US009289568B2

(12) **United States Patent**
Dhuper et al.

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(45) **Date of Patent: Mar. 22, 2016**

(54) **GAS DELIVERY VENTURI**

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(73) Assignee: **AEON RESEARCH AND TECHNOLOGY, INC.**, Hewlett, NY (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 322 days.

(21) Appl. No.: **13/748,305**

(22) Filed: **Jan. 23, 2013**

(65) **Prior Publication Data**

US 2013/0199535 A1 Aug. 8, 2013

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.

(51) **Int. Cl.**
A61M 16/00 (2006.01)
A61M 16/12 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***A61M 16/06*** (2013.01); ***A61M 11/04*** (2013.01); ***A61M 15/0065*** (2013.01); ***A61M 15/0086*** (2013.01); ***A61M 16/0057*** (2013.01); ***A61M 16/1045*** (2013.01); ***A61M 16/12*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC A61M 16/0096; A61M 16/12; A61M 16/122; A61M 16/125; A61M 16/127; A61M 2202/0208; B01F 5/0413; B01F 5/0418; B01F 5/0421; B01F 5/0423; B01F 5/0435; B01F 5/0436; B01F 5/044; B01F 5/0445; B01F 5/0468; B01F 5/0491; F01N 2470/30
USPC 128/203.25, 204.24, 204.25, 205.11, 128/205.23, 205.24, 207.16
See application file for complete search history.

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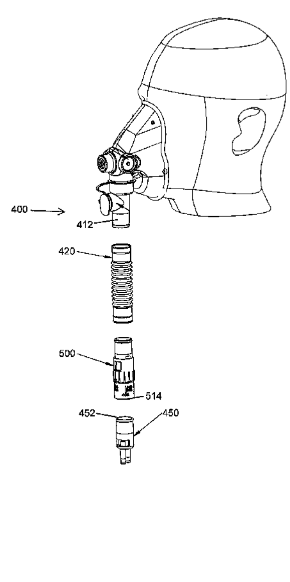
Assistant Examiner — Joseph D Boecker
(74) *Attorney, Agent, or Firm* — Leason Ellis LLP

(57) **ABSTRACT**

A venturi connector includes a housing having a mixing chamber defined therein and at least one window that is in fluid communication with the mixing chamber and is open to atmosphere to allow air to be entrained into the mixing chamber. The connector includes a nozzle actuator member includes a body having a plurality of discrete nozzles formed therein. The nozzles are defined by different sized venturi orifices through which gas flows, thereby allowing the concentration of the gas delivered to the patient to be varied. The nozzle actuator member is disposed within one window formed in the housing between the gas port and the mixing chamber such that the position of the nozzle actuator member within the housing can be adjusted so as to position one of the discrete nozzles into the gas flow path, thereby controlling the flow rate of the gas into the mixing chamber and ultimately the concentration of gas delivered to the patient.

18 Claims, 10 Drawing Sheets



(51) **Int. Cl.**

A61M 16/08	(2006.01)
A61M 16/10	(2006.01)
A61M 16/20	(2006.01)
A61M 16/06	(2006.01)
A61M 11/04	(2006.01)
A61M 15/00	(2006.01)
A61M 16/14	(2006.01)

(52) **U.S. Cl.**
CPC ***A61M 16/127*** (2014.02); ***A61M 16/20*** (2013.01); *A61M 16/0078* (2013.01); *A61M 16/0816* (2013.01); *A61M 16/0875* (2013.01); *A61M 16/14* (2013.01); *A61M 2202/0208* (2013.01)

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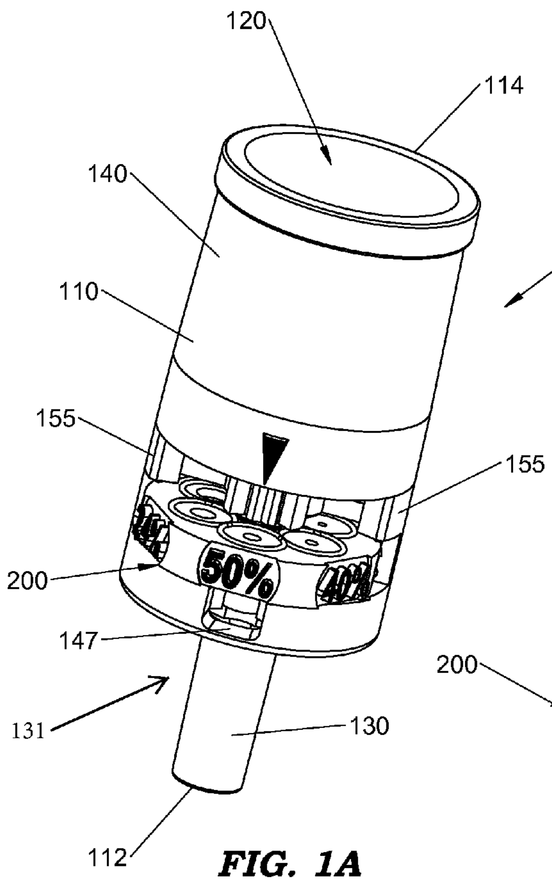
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FIG. 1A

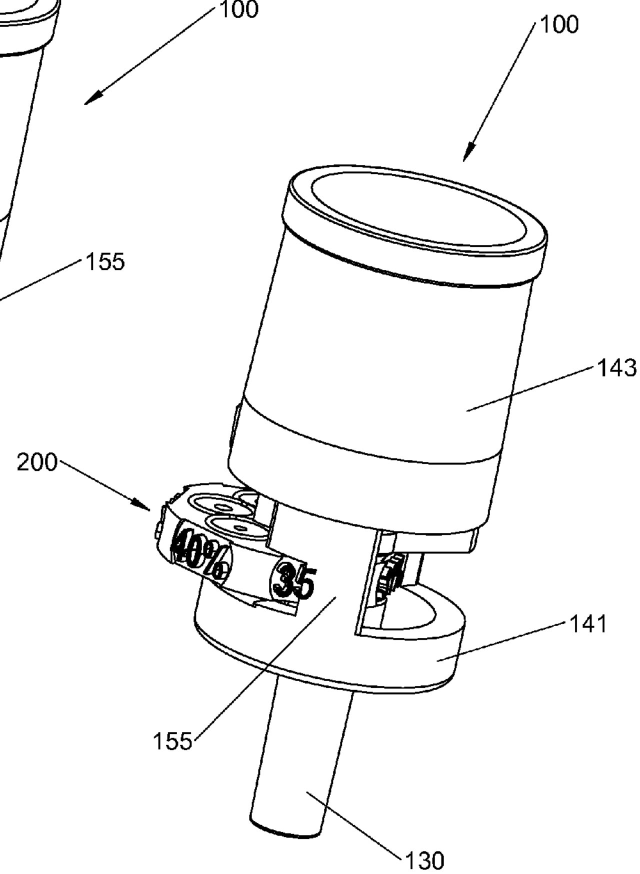
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FIG. 1B

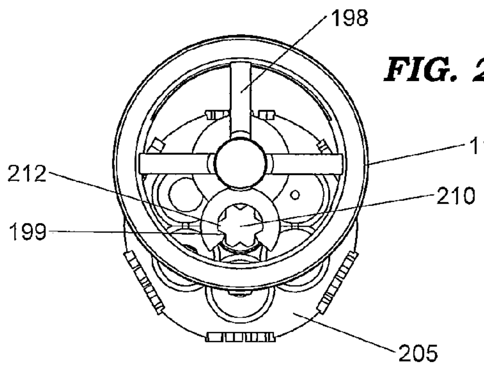
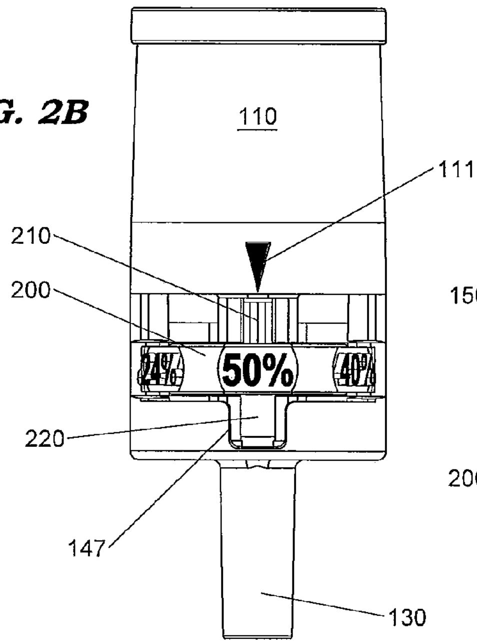


