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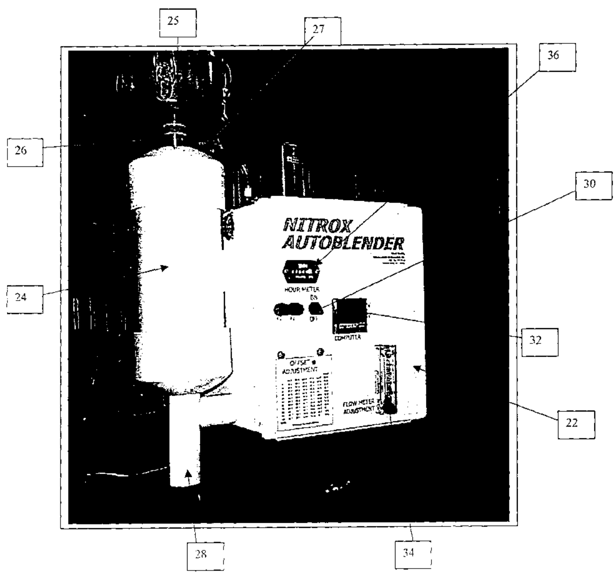
(54) Title: AUTOMATIC GAS BLENDER



(57) Abstract: A system and method for automatically blending gases, comprising an input device for receveiving predetermined mixed gas concentration data from the user, a plurality of gas inlet valves which allow a plurality of gas flows to enter a homogenizing cahmber (24) for mixing the plurality fo gas flows into a mixed gas, at least one gas sensor (38) for detecting the concentration of one or more components of the mixed gas and generating at least one output signal representative thereof; an a manager (32) for receiving the at least one output signal and comparing the at least one output signal with the predetermined mixed gas concentration data and in repsonse generating a signal to at least one gas inlet valve (50) to modify the pluratilty of gas flows to maintain the desired mixed gas concentration.

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Description

AUTOMATIC GAS BLENDER

Related Applications

This application claims the benefit of U.S. Patent Application Serial No. 10/176,767, filed June 21, 2002 , the disclosure of which is incorporated herein by reference in its entirety.

Technical Field

The present invention relates generally to an apparatus for the production of mixed gases. More particularly, the present invention relates to an improved apparatus for mixing two or more gases to a desired gas concentration.

Background Art

Various devices have been available for years for gas mixing purposes, such as systems to be used in mixed-gas diving. Mixed-gas diving has increased in popularity over recent years as a way to limit common injuries sustained by self-contained underwater breathing apparatus (SCUBA) diving activities. Mixed gases have also been used in surface supplied diving and re-breather diving activities. Decompression sickness, commonly referred to as the "bends" is a serious medical condition that can be experienced by divers that are exposed to elevated nitrogen levels forming in the bloodstream as the diver ascends from the increased pressure experienced at deeper depths. The nitrogen level formed in a diver's bloodstream is a direct result of the amount of nitrogen in the air stored in a diver's tanks and breathed at depth. Based on the understanding that the use of air having reduced amounts of nitrogen decreases the occurrence and seriousness of the bends in divers, the National Oceanographic and Atmospheric Association (NOAA) began experimenting with gases labeled "Nitrox" that had reduced levels of nitrogen through the use of supplemental oxygen added to ambient air (Nitrox was first used by the British military in World War II, but NOAA began the first commercial experimentation). While ambient atmospheric air typically has approximately 21% oxygen concentration at sea level and a corresponding 79% nitrogen concentration, Nitrox was primarily developed to contain 32%-36% oxygen, having correspondingly decreased levels of nitrogen. These Nitrox gases that had reduced levels of nitrogen were found to reduce the occurrence and seriousness of divers contracting the bends, while minimizing oxygen toxicity problems. Further Nitrox research resulted in Nitrox blends ranging from 21% to 100% oxygen, depending on the desired use of the mixture and the equipment involved in production of the mixture. With the raised popularity of using Nitrox for recreational and commercial diving, further research led to the development of gases known as Trimix, a mixture of helium, oxygen, and nitrogen gas, which is also used for diving. However, Nitrox is currently the gas mixture of choice for the recreational diver.

The use of Nitrox gases for diving has increased dramatically and likewise has created a great demand in recreational and commercial diving operations for the production of Nitrox gas. Various prior art devices have attempted to address the mixing of gases for Nitrox and other gas production purposes, yet these devices have various shortcomings that are overcome by the present invention.

U.S. Patent No. 4,860,803 to Wells teaches the use of a pressure regulator to control the injection of oxygen into a stream of ambient air in order to produce an oxygen enriched air mixture. This mixture is then compressed and delivered to storage or SCUBA cylinders for use in diving or other applications. Wells discloses a purely mechanical system, with no computer or monitoring control, thus requiring an operator to continuously observe the oxygen analyzer in order to provide the control element. Additionally, the location of the oxygen analyzer at the discharge side of the compressor system results in a large lag time of several minutes between the time adjustment is made to the oxygen concentration and when the results of that adjustment can be observed, leading to concentration maintenance difficulties. Wells also requires a source of oxygen appropriate for injection into the ambient air stream thus producing the chance of explosions and other inherent problems associated with the use of oxygen.

U.S. Patent No. 5,992,464 to Cowell discloses a pre-compression Nitrox in-line blender that uses pressure adjusted by a regulator applied across an orifice to control the amount of oxygen added to ambient air. In Cowell, an oxygen analyzer is observed by the operator in order to provide the operator with information to make adjustments to maintain the desired output concentration. Similar to Wells, there is no computer control or monitoring systems thus requiring an operator to continuously observe the oxygen analyzer in order to provide the control element. The Cowell device also has inherent accuracy and safety problems should the operator be the least inattentive.

U.S. Patent No. 5,915,834 to McCulloh discloses an apparatus for mixing two gases by using a source of forced or pressurized air and a pressurized source of oxygen flowing through regulators in order to supply a control valve entering into a mixing plenum. The shuttling between air and oxygen and the non-proportional nature of the mixing valve apparently renders the machine incapable of supplying a flow suitable for use with a positive displacement continuous flow machine such as a compressor. Additionally, the flow valve as described in McCulloh produces inherent overheating and life cycle limitations if operated in the disclosed manner.

The apparatus of the present invention overcomes many of the problems as found in prior art gas mixing devices by incorporating an input device for receiving desired mixed gas concentration data from the user along with a plurality of gas inlets through which a plurality of gases enter a homogenizing chamber for mixing of the plurality of gases into a mixed gas. One or more gas sensors read the concentration of the mixed gas and generate an output signal representative thereof, sending the output signal to a manager that then compares the output signal with the desired gas concentration data from the user and in turn generates a gas inlet signal to modify the flow of gas to maintain the desired mixed gas concentration.

