and the inhalation valve **1930** opens, the gas from the gas source and reservoir bag **2470** is delivered to the inside of the face mask **1900** to the patient.

[0249] The gas stored in the reservoir **2470** is available once the patient inhales since it can freely flow through the connector **2460** and valve body **1922** to the patient when valve **1930** is open.

[0250] It will be appreciated that a conduit, such as tubing or the like, is used to connect the gas source to the side port **2465**.

[0251] FIG. 33B shows an alternative system **2601** (100% non-rebreather gas (oxygen) delivery) using the face mask **1901**. The connector **2100** is connected to the port **1921** at the first region **2101** thereof. Thus the main inhalation valve **2157** is located below the side ports **2110**, **2120**. The second region **2103** is connected to the connector **2460** of the reservoir **2450** (bag **2470**).

[0252] The inhalation valve **2117** in the side port **2110** is an emergency valve as discussed herein and the exhalation valve **2127** disposed in the second port **2120** is the main exhalation valve. The side port **2465** is connected to the gas source (e.g., oxygen) and when the patient inhales and valve **2157** opens, the gas is delivered to the inside of the face mask **1901** to the patient. When the patient exhales and valve **2157** is closed, the gas flows to the bag **2470** and exhaled air is vented through the side port **2120** (valve **2127**).

[0253] Now referring to FIG. 34A, a system **2700** is shown in the form of low concentration gas (oxygen) delivery with heat and moisture exchange. The system **2700** includes components previously discussed; however, these parts are arranged to provide the intended treatment. In this embodiment, a heat and moisture exchanger (HME) **2710** is used and is configured to attach to different components and in particular, includes a first end **2712** and an opposite second end **2714**. The ends **2712**, **2714** act as connector ends. In between the ends **2712**, **2714**, the HME **2710** includes HME media to perform the heat and moisture exchange. As previously mentioned, the HME media is constructed to heat and humidify inhaled air and in the present system **2700**, the HME media is disposed within the hollow tubular structure of the HME **2710**. The HME media is thus in fluid communication with both the gas to the patient as discussed below for inhalation by the patient and also exhaled gas that flows from the patient as discussed below.

[0254] In the HME mode, the main exhalation valve **1940** of the face mask **1900** is capped so as to disable this valve and this venting port during exhalation. In addition, the main inhalation valve **1930** of the face mask **1900** is also disabled so as to allow exhaled gas to flow into and through the valve

body **1922**. Any number of different means can be used to disable the inhalation valve **1930** and in one embodiment, the HME device **2710** includes an element (not shown) for disabling the main inhalation valve **1930**. For example, the HME device **2710** can include an extension (pin, rod, etc.) that is integrally attached thereto and extends outwardly therefrom and can be received within valve body **1922** so as to forcible contact and open the valve **1930** (as by lifting the valve **1930** away from its seat **1924** (this disables the valve **1930** by preventing it from closing). Since the exhalation valve **1940** is capped and the inhalation valve **1930** is disabled, both inhalation and exhalation is performed through the valve body **1922** and through the HME **2710**. This is required since for the HME **2710** to function, the HME media needs to be in fluid contact with the warm, moist exhaled gas and also in communication with the gas that is inhaled by the patient.

[0255] The end **2712** is connected to the end **1926** of the valve body **1922**, while the end **2714** is connected to the first region **2101** of the connector **2100**. The region **2103** of the connector **2100** is connected to the first end **2202** of the external conduit **2200**. The second end **2204** of the conduit **2200** is connected to the venturi device **2300**. As mentioned herein, the venturi device **2300** can be any number of different types of venturi devices including but not limited to a variable venturi device in which the concentration of the gas being delivered from a gas source to the external conduit **2200** and then ultimately to the patient can be varied.

[0256] The inhalation valve **2117** that is disposed in the first leg **2110** serves as an emergency valve. The exhalation valve **2127** disposed in the second leg **2120** serves as the main exhalation valve of the system since the exhalation valve **1940** of the face mask **1900** is closed as discussed above.

[0257] The system **2700** includes an air entrainment port to permit air to be drawn into the external conduit **2200**. The air entrainment port can be formed in any number of different locations so long as it functions to permit air to flow into the conduit **2200** to mix with the gas delivered through the venturi device **2300**. For example, a connector with an air entrainment port (i.e., an open side port) can be connected between the external conduit **2200** and the venturi device **2300**. Alternatively, the external conduit **2200** can include an air entrainment port (i.e., an open port formed in the side of the external conduit **2200**) to allow air to flow into the external conduit **2200** for mixing with the gas (oxygen) from the gas source. Alternatively, the venturi device **2300** can include an air entrainment port (an open side port) that is in fluid communication with atmosphere to draw air therein for mixing with the gas delivered through the venturi device **2300**.

[0258] The system **2700** is a low concentration gas (oxygen) delivery system since the gas concentration can be controlled by the venturi device **2300** in the manner described hereinbefore. As mentioned earlier, the venturi device **2300** is configured to deliver low concentration (e.g., about 24% to 50%) of gas.

[0259] The system **2700** operates in the following manner. When the patient inhales, the inhalation valve **2157** in the connector **2100** opens and gas can flow into the external conduit **2200** by way of the venturi mechanism **2300**. The inhalation valve **1930** is disabled (remains open) and therefore, the mixed gas flows through the external conduit **2200** to the inside of the face mask **1900**. The mixed gas flows through the HME media **2710** and therefore, is heated and humidified before delivery to the patient. Upon exhalation, the exhaled gas flows through the inside of the face mask **1900** to the

HME device 2710 where it contacts the HME media is exhaled through exhalation valve 2127. As mentioned, the HME media serves to capture heat and moisture from the exhaled air. This allows recharging of the HME media upon each exhalation, thereby allowing the inhaled air to be heated and humidified.

[0260] FIG. 34B is similar to FIG. 34A and discloses a system 2701 which uses mask 1901. The main inhalation valve is valve 2157 with the valve 2117 being an emergency valve as discussed herein. The exhalation valve 2127 is the main exhalation valve of the system. Since connector 2100 is below the HME 2710, both inhaled and exhaled air passes through the HME. The advantage of this mask assembly is that it does not require disabling of inhalation and exhalation valves as described before for embodiment 34A mask where valves 1930 and 1960 had to be disabled.

[0261] The venturi device 2300 can be of a variable type and allows the concentration of gas (oxygen) to be varied and can include an air entrainment port to allow air to flow into the device 2300. The concentration can be varied between about 24% to 50%. Any number of different venturi devices 2300 can be used.

[0262] Now referring to FIG. 35A in which a system 2800 is shown. The system 2800 is a high concentration gas (oxygen) delivery system without heat and moisture exchange.

[0263] In this embodiment, the connector 2100 is connected at its first region 2101 to the end 1926 of the valve body 1922 and the second region 2103 is connected to the reservoir 2450 (e.g., reservoir bag). In particular, the second region 2103 is attached to the connector 2460 associated with the reservoir 2450. The connector 2460 includes the side port 2465.

[0264] Connector 2420 (e.g., elbow connector) is attached at its first end 2422 to the first leg 2110 of connector 2100 and thus, the inhalation valve 2117 is in fluid communication with the connector 2420 and allows fluid to flow into the face mask 1900 under select conditions. The second end 2424 of the connector 2420 is attached to a tee connector 2810 that has a first end 2812 and an opposite second end 2814 with the first end 2812 being attached to the second end 2424 of the connector 2420 and an opposite second end 2814 being attached to the venturi device 2300. The tee connector 2810 includes an intermediate port 2820 that is located between the ends 2812, 2814. The intermediate port 2820 is an open port that functions as an air entrainment port for drawing air into the system at a location above the venturi device 2300 and therefore, the air drawn into the tee connector 2810 is mixed with the gas delivered through the venturi device 2300.

[0265] The venturi device 2300 has an inlet port 2301 associated therein in which the gas (e.g., oxygen) is delivered.

[0266] As in the other embodiments, the venturi device 2300 can be any number of different types of venturi devices.

[0267] In FIG. 35A, a gas source 2850 is shown. The gas source 2850 can be any number of different types of gas sources and the gas can be any number of different types of gas including but not limited to oxygen (e.g., it can also be heliox, etc.). A wye connector 2860 is provided and includes a main leg 2862 that is connected to the gas source 2850 and a pair of split first and second legs 2870, 2880. A distal end 2872 of the split leg 2870 is connected to the inlet port 2301 of the venturi device 2300 for delivering gas thereto. A distal end 2882 of the split leg 2880 is attached to the side port 2465 of the connector 2460 that is associated with the reservoir 2450.

[0268] As described in detail in Applicant's U.S. Pat. No. 7,841,342, which is hereby incorporated by reference in its entirety, the first and second legs 2870 and 2880 can function to meter the flow of the gas to the respective inlet (i.e., to the inlet 2301 and to the side port 2465). For example, the first and second legs 2870, 2880 do not necessarily have a uniform construction relative to one another but instead, the restrictive inside diameter of one leg 2870, 2880 can be different than the other leg for changing the gas flow rate to the respective port. For example, by reducing the diameter of the leg, the flow rate of the gas is reduced, thereby allowing the user to customize and tailor the concentration of the gas that is delivered to the patient. The system 2800 is configured such that gas concentrations of between about 50% and about near 100% is delivered under select conditions described below.

[0269] To achieve maximum gas concentration, the intermediate port 2820 of the tee connector 2810 is capped to prevent air from flowing into the tee connector 2810 and by constructing the tubing wye connector 2860 such the flow rates to the venturi device 2300 and the connector 2460 maximize gas concentration. For example, the leg 2870 connected to the venturi device 2300 can have a reduced gas flow rate compared to leg 2880 and thus, a greater amount of gas is delivered to the patient through the connector 2460 which is located below the internal inhalation valve 2157 of the connector 2100. Thus, when the patient inhales and the inhalation valve 2157 opens, the gas from the gas source flows through the connector 2460 and the valve body 1922 and into the inside of the face mask 1900 to the patient.