FIG. 2C

FIG. 2B



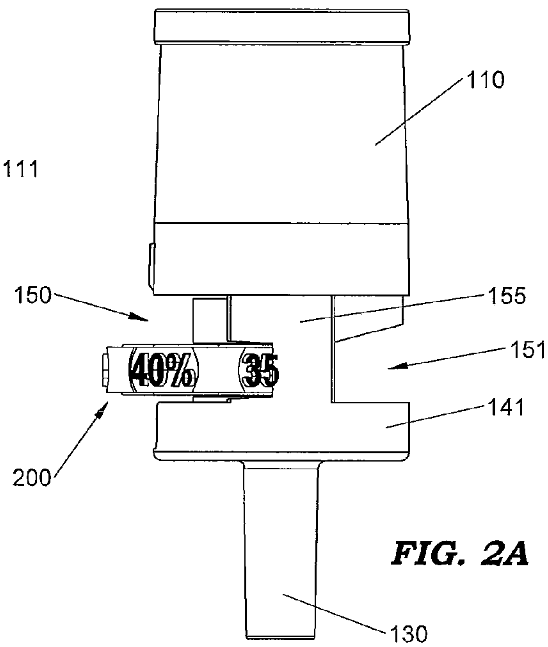


FIG. 2A

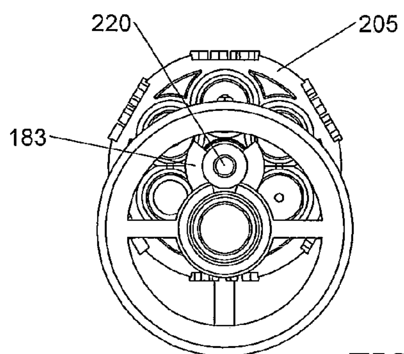


FIG. 2D

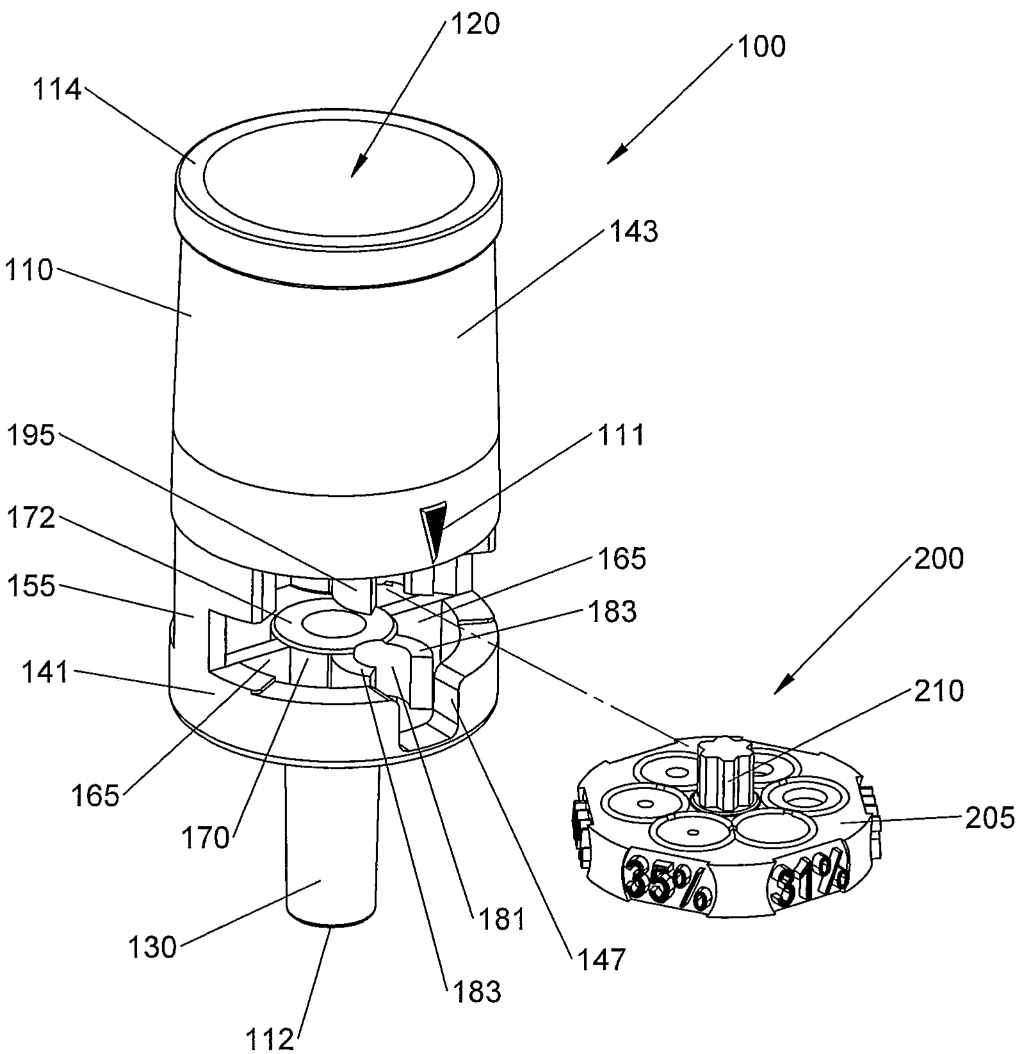

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FIG. 3

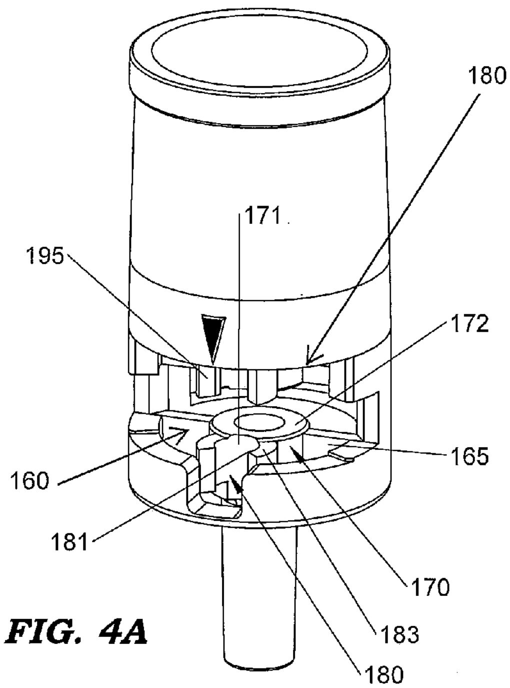


FIG. 4A

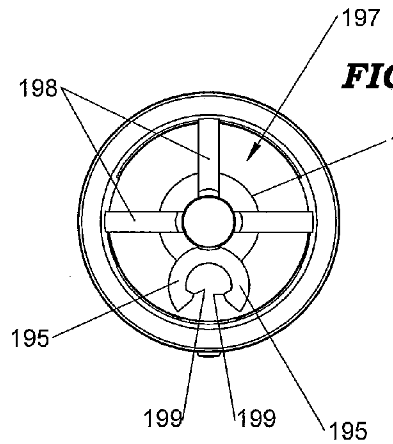
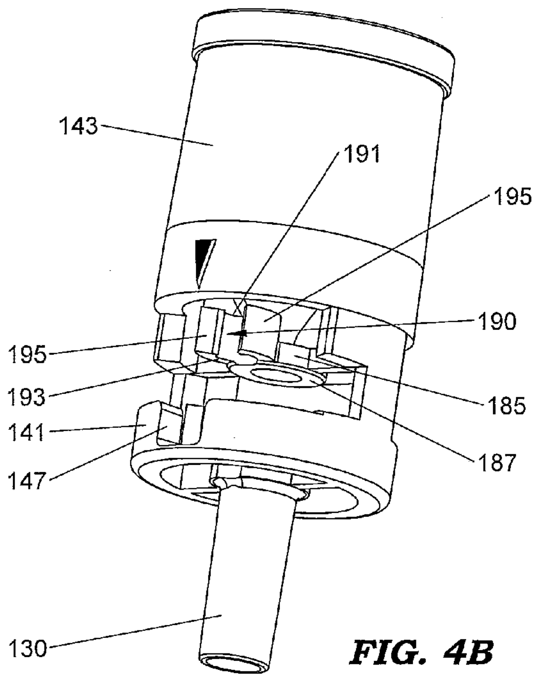


FIG. 4D



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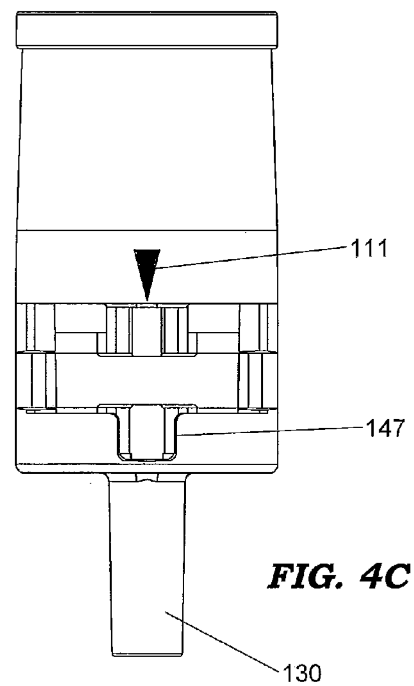


FIG. 4C

FIG. 5A

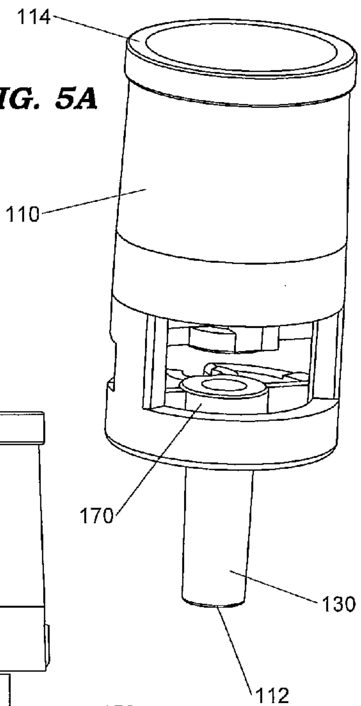
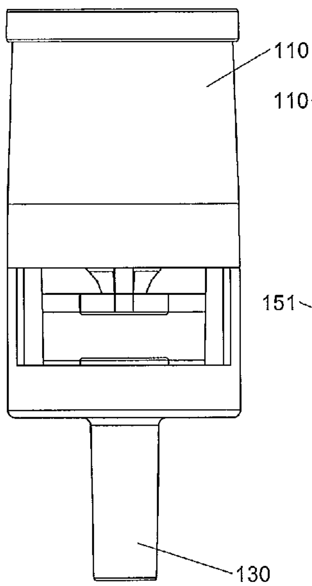


FIG. 5B



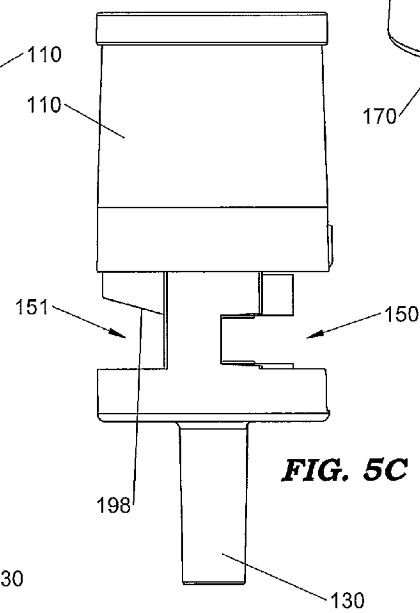


FIG. 5C

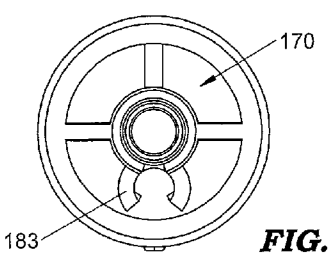
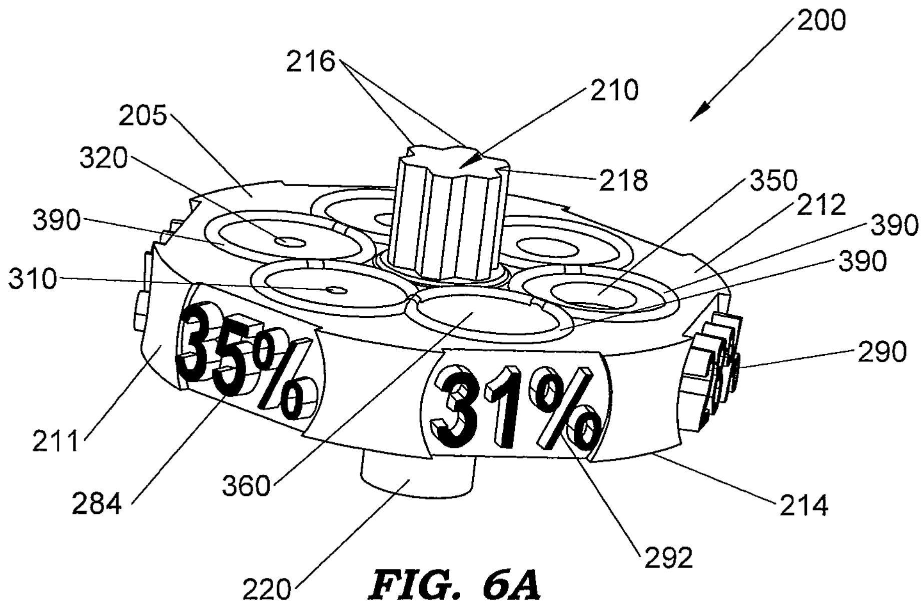