Disclosure of the Invention

In accordance with the present invention, an improved automatic gas blender is provided for automatically mixing two or more gases to a desired gas concentration. The automatic gas blender has an input device for receiving predetermined mixed gas concentration data from the user, such as the level of oxygen desired in a Nitrox mixture of the preferred embodiment. The automatic gas blender further comprises a plurality of gas inlet valves which allow a plurality of gas flows, such as ambient air and oxygen in the preferred embodiment for production of Nitrox gas mixture, to enter a homogenizing chamber where the plurality of gas flows are mixed into a mixed gas through the use of a series of mixing baffles. At least one gas sensor is provided for detecting the concentration of one or more components of the mixed gas and generating at least one output signal representative thereof. A manager is also provided for receiving the at least one output signal and comparing the at least one output signal with the predetermined mixed gas concentration data and in response generating a signal to at least one gas inlet valve to modify the plurality of gas flows to maintain the predetermined mixed gas concentration. Once the predetermined gas concentration is mixed and maintained, the mixed gas exiting the automatic gas blender can be compressed and transferred to high-pressure storage tanks.

In a preferred embodiment of producing a precise mixture of Nitrox (oxygen and ambient air), the user will enter the predetermined oxygen content for the Nitrox mixture into an input device, a preferred concentration of oxygen being between 21% and 40%. A fluid stream of ambient air will then pass through an air inlet valve into the gas addition area while a fluid stream of oxygen will pass through an oxygen inlet valve into the gas addition area. The two gas streams will merge and enter the homogenizing chamber where they will mix by passing across, around, or through at least one mixing baffle. An oxygen sensor will then measure the oxygen concentration of the mixed gas and generate an output signal representative thereof that is sent to the manager. The manager will receive the output signal and compare the signal with the predetermined oxygen content as entered by the user. The manager will then generate an oxygen inlet valve signal that is sent to the oxygen inlet valve in order to modify the valve setting, thus modifying the fluid stream of oxygen entering the gas addition area. This process is repeated until the predetermined oxygen content is reached, upon which time the gas is compressed and transferred to high-pressure storage tanks.

Therefore, it is an object of the present invention to provide a system for automatically blending two or more gases.

It is another object of the present invention to provide a system and method for automatically blending two or more gases to provide a breathing gas mixture for divers that significantly extends bottom time, reduces required decompression, and provides numerous physiologic and other benefits.

Yet another object of the present invention is to provide a method for producing a gas mixture, which can be made into a breathing quality gas mixture, that safely, automatically, accurately, and rapidly combines ambient air and pure oxygen to create a final mixture of a predetermined concentration.

Some of the objects of the invention having been stated hereinabove, other objects will become evident as the description proceeds when taken in connection with the accompanying drawings as best described hereinbelow.

Brief Description of the Drawings

Figure 1 is a schematic of a Nitrox filling system incorporating the automatic gas blender of the present invention;

Figure 2 is a front perspective view of the automatic gas blender of the present invention;

Figure 3 is a front perspective view of the automatic gas blender of the present invention with the casing door open;

Figure 4 is an exploded view of the homogenizing chamber of the automatic gas blender of the present invention;

Figure 5 is a schematic view of the basic system of the automatic gas blender of the present invention; and

Figure 6 is a schematic view of the enhanced system of the automatic gas blender of the present invention.

Detailed Description of the Invention

While it is envisioned that the present invention could be used to produce Trimix gas mixtures (helium-oxygen-nitrogen gas) or other gas mixtures, in a preferred embodiment the automatic gas blender is designed to mix oxygen with ambient air to create Nitrox mixes. Nitrox blends may typically range from 21% to 100% oxygen, depending on the desired use of the mixture and the equipment involved in production of the mixture. Based upon readily available equipment for production of recreational Nitrox mixtures, the preferred embodiment discloses the production of Nitrox containing from 21% to 40% oxygen. Various terms will be used throughout this description and the following definitions can be used to describe the functionality of these terms:

Gas: The gaseous state of matter.

First Gas: The first gas used to combine with a second gas to create a combined gas; the first gas may be a pure gas or a combination of gases.

Second Gas: The second gas used to combine with the first gas to create the combined gas; the second gas may be a pure gas or a combination of gases.

Combined Gas: The combination of the first gas and the second gas.

Valve: An opening through which gas passes. Could be as simple as a hole opening or as sophisticated as mechanical, electrical, or other valves known to those skilled in the art.

Gas Addition Area: A cavity where the second gas is added to the first gas. The gas addition area can be of any shape and configuration necessary for the efficient addition of the second gas to the first gas.

Homogenizing Chamber: A cavity where the first and second gases enter after being combined and are mixed in a turbulent manner to produce a homogeneous combined gas.

Specific Gas Constituent Sensor: A device or mechanism that is uniquely sensitive to a specific gas or one of its properties and is capable of producing a signal which can be transmitted indicating the amount of the specific gas present based on a calibratable sliding scale. For example, in the preferred embodiment, an oxygen sensor will be provided that is a galvanic cell whose reaction is sensitive to oxygen content.

Manager: A computing device with multiple inputs and outputs that is capable of performing the required task according to instructions, the device can be as simple as a programmable logic controller or as sophisticated as a dedicated, specially designed computer, depending on the installed system requirements. Some, but not all, of the functions the manager can perform are: a) displaying in an appropriate manner the amount/portion of the second gas present in the combined gas; b) providing a means for the operator to instruct the manager what the amount/portion of the second gas is to be; c) determining the amount/portion of the second gas to add to the first gas to create the desired combined gas concentration; d) controlling the second gas addition valve to achieve the correct combined gas concentration; e) to communicate with other elements of the system and modify the operation of the installed system to comply with the communicated requirements; and f) inform the operator when an out of tolerance condition exists.

First Signal Conditioner: A device that conditions the signal from the Specific Gas Constituent Sensor for use by the Manager. The requirement of this device depends on the Gas Sensor and/or Manager requirements.

Second Gas Addition Valve: A valve which is infinitely variable in a proportional manner and able to maintain a position between fully open for maximum flow conditions to fully closed for a no flow condition as instructed by a signal.

Second Signal Conditioner: A device that conditions the signal from the Manager for use by the Second Gas Addition Valve. The requirement of this device depends on the Gas Addition Valve and/or Manager requirements.

Gas Sample Collector: A device design using Bernoulli's principles to retrieve a gas sample from the homogenizing chamber.

Gas Sample Return: A device design using Bernoulli's principles to return a gas sample to the homogenizing chamber.

Pumping Mechanism: A device to cause a gas to move in a certain manner. A Gas Sample Pump may be used to move the sample gas past the sensor.

Flow Meter/Regulator: A device that can measure and/or control the flow of a gas.

Nitrox: A gas mixture of air and additional oxygen.