[0270] When the patient inhales, gas is also delivered through the venturi device 2300 and through the elbow connector 2420 and the first leg 2110 of the connector 2100 due to the inhalation valve 2117 in the first leg 2110 opening. Thus, both the gas delivered through the first leg 2870 and through the second leg 2880 meet in the connector 2100 and is delivered into the primary valve body 1922 and to the patient as the valve 1930 opens. It will be appreciated that each of the gas flowing through the first leg 2870 and the gas flowing through the second leg 2880 has to pass through one inhalation valve (i.e., valves 2117, 2157) before meeting in the first region 2101 of the connector 2100 and thus the relative flow paths have equal resistance in terms of flow to the face mask 1900. Thus, one route is not favored over the other at least in terms of flow resistance associated with the individual flow paths. This permits the customization of the gas concentration to be possible and controlled as described herein. Thus, altering/modifying the flow properties (flow rate) of the legs 2870, 2880 has direct effects on the overall concentration of the gas delivered to the patient.

[0271] It will be appreciated that two separate conduits can be used instead of the wye-connector 2860, with one conduit connected to the venturi device 2300 and the other conduit connected to the port 2465. The two conduits (tubes) can be connected to the same gas source 2850 or can be attached to separate gas sources (which can be the same or different gases).

[0272] FIG. 35B shows a system 2801 using mask 1901. The port 1921 is connected to the connector 2100 with the side port 2110 being connected to the elbow connector 2420. The other end 2424 of the elbow connector 2420 is connected to the venturi device 2300. The device 2300 includes an inlet port 2301 connected to gas source 2850. The illustrated device 2300 is of a type that allows the flow rate to be adjusted and also permits adjustment of the degree of air entrainment

as by having an adjustable air entrainment window (as by rotating the device to change the degree of openness of the window 2305, thereby altering the gas concentration).

[0273] The exhalation valve 2127 is the means for exhaling air and the valve 2117 is an emergency valve as discussed herein. As in the previous embodiment, the flow paths through the device 2300 and connector 2460 offer equal degrees of resistance since each has one inhalation valve within the flow path.

[0274] As in FIG. 35A, two conduits instead of a wye-connector 2860 can be used and more than one gas source can be used in FIG. 35B.

[0275] FIG. 36A shows a system 2900 that is very similar to system 2800 with the exception that system 2900 is high concentration gas (oxygen) delivery with heat and moisture exchange. The set-up and arrangement of the components of the system 2900 is virtually identical to the system 2800 with the one exception being the inclusion of the HME device 2710 between the connector 2100 and the primary valve body 1922. The first end 2712 of the HME device 2710 is attached to the valve body 1922, while the second end 2714 is attached to the first region 2101 of the connector 2100.

[0276] As with the previous HME application described herein, the main exhalation valve 1940 is capped (disabled) and the primary inhalation valve 1930 is disabled so as to remain always open. This causes both inhaled and exhaled air (gas) to flow through the HME device 2710 thus causing the media to be charged.

[0277] The tee-connector 2810 can include the port 2820. Gas flows to the patient when inhaling due to the opening of valves 2117, 2157. The main exhalation is at exhalation valve 2127 in side port 2120 of the connector 2100.

[0278] As in the other embodiment, the wye-connector can be substituted with two conduits attached to the device 2300 and the connector port 2465 and one or more gas sources can be used.

[0279] FIG. 36B shows system 2901 using face mask 1901 in which the HME media 2710 is connected to the port 1921. The venturi device 2300 is connected to port 2110 using elbow connector 2420 and the reservoir (bag 2470) is connected via connector 2460. Thus, gas flowing through the port 2465 being stored in reservoir bag 2470 flows through valve 2157 (when patient inhales) and the gas flowing through the venturi device 2300 and connector 2420 flows through the valve 2117 in side port 2110.

[0280] Exhalation is through the valve 2127 in side port 2120 of the connector 2100.

[0281] As in the other embodiment, the wye-connector can be substituted with two conduits attached to the device 2300 and the connector port 2465 and one or more gas sources can be used.

[0282] FIG. 37 shows a system 3000 which is a high dose drug deliver with 100% gas (oxygen) delivery.

[0283] The system 3000 uses face mask 1900 and a first region 2001 of the connector 2000 is connected to the valve body 1922. The open side port 2020 is attached to the elbow connector 2420 at end 2422 thereof. The other end 2424 of the connector 2420 is attached to a dual reservoir 3010. As shown also in FIGS. 42-43, the dual reservoir 3010 can be in the form of a bag that has a first compartment 3020 and a second compartment 3030. The compartments 3020, 3030 can be divided by a shared inner wall 3015. As shown in FIG. 42, the compartments 3020, 3030 has openings or ports 3022, 3032

and can include connector 3023, 3033 that are attached to the ports 3022, 3032 to allow the bag 3010 to be easily attached to another structure.

[0284] In particular, a U-connector 3100 (FIG. 43) is used to connect the reservoir 3010 to the elbow connector 2420. The U-connector 3100 includes a connector body 3110 that includes a first conduit section 3120 and an adjacent, separate second conduit section 3130 that merge into an upper conduit section 3140. The first conduit section 3120 has a side inlet 3125 and a side port 3127, as well as an inhalation valve 3150 formed of a valve seat 3152 and inhalation valve 3154 that mates thereto as described previously with respect to other inhalation valves. The inhalation valve 3150 is positioned within the first conduit section 3120 at a location above the ports 3125, 3127. The side port 3127 contains a relief valve 3160 and includes a relieve valve seat 3152 and a relief valve 3162 that seats thereto and a valve retainer 3164. The relief valve 3160 opens when excess pressure exists in the compartment 3020. The second conduit section 3130 is free of ports and valves and is merely open.

[0285] The side port 3125 is connected to a gas source that flows into the first compartment 3020 for storage therein so as to provide a supplemental gas source for the patient during inhaling.

[0286] The device 2410 (nebulizer) is connected to the region 2003 of the connector 2000. The gas from the nebulizer 2410 is in free communication with bag 3030 and thus when the patient exhales and the inhalation valve 1930 is closed, the aerosolized gas from the nebulizer 2410 flows into the compartment 3030 for storage therein. The supplemental gas stored in the compartment 3020 can flow to the patient when the inhalation valve 3154 opens to allow the supplemental gas to flow through the first conduit section 3120 to the section 3140 and then through connectors 2420, 2000 to the main valve body 1922 and through the main inhalation valve 1930 during inhalation. Thus, the gas flow path from the nebulizer 2410 is preferred since the gas only passes through one inhalation valve (1930) as opposed to the supplemental gas which passes through two inhalation valves 3154, 1930. There is greater resistance in the flow path of the supplemental gas.

[0287] Exhalation is through valve 1940 in the mask 1900.

[0288] FIG. 44A shows a system 3200 that uses mask 1900 and is in the form of 100% non-rebreather gas (oxygen) delivery with heat and moisture exchange. The HME device 2710 is connected to the valve body 1922. As in some of the other HME embodiments, the exhalation valve 1940 is capped and the primary inhalation valve 1930 is disabled (so as to remain open all the time). For example, the HME 2710 can include an extension that forces the valve 1930 open.

[0289] The inhalation valve 2117 is an emergency valve that can open during select conditions.

[0290] The gas flows into the port 2465 and upon inhalation the valve 2157 opens to allow flow to the patient. Exhalation is through the valve 2127.

[0291] FIG. 44B is a system 3201 using the face mask 1901. The HME device 2710 is connected to the primary port 1921 of the mask 1901 at end 2712 and the opposite end 2714 of the HME device 2710 is attached to the first region 2101 of the connector 2100. The region 2103 of the connector 2100 is connected to the connector 2460. Exhalation is through the exhalation valve 2127 in the connector 2100. The inhalation valve 2157 is located above the side port 2465 and the gas flows to the mask 1901 when the valve 2157 opens during

inhalation and when it closes during exhalation, the gas is stored in the bag 2470 to be available during the next breath.

[0292] The gas source is connected to the port 2465.

[0293] FIGS. 45 and 46 illustrate a patient interface system (modular pulmonary treatment system) 4100 in accordance with one embodiment of the present invention. The system 4100 is formed of a number of components that mate together to form the assembled system 4100 and in particular, the patient interface system 4100 includes a patient interface member (face mask) 4110.

[0294] The illustrated face mask 4100 includes a face mask body 4110 that has a front surface or face 4112 and an opposite rear surface or face 4114. The face mask body 4110 includes a nose portion 4116 that is defined by an underside 4117. The face mask body 4110 can be formed of any number of different materials including but not limited to polymeric materials.

[0295] FIG. 45 shows the body 4110 in shell form with some of the operating components being exploded therefrom. While shown in exploded form, it will be understood that the assemblies 4200, 4300 are intended to be integral with the mask body 4110 and not separable therefrom by a user.

[0296] As shown in the shell form, the body 4110 has a number of openings formed therein and in particular, the body 4110 includes a first (front) opening or port 4120; a pair of side openings or ports 4130, 4140 and a bottom opening or port 4145. The openings 4120, 4130, 4140 are formed in the nose portion 4116 of the mask body 4110. The two side openings 4130, 4140 are located opposite one another such that they are formed along the same axis and an axis extending centrally through the front opening 4120 is preferably at a right angle to the axis extending centrally through the two side openings 4130, 4140. A bottom opening 4145 can be formed such that an axis extending centrally therethrough is perpendicular the axis extending centrally through the two side openings 4130, 4140 and can also be perpendicular the axis extending centrally through the front opening 4120.

[0297] The primary gas valve assembly 4200 is in the form of an elongated hollow body 4210, such as a tubular structure that is defined by a first end 4212 and an opposing second end 4214. Between the first and second ends 4212, 4214, there is a side port 4220 that is open to atmosphere. The functionality of the side port 4220 is discussed below and generally, the side port 4220 can function as a secondary gas port. The first end 4212 is intended to mate with the bottom port 4350 of the valve body 4310 such that the hollow interior of the body 4210 communicates with the bottom port 4350 of the valve body 4310. Fluid (gas) that thus flows longitudinally through the hollow body 4210 enters or exits the mask body 4110 through the bottom port 4350 of the valve body 4310. In use, the side port 4220 faces outwardly as shown.

[0298] It will be understood that the primary gas valve assembly 4200 and the mask valve assembly 4300 are intended to be integral to the mask body 4110 and thus, are not intended to be separated from the mask body 4110. For example, the assembly 4200 and the assembly 4300 can be permanently assembled with the mask body 4110 at the point of manufacture. Any number of different techniques can be used to attach assemblies 4200, 4300 to the mask body 4110 including but not limited to using a non-releasable snap-fit. When attached, the primary gas valve assembly 4200 provides a conduit member that extends downwardly from the nose portion of the mask body 4110.

[0299] The mask valve assembly 4300 is intended for placement within the hollow interior of the mask body 4110 and as described herein, the mask valve assembly 4300 provides a plurality of valves that operate during use of the system.