FIG. 5D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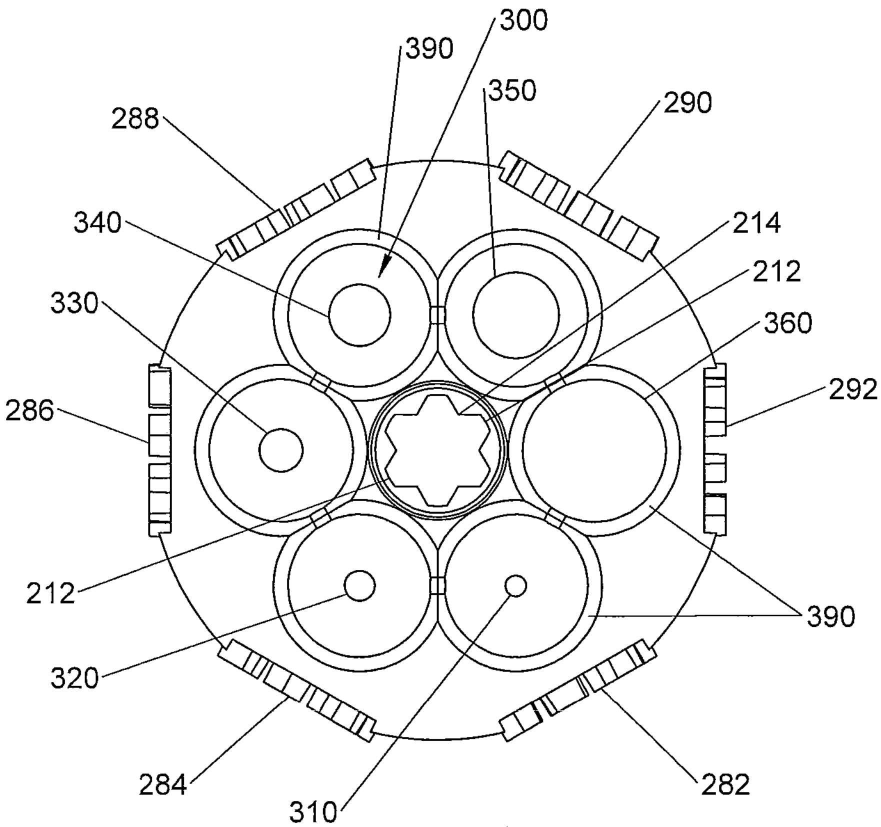
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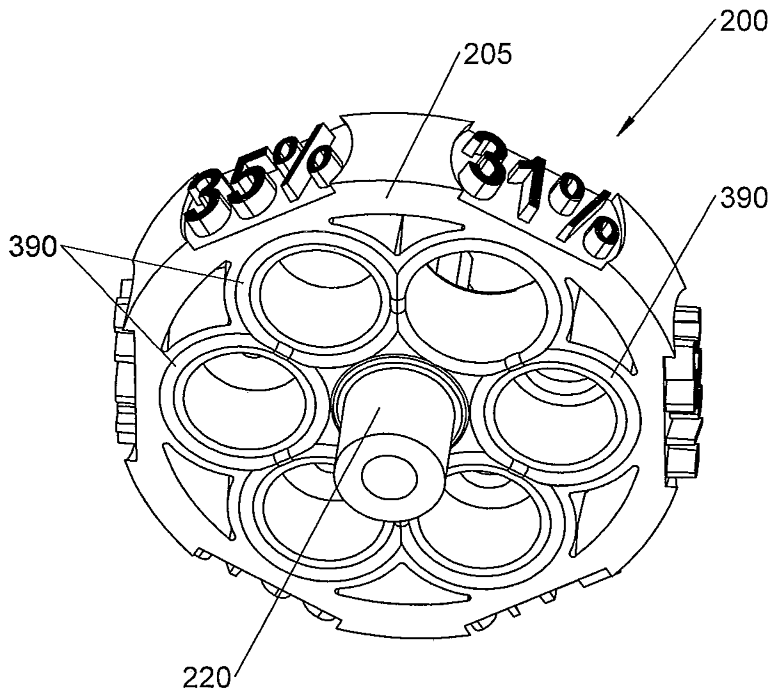

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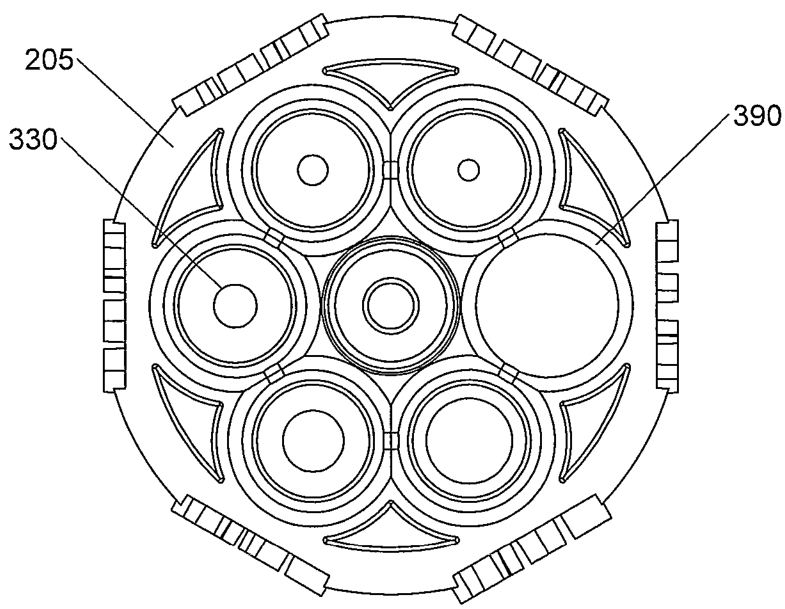

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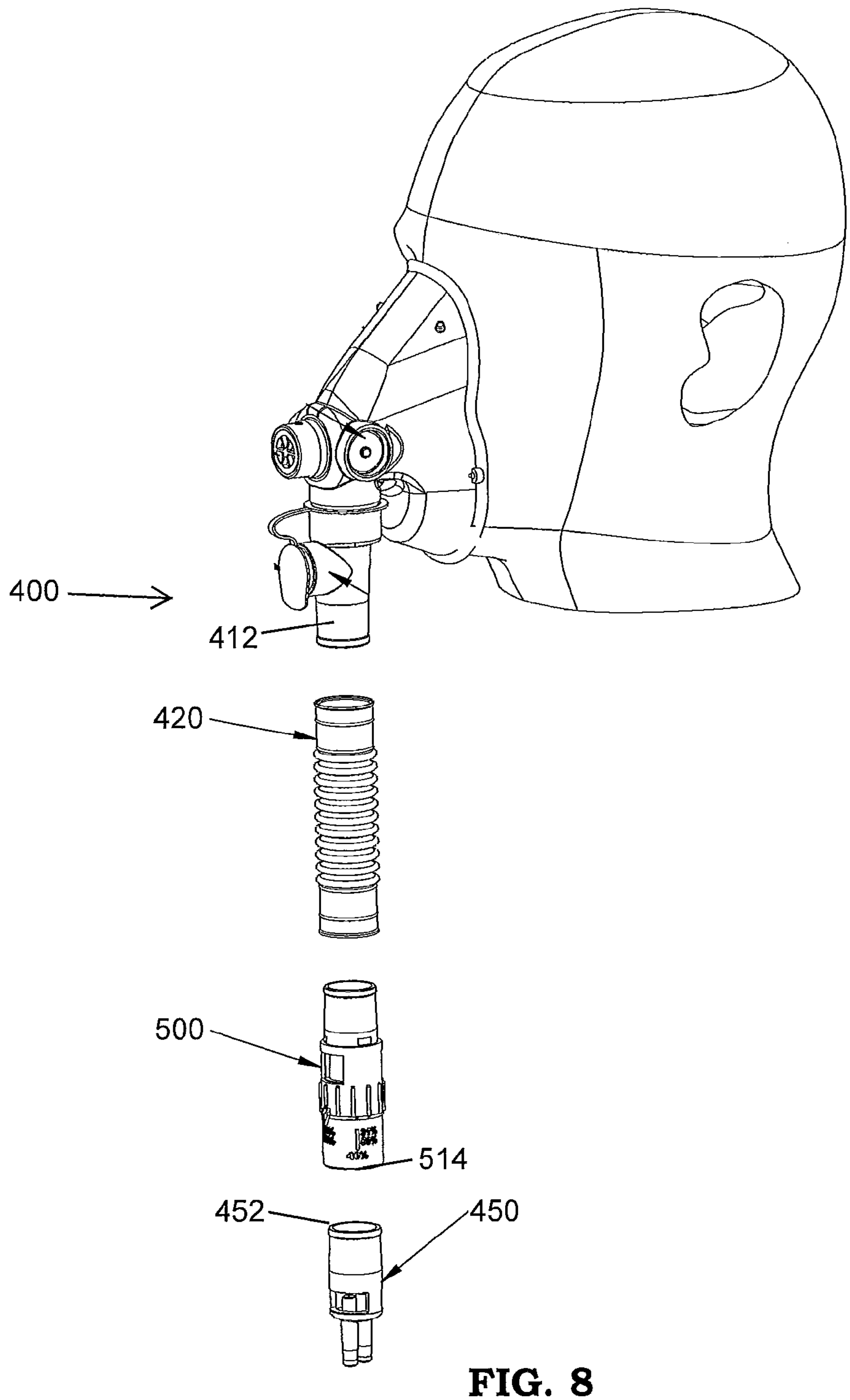

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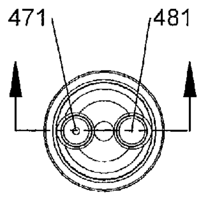

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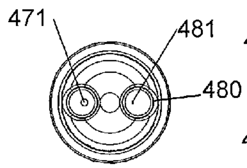

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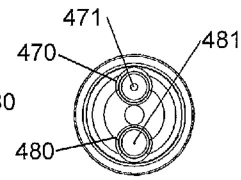

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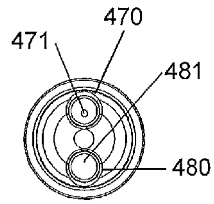

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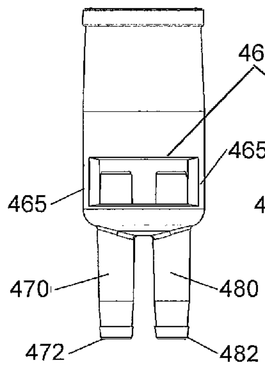

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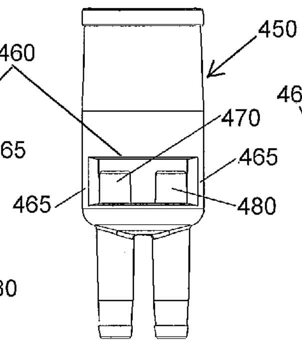