Individual specifications for the automatic gas blender are based upon the desired end use of the gas mixture and the available equipment for production of the gas mixture. As an example, the specifications of a preferred embodiment of the automatic gas blender for the production of Nitrox gas mixture are as follows:

Air Flow Rate	0 – 7.5 cfm; 7.5 - 20 cfm; or 20 – 50 cfm (based on compressor system)
Oxygen Percentage Range	20.9% - 40%
Mixing Tolerance	+/- 0.5%
Oxygen Purity Requirement	> 99.5%
Ambient Temperature Range	55° - 95° F
Ambient Humidity Range	20% - 90% Relative Noncondensing
Inlet Air Temperature Range	55° - 95° F
Inlet Air Humidity Range	20% - 90% Relative
Power Requirement	6 amp, 115 volts +/- 10% @ 60 Hz

As shown in FIG. 1, in a preferred embodiment of the invention for the production of Nitrox gas mixture, the automatic gas blender **10** will be located in-line between the oxygen source (liquid oxygen canisters **12**, high pressure oxygen **14**, and/or other oxygen source such as production of oxygen through oxidation or other chemical reactions) and the compressor **16.** The automatic gas blender **10** will be mounted to a rigid structure that is not affected by vibration, such as the vibration resulting from a compressor. Ideally, this rigid structure location would be a structural wall, column, or some similar part of a building. The location chosen should be as close to the compressor intake as possible, having approximately two feet of clearance on the top, bottom, and both sides of the unit, and not be exposed to direct sunlight. Mixed Nitrox gas that exits the automatic gas blender **10** will be compressed by the compressor **16** for the filling of SCUBA tanks **18** and/or other suitable Nitrox storage containers **20.**

Referring now to FIG. 2, the exterior of the automatic gas blender **10** comprises a preferably metal casing **22** that houses the interior components of the automatic gas blender, a homogenizing chamber **24** for the mixing of the gases, an air filter **25** placed on top of the homogenizing chamber for filtering raw air, a first gas (air) inlet **26** located on top of the homogenizing chamber, a second gas (oxygen) inlet **27** located on top of the homogenizing chamber, and the mixed (combined) gas outlet **28** at the bottom of the homogenizing chamber. The operator of the system will perform various tasks from the front of the casing including activating the ON/OFF switch **30**, input and data reading from the manager **32**, data reading from the flow meter **34**, and data reading from the hour meter **36.**

Referring now to FIG. 3, the inside of the casing **22** of the automatic gas blender **10** holds a majority of the electronic and mechanical components comprising the system. Prominent features found inside the automatic gas blender casing are as follows: the manager **32**, a specific gas constituent sensor **38**, a first signal conditioner **40**, a sample pump **42**, the power supply **44**, relay switch **46**, a second signal conditioner **48**, and the second gas addition valve **50**. A casing vent **52** may also be found in the side of metal casing **22**.

As shown in FIG. 4, the homogenizing chamber **24** of the present invention is shown in more detail. The homogenizing chamber **24** of the present invention consists of a top cap **54** that houses the gas addition area **55** and in which further includes first gas source inlet **26** and second gas source inlet **27**. The homogenizing chamber **24** further includes a series of baffled devices **62** and an outer skin **60** that surrounds the baffled devices. The baffled devices **62** may be in press fit relationship with the outer skin **60**. Towards the bottom of the homogenizing chamber **24** is a combined gas exit **28** wherein the homogenized gas will exit the chamber.

Referring now to FIG. 5, the operation of the automatic gas blender **10** of the present invention will be described in more detail. A first gas source **57**, such as ambient air in a preferred embodiment for the production of Nitrox gas mixture, will enter the gas addition area **55** through the first gas source inlet **26**. A second gas source **59**, such as oxygen, will enter the gas addition area **55** through a second gas source inlet **27** after passing through a second gas addition valve **50**. Once the two gases are added to the gas addition area **55**, the gases will then enter the homogenizing chamber **24** where a series of baffled devices **62** create turbulent flow along the length of the homogenizing chamber **24** thus causing the two gases to mix completely. Once the mixed gas reaches the combined gas exit **28**, a gas sample is pulled from the combined gas sample point **66**. A specific gas constituent sensor **38** is installed so that the specific gas-sensing element of the specific gas constituent gas sensor **38** is in direct contact with the combined gas that is pulled at the combined gas sample point **66**.

A second embodiment of automatic gas blender **100** is shown in FIG. 6 wherein the combined gas sample point **66** may consist of a gas sample collector **68** that pulls a sample of the combined gas **69** through the use of a pumping mechanism **70** and a flow meter regulator **72** that pulls the gas sample and runs it through the specific gas constituent sensor **38**. In this enhanced system, once the data from the gas sample is read, the collected gas may be returned to the combined gas exit area **28** through the use of a gas sample return **74**.

In the preferred use of automatic gas blenders **10** and **100** for the production of Nitrox gas mixture, the specific gas constituent sensor **38** may measure the percentage of oxygen in the mixed gas (Nitrox mixture of ambient air and oxygen). In an alternate embodiment, such as the production of a Trimix mixture (helium-nitrogen-oxygen), the specific gas constituent sensor **38** will measure the concentration of the components: oxygen, moisture content, temperature, and thermal conductivity of the mixture using four sensors sending their outputs to the manager **32** which will be able to display and control the percentage of each gas present in the mixture.

Once the specific gas constituent sensor **38** has analyzed the gas sample, the sensor produces a signal through a first signal conditioner **40** describing the amount/portion of a specific gas present in the combined gas and this signal is transmitted to the manager **32**. The manager **32** is capable of performing several functions that are determined by the requirements of the installed system. The manager **32** will then send a signal through a second signal conditioner **48** instructing the second gas addition valve **50** to open or close depending on the concentration of the second gas needed. The amount of second gas that is now entering the second gas source inlet **27** will vary depending on the opening and closing of the second gas addition valve **50**, which is in turn reacting to data sent from the manager **32**. Once this higher or lower concentration of the second gas is mixed with the first gas through the homogenizing chamber **24**, another sample is taken and the specific gas constituent sensor **38** will send a new signal representing the portion of the specific gas present in the new combined gas. Once the manager **32** receives this signal and compares the amount of the specific gas present with the instructions given by the operator, another signal is sent to the second gas addition valve **50** to maintain or change the amount of the second gas being sent to the gas addition area **55** to create the required formulation.

The sensor process cycle consists of: the specific gas constituent sensor **38** sending information to the manager **32**; the manager **32** comparing the amount of the specific gas present with the instructions from the operator; and the manager **32** signaling the second gas addition valve **50** to maintain or change the amount of the second gas sent to the second gas source inlet **58**. This cycle is continuous during the time the combined gas is made.

Set-up and operation of the present invention for the preferred use to make Nitrox gas mixture will now be described in detail.

A delivery hose **76** connects the automatic gas blender **10** discharge to the compressor filter air intake for feeding of mixed Nitrox gas to the compressor **16**. The recommended hose size for this delivery hose, designed for an air flow rate of 20 cfm, is 1 ¼" inside diameter and should have a smooth interior surface. Lower airflow rates such as 7.5 cfm or larger airflow rates such as 50 cfm would use proportionally smaller or larger hose sizes, respectively. The discharge pipe from the automatic gas blender is preferably 1 ¼" pipe made from PVC or similar materials. A hose barb properly sized for the delivery hose is attached to the outer end of the automatic gas blender discharge pipe. The hose barb connects to one end of the delivery hose and the other end of the delivery hose is attached to the compressor filter intake port. If the compressor filter intake port is threaded (usually a pipe thread) then a hose barb may be screwed into the compressor filter intake port and the delivery hose attached to this hose barb. If the compressor intake port is not threaded, then a stretchable plumbing fitting that is tightened using screw-type band clamps will be needed to attach the hose barb.