[0300] The mask valve assembly 4300 includes a valve body 4310 that is intended for insertion into and coupling within the hollow interior of the mask. The body 4310 has a complementary construction as the nose portion of the face mask since it is intended to be placed therein. The body 4310 thus houses a plurality of valves and in particular, the body 4310 includes a first valve member 4320, a second valve member 4330, and a third valve member 4340. The first valve member 4320 is disposed within the front opening 4120 of the mask body 4110. The body 4310 also includes second and third valve members 4340, 4350 that are opposite one another in that they are formed along the same axis. The second and third valve members 4330, 4340 are disposed within the pair of side openings or ports 4130, 4140, respectively, of the mask body 4110.

[0301] As best shown in FIG. 51, the first valve member 4320 serves as an inhalation valve, while the second and third valve members 4330, 4340 serve as exhalation valves. As shown and according to one exemplary embodiment, the first valve member 4320 is formed of a valve seat 4322 and a valve 4324 that is coupled to the seat 4322 as by being seated over a valve retention knob 4345 that is formed as part of the valve seat 4322. Since the valve member 4320 functions as an inhalation valve, the valve 4324 is a one-way valve that lifts off of the seat when the patient inhales. The valve seat 4322 can have a spoke construction as shown to permit air flow therethrough.

[0302] As described below, the first valve member 4320 acts as an emergency air valve.

[0303] The second valve member 4330 is similar or identical to the first valve member 4320 and is formed of a valve seat 4334 and a valve 4332 that is coupled to the seat 4334 as by being seated over a valve retention knob 4345 that is formed as part of the valve seat 4334. Since the valve member 4330 functions as an exhalation valve, the valve 4332 is a one-way valve that lifts off of the seat when the patient exhales. The valve seat 4334 can have a spoke construction as shown to permit air flow therethrough.

[0304] The third valve member 4340 is similar or identical to the second valve member 4330 and is formed of a valve seat 4342 and a valve 4344 that is coupled to the seat 4342 as by being seated over a valve retention knob 4345 that is formed as part of the valve seat 4342. Since the valve member 4340 functions as an exhalation valve, the valve 4344 is a one-way valve that lifts off of the seat when the patient exhales. The valve seat 4342 can have a spoke construction as shown to permit air flow therethrough.

[0305] As mentioned and shown, the two valve members 4330, 4340 are disposed 180 degrees apart.

[0306] As best shown in the side elevation view of FIG. 52, the body 4310 includes a rear notch 4315 that is formed therein. The notch 4315 functions to receive and mount an HME member within the face mask body as described below. The body 4310 also includes a key slot 4317 and a hinge pin retention posts 4319 that are located along the rear face of the body 4310 below the notch 4315.

[0307] As shown in FIGS. 46-53, the primary gas valve assembly 4200 and the mask valve assembly 4300 can be configured to mate directly to one another and thus be coupled

to one another while being maintained integral to the mask body 4110. As shown in FIG. 47, the primary gas valve assembly 4200 includes a key 4201 in the form of a protrusion that is designed to be received within the key slot 4317 for coupling the two together. The key 4201 and key slot 4317 thus serve as locating members for properly orienting the primary gas valve assembly 4200 and a mask valve assembly 4300. The body of the primary gas valve assembly 4200 includes a locating shoulder 4211.

[0308] In accordance with the present invention, a primary inhalation valve 4250 is disposed within the body of the primary gas valve assembly 4200. As best shown in the cross-sectional view of FIG. 50, the body of the primary gas valve assembly 4200 includes an annular seat 4260 formed therein and located above the secondary gas (side) port 4220. Along the annular seat 4260, a mounting cradle 4270 is formed. The primary inhalation valve 4250 is of a swing type in that the inhalation valve pivots or swings between open and closed positions depending upon the degree of force and the direction of the force. The primary inhalation valve 4250 includes a valve member 4252 and a pin 4255 that is received through a bore formed in an enlarged section of the valve member 4252. In the illustrated embodiment, the valve member 4252 generally has a circular shape; however, other shapes are possible. The pin 4255 is thus coupled to the valve member 4252 by being disposed within the bore, thereby allowing the two parts to move (rotate) independently with respect to one another. The hinge pin 4255 has a length that is such that the ends thereof extend beyond the sides of the valve member 4252, thereby allowing the hinge pin 4255 to be received within the mounting cradle 4270 for attaching the primary inhalation valve 4250 to the body of the primary gas valve assembly 4200. As shown in FIG. 50, the primary inhalation valve 4250 is disposed above the side port 4220. The opening (port) 4251 which is covered by the primary inhalation valve 4250 in the closed position thereof can be an eccentric opening 4251 relative to the body of the primary gas valve assembly 4200 as shown in FIG. 48.

[0309] In accordance with one embodiment of the present invention, the primary inhalation valve 4250 has two different degrees of rotation. In particular, the valve 4252 itself rotates along the axis of the pin 4255 as the pin 4255 itself rotates when an appropriate force is applied to the valve 4252. The additional degree of rotation is that, in some embodiments, the valve 4252 can rotate physically relative to the pin 4255 itself. Thus, the combined pin 4255 and valve 4252 can rotate together and/or the valve 4252 can rotate independently relative to the pin 4255.

[0310] FIGS. 51 and 53 also show another feature of the present invention in that an MDI nozzle connector feature is incorporated into the port 4320. In particular, the port 4320 includes an opening 4390 formed in the side wall of the port 4320 and open to the exterior. Opening 4390 serves as an MDI port. Within the inside of the port 4320, there is a depending finger 4392 that extends inwardly into the port 4320. The finger 4392 has a central bore formed therein, with the opening 4390 defining an entrance into the central bore. At an opposite end of the bore, an MDI injection orifice 4394 is formed. As shown, an axis through the orifice 4394 is formed at an angle (e.g., 90 degree) relative to an axis through the central bore (and opening 4390). When the MDI is connected to the port 4320, the MDI nozzle partially enters into the central bore and the discharged medication flows through the bore and exits the orifice 4394 and flows directly to the patient

(the orifice 4394 directly faces the patient and the finger 4392 is located behind the emergency inhalation valve assembly).

[0311] While FIGS. 46-53 show the use of a valve seat that has a flat valve seat surface, it will be appreciated that different valve seat constructions can be used such as the construction shown in FIGS. 86-87. For example, each of the exhalation valve assemblies and the secondary (emergency) inhalation valve assembly can use the valve seat construction illustrated in FIGS. 86-87. As shown in FIGS. 86-87, a valve seat 4395 is provided and includes hub 4396 and a valve retention knob (integral to the hub) 4397. The valve seat 4395 includes a valve seat surface 4398 that is a non-planar surface and in particular, as illustrated, the valve seat surface 4398 has a conical shape (but can have any of the shapes described above).

[0312] In contrast to a flat seat geometry, the valve seat surface can have a non-planar construction and more particularly and in accordance with the present invention, the valve seat construction can be a construction selected from the group consisting of: a conical valve seat (FIGS. 86-87); a conical valve seat, a concave valve seat and a parabolic valve seat. It will be understood that a flat valve can still be used with any of the above seat geometries. A flat valve tends to take the shape of the valve seat and by taking the shape of the seat the valve remains in a non-relaxed state causing internal stresses within the valve. The internal stresses within the valve tend to push the valve into the valve seat creating a more effective seal between the valve and the seat. The dimensional distance between the seat and the under-side of the valve retention knob 4397 forces the valve to take the shape of the seat.

[0313] Now turning to FIGS. 54-55 which are rear perspective views showing the hollow interior of the patient interface 4100. FIG. 54 shows the patient interface 4100 and an HME assembly 4280 that is shown exploded therefrom. As shown and as mentioned above, the mask valve assembly 4300 is a hollow structure and includes a rear opening 4311 that is defined by an annular shaped flange or lip 4313. FIG. 55 shows the HME assembly 4280 inserted and securely attached to the mask valve assembly 4300 (i.e., disposed within the rear opening 4311). The HME assembly 4280 is positioned within the mask so as to function as an HME exchange in that both inhaled air and exhaled air of the patient passes through the HME assembly 4280.

[0314] FIGS. 56-57 show the HME assembly 4280 in more detail. The HME assembly 4280 includes an HME housing 4290 that is a generally hollow structure with an open first end 4292 and an open second end 4294. The housing 4290 generally includes an annular wall 4295 that terminates at the second end 4294 and an annular sealing flange 4296 at the first end 4292. The annular flange 4296 has a greater diameter than the annular wall 4295 and thus protrudes outwardly therefrom. As a result, an annular shaped space is formed between the annular wall 4295 and the annular flange 4296.

[0315] The annular wall 4295 has integrally formed therewith one or more HME retention snaps 4297 that assist in retaining the HME media 4299 within the annular wall 4295 of the HME housing 4290. The HME assembly 4280 also includes HME media 4299 that is sized and configured to fit within the hollow space inside the annular wall 4295. Any number of techniques can be used to securely couple the HME media 4299 within the hollow space inside the annular wall 4295. For example, the HME media 4299 can be frictionally fit, bonded using adhesive or snapped into the hollow

space inside the annular wall **4295**. The HME media **4299** can be a traditional heat moisture exchange media (i.e., foam, wovens, pleated paperboard, etc. . . .). The illustrated HME media **4299** has a solid cylindrical shape.

[0316] The annular sealing flange **4296** can include a tab **4309** that serves as finger hold for both insertion and removal of the HME assembly **4280** from the mask valve assembly. The tab **4309** extends outwardly from the annular flange **4296**.

[0317] The HME assembly **4280** is intended to be securely attached to the body of the mask valve assembly **4310** by a mechanical fit, such as a frictional fit or snap-fit. For example, the lip **4313** of the body of the mask valve assembly can be received within the annular shaped space that is formed between the annular wall **4295** and the annular flange **4296**. This is very much similar to how a lid of a plastic food container mates with the base in a sealing manner. When inserted into the rear opening **4311** of the body of the mask valve assembly, the HME assembly **4280** is securely contained and held in place within the interior of the face mask body in a location in which the open end **4292** faces the patient and thus, one end (face) of the HME media **4299** is exposed and faces the patient.

[0318] It will be appreciated that the HME assembly **4280** is thus designed to receive the inhaled breath and exhaled breath of the user (patient) and thereby serve as a heat moisture exchanger.