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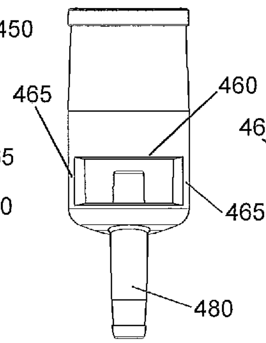

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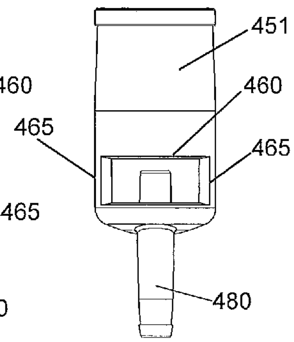

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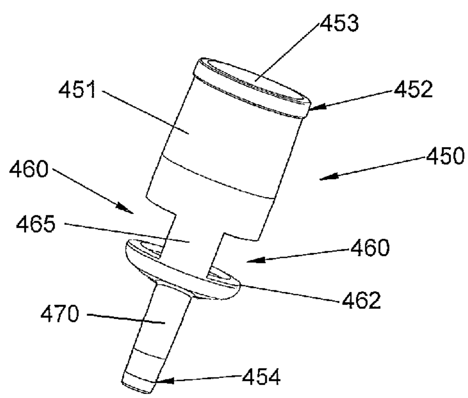

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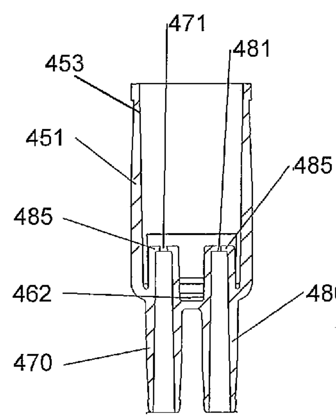

SECTION A-A

FIG. 12

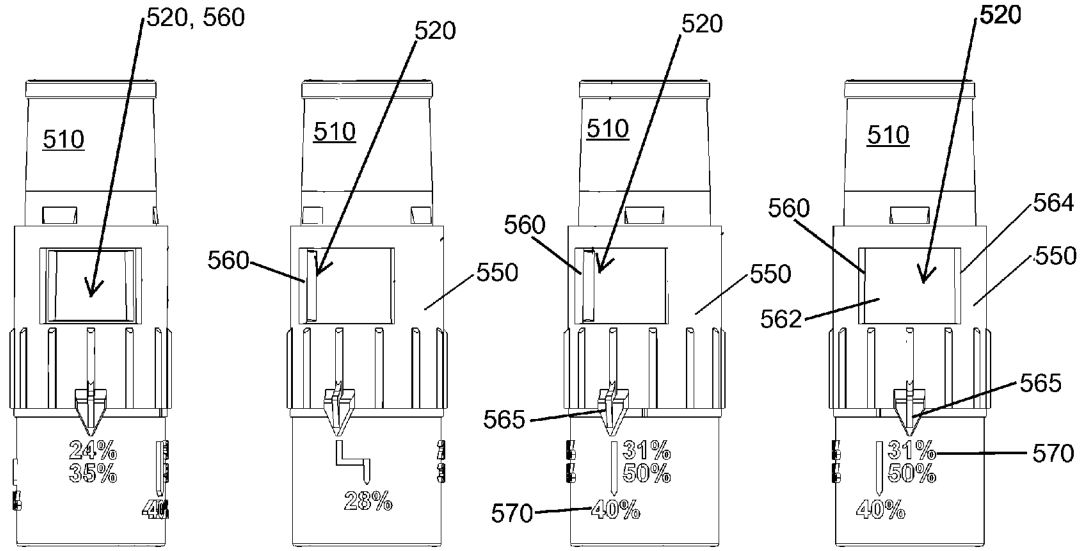

FIG. 20A FIG. 20B FIG. 20C FIG. 20D

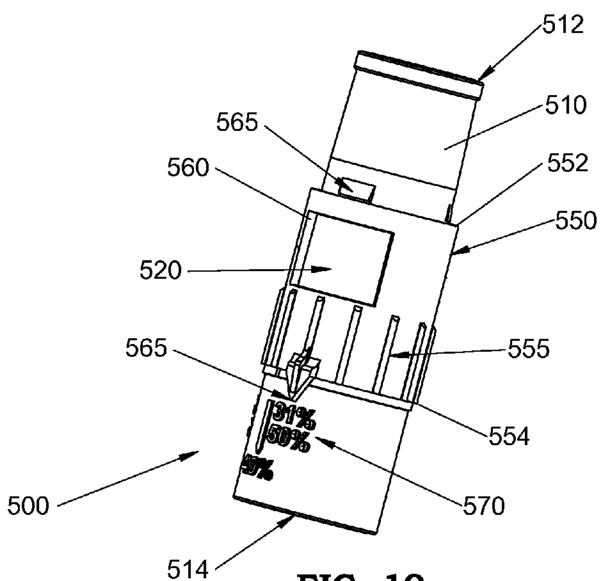

FIG. 19

GAS DELIVERY VENTURI

CROSS-REFERENCE TO RELATED APPLICATIONS

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 Ser. No. 61/610,828, filed Mar. 14, 2012 and U.S. patent application Ser. No. 61/694,020, filed Aug. 28, 2012, each of which is hereby incorporated by reference in its entirety.

BACKGROUND

The venturi effect is the reduction in fluid pressure that results when a fluid flows through a constricted section of pipe. Many hospital patients require a supplementary level of oxygen in the room air they are breathing, rather than pure or near pure oxygen and this can be delivered through a number of devices dependant on the diagnoses, clinical condition of a patient, level of blood oxygenation (hypoxemia), flow requirement and in some instances patient preference. There are also a number of devices available for oxygen delivery in a spontaneously breathing patient, some of the options being low flow nasal cannula, high flow nasal cannula, face mask, venturi mask, non-rebreather mask, oxygen tent, CPAP/BI-PAP mask, etc. The venturi mask is especially desirable where highly controlled low concentration is required, especially in patients who are sensitive to high concentration oxygen and are at a risk of carbon dioxide retention when given high concentration oxygen (an example of such patient would be one with the diagnoses of COPD).

The venturi mask, also known as an air-entrainment mask, is a medical device to deliver a known oxygen concentration to patients on controlled oxygen therapy. Venturi devices often use flow rates between 2 and 12 LPM, with a concentration of oxygen delivered to the patient of between 24% and 50%. Venturi masks are considered high-flow oxygen therapy devices. This is because venturi masks are able to provide total inspiratory flow at a specified F_iO_2 (fraction of inspired oxygen) to a patient's therapy. The kits usually include multiple jets in order to set the desired F_iO_2 which are usually color coded. The color of the device reflects the delivered oxygen concentration, for example: blue=24%; yellow=28%; white=31%; green=35%; pink=40%; orange=50%. The color however varies with different brands and the user must check the instructions for use to determine the correct color for the desired F_iO_2. A venturi connector can be used and is connected to the patent through a face mask or the like and to a gas source (in this case oxygen) which delivers oxygen to the patient by means of the face mask. The venturi connector has air entrainment openings or ports that draw air into the connector for mixing with the gas (oxygen) that is flowing through the venturi connector to deliver a metered amount of a gas mixture to the patient.

Though venturi masks may accurately deliver a predetermined oxygen concentration to the trachea, generally up to 50%, there could be a greater level of inaccuracy in delivering higher concentration when a patient's flow requirement is high during respiratory distress and a high level of air entrainment happens through the secondary entrainment ports that are mostly a part of the interface mask device. There may be a reasonable level of predictability when considering primary air entrainment from the primary venturi entrainment ports but there is high level of unpredictability when considering the secondary entrainment from the interface mask device entrainment ports. Hence, a patient could be at a risk of

developing hypoxemia due to inaccurately delivered low oxygen concentration than stated or predicted. The current venturi devices are therefore fraught with problems and need improvement and better accuracy or predictability.

There are other disadvantages with a venturi system, and that is that there are a large number of parts that are included in the venturi kit, especially multiple venturi connectors and therefore, the kit can be rather bulky and cumbersome. For example, if the oxygen concentration has to be varied, a completely new venturi connector having the proper jet (nozzle) is needed and thus, requires the previous nozzle to be removed and then the new nozzle is connected to the rest of the equipment. In addition, the flow of oxygen has to be adjusted for each venturi connector. This task requires time and moreover, is an interruption to the patient's treatment. In addition, most medical providers other than respiratory therapists are not easily familiar with the intricacies of venturi devices, they are not familiar with venturi principals, they require special training, and as such the devices currently being used are not user friendly. The parts of the kit that are not used, thus must be carefully stored and kept track of and could easily get misplaced which is not common in a hospital setting.

There is therefore a need for an improved venturi gas delivery system.

SUMMARY

A venturi connector includes a housing having a mixing chamber defined therein and at least one window that is in fluid communication with the mixing chamber and is open to atmosphere to allow air to be entrained into the mixing chamber. The venturi connector also includes a gas port extending outwardly from the housing for connecting to a gas source. The gas port defines a gas flow path for delivering the gas to the mixing chamber. In addition, a nozzle actuator member includes a body having a plurality of discrete nozzles formed therein. The nozzles are defined by different sized venturi orifices through which gas flows, thereby allowing the concentration of the gas delivered to the patient to be varied. The nozzle actuator member is disposed within one window formed in the housing between the gas port and the mixing chamber such that the position of the nozzle actuator member within the housing can be adjusted so as to position one of the discrete nozzles into the gas flow path, thereby controlling the flow rate of the gas into the mixing chamber and the gas concentration delivered to the patient.