Next, a connection from the coil circuit of the magnetic starter for the compressor motor to the safety relay connection in the automatic gas blender is made. This connection should be installed in a flexible conduit between the panel where the magnetic starter for the compressor is located and the port provided on the bottom of the casing for the automatic gas blender. The two wires from the coil circuit on the compressor's magnetic starter are connected to tabs inside the automatic gas blender casing. This wire should preferably be 16 or 18 gauge stranded THHN or MTW wire. The automatic gas blender requires 6 amps of 120 VAC 60 Hz power. A surge suppressor to protect the electronic components in the automatic gas blender should be installed between the automatic gas blender and the receptacle used to provide power to the automatic gas blender.

The oxygen pressure-reducing regulator of the automatic gas blender is then connected to the CGA 540 fitting on the oxygen supply container (**12** or **14**) and installation is then complete.

The first step in operating the automatic gas blender **10** is to check the oxygen supply **12** or **14** to determine if the quantity of oxygen in the oxygen storage container **12** or **14** that is connected to the oxygen regulator of the automatic gas blender is sufficient to make the desired amount of Nitrox. The user will then start the compressor **16** following the compressor manufacturer's routine start-up procedures. The user will then place the power switch **30** on the front panel of the automatic gas blender into the ON position which in turn will initiate the manager **32** to execute a self-start program. The user will then adjust the flow meter **34** on the front panel of the automatic gas blender so that the flow meter ball indicator is centered on the 1.5 line but no lower than the red line, which indicates a flow rate of 1.0 liters per minute (lpm). A flow rate of 1.5 lpm is optimal, however, the automatic gas blender will function reliably with flows as low as 1.0. The user will next check the SV line on the manager display to ensure it is set to "20.0".

The user will then read the values on the temperature and humidity gauge that is located next to the automatic gas blender ambient air intake. These values are then located on the top and left side of the % oxygen offset chart that is provided with the automatic gas blender. The temperature column is followed downward and the humidity column is followed to the right to find the place where the two lines intersect. This number at the point of intersection is the humidity offset value. The user will then adjust the humidity offset on the front panel of the automatic gas blender so that the PV value on the manager **32** display matches the humidity-offset value from the chart. If either the temperature or humidity does not match one of the values on the % oxygen offset chart, then the column or row closest to the value shown on the temperature and humidity gauge are to be chosen.

Next, the user will turn on the oxygen supply valve and adjust the oxygen regulator to a pressure of 20 PSI on the oxygen pressure reducing regulator output pressure gauge. To enter the desired Nitrox mixture concentration, the user will press the index button on the lower edge of the manager display. The user will then press the up or down arrow buttons to raise or lower the number shown on the SV line on the manager display, representing the desired oxygen content for the Nitrox mixture. The user will then press the enter button on the lower edge of the manager to set the value entered. In a preferred embodiment based on Nitrox concentration of between 21% and 40% oxygen, if the user attempts to enter a value greater than "40.0" the manager will not accept this value and the automatic gas blender will fail to operate. The manager is preprogrammed to not accept values greater than "40.0". Once the user has entered the desired Nitrox concentration, the manager will now start controlling the oxygen flow to achieve the SV value entered. When the PV value matches the SV value, the automatic gas blender is making the requested Nitrox percentage. This process may take several minutes to complete. The user will then allow the compressor **16** to run long enough for the desired Nitrox mixture to purge the compressor, the associated plumbing and the filtration before filling storage **20** or diving cylinders **18**. Note that usually a tolerance of +/- 0.5% is acceptable to start filling storage or diving cylinders. If a closer tolerance is desired, the user will simply wait until the Nitrox mixture within the desired tolerance is discharging.

Once the storage or diving cylinder has been filled with the desired Nitrox mixture, if the user wishes to enter a different Nitrox mixture concentration the user will simply press the index button on the lower edge of the manager display and then press the up or down arrow buttons to raise or lower the value shown on the PV line on the manager display. The user will then press the enter button on the lower edge of the manager display to set the new Nitrox concentration value entered. The manager will then start controlling the oxygen flow to achieve the SV value entered. When the PV value matches the SV value, the automatic gas blender is making the new requested Nitrox percentage. This process may take several minutes to complete, in which the user shall allow enough time for the desired Nitrox mixture to purge the compressor, the associated plumbing, and the filtration before filling storage or diving cylinders with the new Nitrox mixture.

Once the user has completed filling the storage or diving cylinders with the Nitrox mixture, the user may follow the following shutdown procedures in order to secure the system. The user will first change the Nitrox concentration mixture to “20.0” by pressing the index button on the lower edge of the manager display. The user will then press the down arrow button to lower the value on the PV line of the manager display to a value of “20.0”. The manager will now start controlling the oxygen flow to achieve the SV value entered. When the PV value is less than “21.0”, the automatic gas blender has stopped making a Nitrox mixture. This process can take several minutes to complete.

The user will then stop the flow of oxygen from the oxygen storage containers **12** or **14** by turning off the oxygen supply valve on the oxygen storage container. The user will then open the compressor discharge and allow the compressor **16** to run until the compressor, the associated plumbing, and the filtration has been purged of all Nitrox mixture and only ambient air is coming out of the discharge. The compressor discharge valve is usually located either on the fill whip or some other location that will allow the entire system to be either purged or emptied, allowing for purging of the compressor system before filling of tanks with mixed gas or upon system shut-down. The user will then place the power switch **30** on the front of the automatic gas blender into the off position.

The following maintenance instructions should be followed in order for the automatic gas blender to be maintained in a first-rate operating condition.

The inlet air filter **25** is the gray cylinder located on the top of the homogenizing chamber **24**. The filter element within the inlet air filter **25** should be changed every 100 hours of operation and in operating environments with normal dust conditions. To change the filter element, the user will remove the wing nut on top of the gray cylinder and remove the outer shell. The filter is located inside this outer shell. The user will then replace the old filter element with a new filter element, replace the outer shell and secure the unit with the wing nut. The filter element to be used is a standard 10 micron absolute filter available at any high-pressure compressor dealer.

The casing **22** of the automatic gas blender **10** contains a filter screen **52** on the lower right side that should be cleaned every 100 hours of operation. To clean the filter screen **52**,use the end of a hose of a house-type vacuum cleaner to suction off any dust or dirt that has accumulated on the screen.

The internal calibrated oxygen sensor assembly **38** of the preferred embodiment must be replaced every two years or 3,000 hours, whichever comes first.

It will be understood that various details of the invention may be changed without departing from the scope of the invention. Furthermore, the foregoing description is for the purpose of illustration only, and not for the purpose of limitation - the invention being defined by the claims.