[0319] FIG. **58** shows one operating mode for the patient interface system (modular pulmonary treatment system) **4000** and in particular, the system of FIG. **58** is arranged for low concentration oxygen delivery with or without heat and moisture exchange dependent upon whether or not the HME assembly **4280** is placed within the patient interface **4000** as previously described. As shown, the secondary gas port **4220** is capped in this operating mode by means of a cap **4190** (that can be integrally attached to the body of the primary gas valve assembly as by a tether). In this operating mode, a venturi entrainment assembly **4400** is used. The assembly **4400** is formed of a number of parts (components) that interact with one another to provide for controlled gas delivery to a patient. The assembly **4400** is meant for use with a patient interface member (assembly) **4000** that is designed to interact with the patient and in one exemplary embodiment, the interface member **4000** is in the form of a mask assembly. It will be appreciated that the illustrated interface member **4000** is merely exemplary in nature and any number of other types of interface members can be used for delivery gas to the patient. The interface member **4000** includes the primary gas valve assembly **4200** for receiving the gas from the venturi assembly **4400**. An elongated conduit member **4410** is connected to the primary gas valve assembly **4200** and to the venturi assembly **4400** for delivering the gas from the venturi assembly **4400** to the interface member **4000**. The elongated conduit member **4410** can be in the form of an elongated tube which can be of a type which is expandable/retractable in that a length of the elongated conduit member **4410** can be varied. Conventional methods of attachment can be used to attach the elongated conduit member **4410** to both the interface member **4000** and the venturi assembly **4400**.

[0320] FIGS. **59-70D** illustrate in more detail the venturi assembly **4400** according to one embodiment of the present invention. The venturi assembly **4400** is formed of two main components, namely, a multi-port venturi member **4500** and a secondary gas entrainment valve member **4600**. FIGS. **59-68**

show the multi-port venturi member **4500** according to one embodiment. The multi-port venturi member **4500** has a first end **4502** and an opposite second end **4504**. The multi-port venturi member **4500** is a generally hollow body **4501** that includes a main hollow space **4503** at the first end **4502**. In the illustrated embodiment, the body **4501** has a cylindrical shape; however, it will be appreciated that the body **4501** can have any number of other shapes.

[0321] The body **4501** also has an air entrainment window **4560** formed therein below the main hollow space **4503**. The air entrainment window **4560** is thus located intermediate to the ends **4502**, **4504**. The member **4500** also includes a lower body section **4562** that is connected to the hollow body **4501** by means of a pair of opposing walls **4565** (e.g., a pair of vertical walls located 180 degrees apart). The wall **4565** thus partially defines the air entrainment window **4560**. The lower body section **4562** is a disk shaped structure that lies below the air entrainment window **4560** and serves as a floor of the air entrainment window **4560**. The air entrainment window **4560** is thus open to atmosphere and serves to allow air to flow into the hollow space **4503** and then flow ultimately to the patient (by means of the elongated conduit member **4410** to the interface member **4000**).

[0322] The member **4500** also includes at least one and preferably a plurality of gas port members **4570**, **4580** that extend downwardly from the lower body section **4562**. The gas port members **4570**, **4580** are configured to be individually connected to a gas source (such as an oxygen gas source). As shown in the cross-sectional view of FIG. **62**, the gas port members **4570**, **4580** are elongated hollow conduits that each allows a fluid, such as gas, to enter at an exposed, free distal end **4572**, **4582** and flow therethrough into the hollow space **4503** while flowing by the air entrainment window **4560** which is designed to allow atmospheric gas (air) to be entrained by the gas flow through the gas port orifices **4571**, **4581**. Entrainment of air through the window **4560** results due to the pressure drop created by the gas flowing through one of the gas port members **4570**, **4580** and its respective orifice **4571** or **4581**. The distal ends **4572**, **4582** can be barbed ends to facilitate mating of the gas port members **4570**, **4580** to conduits (tubing) that is connected to the same, single gas source or to different gas sources.

[0323] In another embodiment, the member **4500** includes only a single gas port member.

[0324] It will be understood that at any one operating time, gas is flowing through only one of the gas port members **4570**, **4580**. As described below, the gas port members **4570**, **4580** have different gas flow characteristics and therefore, depending upon the desired gas concentration that is chosen to be delivered to the patient, the user selects one of the gas port members **4570**, **4580** to use. Once again, at any one point in time, only one of the gas port members **4570**, **4580** is active in that gas is flowing therethrough. Alternatively, both gas ports could be used simultaneously using two gas sources or via a single gas source using a wye-tubing.

[0325] As best shown in FIGS. **59-62**, the gas port members **4570**, **4580** are constructed so as to provide known gas flow rates. In particular, a top wall **4585** is formed across the tops of the gas port members **4570**, **4580** and defines the ceiling of the gas port members **4570**, **4580**. An orifice (through hole) **4571**, **4581** is formed in the top walls **4585** of the gas port members **4570**, **4580**, respectively. The shape and dimensions of the orifices **4571**, **4581** define the gas flow characteristics base upon the flow and pressure of the gas provided

by the gas source to either of the gas port members **4570**, **4580**. Hence the degree of pressure drops could be influenced to allow predictable air entrainment to ultimately influence the final oxygen concentration of the gas mixture.

[0326] As a result, the gas port member **4570** has different flow characteristics than the gas port member **4580**. It will be appreciated that the system **4400** can include a plurality of multi-port venturi members **4500** that can be grouped as a kit. This allows the user to select the venturi member **4500** that has the desired, chosen gas flow characteristics. The venturi members **4500** can be interchanged as part of the overall system **4400** depending upon the precise application and desired gas concentration to be delivered to the patient.

[0327] As best shown in the cross-sectional view of FIG. **62**, first lengths of the elongated gas port members **4570**, **4580** are located above the lower body section **4562** and second lengths of the elongated gas port members **4570**, **4580** are located below the lower body section **4562** (which is generally in the form of a disk that defines a floor of the member). The second lengths are greater than the first lengths and therefore, more of the gas port members **4570**, **4580** are located below the lower body section **4562**. The lower body section **4562** defines a solid wall structure between the gas port members **4570**, **4580**. The tops of the gas port members **4570**, **4580** are disposed within the air entrainment window. In other words, the height of the gas port members **4570**, **4580** is such that the tops are disposed within the air entrainment window and therefore, gas exiting the top of one of the gas port members **4570**, **4580** is mixed with entrained air flowing into the air entrainment window **4560**.

[0328] The gas flow rates associated with the gas port members **4570**, **4580** can be the same or the flow rates can be different. FIGS. **60-61** illustrate a laterally disposed gas injection arrangement in which the gas port members **4570**, **4580** are located adjacent the vertical walls **4565** as best shown in FIG. **60** and the orifices **4571**, **4581** are centrally located with respect to the center bore of the gas port members **4570**, **4580**. The orifice **4571** has a greater size than the orifice **4581** and therefore, different flow characteristics. It will be appreciated that the orifices **4571**, **4581** thus serve to meter the gas from the gas source as it flows through the gas port members **4570**, **4580** into the hollow space **4503**.

[0329] As will be appreciated by the following discussion, the arrangement in FIG. **58** serves as a low concentration gas (oxygen) delivery system. The dual nature of the air entrainment windows provides for a reduced or lower concentration of gas being delivered to the patient. As described herein, the user can control the concentration of the gas (oxygen) being delivered to the patient by selecting the desired gas port member **4570**, **4580** and by manipulating the shutter **4650** to thereby change the degree the air entrainment window is open (or whether it is closed).

[0330] During inhalation, the primary inhalation valve **4250** (which is located within the hollow body of the primary gas valve assembly **4220**) opens in such a way, at least in one embodiment, that it gets significantly out of the way of the flow passage of the gas and/or aerosolized medication flow through the member **4200**. This can be achieved by constructing the valve body **4252** as a flapper valve, umbrella valve, or swing valve and the valve body **4252** can be of a rigid construction or of a flexible construction.

[0331] It will be appreciated that the emergency inhalation valve member **4324** does not open during normal inhalation activity as a result of the construction and design differences

between the primary and emergency inhalation valves **4250**, **4324**. In particular, the two valves **4250**, **4324** can be specifically designed to generate differential resistance and differential opening in response to an applied inspiratory flow or pressure. In other words, the two different valves are constructed such that the emergency valve **4324** only opens when an elevated force is applied thereto as compared to the primary valve **4250** which opens when normal inhalation forces are applied. As a result, when normal inhalation forces (pressures) are applied to both during patient inhalation, the primary valve **4250** only will open since the opening pressure requirement of the primary valve is reached; however, the normal inhalation forces (pressures) are not sufficient to open the emergency valve **4324**. As a result, the emergency valve **4324** requires more applied force (pressure) to open and only in an emergency are such elevated applied forces (pressures) achieved especially when the gas flow through the primary inhalation valve may not be sufficient to meet patient's gas flow requirement.

[0332] Once the primary valve **4250** opens, the gas (oxygen) can flow directly into the inside of the mask to the patient. When the patient exhales, the primary valve **4250** closes and one or both of the exhalation valves **4332**, **4334** open to release the exhaled air.

[0333] As will be appreciated by FIGS. **54-57**, the HME assembly **4280** can be used as part of this gas delivery operating mode. When the HME assembly **4280** is installed, the HME media **4299** is positioned between the patient and each of the patient interface system **4000** valves and valves of the primary gas valve assembly system **4200** that form a part of the overall system.

[0334] Thus, it will be appreciated that the HME assembly **4280** is so positioned within the patient interface **4100** that inhaled emergency air passes first through the emergency valve **4324** before coming into contact with the HME media **4299** and passing therethrough to the patient. Even in the unlikely event that the emergency inhalation valve **4324** opens and air flows therethrough, such air flows also through the HME media **4299** before reaching the patient. Similarly, exhaled air passes through the HME media **4299** before then exiting through one or both of the exhalation valves **4332**, **4334**.

[0335] The HME assembly **4280** is thus positioned strategically within the mask such that both inhaled and exhaled air pass therethrough and at the same time, the modular nature (cartridge nature) of the HME assembly **4280** permits the user to easily implement the HME functionality.

[0336] The HME assembly **4280** can easily be inserted and removed from the patient interface **4000** due the unique manner in which it seats within the interface **4000** and therefore, the user can easily convert the face interface **4000** between both an HME operating mode and a non-HME operating mode.

[0337] The present invention also provides for user adjustment in real-time to alter the concentration of the gas being delivered to the patient since the shutter (**4650**, FIG. **69**) can be readily adjusted.