BRIEF DESCRIPTION OF THE DRAWING FIGURES

FIGS. **1**A-B show a gas delivery venturi connector according to one exemplary embodiment of the present invention;

FIG. **2**A is a side elevation view of the gas delivery venturi connector of FIG. **1**;

FIG. **2**B is a side elevation view of the gas delivery venturi connector of FIG. **1**;

FIG. **2**C is a top plan view of the gas delivery venturi connector of FIG. **1**;

FIG. **2**D is a bottom plan view of the gas delivery venturi connector of FIG. **1**;

FIG. **3** is an exploded perspective view of the venturi connector with an actuator (selector member) being exploded from a connector body;

FIG. **4**A is side perspective view of the gas delivery venturi connector body of FIG. **1**;

FIG. 4B is side perspective view of the gas delivery venturi connector body of FIG. 1;

FIG. 4C is side elevation view of the gas delivery venturi connector body of FIG. 1;

FIG. 4D is a top plan view of the gas delivery venturi connector body of FIG. 1;

FIG. 5A is a side perspective view of the gas delivery venturi connector body of FIG. 1;

FIG. 5B is a side elevation view of the gas delivery venturi connector body of FIG. 1;

FIG. 5C is a side elevation view of the gas delivery venturi connector body of FIG. 1;

FIG. 5D is a bottom perspective view of the gas delivery venturi connector body of FIG. 1;

FIG. 6A is a side perspective view of the actuator (selector member);

FIG. 6B is a top plan view of the actuator (selector member);

FIG. 7A is a bottom perspective view of the actuator (selector member);

FIG. 7B is a bottom plan view of the actuator (selector member)

FIG. 8 is an exploded perspective view of a venturi assembly in accordance with another embodiment of the present invention;

FIG. 9 is a side perspective view of a multi-port venturi member that is part of the venturi assembly of FIG. 8;

FIG. 10 is a side elevation view of the multi-port venturi member of FIG. 9 and according to a first embodiment;

FIG. 11 is a top plan view of the multi-port venturi member of FIG. 10;

FIG. 12 is a cross-sectional view of the multi-port venturi member taken along the lines 12-12 of FIG. 11;

FIG. 13 is a side elevation view of the multi-port venturi member according to a second embodiment;

FIG. 14 is a top plan view of the multi-port venturi member of FIG. 13;

FIG. 15 is a side elevation view of the multi-port venturi member according to a third embodiment;

FIG. 16 is a top plan view of a multi-port venturi member of FIG. 15;

FIG. 17 is a side elevation view of the multi-port venturi member according to a fourth embodiment;

FIG. 18 is a top plan view of the multi-port venturi member of FIG. 17;

FIG. 19 is a side perspective view of a secondary gas entrainment valve member that is part of the assembly of FIG. 8;

FIG. 20A is a side elevation view showing the secondary gas entrainment valve member in a fully open position;

FIG. 20B is a side elevation view showing the secondary gas entrainment valve member in a partially open position;

FIG. 20C is a side elevation view showing the secondary gas entrainment valve member in a partially open position; and

FIG. 20D is a side elevation view showing the secondary gas entrainment valve member in a fully closed position.

DETAILED DESCRIPTION OF CERTAIN EMBODIMENTS

FIGS. 1A-B illustrate a venturi connector **100** according to one embodiment for use in a venturi gas delivery system. As described above, a venturi gas delivery system includes a patient interface/face mask and the venturi (connector, etc.) that includes a jet (nozzle) having a specific gas flow rate to provide a total inspiratory flow at a specified F_iO_2 for patient therapy. The connector **100** is formed of two distinct parts, namely, a venturi connector body or housing **110** and an adjustable actuator member **200** that permits the user to choose from among a plurality of different inspiratory oxygen concentrations depending upon the precise application and the patient's needs. As described herein, the actuator member **200** is received within but is movable relative to the housing **110** to allow the user to effectively select (e.g., dial in) the desired inspiratory oxygen concentration delivered to the patient.

In accordance with the present invention, the venturi connector **100** is constructed to be attached to a gas source (not shown), such as an oxygen gas source, and is also connected to a face mask (not shown) or the like that delivers the inhalation gas to the patient.

The venturi connector **100** includes the connector body or housing **110** that has a first end **112** and an opposing second end **114**. The first end **112** is the end of the housing **110** that is connected to the gas source, while the second end **114** is connected via a conduit member to the face mask. The housing **110** is a substantially hollow structure and thus fluid can flow therethrough. The housing **110** thus has an inner cavity or chamber **120** that is open at the second end **114**.

As shown in FIGS. **1-5**, the housing **110** generally has two distinct sections, namely a first section **131** that terminates at the first end **112** and a second section **140** that terminates at the second end **114**. The first section **131** is in the form of a gas port that can be an elongated tube through which gas from the gas source can flow into the second section **140** of the housing **110**. As described herein, the second section **140** is the portion of the housing **110** in which air is entrained into the flow of the gas (from the gas source) to form a gas mixture that is delivered to the patient. The inner cavity **120** is located within the second section **140**.

The second section **140** includes one or more air entrainment windows **150**, **151**. The air entrainment window **150** is an opening (slot) formed in the housing **110** at a location that allows air to freely flow into the inner cavity **120** where is mixed with the gas that is delivered into the housing **110** via the gas port **130**. In the illustrated embodiment, the air entrainment window **150** is in the form of an arcuate shaped window formed in the housing **110**. The window **150** has a width (W) and a height (H). As explained below, the window **150** is generally located between the inner cavity **120** (mixing chamber) and the gas port **130**. The window **150** partitions the second section **140** into a first portion **141** that is located between the window **150** and the port **130** and a second portion **143** that is located between the window **150** and the second end **114**.

In the illustrated embodiment, there are two windows **150**, **151** with the two windows **150**, **151** being separated by a pair of vertical posts **155** that are spaced opposite (180 degrees) one another.

The first portion **141** includes a structure **160** that holds the port **130** in place. For example, the structure **160** can be in the form of a spoked rib construction **165** that extends between the port **130** and an inner surface of the annular shaped first portion **141**. Between the spokes **165**, open spaces are formed and thus, the first portion **141** is at least substantially hollow and open to permit air flow into the bottom of the housing **110**.

As best shown in FIGS. **3-4**, a top end of the port **130** defines a lower hub **170** that has an exposed lower sealing surface **172**. As shown, the lower hub **170** can be in the form of a top end section of the port **130**. As shown, the lower sealing surface **172** can be in the form of an annular shaped exposed surface. The spokes **165** can be seen integrally connected to the lower hub **170** (e.g., can be integrally formed during a common molding process). The lower sealing surface **172** is a flat surface.

The first portion **141** includes additional features as described below. First, the first portion **141** includes a first retention means (member) **180** for securely coupling the adjustable actuator member **200** to the housing **110**. The first retention member **180** is in the form of an open collar or open clamp member. The first retention member **180** has an opening or slot **181** formed therein to permit access of a portion of the adjustable actuator member **200**. The first retention member **180** is generally C-shaped with the opening **181** defining the break in the first retention member **180**. The first retention member **180** is integrally formed with the lower hub **170** (e.g., as by a common molding process). The first retention member **180** generally has a circular shape with the opening **181** being defined as a break within the circular shaped structure. The opening **181** faces outward toward the peripheral edges of the first portion **141** but the first retention member **180** is not in physical contact with the housing **110**. The closed rear wall (surface) of the first retention member **180** can be defined by an arcuate shaped cut-out **171** formed in the lower hub **170**. In this embodiment, the first retention member **180** is defined by a pair of fingers **183** that are spaced from one another and extend outwardly from the lower hub **170**. The fingers **183** and the cut-out in the lower hub form a smooth arcuate shaped surface. The fingers **183** also provide some flexing action since that are only connected at one end to the lower hub **170**.

The first portion **141** also includes a cut-out or notch **147** formed therein and open along the outer surface of the housing **110**. In particular, the notch **147** can be a U-shaped opening that is formed in the peripheral wall of the housing **110** in the first portion **141** thereof. The notch **147** is thus open along the top thereof due to the presence of window **150** thereabove. The notch **147** is axially aligned with the first retention member **180**. The height of the notch **147** and the height of the first retention member **180** are about equal since the notch **147** defines an entrance into the first retention member **180**, thereby allowing reception of a portion of the adjustable actuator member **200**. More specifically and as described further below, the adjustable actuator member **200** is inserted laterally into the housing **110** through window **150** and by means of the notch **147**. The width of the notch **147** is thus greater than or equal to the the width of the portion of the adjustable actuator member **200** to allow the portion of the adjustable actuator member **200** to be received within the first retention member **180**.

The lower sealing surface **172** is preferably located above the top of the first retention member **180** and the open top of the notch **147**.

As shown in FIG. **3**, the second portion **143** of the second portion **140** has some internal structures similar to the first portion **141** but represents the entrance into the interior cavity **120** which is in the form of a gas mixing chamber in which the gas flowing through the port **130** mixes with air that flows through the windows **150**, **151**.

The second portion **143** is a substantially hollow structure since it represents a gas mixing chamber. Similar to the first portion **141**, the second portion **143** includes a reinforcement structure **197** that holds an upper hub **185** in place. For example, the structure **197** can be in the form of a spoked rib construction or stiffening gusset structure **198** that extends between the upper hub **185** and an inner surface of the annular shaped second portion **143**. Between the spokes **198**, open spaces are formed and thus, the second portion **143** is at least substantially hollow and open to permit air flow into the mixing chamber **120** which lies directly above the upper hub **185**.

Similar to the lower hub **170**, the upper hub **185** has an annular shape with a center bore (flow hole) formed therein. The lower hub **170** and upper hub **185** lie in parallel planes with respect to one another with a space (D1) formed therebetween. The space D1 is selected to receive a main body portion **205** of the adjustable actuator member **200** and securely position the actuator member **200** therebetween, while allowing the actuator member **200** to move (rotate) within the housing **110**.

The upper hub **185** is axially aligned with the lower hub **170** to allow the gas from the gas source to flow through the gas port **130**, through the actuator member **200** (as described below) and through the upper hub **185** and into the gas mixing chamber **120**. The reinforcement structures **165** and **197** thus centrally locate the two hubs **170**, **185** within the housing **110**.

As best shown in FIGS. **4**A-D, the upper hub **185** has an exposed upper sealing surface **187**. As shown, the upper sealing surface **187** can be in the form of an annular shaped exposed surface. The spokes (gussets) **197** can be seen integrally connected to the upper hub **185** (e.g., can be integrally formed during a common molding process). The upper sealing surface **187** is a flat surface.

Similar to the lower hub **170**, the upper hub **185** includes a second retention means (member) **190** for securely coupling the adjustable actuator member **200** to the housing **110**. The second retention member **190** is in the form of an open collar or open clamp member. The second retention member **190** has an opening or slot **191** formed therein to permit access of a portion of the adjustable actuator member **200**. The second retention member **190** is generally C-shaped with the opening **191** defining the break in the second retention member **190**. The second retention member **190** is integrally formed with the upper hub **185** (e.g., as by a common molding process). The second retention member **190** generally has a circular shape with the opening **191** being defined as a break within the circular shaped structure. The opening **191** faces outward toward the peripheral edges of the second portion **143** but the second retention member **190** is not in physical contact with the housing **110**. The opening **191** overlies the opening **181** of the first retention member **180**.

The closed rear wall (surface) of the second retention member **190** can be defined by an arcuate shaped cut-out **193** formed in the upper hub **185**. In this embodiment, the second retention member **190** is defined by a pair of fingers **195** that are spaced from one another and extend outwardly from the upper hub **185**. The fingers **195** and the cut-out in the upper hub form a smooth arcuate shaped surface. The fingers **195** also provide some flexing action since they are only connected at one end to the upper hub **185**.

As described below, the first and second retention members **180**, **190** can be constructed such that they function as snap-fit coupling members in that portions of the actuator member **200** are snap-fittingly received and mated thereto. Preferably, the coupling between the actuator member **200** and the housing **110** is of a type that prevents the subsequent removal of the actuator member **200** from the housing **110** after insertion therein. In other words, the actuator member **200** is intended to be inserted and locked in place with respect to the housing **110** to form a disposal product that is discarded after use.

The inner cavity (mixing chamber) **120** is located above both the upper hub **185** and second retention member **190**, as well as above the reinforcement structure **197**. As mentioned, there are open spaces formed around the reinforcement structure **197** to allow air to flow therethrough into the mixing chamber **120**. More specifically, air that flows through the air entrainment windows **150**, **151** flows into the mixing chamber **120**.