CLAIMS

What is claimed is:

1. A system for automatically blending gases, comprising:
   (a) an input device for receiving predetermined mixed gas concentration data from the user;
   (b) a plurality of gas inlet valves which allow a plurality of gas flows to enter a homogenizing chamber for mixing the plurality of gas flows into a mixed gas;
   (c) at least one gas sensor for detecting the concentration of one or more components of the mixed gas and generating at least one output signal representative thereof; and
   (d) a manager for receiving the at least one output signal and comparing the at least one output signal with the predetermined mixed gas concentration data and in response generating a signal to at least one gas inlet valve to modify the plurality of gas flows to maintain the predetermined mixed gas concentration.
2. The system of claim 1 further comprising a gas sample collector that pulls a sample of the mixed gas prior to the reading of the concentration of one or more components by the at least one gas sensor.
3. The system of claim 2 further comprising a gas sample return that returns the gas sample after the reading of the concentration of one or more components by the at least one gas sensor.
4. The system of claim 1 wherein the mixed gas is a mixture of ambient air and oxygen gas.
5. The system of claim 4 wherein the at least one gas sensor measures the percentage of oxygen in the mixed gas.
6. The system of claim 1 wherein the mixed gas is a mixture of helium, oxygen, and/or nitrogen gas.
7. The system of claim 6 wherein the at least one gas sensor measures the percentage of oxygen, moisture content, temperature, thermal conductivity, and/or other specific gases in the mixed gas.

8. The system of claim 1 wherein the homogenizing chamber further comprises at least one mixing baffle.

9. A method for automatically blending gases, comprising:

(a) providing an input device for receiving predetermined mixed gas concentration data from the user;

(b) providing a plurality of gas inlet valves which allow a plurality of gas flows to enter a homogenizing chamber for mixing the plurality of gas flows into a mixed gas;

(c) providing at least one gas sensor for detecting the concentration of one or more components of the mixed gas and generating at least one output signal representative thereof; and

(d) providing a manager for receiving the at least one output signal and comparing the at least one output signal with the predetermined mixed gas concentration data and in response generating a signal to at least one gas inlet valve to modify the plurality of gas flows to maintain the predetermined mixed gas concentration.

10. The method of claim 9 wherein the mixed gas is a mixture of ambient air and oxygen gas.

11. The method of claim 10 wherein the at least one gas sensor measures the percentage of oxygen in the mixed gas

12. The method of claim 9 wherein the mixed gas is a mixture of helium, oxygen, and nitrogen gas.

13. The method of claim 12 wherein the at least one gas sensor measures the percentage of oxygen, moisture content, temperature, and thermal conductivity in the mixed gas.

14. A method of producing a precise mixture of oxygen and air in a oxygen and air mixed breathing gas, comprising:

(a) entering a predetermined oxygen content for the oxygen and air mixed breathing gas into an input device;

(b) supplying a fluid stream of ambient air through an air inlet valve;

(c) supplying a fluid stream of oxygen through an oxygen inlet valve;

(d) mixing the air and oxygen streams in a homogenizing chamber to form a mixed breathing gas;

(e) measuring the oxygen concentration of the mixed breathing gas and generating an output signal representative thereof;

(f) receiving the output signal and comparing the output signal with the predetermined oxygen content and generating a signal to the oxygen inlet valve to modify the fluid stream of oxygen to maintain the predetermined oxygen content in the mixed breathing gas;

(g) once the predetermined oxygen content is reached, compressing the mixed breathing gas to a high pressure mixed breathing gas; and

(h) transferring the mixed breathing gas into high pressure storage tanks.

15. The method of claim 14 wherein the step of entering the predetermined oxygen content provides an oxygen concentration in the mixed breathing gas of between 21% and 40% oxygen.