[0338] In the embodiment of FIGS. **60-61**, the gas port members **4570**, **4580** are thus not located directly within the air entrainment window due to the members **4570**, **4580** being disposed adjacent the vertical walls **4565**.

[0339] FIGS. **63-64** show a different embodiment and in particular, show laterally disposed eccentric gas injection. As with FIGS. **63-64**, the gas port members **4570**, **4580** are

disposed laterally in that these members are formed adjacent the vertical walls 4565; however, in this embodiment, the orifices 4571, 4581 are not located centrally within the gas port members 4570, 4580, respectively. Instead, the orifices 4571, 4581 are eccentrically formed within the gas port members 4570, 4580.

[0340] FIGS. 65-66 show a different embodiment and in particular, show centrally disposed gas injection. Opposite to the arrangement shown in FIGS. 60-61, the gas port members 4570, 4580 in FIGS. 65-66 are disposed centrally in that the gas port members 4570, 4580 are not located adjacent the pair of vertical walls 4565 as best shown in FIG. 65. Instead, the gas port members 4570, 4580 are located spaced (offset) from the vertical walls 4565 and are disposed directly within the air entrainment window 4560. The orifices 4571, 4581 are located centrally within the gas port members 4570, 4580, respectively.

[0341] FIGS. 67-68 show a different embodiment and in particular, show centrally disposed eccentric gas injection. Opposite to the arrangement shown in FIGS. 63-64, the gas port members 4570, 4580 in FIGS. 67-68 are disposed centrally in that the gas port members 4570, 4580 are not located adjacent the pair of vertical walls 4565 as best shown in FIG. 67. Instead, the gas port members 4570, 4580 are located spaced (offset) from the vertical walls 4565 and are disposed directly within the air entrainment window 4560. Unlike the centrally disposed gas injection of FIGS. 65 and 66, the orifices 4571, 4581 in FIGS. 67 and 68 are eccentrically formed within the gas port members 4570, 4580.

[0342] It will be appreciated that the relative sizes of the orifices 4571, 4581 are merely exemplary in nature and the sizes of orifices 4571, 4581 can be readily changed. For instance, the orifice 4581 can be larger in size than orifice 4571.

[0343] In one exemplary embodiment, the end 4502 of body 4501 has a outside diameter of about 22 mm.

[0344] FIG. 69 shows the secondary gas entrainment valve member 4600 which is formed of a generally hollow body 4610 that has a first end 4612 and an opposing second end 4614. As shown in FIG. 58, the second end 4614 is configured to mate with the first end 4502 of the multi-port venturi member 4500. The second end 4614 can be a female connector type, while the first end 4502 of the multi-port venturi member 4500 is of a male connector type. Similarly, the first end 4612 can be a male connector type that is designed to mate with the elongated conduit member 4410.

[0345] The generally hollow body 4610 has a secondary air entrainment window 4620 formed integrally therein. The air entrainment window 4620 extends circumferentially about the body 4610 and thus is defined by a first end (in the form of a vertical edge) and a second end (in the form of a vertical edge). The air entrainment window 4620 is intended to allow atmospheric gas (air) to flow into the hollow interior of the body 4610 where it mixes with the gas that flows out of the multi-port venturi member 4500 (which one will appreciate is already mixed gas due to air being entrained through the air entrainment window 4560 (which can be thought of as being a main or primary air entrainment window). The air entrainment window 4620 is a secondary window since it serves as a second window between the gas source and the patient interface 4000 in which air can be entrained through to mix with the gas for purposes of altering the characteristics, and in particular, the gas concentration, of the gas that is delivered to the patient.

[0346] In accordance with the present invention, the secondary gas entrainment valve member 4600 includes a rotatable shutter 4650 that is cylidrically and vertically coupled to the body 4610 and more specifically, the shutter 4650 is disposed about the body 4610 in the location of the air entrainment window 4620 to allow the shutter 4650 to either open or close the secondary gas entrainment window 4620 depending upon the desired setting as described below. The shutter 4650 has a first (top) end 4652 and an opposite second (bottom) end 4654.

[0347] Any number of different techniques for coupling the shutter 4650 to the body 4610 can be used. For example, different types of mechanical attachment techniques can be used including a friction fit, a snap fit, etc. In FIG. 69, the body 4610 includes a shutter retaining mechanism in the form of tabs 4665 spaced apart from one another and located circumferentially about the body 4610. The top end 4652 of the shutter 4650 is located below the tabs 4665.

[0348] The shutter 4650 itself has an air entrainment window 4660 formed therein. The air entrainment window 4660 is defined by a first end 4662 (vertical wall) and a second end 4664 (vertical wall).

[0349] There is a rotational correlation between the degree of registration between the air entrainments windows 4620, 4660 and more particularly, the degree of overlap and openness of the two windows 4620, 4660 factors into the amount of air being entrained through the secondary gas entrainment valve member 4600 and thus, the concentration of the gas delivered to the patient.

[0350] The shutter 4650 rotates about the body 4610 as mentioned above and therefore, the shutter 4650 can include features 4655 as a means to assist the user in rotating the shutter 4650. In particular, the features 4655 can be in the form of ribs that are spaced apart and extend circumferentially about the shutter 4650. The ribs 4655 are raised structures that permit the user to more easily grip and rotate the shutter 4650 relative to the body 4610.

[0351] The secondary gas entrainment valve member 4600 also preferably includes indicia to allow the user to set the degree of air entrainment and thus, to position the secondary gas entrainment valve member 4600 at a setting that achieves the desired gas concentration being delivered to the patient.

[0352] For example, the shutter 4650 can include a gas concentration pointer 4665 that is formed along the bottom edge 4654 of the shutter 4650 and the lower region of the body 4610 includes gas concentration indicator markings 4670. For example, the markings 4670 include a plurality of gas concentrations (in percentages) that correspond to the concentration of the gas that is delivered to the patient. The markings 4670 directly correspond to the degree of overlap between the windows 4620, 4660 in that the greater the overlap (registration) between the windows 4620, 4660, the greater the openness of the secondary air entrainment window resulting in a greater flow of atmospheric air into the member 4600 (thereby resulting in a reduced gas concentration being delivered to the patient as a result of more mixing between atmospheric gas and the mixed gas from the multi-port venturi member 4650).

[0353] The rotatability of the shutter 4650 allows the user to effectively and easily "dial in" the desired gas concentration for delivery to the patient by simply rotating the shutter 4650 to cause the pointer 4665 to point to the desired, selected gas concentration indicator marking 4670 (which has the desired

gas concentration indicia listed). This results in the window being open the proper desired amount to achieve the target mixing, etc.

[0354] FIGS. 70A-70D shows the various operating states of the secondary gas entrainment valve member 4600.

[0355] FIG. 70A shows the air entrainment port in a fully opened position (i.e., complete registration between the windows 4620, 4660). As will be seen in FIG. 70A, the markings 4670 include two numbers, namely, a first number that is disposed on top of a second number. These two numbers correspond to the gas concentrations (%) that are obtained depending upon which of the venturi gas port members 4570, 4580 is used. In the example shown in FIG. 70A, the second number (35%) corresponds to the gas port member 4570 (which has a larger orifice 4571 compared to the orifice 4581 of gas port member 4580). The first number (24%) corresponds to the gas concentration obtained with gas port member 4580.

[0356] FIG. 70D shows the air entrainment port in a fully closed position (i.e., complete non-registration between the windows 4620, 4660). As will be seen in FIG. 70D, the markings 4670 include two numbers, namely, a first number that is disposed on top of a second number. These two numbers correspond to the gas concentrations (%) that are obtained depending upon which of the gas port members 4570, 4580 is used. In the example shown in FIG. 70D, the second number (50%) corresponds to the gas port member 4570 (which has a larger orifice 4571 compared to the orifice 4581 of gas port member 4580). The first number (31%) corresponds to the gas concentration obtained with gas port member 4580.

[0357] FIGS. 70B and 70C show the air entrainment window in partially open positions in which the window 4660 formed in the shutter 4650 is not in complete registration with the window 4620 formed in the body 4610. It will be appreciated that FIG. 70B is a partially open window.

[0358] It will be appreciated that the openness of the air entrainment window is very similar in FIG. 70B and in FIG. 70C; however, the two different resulting gas concentrations (e.g., 28% vs. 40%) is based on whether the gas port member 4570 or gas port member 4580 is used. When the larger sized gas port member 4570 is used, the 40% is obtained when the window is in the position of FIG. 70C. Conversely, when the smaller sized gas port member 4580 is used, a gas concentration of 28% is obtained when the air entrainment window is placed in the partially open position of FIG. 70B. It is to be appreciated that the openness of the entrainment windows in 70B and 70C may be different and varied to achieve different concentrations of oxygen delivery based on whether the gas port member 4570 or gas port member 4580 is used.

[0359] It will be appreciated that other partially open positions can be used with the present system.

[0360] It will also be understood that the gas entrainment valve member 4600 can be used with other venturi members besides the multi-port venturi member 4500 that is shown paired with the member 4600 in assembly 4400. For example, the venturi connector assemblies of FIGS. 25, 28-29, 30 and 34-36 can be used with the gas entrainment valve member 4600. In particular and similar to the system of FIG. 58, the combination of any of the above mentioned venturi connector assemblies and with the gas entrainment valve member 4600 provides two different air entrainment windows that are spaced apart from one another. More specifically, the combination provides two air entrainment windows that are located

in series between the gas source and the patient interface (mask) 4000. It will also be appreciated that the gas entrainment valve member 4600 can be used with any traditional venturi (venturi connector) to provide a dual air entrainment window structure.

[0361] Unlike conventional venturi design, the present invention teaches the use of two connector members that provide the dual window design (dual air entrainment windows) with one air entrainment window being located serially downstream from the other window and at least one window is adjustable in nature in that the degree of which the window is open can be adjusted by the user.

[0362] It will be appreciated that the elongated conduit 4410 can vary in its diameter and/or length and the size and length of the elongate conduit 4410 dictates the reservoir capacity and provides a means of reducing the noise level of the gas delivery mechanism experienced by the patient.

[0363] FIG. 71 illustrates one operating mode of the system in accordance with the present invention and in particular, utilizes the patient interface (mask) 4000. The operating mode shown in FIG. 71 can be characterized as being a high concentration oxygen delivery operating mode. In this operating mode, the second (distal) end 4214 of the primary gas valve assembly 4200 is attached to a high concentration gas delivery assembly 4700. The assembly 4700 includes a reservoir member 4710 which can be in the form of an inflatable bag that has an opening 4712 at one end.