In accordance with the present invention, the second retention member **190** includes detents **199** located at but not limited to the free ends of the fingers **195**. As described below, these detents **199** not only provide a locking means but they also provide tactile feedback to the user as the actuator member **200** is moved within the housing **110**. While the fingers **183** are shown to not include detents, detents can be provided thereon similar to the detents **199**.

The housing **110** also includes indicia **111** formed thereon for indicating the setting (rotational location) of the actuator member **200** within the housing **110**. In the illustrated embodiment, the indicia **111** is in the form of a downward pointing arrow. In particular, the arrow **111** points down toward to the notch **147** and thus also points to and is axially aligned with the upper hub **185** and lower hub **170**.

As discussed herein, the port **130**, lower hub **170** and upper hub **185** define a flow path for the supplemental gas (e.g., oxygen) that is being delivered from the gas source to the mixing chamber **120** for mixing with air that is entrained and flows through the windows **150**, **151** (and through other openings formed in the housing **110**) to the mixing chamber **120**.

As best shown in FIGS. **6**-**7**, the adjustable actuator member **200** includes a body **205** that has a top surface **212** and an opposing bottom surface **214**. When the actuator member **200** is inserted into the housing **110**, the top surface **212** faces upward toward the upper hub **185** and the bottom surface **214** faces toward the lower hub **170**. The body **205** has a peripheral edge **211**. In the illustrated embodiment, the body **210** has a generally circular shape. The actuator member **200** includes a central shaft about which it moves when coupled to the housing **110**. As shown, the central shaft can be formed of a first shaft section (upper shaft section) **210** that extends outwardly from the top surface **212** and a second shaft section (bottom shaft section) **220** that extends downwardly from the bottom surface **214**. The first and second shaft sections **210**, **220** are axially aligned and centrally located with respect to the body **205**.

The second shaft section **220** can thus be in the form of a cylindrically shaped post. As illustrated, the outer surface of the second shaft section **220** can be a smooth surface. In contrast, the first shaft section **210** has a contoured outer surface that is complementary to the shape of the detents **199**. More specifically and as shown, the first shaft section **210** can be a ribbed structure and be formed of a plurality of axially extending ridges (detents) **216** formed along the length of the first shaft section **210**. As shown in FIGS. **6**A-B, between adjacent ridges (detents) **216**, valleys or pockets **218** are formed. The ridges **216** are formed in view of the detents **199** such that the detent **199** engages the ridges **216** in a locking manner yet the first shaft section **210** can be advanced (rotated) in a ratchet like manner. The ridges **216** and detent **199** thus are similar to a pawl/teeth arrangement in a ratchet environment. However, the first shaft section **210** can be rotated in both a clockwise direction and a counter clockwise direction.

One of the primary features of the ridges **216** is to provide tactile feedback to the user in that as the second shaft section **220** is advanced (rotated), the user feels the engagement between the ridges **216** and the detents **199**. This provides tactile confirmation to the user that the actuator member **200** has been advanced. The momentary locking between the ridges **216** and detents **199** also provides a locating and retention means for holding the actuator member **200** in one discrete position within the housing **110**.

Though the detent **199** and the ridge (detents) **216** are shown integral to second retention member **190** and shaft section **210**, they could be added to first retention member **180** and second shaft section **220** to provide a more robust ratcheting and tactile feedback mechanism.

A plurality of jets or nozzles **300** are formed within the body **210** at select locations about the first and second shaft sections **210**, **220**. For example and as shown, the jets or nozzles **300** can be formed circumferentially about the first and second shaft sections **210**, **220**. Each of the jets/nozzles **300** has its own flow construction so as to produce a desired flow rate therethrough. The jets/nozzles **300** can be thought of as being venturi orifices.

In the illustrated embodiment, the body **210** has six (6) jets/nozzles **300** formed therein, with each jet/nozzle **300** having an associated flow rate. More specifically, the body **205** has formed therein a first nozzle (venturi orifice) **310**; a second nozzle (venturi orifice) **320**; a third nozzle (venturi orifice) **330**; a fourth nozzle (venturi orifice) **340**; a fifth nozzle (venturi orifice) **350**; and a sixth nozzle (venturi orifice) **360**. As will be appreciated, the sizes of the orifices of the respective nozzles vary to produce different gas flow rates. As the size (diameter) of the orifice increases, the flow rate likewise increases. The size of the orifice progressively increases from the first nozzle **310** to the sixth nozzle **360**. In other words, the first nozzle **310** has the smallest sized orifice, while the sixth nozzle **360** has the largest sized nozzle. The orifices are centrally located within the individual nozzles **300**. Each of the jets/nozzles **300** includes a seal member **390** formed therearound both along the top surface **312** and the bottom surface **314**. The seal member **390** can be formed of the same material that forms the body of the actuator member or it can be formed of a different material. For example, the seal member **390** can be formed of a conventional sealing material, such as rubber or a polymeric material. The seal member **390** functions as an O-ring or the like and provides a seal.

The actuator member **200** is disposed within the housing **110** by being inserted into the window **150**. In particular, the actuator member **200** is held upright and the second shaft section **220** is passed through the notch **147**. The second shaft section **220** is introduced through the opening **181** of the first retention member **180**. The fingers **183** have a degree of flexibility and flex outwardly to allow the second shaft section **220** to pass into the first retention member **180** (between the fingers **183**) and once the shaft clears, the fingers **183** flex back to capture the second shaft section **220**. Similarly, the first shaft section **210** is received into the second retention member **190** by passing through the opening **191** between the fingers **195**. The fingers **195** flex outwardly to allow reception of the first shaft section **210** and once the shaft clears, the fingers **195** flex back to capture the first shaft section **210**.

The detents **199** of the second retention member **190** engage the ridges **216** of the first shaft section **210** for securely locking the actuator member **200** in place.

The actuator member **200** is eccentrically mounted within the housing **110** and in particular, the actuator member **200** is constructed and is mounted in the housing **110** in such a way that one of the nozzles **310**, **320**, **330**, **340**, **350**, **360** is axially and fluidly aligned with the lower hub **170** and the upper hub **185**. The nozzle that is in fluid registration with the lower hub **170** and the upper hub **185** is the nozzle that is currently selected and active in that it is located within the flow path of the gas from the gas source to the mixing chamber **120** and thus, serves to restrict the flow of the gas according to the characteristics (e.g., size) of the orifice.

As a result of this eccentric orientation, a portion of the body **205** of the actuator member **200** extends beyond the peripheral side of the housing **110** as shown. The actuator member **200** is thus coupled to the housing **110** in such a manner that as the body **205** is rotated within the retention members **180**, **190**, the individual nozzles **300** are brought into fluid communication with the bores formed within hubs **170**, **185**. However, at any one time, only a single nozzle is in fluid registration with the hubs **170**, **185**. This single nozzle can be referred to as the selected nozzle since it is the only nozzle amongst the group that is actively metering and controlling the flow rate of the supplemental gas as it is delivered to the mixing chamber **120**. As the actuator member **200** is rotated, clicks are felt by the user as a result of the detents **199** engaging the ridges **216**.

A sealing action is provided between the upper sealing surface **187** and one seal member **390** and similarly between the lower sealing surface **172** and one seal member **390**. This sealing action prevents any gas from escaping between the interfaces between the body **205** of the actuator member **200** and the lower hub **170** and upper hub **185** as the gas flows from the port **130** through the selected nozzle and into the mixing chamber **120**.

The venturi connector **100** of the present invention thus permits the user to select the supplemental gas (oxygen) concentration that is delivered to the patient. The nozzles **300** can be constructed such that the sizes of the orifices results in the first nozzle **310** delivering 24% oxygen; the second nozzle **320** delivering 28%; the third nozzle **330** delivering 31%; the fourth nozzle **340** delivering 35%; the fifth nozzle **350** delivering 40% and the sixth nozzle **360** delivering 50%. It will be appreciated that the following is merely an exemplary construction and not limiting since the nozzles **300** can be constructed to produce any number of flow rates and oxygen delivery concentrations.

To change the flow rate of the gas (oxygen) being injected into the mixing chamber **120**, the user simply adjusts the flow rate to port **130** and rotates the actuator member **200** until the appropriate nozzle is in fluid registration with the hubs **170**, **185**.

The figures show the difference between the two windows **150**, **151**. In particular, the window **150** is obstructed at least partially by the actuator member **200** since the actuator member **200** is received within the window **150**. In contrast, the actuator member **200** does not extend into the window **151** and therefore, the window **151** is more open and serves more as an air entrainment window to allow air to flow into the mixing chamber **120**. Air thus is drawn into the window **151** and flows through the open spaces between the spokes **198** and directly into the mixing chamber **120** which is located above the upper hub **185**. The bore formed in the upper hub **185** is open at the top of the upper hub **185** and therefore, this defines the exit port of the gas (oxygen) flowing through the port **130** and through the nozzle **300** of the actuator member **200** and allows the gas to flow into the mixing chamber **120** where it mixes with the air being entrained through the windows **150**, **151**.

The peripheral edge **211** of the body **210** includes indicator indicia **280** that relates to the characteristics of the individual nozzles **300**. For example, as illustrated, the nozzle **310** includes first indicia **282** disposed proximate thereto (adjacent thereto); the nozzle **320** includes second indicia **284**; the nozzle **330** includes third indicia **286**; the nozzle **340** includes fourth indicia **288**; the nozzle **350** includes fifth indicia **290**; and the nozzle **360** includes sixth indicia **292**. The indicia indicates a flow rate of one corresponding orifice.

In accordance with the present invention and as discussed below, the indicia is offset relative to the nozzle to which it relates and to which is designates the oxygen concentration. In other words, the first indicia **282** that is physically next to the first nozzle **310** in fact indicates the flow rate of the nozzle **340** which is 180 degrees away from the first indicia **282**; the second indicia **284** that is physically next to the second nozzle **320** in fact indicates the flow rate of the nozzle **350**; the third indicia **286** that is physically next to the third nozzle **330** in fact indicates the flow rate of the nozzle **360**; the fourth indicia **288** that is physically next to the fourth nozzle **340** in fact indicates the flow rate of the nozzle **310**; the fifth indicia **290** that is physically next to the fifth nozzle **350** in fact indicates the flow rate of the nozzle **320**; and the sixth indicia **292** that is physically next to the sixth nozzle **360** in fact indicates the flow rate of the nozzle **330**. In other words, the indicia is located 180 degrees from the nozzle to which it relates and as a result of the active nozzle being located centrally within the housing **110** in registration with the hubs **170**, **185**, its correlating indicia is located on the periphery of the body **205** 180 degrees from the active nozzle (i.e., the indicia is located on the portion of the actuator member **200** that overhangs the housing **110**).

The present invention thus provides a compact multi-nozzle venturi connector **100** that overcomes the disadvantages associated with the prior art, especially the need for having a kit of multiple connectors when only a single connector may be needed and used. In this present invention, a single device is provided and the user can simply manipulate the actuator member **200** to cause the desired nozzle **300** to be placed in the active position in which the gas flows therethrough and is metered to achieve the desired oxygen concentration/flow rate to the patient.