16. The method of claim 14 wherein the high pressure mixed breathing gas has a pressure of up to 6000 PSI.

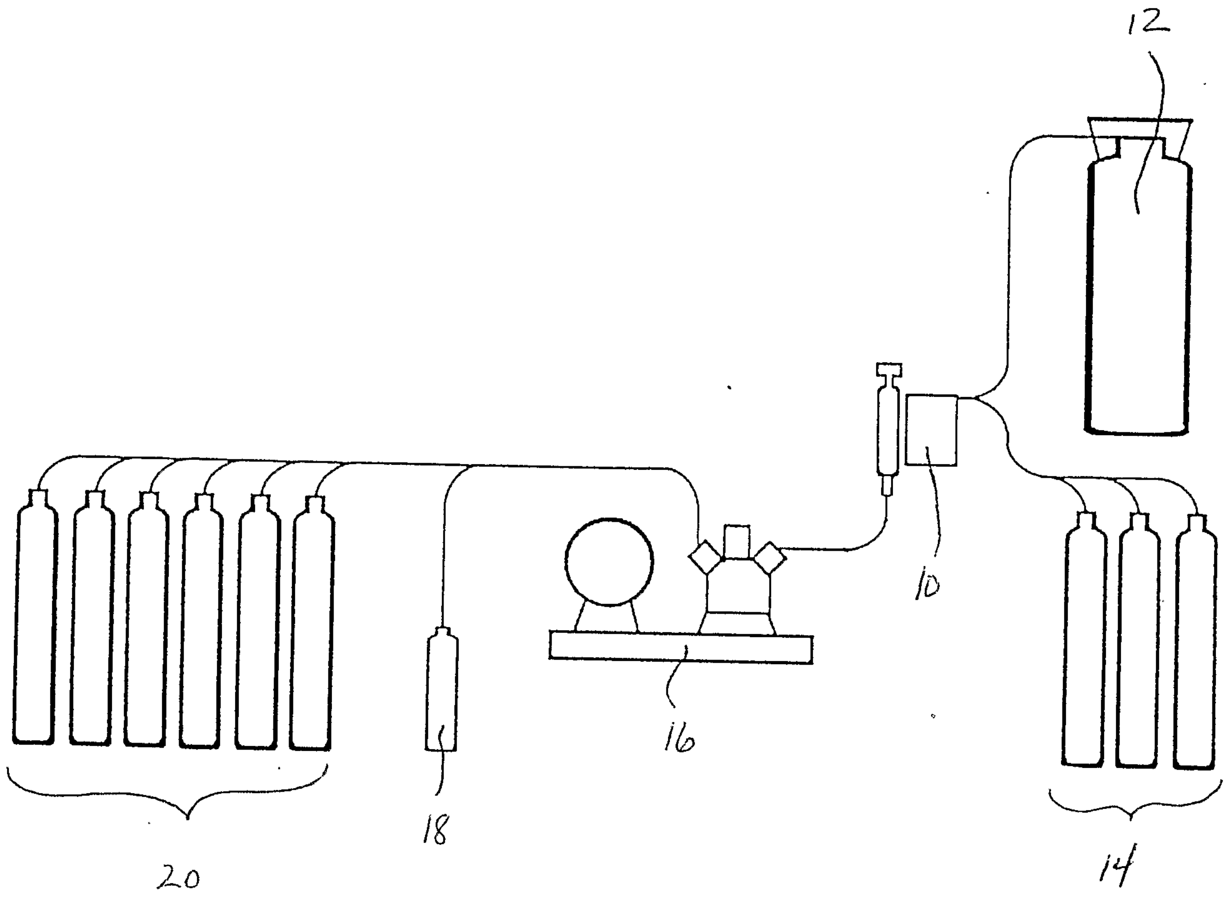
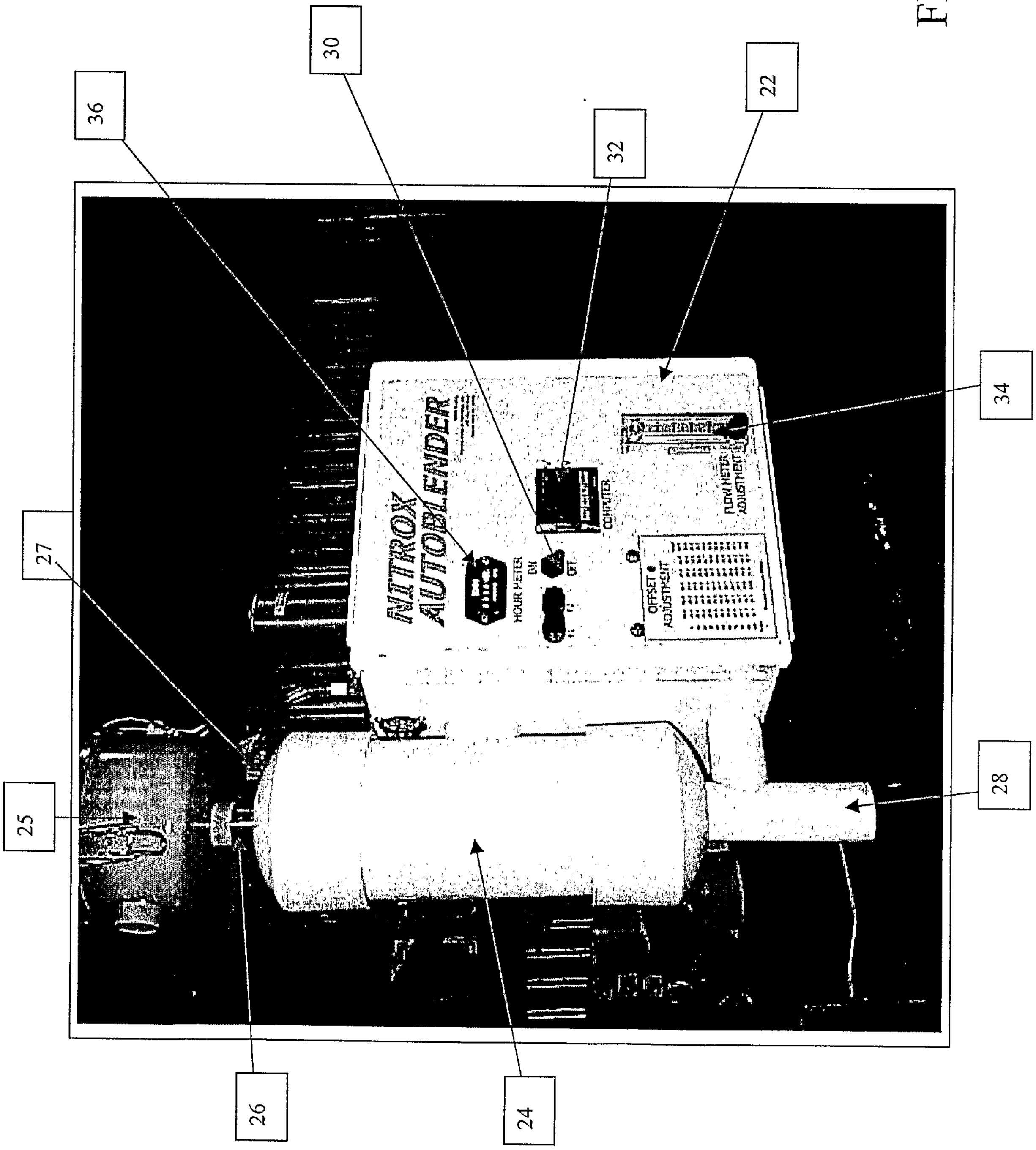


FIG. 1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AUTOBLENDER
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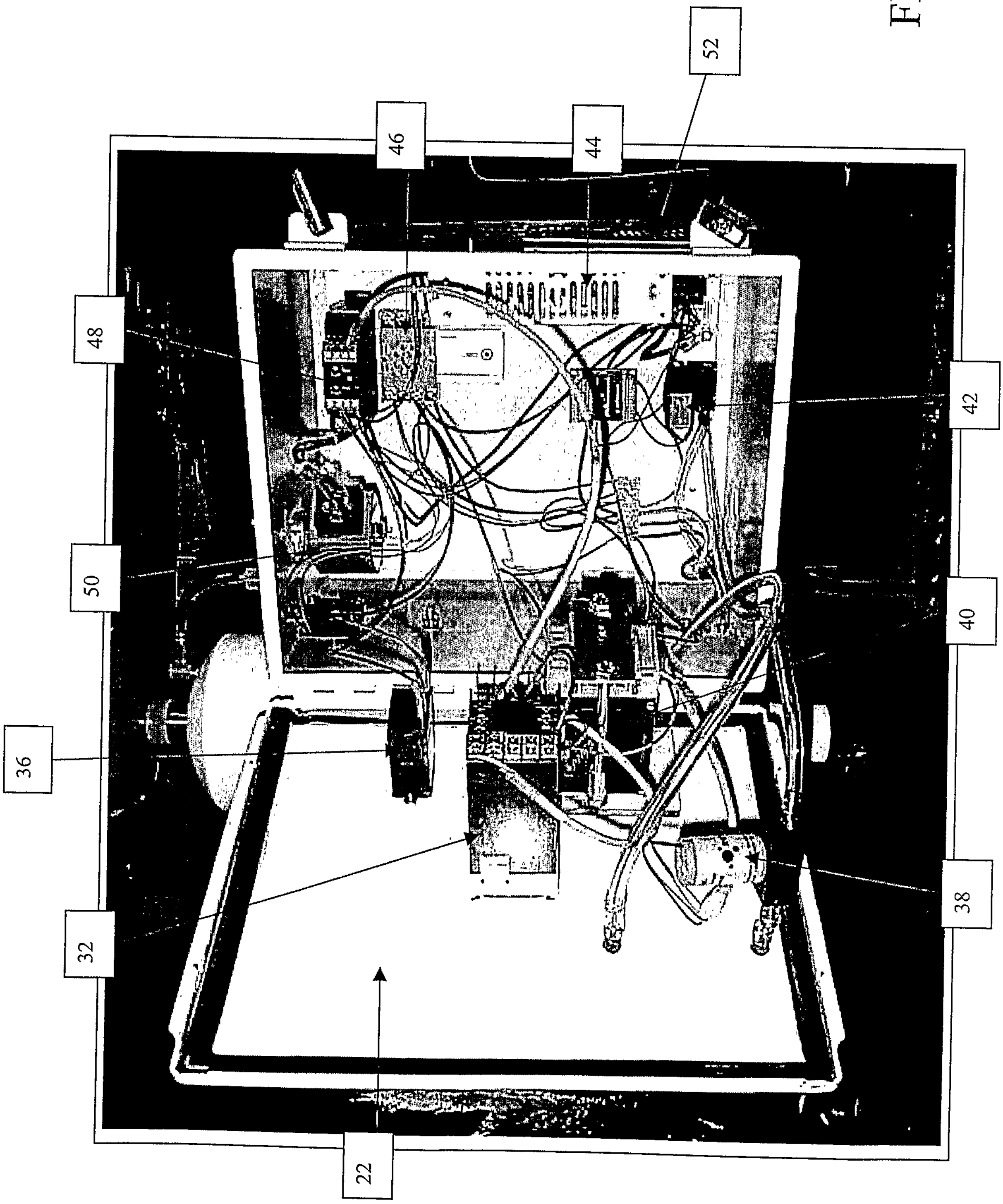
ADJUSTMENT