[0364] The assembly 4700 also includes a high concentration gas valve connector 4720 which is configured to mate with and seal to the bag opening 4712. As best shown in FIGS. 72-76, the connector 4720 is formed of a valve body 4722 that has a first end 4724 and an opposing second end 4726. The valve body 4722 is an elongated hollow structure to allow fluid (gas) to readily flow therethrough. The valve body 4722 includes a retaining ring 4725 that assists in coupling the reservoir member 4710 to the valve body 4722. However, it will be appreciated that other retaining mechanisms can be used.

[0365] As shown, the valve body 4722 includes a first gas port 4730 and a second gas port 4740, each of which is disposed along one side of the body 4722. The first gas port 4730 is located closer to the first end 4724 and can be in the form of a barbed gas port that is attached to a conduit (e.g., tube) that is attached to a gas source (e.g., oxygen). The second gas port 4740 is located below the first gas port 4730 and includes a main port body 4750 that is integrally formed with the body 4722. The main port body 4750 is a hollow structure (tubular) that has an open end 4751 and includes along its outer surface a detent ring 4752. The main port body 4750 also includes an air entrainment window 4755 that is formed therein circumferentially about the main port body 4750.

[0366] The second gas port 4740 is of an adjustable type in that it includes a rotating shutter 4760 that is cylindrically and horizontally coupled to the main port body 4750. As shown, the rotating shutter 4760 can be in the form of cap-like structure that is received on the open end of the main port body 4750. The shutter 4760 has an open end (which receives the main port body 4750) and an opposite closed end. The shutter 4760 has a main section that has an air entrainment window 4762 formed therein. The air entrainment window 4762 extends circumferentially about a portion of the body 4750. The air entrainment window 4762 is formed at a location on the shutter 4760 such that it overlaps (is in registration) with

the window 4755 of the main port body 4750 and preferably, the dimensions of the window 4762 are greater than the dimensions of the window 4755.

[0367] The rotating shutter 4760 also includes a (barbed) gas port member 4770 that extends radially outward from the closed end of the shutter 4760 and also is formed internally within the shutter 4760 as shown in FIG. 75. The internal section of the member 4770 serves as a gas injection orifice that directs the gas into the hollow interior of the body 4722. The open end of the internal section of the member 4770 is located preferably in-line with the windows 4755, 4762 since the internal section is physically received within the hollow interior of the main port body 4750. Orifice 4770 could be of variable size (diameter) to allow variable gas flow and pressure drop for air entrainment from window 4762. Multiple venturi arrangement can be made like FIGS. 25, 28-29, 30-36.

[0368] Similar or identical to the shutter 4650, the shutter 4760 also includes a gas concentration pointer 4767 that extends outwardly from (and beyond) the open end of the shutter 4760. The valve body 4722 includes gas concentration indicator markings 4769 that are formed thereon. For example, the markings 4769 can be vertically displayed along the connector body 4722. As the user rotates the shutter 4760, the degree of registration between the windows 4755, 4762 changes (between a fully open position and a fully closed position, as well as intermediate, partially open states). To change the concentration of the gas being delivered through the second gas port 4750, the user simply adjusts the shutter 4760 and thereby changes the amount of air entrainment that occurs. In the fully open position of the shutter, more air is entrained with the gas flow and therefore, the concentration of the gas (e.g., oxygen) that is delivered to the patient is lower. FIG. 76 shows the air entrainment window partially open.

[0369] One will appreciate that by having two different gas port entry points, different concentration of gas can be achieved and then delivered to the patient. For example, the first gas port 4730 is unmeted and therefore produces a fixed flow rate of the gas (gas concentration) that flows there-through into the main body. However, as discussed above, the second part port 4740 is metered and produces a variable gas concentration since an amount of air is entrained with the gas that flows through the port member 4770. Much like the shutter 4650 described hereinbefore, the shutter 4760 can be rotated to adjust the degree of air entrainment and thereby, directly alter the mixed gas that is delivered into the main port body to the patient. It is expected that in most applications, both the first and second gas ports 4730, 4740 are attached to the gas source and are both actively receiving the gas at the same time. In the event that the shutter 4760 is closed, the concentration of the gas flowing through the first and second gas ports 4730, 4740 is the same. However, in one embodiment, at least one of the first gas port 4730 and the second gas port 4740 can be sealingly closed, as by a cap, thereby leaving one active gas port.

[0370] As shown in FIG. 71, the first and second gas ports 4730, 4740 are located below the primary inhalation valve 4250 (that is part of the patient interface 4000); however, there is free, unobstructed flow between the first and second gas ports 4730, 4740 and the interior of the reservoir member 4710. Thus, when the primary inhalation valve 4250 is closed, any gas flowing through the first and second ports 4730, 4740 flows directly into the interior of the reservoir member 4710. The bag 4710 can expand as it fills up.

[0371] When the patient inhales, the primary inhalation valve 4250 opens as discussed herein before and gas can flow directly from the first and second gas ports 4730, 4740 and also any gas stored in the reservoir bag 4710 can flow to the patient through the primary inhalation valve 4250.

[0372] Now turning to FIG. 77 which shows another operating state of the system 4000 in accordance with the present invention. The embodiment shown in FIG. 77 can be thought of as a 100% non-rebreather gas (oxygen) delivery system. In this embodiment, the reservoir member 4710 is connected to a connector 4800 that is a hollow (tubular) structure that includes a single gas port 4810 extending outwardly therefrom. This gas port 4810 is intended for connection to a gas source, such as oxygen.

[0373] Since gas is delivered through the gas port 4810 by means of the gas port 4810, the concentration of the gas is fixed and there is no air entrainment (venturi) in this embodiment (thus, the concentration of the gas is not diluted with air). When the primary inhalation valve 4250 is closed, the gas flows through the gas port 4810 into the reservoir member 4710 for storage therein. When the primary inhalation valve 4250 opens, the gas flowing through the gas port 4810 and the gas stored in the reservoir member 4710 can flow to the patient interface 4000.

[0374] Now turning to FIG. 78 which shows another operating mode of the system 4000 of the present invention and in particular, shows a standard dose aerosol drug delivery system. In this embodiment, the secondary port 4220 is not capped with a cap or plug 4190 and a nebulizer device 4900 is sealingly fitted to the open second (distal) end of the primary gas valve assembly 4200. The nebulizer device 4900 is thus located below the primary gas valve 4250. The aerosolized medication from the nebulizer device 4900 is thus delivered into the hollow space of the assembly 4200 and upon opening of the primary gas valve 4250, the aerosolized medication flows directly into the interior of the face mask 4110 to the patient.

[0375] Since the secondary gas port 4220 remains open and is located below the primary gas valve 4250, the aerosolized medication is free to flow out of the secondary gas port 4220 when the primary gas valve 4250 is closed as during exhalation. The secondary gas port 4220 thus serves as exit or outlet for the aerosolized medication during exhalation and as a supplemental gas source in addition to the aerosolized medication delivered by the nebulizer 4900 during inhalation.

[0376] FIG. 79 shows a different operating mode of the system 4000 of the present invention and in particular, this operating mode is an enhanced dose aerosol drug delivery mode. As with the standard dose aerosol drug deliver mode of FIG. 78, the operating mode of FIG. 79 includes the nebulizer 4900 attached to the distal end of the primary gas valve assembly 4200. Instead of the secondary gas port 4220 being used as a vent or supplemental gas source, a reservoir assembly 5000 is attached to the secondary gas port 4220 for storing the aerosolized medication when the primary gas valve 4250 is closed.

[0377] In the illustrated embodiment, the reservoir assembly 5000 comprises several components that mate together to provide a reservoir for storing the aerosolized medication. For example, the illustrated assembly 5000 includes a connector 5010 that sealingly mates with the secondary gas port 4220. As shown, the connector 5010 can be in the form of a 90 degree elbow connector that attaches at a first end 5012 to the secondary gas port 4220 and has an opposite second end

5014. The assembly **5000** also includes a reservoir member **5100** which, as illustrated, is in the form of an elongated reservoir tube that has a first end **5102** and an opposite second end **5104**. The first end **5102** is sealingly attached to the second end **5014** of the connector **5010**.

[0378] It will be appreciated that the reservoir tube **5100** can be a corrugated tube and can have an adjustable length. In addition, the diameter of the tube **5100** can vary. It will be appreciated that by changing one or both of the length and diameter of the tube **5100**, the storage capacity of the reservoir changes.

[0379] The secondary gas port **4220** is located below the primary gas valve **4250** and the aerosolized drug is introduced into the assembly **4200** at a location below the primary gas valve **4250** and therefore, when the primary gas valve **4250** is closed, the aerosolized medication flows directly into the reservoir assembly **5000** and more particularly, the aerosolized medication can flow through the secondary gas port **4220** through the connector **5010** and into the reservoir tube **5100**. The aerosolized medication thus resides within the tube **5100** and is stored therein.

[0380] The enhancement in the drug delivery of the aerosolized drug (medication) results as a result of the secondary gas port **4220** not being simply open to atmosphere as in the embodiment of FIG. **78** but instead is configured to a reservoir member in the form of the tube **5100** in which aerosolized medication is contained (stored) therein.

[0381] Now referring to FIG. **80** in which yet another operating mode of the system **4000** is shown and in particular, the illustrated operating mode is a high dose aerosol drug delivery operating mode. In this embodiment, the patient interface (mask) **4000** is connected to components previously described herein and therefore, like numbers are used in the figures to identify the same components. More specific, the elbow connector **5010** is sealingly attached to the secondary gas port **4220**; however, instead of the connecting the nebulizer device **4900** to the open end of the primary gas valve assembly **4200**, the nebulizer device **4900** is attached to the end **5014** of the elbow connector **5010**.