It will be appreciated and understood that the second end **114** of the housing **110** can be connected either directly or indirectly to the face mask using a tube, such as a corrugated tube, etc., that is connected to an inhalation inlet of the face mask. However, other means for connecting the two can be used.

FIG. **8** is an exploded perspective view of a venturi assembly **400** in accordance with another embodiment of the present invention. The assembly **400** is formed of a number of parts (components) that interact with one another to provide for controlled gas delivery to a patient. The assembly **400** is meant for use with a patient interface member (assembly) **410** that is designed to interact with the patient and in one exemplary embodiment, the interface member **410** is in the form of a mask assembly. It will be appreciated that the illustrated interface member **410** is merely exemplary in nature and any number of other types of interface members can be used for delivering gas to the patient. The interface member **410** includes a main port **412** for receiving the gas from the venturi assembly **400**. An elongated conduit member **420** is connected to the main port **412** and to the venturi assembly **400** for delivering the gas from the venturi assembly **400** to the interface member **410**. The elongated conduit member **420** 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 **420** can be varied. Conventional methods of attachment can be used to attach the elongated conduit member **420** to both the interface member **410** and the venturi assembly **400** (e.g., conical fitting, frictional fit, snap, etc. . . .).

FIGS. **8-20** illustrate in more detail the venturi assembly **400** according to one embodiment of the present invention. The venturi assembly **400** is formed of two main components, namely, a multi-port venturi member **450** and a secondary gas entrainment valve member **500**. FIG. **9** shows the multi-port venturi member **450** according to one embodiment. The multi-port venturi member **450** has a first end **452** and an opposite second end **454**. The multi-port venturi member **450** is a generally hollow body **451** that includes a main hollow space **453** at the first end **452**. In the illustrated embodiment, the body **451** has a cylindrical shape; however, it will be appreciated that the body **451** can have any number of other shapes.

The body **451** also has an air entrainment window **460** formed therein below the main hollow space **453**. The air entrainment window **460** is thus located intermediate to the ends **452**, **454**. The member **450** also includes a lower body section **462** that is connected to the hollow body **451** by means of a pair of opposing walls **465** (e.g., a pair of vertical walls located 180 degrees apart). The walls **465** thus partially define the air entrainment window **460**. The lower body section **462** is a disk shaped structure that lies below the air entrainment window **460** and serves as a floor of the air entrainment window **460**. The air entrainment window **460** is thus open to atmosphere and serves to allow air to flow into the hollow space **453** and then flow ultimately to the patient (by means of the elongated conduit member **420** and the interface member **410**).

The member **450** also includes at least one and preferably a plurality of gas port members **470**, **480** that extend downwardly from the lower body section **462**. The gas port members **470**, **480** 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. **12**, the gas port members **470**, **480** are elongated hollow conduits that each allows a fluid, such as gas (oxygen), to enter at an exposed, free distal end **472**, **482** and flow therethrough into the hollow space **451** while flowing by the air entrainment window (which is designed to allow atmospheric gas (air) to be entrained by the gas flow through the gas port members **470**, **480**). Entrainment of air through the window **460** results due to the the pressure drop created by the gas that flows through either of the gas port members **470**, **480**. The distal ends **472**, **482** can be barbed ends to facilitate mating of the gas port members **470**, **480** to conduits (tubing) that is connected to the same, single gas source or to multiple gas sources.

In another embodiment, the member **450** includes only a single gas port member.

It will be understood that at any one operating time, gas is flowing through only one of the gas port members **470**, **480**. As described below, the gas port members **470**, **480** have different gas flow characteristics and therefore, depending upon the desired gas concentration that is chosen to be delivered to the patent, the user selects one of the gas port members **470**, **480** to use. Once again, at any one point in time, only one of the gas port members **470**, **480** is active in that gas is flowing therethrough.

As best shown in FIGS. **10-12**, the gas port members **470**, **480** are constructed so as to provide a known gas flow rate. In particular, a top wall **485** is formed across the tops of the gas port members **470**, **480** and defines the ceiling of the gas port members **470**, **480**. An orifice (through hole) **471**, **481** is formed in the top walls **485** of the gas port members **470**, **480**, respectively. The shape and dimensions of the orifices **471**, **481** define the gas flow rates of the gas port members **470**, **480** and more particularly, by varying the shape and size of the orifices, the gas flow rate associated with the gas port member is likewise changed.

As a result, the gas port member **470** has one associated gas flow rate, while the gas port member **480** has a different gas flow rate associated therewith. It will be appreciated that the system **400** can include a plurality of single or multi-port venturi members **450** that can be grouped as a kit. This allows the user to select the venturi member **450** that has the desired, chosen gas flow rate. The venturi members **450** can be interchanged as part of the overall system **400** depending upon the precise application and desired gas concentration to be delivered to the patient.

As best shown in the cross-sectional view of FIG. **12**, first lengths of the elongated gas port members **470**, **480** are located above the lower body section **462** and second lengths of the elongated gas port members **470**, **480** are located below the lower body section **462** (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 **470**, **480** are located below the lower body section **462**. The lower body section **462** defines a solid wall structure between the gas port members **470**, **480**. The tops of the gas port members **470**, **480** are disposed within the air entrainment window. In other words, the height of the gas port members **470**, **480** 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 **470**, **480** is mixed with entrained air flowing into the air entrainment window **460**.

The gas flow rates associated with the gas port members **470**, **480** can be the same or as shown in FIGS. **10-12**, the flow rates can be different. FIGS. **10-12** illustrate a laterally disposed gas injection arrangement in which the gas port members **470**, **480** are located adjacent the vertical walls **465** as best shown in FIG. **10** and the orifices **471**, **481** are centrally located with respect to gas port members **470**, **480**. The orifice **471** has a greater size than the orifice **481** and therefore, has a greater associate gas flow rate. It will be appreciated that the orifices **471**. **481** thus serve to meter the gas from the gas source as it flows through the gas port members **470**, **480** into the hollow space **451**.

In the embodiment of FIGS. **10-12**, the gas port members **470**, **480** are thus not located directly within the air entrainment window due to the members **470**, **480** being disposed adjacent the vertical walls **465**.

FIGS. **13-14** show a different embodiment and in particular, show laterally disposed eccentric gas injection. As with FIGS. **10-12**, the gas port members **470**, **480** are disposed laterally in that these members are formed adjacent the vertical walls **465**; however, in this embodiment, the orifices **471**, **481** are not located centrally within the gas port members **470**, **480**, respectively. Instead, the orifices **471**, **481** are eccentrically formed within the gas port members **470**, **480**.

FIGS. **15-16** show a different embodiment and in particular, show centrally disposed gas injection. Opposite to the arrangement shown in FIGS. **10-12**, the gas port members **470**, **480** in FIGS. **15-16** are disposed centrally in that the gas port members **470**, **480** are not located adjacent the pair of vertical walls **465** as best shown in FIG. **15**. Instead, the gas port members **470**, **480** are located offset from the vertical walls **485** and are disposed directly within the air entrainment window **460**. The orifices **471**, **481** are located centrally within the gas port members **470**, **480**, respectively.

FIGS. **17-18** show a different embodiment and in particular, show centrally disposed eccentric gas injection. Opposite to the arrangement shown in FIGS. **10-12**, the gas port members **470**, **480** in FIGS. **17-18** are disposed centrally in that the gas port members **470**, **480** are not located adjacent the pair of vertical walls **465** as best shown in FIG. **17**. Instead, the gas port members **470**, **480** are located offset from the vertical walls **465** and are disposed directly within the air entrainment window **460**. Unlike the centrally disposed gas injection of FIGS. **15** and **16**, the orifices **471**, **481** in FIGS. **17** and **18** are eccentrically formed within the gas port members **470**, **480**.

It will be appreciated that the relative sizes of the orifices **471**, **481** are merely exemplary in nature and the sizes of orifices **471**, **481** can be readily changed. For instance, the orifice **481** can be larger in size than orifice **471**.

In one exemplary embodiment, the outside periphery of end **452** has a diameter of about 22 mm.

FIG. **19** shows the secondary gas entrainment valve member **500** which is formed of a generally hollow body **510** that has a first end **512** and an opposing second end **514**. As shown in FIG. **8**, the second end **514** is configured to mate with the first end **452** of the multi-port venturi member **450**. The second end **514** can be a female connector type, while the first end **452** of the multi-port venturi member **450** is of a male connector type. Similarly, the first end **512** can be a male connector type that is designed to mate with the elongated conduit member **420**. The first end **512** can thus have smaller dimensions compared to the second end **514**.

The generally hollow body **510** has a secondary air entrainment window **520** formed integrally therein. The air entrainment window **520** extends circumferentially about the body **510** 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 **520** is intended to allow atmospheric gas (air) to flow into the hollow interior of the body **510** where in mixes with the gas that flows out of the multi-port venturi member **450** (which one will appreciate is already mixed gas due to air being entrained through the air entrainment window **460** (which can be thought of as being a main or primary air entrainment window). The air entrainment window **520** is a secondary entrainment window since it serves as a second window between the gas source and the patient interface **410** 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.

In accordance with the present invention, the secondary gas entrainment valve member **500** includes a rotatable shutter **550** that is rotatably and cylindrically coupled to the body **510** and more specifically, the shutter **550** is disposed about the body **510** in the location of the air entrainment window **520** to allow the shutter **550** to either open or close the secondary gas entrainment window **520** depending upon the desired setting as described below. The shutter **550** has a first (top) end **552** and an opposite second (bottom) end **554**.

Any number of different techniques for coupling the shutter **550** to the body **510** can be used. For example, different types of mechanical attachment techniques can be used including a friction fit, a snap fit, etc. In FIG. **19**, the body **510** includes a shutter retaining mechanism in the form of tabs **565** spaced apart from one another and located circumferentially about the body **510**. The top end **552** of the shutter **550** is located below the tabs **565**.

The shutter **550** itself has an air entrainment window **560** formed therein. The air entrainment window **560** is defined by a first end **562** (vertical wall) and a second end **564** (vertical wall).

There is a correlation between the degree of registration between the air entrainments windows **520**, **560** and more particularly, the degree of overlap and the openness of the two windows **520**, **560**, which factors into the amount of air being entrained through the secondary gas entrainment valve member **500** and thus, the concentration of the gas delivered to the patient. The height of the window **560** is preferably equal to or greater than the height of the window **520** and preferably, the length of the window **560** is preferably equal to or greater than the length of the window **520**.

The shutter **550** rotates about the body **510** as mentioned above and therefore, the shutter **550** can include features **555** (means) to assist the user in rotating the shutter **550**. In particular, the features **555** can be in the form of ribs that are spaced apart and extend circumferentially about the shutter **550**. The ribs **555** are raised structures that permit the user to more easily grip and rotate the shutter **550** relative to the body **510**.