FIG. 2

FIG. 3



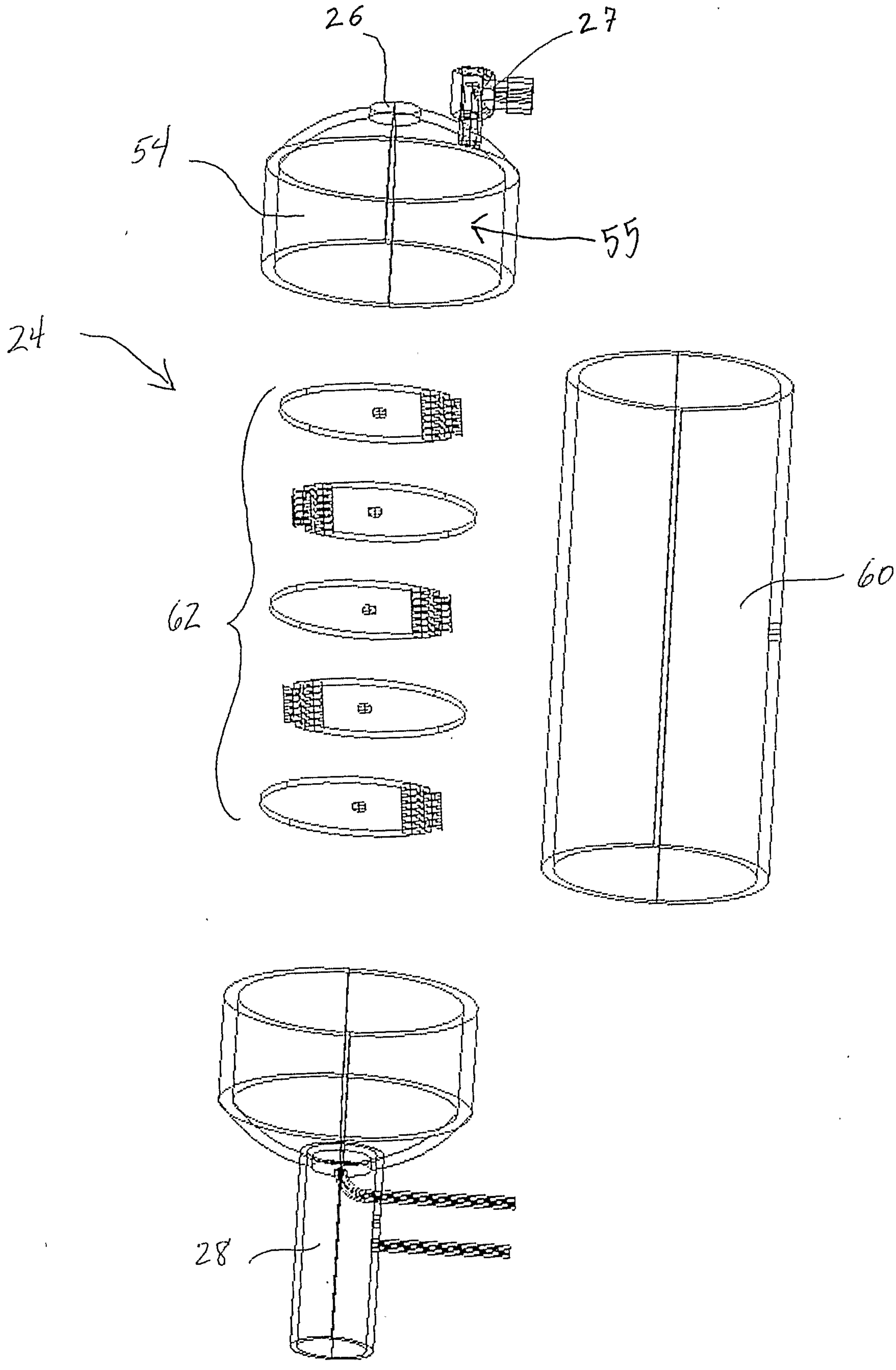


FiG. 4

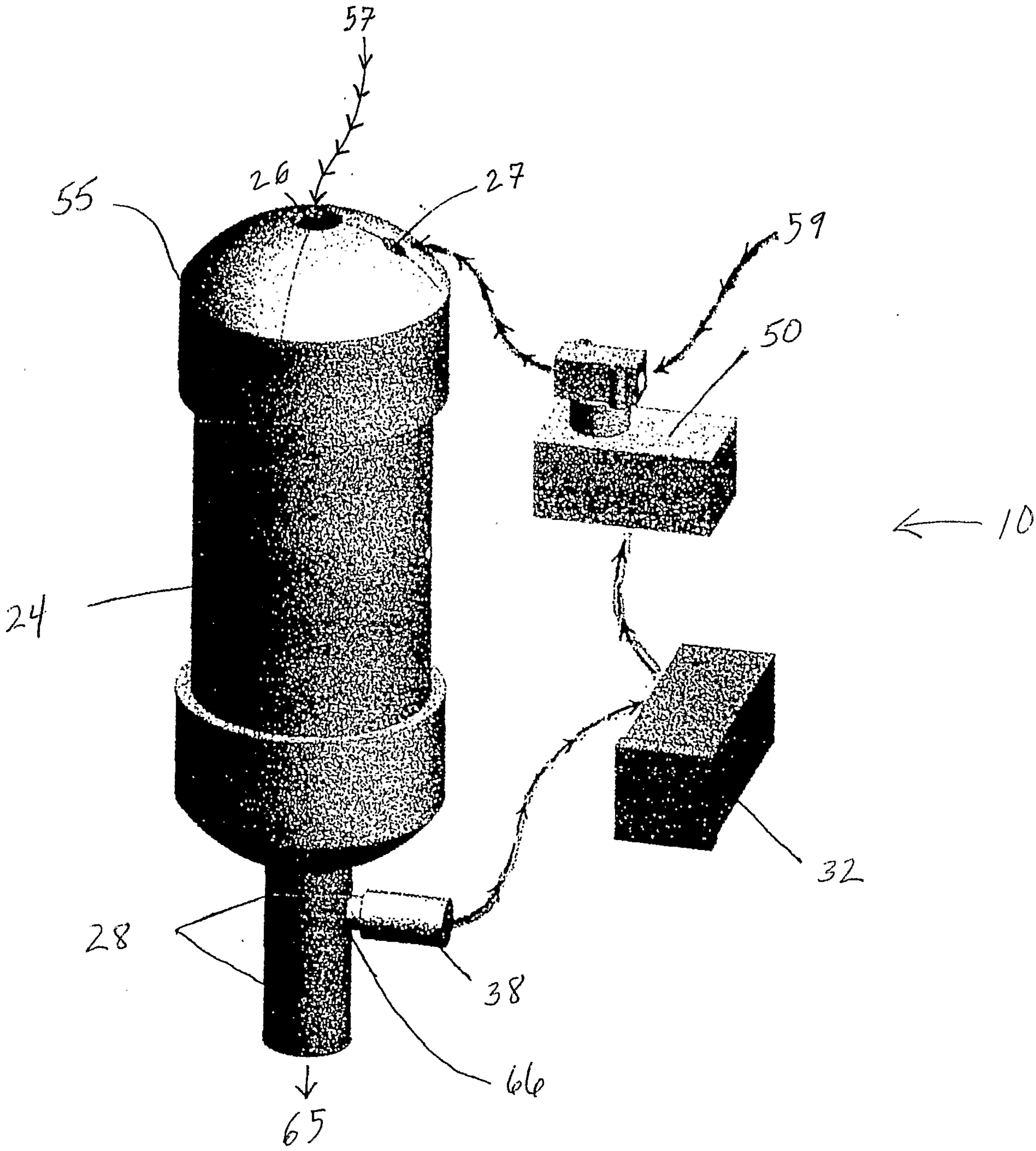


Fig. 5

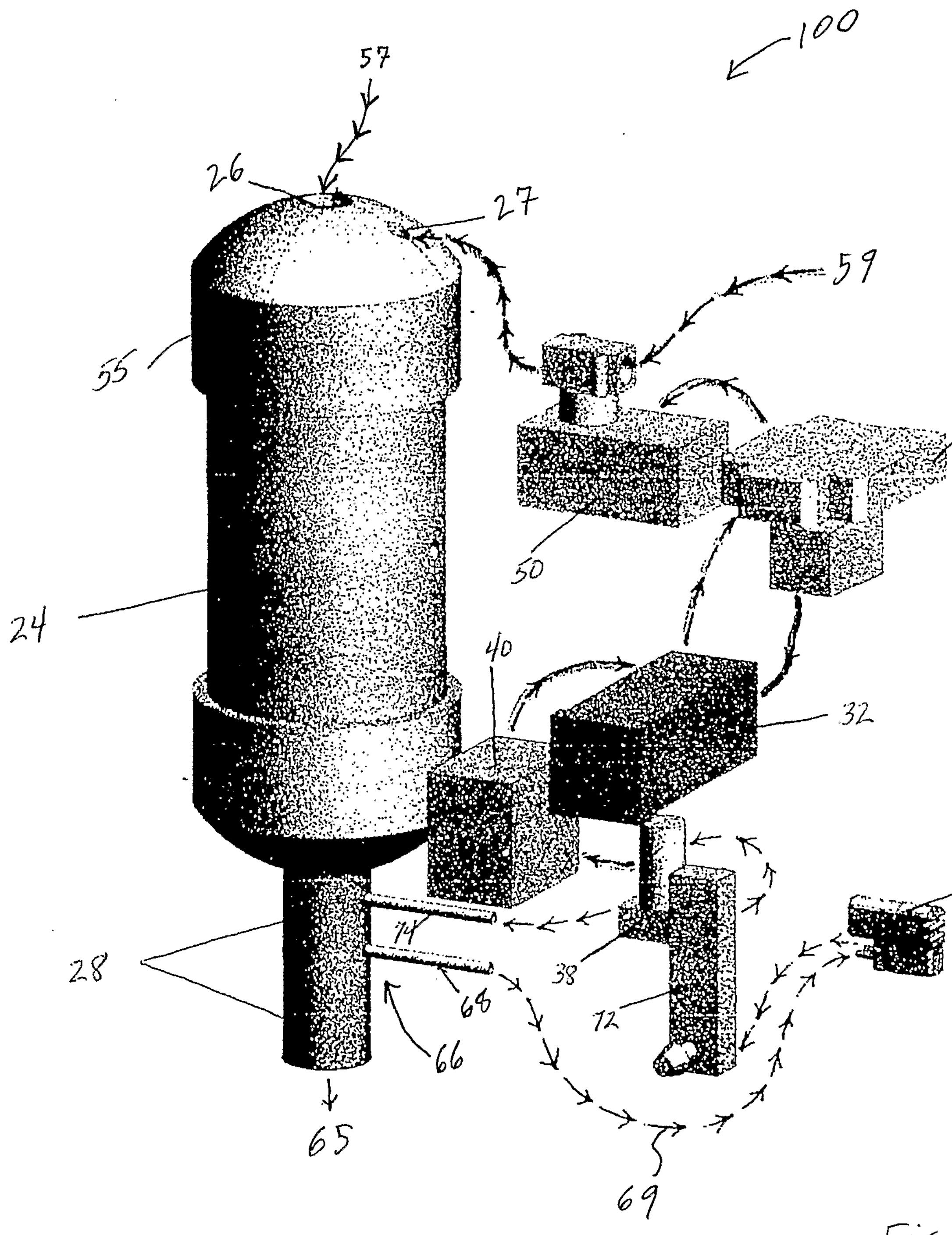


Fig. 6

INTERNATIONAL SEARCH REPORT

International application No. PCT/US03/18991

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : A61M 15/00, 16/00; A62B 7/00, 9/00, 18/10; B63C 11/02; A61B 19/00; B65B 1/04

US CL : 128/200.24, 201.27, 201.28, 204.18, 204.21, 204.22, 204.26, 205.11, 205.18, 205.22, 205.24, 898; 141

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 128/200.24, 201.27, 201.28, 204.18, 204.21, 204.22, 204.26, 205.11, 205.18, 205.22, 205.24, 898; 141/9, 10, 104

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US 5,915,834 A (MCCULLOCH) 29 June 1999, see figures 1-3, column 1, lines 35-46 and column 2, lines 41-65	1,2, 4-7 ----------- 6,9-14
Y	US 5,992,464 A (COWELL) 30 November 1999, see figures 11-3 and 5, column 2, lines 28-31, 54-62, column 4, lines 50-55, column 6, lines 24-37.	8,15
Y	US 5,858,064 A (DELP, II) 12 January 1999, see column 2, lines 57-60	16

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

29 September 2003 (29.09.2003)

Date of mailing of the international search report

30 OCT 2003

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