[0382] Similar to the operating mode shown in FIG. **71**, the operating mode of FIG. **80** includes the use of the high concentration gas delivery assembly **4700**, which is connected to the second (distal) end of the primary gas valve assembly **4200**. The reservoir member **4710** is in the form of an inflatable bag. The gas delivery assembly **4700** includes the first gas port **4730** and the second gas port **4740** and as previously discussed, this permits one of these ports to be connected to a gas (e.g., oxygen or heliox, etc.) that is for delivery to the patient. As discussed with reference to FIG. **71**, a wye tube can be used to connect the two ports **4730**, **4740** to a single gas source or separate tubes (conduits) can be used to connect the two ports **4730**, **4740** to two different gas sources. As mentioned herein, during normal operating conditions both the first and second gas ports **4730**, **4740** are attached to the gas source and are both actively receiving the gas at the same time. When a wye tube is used, it will be appreciated that the two distal legs of the wye tube can have the same or different diameters. By controlling the diameters of the distal legs, different gas flow rates can be achieved in the distal legs and thus, different gas flow rates are provided to the nebulizer and one of the gas ports **4730**, **4740**. Though two separate gas sources could be used, the system of delivery is intended to be used in conjunction with a wye tube, as previously discussed, with the exception that in this case one leg of the wye tube

provides gas to the nebulizer **4900** and the other leg of the wye is connected to either one of gas ports **4730** or **4740** to control the oxygen concentration of the gas delivered to the patient. The other port that is not connected to the tubing may remain open or can be capped/plugged using a tethered cap or plug. One could in an alternative mode of delivery simultaneously choose two sources of gas and connect one gas source to the nebulizer and one gas with a wye-tubing to both the ports at the same time during medication delivery to adjust medication delivery and oxygen concentration at the same time.

[0383] The shutter **4760** can be rotated to adjust the degree of air entrainment and thereby, directly alter the mixed gas that is delivered into the main port body to the patient. The first and second gas ports **4730**, **4740** are located below the primary inhalation valve **4250** (that is part of the patient interface **4000**); however, there is free, unobstructed flow between the first and second gas ports **4730**, **4740** and the interior of the reservoir member **4710**. Thus, when the primary inhalation valve **4250** is closed, any gas flowing through the first or second ports **4730**, **4740** flows directly into the interior of the reservoir member **4710**. The bag **4710** can expand as it fills up.

[0384] When the patient inhales, the primary inhalation valve **4250** opens as discussed hereinbefore and gas can flow directly from either the first or second gas port **4730**, **4740** and also any gas stored in the reservoir bag **4710** can flow to the patient through the primary inhalation valve **4250**.

[0385] It will also be appreciated that the reservoir member (bag) **4710** stores aerosolized medication from the nebulizer device **4900** as a result of its positioning and based on the fact that there is a free, unobstructed flow path from the nebulizer device **4900** to the inside of the reservoir bag **4710**. In particular, since the nebulizer device **4900** is connected to the secondary gas port **4220**, which is below the primary inhalation valve **4250**, the aerosolized medication from the nebulizer device **4900** can freely flow into the assembly **4200** (at a location below the primary inhalation valve **4250**) and then through the connector **4720** and into the inside of the bag **4710** when the primary inhalation valve **4250** is closed (i.e., as during exhalation of the patient).

[0386] Conversely, when the patient inhales, the primary inhalation valve **4250** opens and the aerosolized medication (drug) can flow directly from the nebulizer device **4900** through the assembly **4200** to the patient. In addition, the connector **4720** is fluidly connected to the assembly **4200** and thus, the gas delivered through either of the ports **4730**, **4740** is delivered through the open primary inhalation valve **4250** to the patient. There are thus two gas flow paths to the patient when the patient inhales. During exhalation, the reservoir bag **4710** stores both the gas delivered through either port **4730** and/or **4740**, and/or the aerosolized medication delivered from the nebulizer device **4900** through the connector **5010**.

[0387] The embodiment of FIG. **80** thus provides a high dose aerosol drug delivery system.

[0388] FIG. **81** illustrates another operating mode for the system **4000** and in particular, this operating mode is a high dose aerosol drug delivery with gas delivery operating mode. This operating mode is similar to the operating mode of FIG. **80** with the exception that the high concentration gas delivery assembly **4700** is replaced with a high dose aerosol drug/gas delivery mechanism **5100** which is shown in more detail in FIGS. **83-85**.

[0389] The high dose aerosol drug/gas delivery mechanism **5100** is a dual reservoir system that is formed of a dual

reservoir member (bag) **5110** that has two different (separate) interior compartments for storage of a fluid (gas). In the illustrated embodiment, the dual reservoir member **5110** is in the form of a bifurcated bag that has a first chamber (compartment) **5112** and a second chamber (compartment) **5114**. The bag **5110** includes a neck portion that includes a first opening **5115** and a second opening **5117** (side by side relationship). Note that the dual bag reservoir system for dose drug delivery and high concentration oxygen delivery has been described earlier in FIGS. **37** and **43**.

[0390] The mechanism **5100** includes connectors **5120** that are constructed to mate with the two openings **5115**, **5117** of the reservoir bag **5110**. Each connector **5120** has a retaining member **5125**, such as a retaining ring, which serves to attach the connector **5120** to the bag **5110**. The conduit members **5122**, **5124** of connectors **5120** define fluid flow paths allowing gas to flow into and out of the bag **5110**.

[0391] The mechanism **5100** also includes a high dose valve body **5130** that includes a first end **5132** and an opposing second end **5134**. The first end **5132** is a single conduit member **5135** in that it defines a single flow path, while the second end **5134** has a dual conduit structure in that the second end **5134** includes two side-by-side conduit members **5140**, **5150** as best shown in the cross-sectional view of FIG. **85**. The conduit members **5140**, **5150** resemble legs. The conduit members **5135**, **5140**, **5150** are all in fluid communication with one another; however, as discussed below, the conduit member **5140** has a selective fluid communication due to the presence of a valve therein. The second end **5134** can thus generally have a U-shape as shown. The first end **5132** can be in the form of a 22 mm female connector.

[0392] The valve body **5130** also includes an over-inflation valve assembly **5200**. More specifically, the valve body **5130** has a side port **5210** formed therein which is formed in the conduit member (leg) **5140**. The valve assembly **5200** is disposed within the side port **5210** and more particularly, the valve assembly **5200** includes a valve seat **5220** that is disposed within the side port **5210** and is securely attached to the valve body **5130**. The valve seat **5220** can be a spoke-like structure with a plurality of openings formed between the spokes and also includes a valve mounting post **5222** extending outwardly therefrom. An over-inflation valve **5230** is mated to the post **5222** (by reception of the post **5222** within an opening) and lies over the valve seat **5220**.

[0393] In accordance with the present invention, a valve retention thimble **5240** is provided and is received over the post **5222**. The valve retention thimble **5240** is constructed and intended to control valve movement. The thimble **5240** is adjustable on the post **5222** and thereby can control the maximum valve movement distance. In other words, the thimble **5240** can be set at a specific distance from the valve seat **5220** and thus from the valve **5230** itself since the thickness of the valve **5230** is known. For a given valve **5230**, the greater the distance from the thimble **5240** to the valve seat and the valve, then the greater the degree of permitted movement for the valve **5230**, thereby allowing a greater degree of opening for the valve **5230**. In one embodiment, the thimble **5240** is adjusted until it is at a desired location along the post and is then set at the site of the manufacturer. Any number of techniques can be used to set it in place including using an adhesive. The use of an adjustable thimble **5240** allows the manufacturer to select and set the position of the thimble **5240**, thereby controlling the degree of movement of the valve. It

will be appreciated that the thimble **5420** can be used on the exhalation valves described herein with respect to the face mask.

[0394] The valve body **5130** also includes a gas valve assembly **5300** that is disposed within the conduit member (leg) **5140**. The gas valve assembly **5300** includes a valve seat **5310** that is disposed within conduit member **5140** and is securely attached to the valve body **5130**. The valve seat **5310** can be a spoke-like structure with a plurality of openings formed between the spokes and also includes a valve retention knob (protrusion) or the like **5312** extending outwardly therefrom. A gas valve **5320** is mated to the knob **5312** (by reception of the knob **5312** within an opening in the valve) and lies over the valve seat **5310**. As best shown in FIG. **85**, the gas valve **5320** is positioned proximate to the interface between the leg **5140** and the single conduit **5135** and is thus located above the over-inflation valve assembly.

[0395] The gas valve assembly **5300** serves as an inhalation valve that opens upon inhalation.

[0396] The valve body **5130** also includes a side gas port assembly **5400** that permits a gas, of variable concentration, to be delivered into the leg **5140** at a location below the gas valve assembly **5300**. The side gas port assembly **5400** has a hollow side port body **5410** that extends outwardly from the side of the leg **5140**. The side port body **5410** includes an air entrainment window **5415** formed therein to allow fluid flow into the hollow interior thereof. The side gas port assembly **5400** is similar to or identical to the second gas port **4740** and therefore, is of an adjustable type in that it includes a rotating shutter **5420** that is rotatably coupled to the side port body **5410**.

[0397] As shown, the rotating shutter **5420** can be in the form of cap-like structure that is received on the open end of the side port body **5410**. The shutter **5420** has an open end (which received the side port body **5410**) and an opposite closed end. The shutter **5420** has a main section that has an air entrainment window **5422** formed therein. The air entrainment window **5422** extends circumferentially about a portion of the shutter. The air entrainment window **5422** is formed at a location on the shutter **5420** such that it overlaps (is in registration) with the window **5415** of the side port body **5410** and preferably, the dimensions of the window **5422** are greater than the dimensions of the window **5415**.

[0398] A (barbed) gas port member **5430** that extends radially outward from the closed end of the shutter **5420** and also is formed internally within the shutter **5420**. The internal section of the member **5430** serves as a gas injection orifice that directs the gas into the hollow interior of the body **5410**. The open end of the internal section of the member **5430** is located preferably in-line with the windows **5415**, **5422** since the internal section is physically received within the hollow interior of the side port body **5410**.

[0399] Similar or identical to the shutter **4650**, the shutter **5420** also includes a gas concentration pointer **4767** that extends outwardly from (and beyond) the open end of the shutter **5420**. The body **5410** or some other proximate structure includes gas concentration indicator markings (similar to markings **4769**) that are formed thereon. As the user rotates the shutter **5420**, the degree of registration between the windows **5415**, **5422** changes (between a fully open position and a fully closed position, as well as intermediate, partially open states). To change the concentration of the gas being delivered through the side gas port, the user simply adjusts the shutter **5420** and thereby changes the amount of air entrainment that

occurs. In the fully open position of the shutter, more air is entrained with the gas flow and therefore, the concentration of the gas (e.g., oxygen) that is delivered to the patient is lower.