The secondary gas entrainment valve member **500** also preferably includes indicia **570** to allow the user to set the degree of air entrainment and thus, to position the secondary gas entrainment valve member **500** at a setting that achieves the desired gas concentration being delivered to the patient. The indicia **570** are also raised structures that permit the user to more easily grip the body **510** while rotating the shutter **550** to achieve the desired gas concentration.

For example, the shutter **550** can include a gas concentration pointer **565** that is formed along the bottom edge **554** of the shutter **550** and the lower region of the body **510** includes gas concentration indicator markings **570**. For example, the markings **570** include a plurality of gas concentrations (in percentages) that correspond to the concentration of the gas that is delivered to the patient. The markings **570** directly correspond to the degree of overlap between the windows **520**, **560** in that the greater the overlap (registration) between the windows **520**, **560**, the greater the openness of the secondary air entrainment window resulting in a greater flow of atmospheric air into the member **500** (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 **450**).

The rotatability of the shutter **550** allows the user to effectively and easily "dial in" the desired gas concentration for delivery to the patient by simply rotating the shutter **550** to cause the pointer **565** to point to the desired, selected gas concentration indicator marking **570** (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.

FIGS. **20**A-**20**D shows the various operating states of the secondary gas entrainment valve member **500**.

FIG. **20**A shows the air entrainment port in a fully opened position (i.e., complete registration between the windows **520**, **560**). As will be seen in FIG. **20**A, the markings **570** 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 **470**, **480** of the venturi member **450** is used and the desired gas concentration to be delivered. In the example shown in FIG. **20**A, the second number (35%) corresponds to the gas port member **470** (which has a larger orifice **471** compared to the orifice **481** of gas port member **480**). The first number (24%) corresponds to the gas concentration obtained with gas port member **480**.

FIG. **20**D shows the air entrainment port in a fully closed position (i.e., complete registration between the windows **520**, **560**). As will be seen in FIG. **20**D, the markings **570** 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 **470**, **480** of the venturi member **450** is used and the desired gas concentration to be delivered. In the example shown in FIG. **20**D, the second number (50%) corresponds to the gas port member **470** (which has a larger orifice **471** compared to the orifice **481** of gas port member **480**). The first number (31%) corresponds to the gas concentration obtained with gas port member **480**.

FIGS. **20**B and **20**C show the air entrainment window in partially open positions in which the window **560** formed in the shutter **550** is not in complete registration with the window **520** formed in the body **510**. It will be appreciated that FIG. **20**B shows a partially open air entrainment window.

It will be appreciated that the openness of the air entrainment window is very similar in size in FIG. **20**B and in FIG. **20**C; however, the two different resulting gas concentrations (e.g., 28% vs. 40%) is based on whether the gas port member **470** or gas port member **480** is used. When the larger sized gas port member **470** is used, a gas concentration of 40% is obtained when the window is in the position of FIG. **20**C. Conversely, when the smaller sized gas port member **480** is used, a gas concentration of 28% is obtained when the air entrainment window is placed in the partially open position of FIG. **20**B.

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

It will also be understood that the gas entrainment valve member **500** can be used with other venturi members besides the multi-port venturi member **450** that is shown paired with the member **500** in the assembly of FIG. **8**. For example, the venturi connector assembly of FIGS. **1-7** can be used with the gas entrainment valve member **500**. In particular and similar to the system of FIG. **8**, the combination of the venturi connector assembly of FIGS. **1-7** and with the gas entrainment valve member **500** 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) **410**. It will also be appreciated that the gas entrainment valve member **500** can be used with any traditional venturi (venturi connector) to provide a dual air entrainment window structure.

Unlike a 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 one window being adjustable in nature in that the degree of which the window is open can be adjusted by the user.

The invention is described in detail with reference to particular embodiments thereof, but the scope of the invention is to be gauged by the claims that follow and also by those modifications that provide equivalent features to those that are claimed as such modifications are still within the spirit and scope of the invention.

What is claimed is:

1. A venturi connector assembly comprising:

a non-adjustable venturi member in the form of a generally hollow body that includes a first end, a second end, and at least a first gas port connector at the second end for connection to a gas source, the body including a first air entrainment window that is always open to atmospheric air to allow air to mix with gas from the gas source, the at least one gas port connector comprising a tubular structure having an orifice at one end that is in alignment with the first air entrainment window and is positioned between top and bottom edges of the first air entrainment window; and

an adjustable secondary gas entrainment valve member in the form of a generally hollow body that includes a first end and a second end, the second end being configured to mate with and be placed in direct contact with the first end of the venturi member for securely coupling the venturi member to the secondary gas entrainment valve member so as to define a linear flow path from the venturi member to the secondary gas entrainment valve member which is located downstream of the venturi member, the body of the secondary gas entrainment valve member including a second air entrainment window that is located remote from the at least one gas port connector, wherein the secondary gas entrainment valve member further includes a movable shutter that moves about the venturi member and includes a third air entrainment window, wherein the shutter is movable between: (1) a first position in which the second and third air entrainment windows are in full registration allowing atmospheric air to flow therethrough, thereby representing a fully open position of the secondary gas entrainment valve member; and (2) a second position in which the second and third air entrainment windows are offset from one another, thereby representing a fully closed position of the secondary gas entrainment valve member, wherein the first end of the secondary gas entrainment valve member is for attachment to a patient interface device.

2. The venturi connector of claim **1**, wherein the at least one gas port connector includes first and second gas port connectors at the second end for connection to the gas source, the first and second gas port connectors having orifices that have different dimensions so as to produce different gas flow rates.

3. The venturi connector of claim **2**, wherein the movable shutter includes an indicator member that extends downwardly therefrom and the hollow body of the secondary gas entrainment valve member includes gas concentration markings, wherein the shutter can be rotated until the indicator member points to one of the gas concentration markings which represents the gas concentration value for the gas that exits the secondary gas entrainment value member.

4. The venturi connector of claim **3**, wherein for at least one setting for the secondary air entrainment window there are two corresponding gas concentration markings which represent the two different gas concentration values of the respective first and second gas port connectors.

5. The venturi connector of claim **4**, wherein the two different gas concentration values includes a first value which is greater than a second value, the first value corresponding to the first gas port connector which is configured such the orifice thereof has greater dimensions compared to the orifice of the second gas port connector.

6. The venturi connector of claim **2**, wherein the orifices are eccentrically formed with respect to the first and second gas port connectors.

7. The venturi connector of claim **1**, wherein the generally hollow body of the venturi member includes two first air entrainment windows that are spaced apart from one another and a top edge of the first gas port connector lies in a horizontal plane that intersects each of the two first air entrainment windows between top and bottom edges thereof.

8. The venturi connector of claim **1**, wherein the generally hollow body of the venturi member includes two first air entrainment windows spaced apart from one another by a pair of vertical walls and includes a second gas port connector spaced opposite the first gas port connector, the first and second gas port connectors being disposed adjacent the pair of vertical walls.

9. The venturi connector of claim **1**, wherein the generally hollow body of the venturi member includes two first air entrainment windows spaced apart from one another by a pair of vertical walls and includes a second gas port connector spaced opposite the first gas port connector, the first and second gas port connectors being disposed offset from the pair of vertical walls and within the two first air entrainment windows.

10. A venturi connector comprising:

a hollow venturi member for connection to a source of gas and defined by a body that includes at least a first gas port connector at one end of the body for connection to a gas source, the hollow body further including: (1) a first air entrainment window that always remains open and is proximate a first open end of the first gas port connector so as to create a venturi structure, the first air entrainment window being open to atmospheric air to allow air to mix with gas from the gas source; and (2) a second air entrainment window that is spaced longitudinally downstream of the first air entrainment window and includes a mechanism for closing the second air entrainment window, thereby changing a degree at which the second air entrainment window is open resulting in a change in a flow rate of the air flowing through the second air entrainment window, wherein a gas flow path is defined along a longitudinal axis of the hollow venturi member as gas flows at least partially by the first air entrainment window and by the second air entrainment window, wherein the mechanism for closing the second air entrainment window is spaced from and does not overlie the first entrainment window; and

wherein the mechanism comprises a movable shutter that rotates about the hollow body and includes a shutter opening, the shutter moving between (1) a first position in which the second air entrainment window and the shutter opening are in full registration allowing atmospheric air to flow therethrough, thereby representing a fully open position of the second air entrainment window; and (2) a second position in which the second air entrainment window and the shutter opening are completely offset from one another, thereby representing a fully closed position of the second air entrainment window.

11. The venturi connector of claim **10**, wherein the first gas port connector comprises a tubular structure that has a second open end for connection to the gas source and the first open end includes an orifice having a selected diameter to meter the flow of gas therethrough.

12. The venturi connector of claim **10**, further including a second gas port connector that is spaced from the first gas port connector and positioned parallel thereto such that the first and second gas port connectors have a first portion disposed inside the hollow venturi member and a second portion that lies outside the hollow venture member, the first and second portions of the first and second gas port connectors being parallel to one another, the first and second gas port connectors being fluidly connected to the same gas source, wherein an orifice formed in the first gas port connector at a first end thereof defines a first gas flow rate and an orifice in the second gas port connector at a first end thereof defines a second gas flow rate which is different from the first gas flow rate, wherein the first ends of the first and second gas port connectors are located in a same transverse plane that is perpendicular to the longitudinal axis.

13. The venturi connector of claim **10**, wherein the hollow body includes two first air entrainment windows that are spaced apart from one another and a top edge of the first gas port connector lies in a horizontal plane that intersects each of the two first air entrainment windows between top and bottom edges thereof.

14. The venturi connector of claim **10**, wherein the hollow body includes two first air entrainment windows spaced apart from one another by a pair of vertical walls and includes a second gas port connector spaced opposite the first gas port connector, the first and second gas port connectors being disposed adjacent the pair of vertical walls.

15. The venturi connector of claim **10**, wherein at least a portion of the first air entrainment window is located upstream of the first open end of the gas port connector.

16. The venturi connector of claim **10**, wherein the movable shutter includes an indicator member that extends downwardly therefrom and the hollow body includes gas concentration markings, wherein the movable shutter can be rotated until the indicator member points to one of the gas concentration markings which represents the gas concentration value for the gas that exits the hollow body.

17. The venturi connector of claim **10**, wherein the hollow body includes an end portion at another end opposite the one end that contains the first gas port connector, the end portion being longitudinally downstream of the second air entrainment window and is configured to be attached to a fluid connector for delivering air entrained gas to a patient interface device.

18. The venturi connector of claim **1**, further including a second gas port connector that is spaced from the first gas port connector and positioned parallel thereto such that the first and second gas port connectors have a first portion disposed inside the venturi member and a second portion that lies outside the hollow venture member, the first and second portions of the first and second gas port connectors being parallel to one another, the first and second gas port connectors being fluidly connected to the same gas source, wherein an orifice formed in the first gas port connector at a first end thereof defines a first gas flow rate and an orifice in the second gas port connector at a first end thereof defines a second gas flow rate which is different from the first gas flow rate, wherein the first ends of the first and second gas port connectors are located in a same transverse plane that is perpendicular to the longitudinal axis.

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