What is claimed is:

1. A patient interface device for delivering a gas to a patient comprising:

a main body for placement against a face of the patient, the main body including a conduit portion that is open at a first end to a hollow interior of the main body and a free second end for attachment to another object in a sealed manner;

at least one exhalation valve assembly that is disposed within a first port formed in the main body and includes an exhalation valve member that is configured to vent exhaled air when open;

a primary inhalation valve assembly that is disposed within the conduit portion and includes a primary valve member that moves between open and closed positions; and
a secondary inhalation valve assembly that is disposed within a second port formed in the main body and includes a secondary valve member that moves between open and closed positions;

wherein the body includes an HME (heat moisture exchange) seat for receiving an HME unit and being located in relationship to the least one primary inhalation valve assembly and the at least one exhalation valve assembly to: (1) allow passage of inhaled gas, that flows through the primary inhalation valve assembly, through the HME seat before flowing into the hollow interior of the main body and to the patient and (2) allow passage of exhaled gas from the patient through the HME seat before exiting to atmosphere through the at least one exhalation valve assembly, wherein the HME seat is at least partially defined by a wall that in integral to the main body and defines a hollow space for receiving the HME unit, the wall being constructed for mating with the HME unit for the secure, yet releasable, attachment of the HME unit to the HME seat.

2. The patient interface device of claim **1**, wherein the primary inhalation valve assembly has a first flow resistance associated therewith and the second inhalation valve assembly has a second flow resistance associated therewith which is greater than the primary inhalation valve assembly and as a result, the secondary inhalation valve assembly acts as an emergency inhalation valve.

3. The patient interface device of claim **1**, wherein the at least one exhalation valve assembly includes a pair of coaxial exhalation valve assemblies formed in coaxial first and third ports formed in the main body.

4. The patient interface device of claim **1**, wherein an axis extending centrally through the first port is perpendicular to an axis extending centrally through the second port.

5. The patient interface device of claim **1**, wherein the primary inhalation valve is constructed such that in an open position thereof, a valve member thereof moves such that a flow passage defined within the conduit portion is at least substantially open and substantially free of occlusion by the valve member.

6. The patient interface device of claim **5**, wherein the valve member of the primary inhalation valve assembly is a swing valve which includes a base section that includes a bore formed therein that receives an elongated pin and the conduit

portion includes a cradle for capturing ends of the pin such that the swing valve rotates between the open and closed positions.

7. The patient interface device of claim **6**, wherein the valve member of the primary inhalation valve assembly has two different degrees of rotation in that the elongated pin rotates within the structure of the valve seat and the swing valve can independently rotate about the elongated pin.

8. The patient interface device of claim **1**, wherein the primary valve member is disposed eccentrically relative to the conduit portion in which the primary valve member is disposed.

9. The patient interface device of claim **1**, wherein the conduit member includes a secondary gas port formed therein at a location below the primary inhalation valve assembly.

10. The patient interface device of claim **1**, further including a mask valve assembly which includes a body in which the exhalation and secondary inhalation valve assemblies are disposed and for receipt within the main body, the body of the mask valve assembly including a first locator member which mates with a complementary second locator member formed in the conduit portion for coupling the mask valve assembly to the conduit portion.

11. The patient interface device of claim **10**, wherein the body of the face mask assembly includes a retention post for retaining a pin about which a valve member of the primary inhalation valve assembly rotates.

12. The patient interface device of claim **1**, wherein the at least one exhalation valve includes a valve seat and an exhalation valve member that is coupled to a mounting post that is formed as part of the valve seat and wherein excursion of the exhalation valve member is controlled by a thimble that is adjustably disposed on the mounting post, with the exhalation valve member being disposed between the thimble and the valve seat.

13. The patient interface device of claim **12**, wherein the thimble is set on the mounting post at a position such that a target distance from an underside of the thimble to the exhalation valve member is achieved, thereby controlling a degree of which the exhalation valve member can open.

14. The patient interface device of claim **1**, further including an HME unit that is disposed within the HME seat such that the HME unit is securely attached to the main body but also can be readily removed therefrom, the HME unit having a base structure that contains HME media, the base structure having a first wall which contains the HME media and a flange structure that extends outwardly from the first wall so as to define a space, the wall of the HME seat being received within the space so as to couple the HME unit to the HME seat.

15. The patient interface device of claim **14**, wherein the flange structure includes a finger hold for removing the HME unit from the HME seat.

16. The patient interface device of claim **1**, wherein the main body comprises a face mask and the conduit portion extends downwardly from a front portion of the main body, the free second end of the conduit portion being disposed below a bottom edge of the face mask.

17. A patient interface system for delivering a gas to a patient comprising:

a patient interface device include a main body for placement against a face of the patient for delivering the gas

thereto, the patient interface device including at least one inhalation valve and at least one exhalation valve; and

a venturi device that is fluidly connected to the free second end of the conduit portion, the venturi device having at least one port for connection to a gas source, the venturi device having at least one primary air entrainment window and at least one secondary air entrainment window which is downstream of the at least one primary air entrainment window and thus closer to the main body of the patient interface device;

wherein the at least one inhalation valve is disposed between: (1) the main body and (2) the primary and secondary air entrainment windows of the venturi device;

wherein at least one of the primary air entrainment window and secondary air entrainment window includes a means for closing the respective window, thereby changing a degree at which the respective window is open and changing a flow rate of the air flowing through the respective window.

18. The patient interface system of claim **17**, wherein the primary and secondary air entrainment windows permit atmospheric air to be entrained with and mix with gas from the gas source so as to form a gas mixture that flows through the at least one inhalation valve when the inhalation valve opens during patient inhalation.

19. The patient interface system of claim **17**, wherein the first air entrainment window is formed in a first venturi part and the second air entrainment window is formed in a second venturi part that is separate from but mates with the first venturi part to form a venturi assembly that is fluidly attached to the main body.

20. The patient interface system of claim **17**, wherein the means comprises a shutter that is coupled to the venturi device and is rotatable about the secondary air entrainment window so as to change a degree at which the secondary air entrainment window is open to atmosphere.

21. The patient interface system of claim **19**, wherein the first part of the venturi device includes two ports for connection to the gas source, the two ports having respective orifices that define a flow rate of gas through the respective port, wherein the orifices of the two ports have different dimensions resulting in different gas flow rates, wherein first ends of the two ports are located proximate the first air entrainment window.

22. The patient interface system of claim **21**, wherein the secondary air entrainment window is defined in part by a first air entrainment opening formed in the second part and the means comprises a shutter that is coupled to the second part of venturi device and is rotatable about the secondary air entrainment window so as to change a degree at which the secondary air entrainment window is open to atmosphere as a result of registration between a second air entrainment opening that formed in the shutter and the first air entrainment opening of the second part, the shutter including a gas concentration pointer and the second part include gas concentration indicator markings disposed circumferentially about the second part, the gas concentration indicator markings corresponding to the gas concentration which is realized when the shutter is in a select position relative to the second part and the pointer is aligned with one of the gas concentration markings.

23. The patient interface system of claim **22**, wherein one of the gas concentration markings includes two gas concentration values which correspond to the two ports which have two different gas flow rates.

24. A patient interface system for delivering a gas to a patient comprising:

a patient interface device for delivering a gas to a patient comprising:

a main body for placement against a face of the patient, the main body including a conduit portion that is open at a first end to a hollow interior of the main body and a free second end for attachment to another object in a sealed manner;

at least one exhalation valve assembly that is disposed within a first port formed in the main body and includes an exhalation valve member that is configured to vent exhaled air when open;

a primary inhalation valve assembly that is disposed within the conduit portion and includes a primary valve member that moves between open and closed positions; and

a secondary inhalation valve assembly that is disposed within a second port formed in the main body and includes a secondary valve member that moves between open and closed positions; and

a first accessory that is fluidly attached to the conduit portion;

wherein the primary inhalation valve assembly has a first flow resistance associated therewith and the second inhalation valve assembly has a second flow resistance associated therewith which is greater than the primary inhalation valve assembly and as a result, the secondary inhalation valve assembly acts as an emergency inhalation valve.

25. The patient interface system of claim **24**, wherein the first accessory comprises a reservoir device having a flexible, expandable chamber and a connector that is fluidly connected to the conduit portion, the connector being defined by a body having a first gas port for connection to a gas source and a separate second gas port for connection to the gas source, wherein the second gas port includes a first air entrainment opening formed therein and a rotatable shutter having a second air entrainment opening formed therein is rotatably coupled about the second gas port, the first and second air entrainment openings defining an air entrainment window which is selectively open to atmosphere, the reservoir device being free of a valve member.

26. The patient interface system of claim **25**, wherein the first gas port is located closer to a top open end of the connector compared to the second gas port and the shutter including a gas concentration pointer and the connector includes gas concentration indicator markings disposed vertically on an exterior surface of the connector, the gas concentration indicator markings corresponding to the gas concentration which is realized when the shutter is in a select position relative to the second part and the pointer is aligned with one of the gas concentration markings.

27. The patient interface system of claim **24**, wherein the first accessory comprises a device selected from the group consisting of an MDI and a nebulizer.

28. The patient interface system of claim **24**, wherein the conduit portion further has a secondary gas port formed therein at a location below the primary inhalation valve assembly and wherein in at least one operating state, a second

accessory is fluidly attached to the secondary gas port, wherein at least one of the first and second accessories delivers aerosolized medication and the other of the first and second accessories delivers a gas to the patient, wherein the gas and aerosolized medication communicate with one another upstream of the primary inhalation valve assembly.

29. The patient interface system of claim **28**, wherein the second accessory comprises one of an MDI and a nebulizer device that delivers the aerosolized medication and the first accessory comprises a reservoir device that includes a connector for attachment to the conduit portion and at least one port for delivering the gas to the conduit portion and a chamber for storing the gas as well as the aerosolized medication when the primary inhalation valve assembly is closed during patient exhalation.

30. The patient interface system of claim **29**, wherein the first accessory comprises a dual chamber reservoir device having separate first and second holding chambers, wherein the first holding chamber is for storing the aerosolized medi-

cation and the second holding chamber is in fluid communication with an external gas port that is connected to a gas source that delivers the gas.

31. The patient interface system of claim **30**, wherein the external gas port includes an adjustable air entrainment window that is configured to alter a concentration of the gas by varying an amount of air that is entrained through the air entrainment window and mixes with the gas from the gas source.

32. The patient interface system of claim **31**, wherein the connector of the reservoir device has first and second legs, the first leg being in fluid communication with the first holding chamber and the second leg being in fluid communication with the second holding chamber, the second leg containing an inhalation valve assembly that is positioned above the external gas port to permit the gas therefrom to only flow to the conduit portion when the inhalation valve assembly in the second leg is open.

* * * * *