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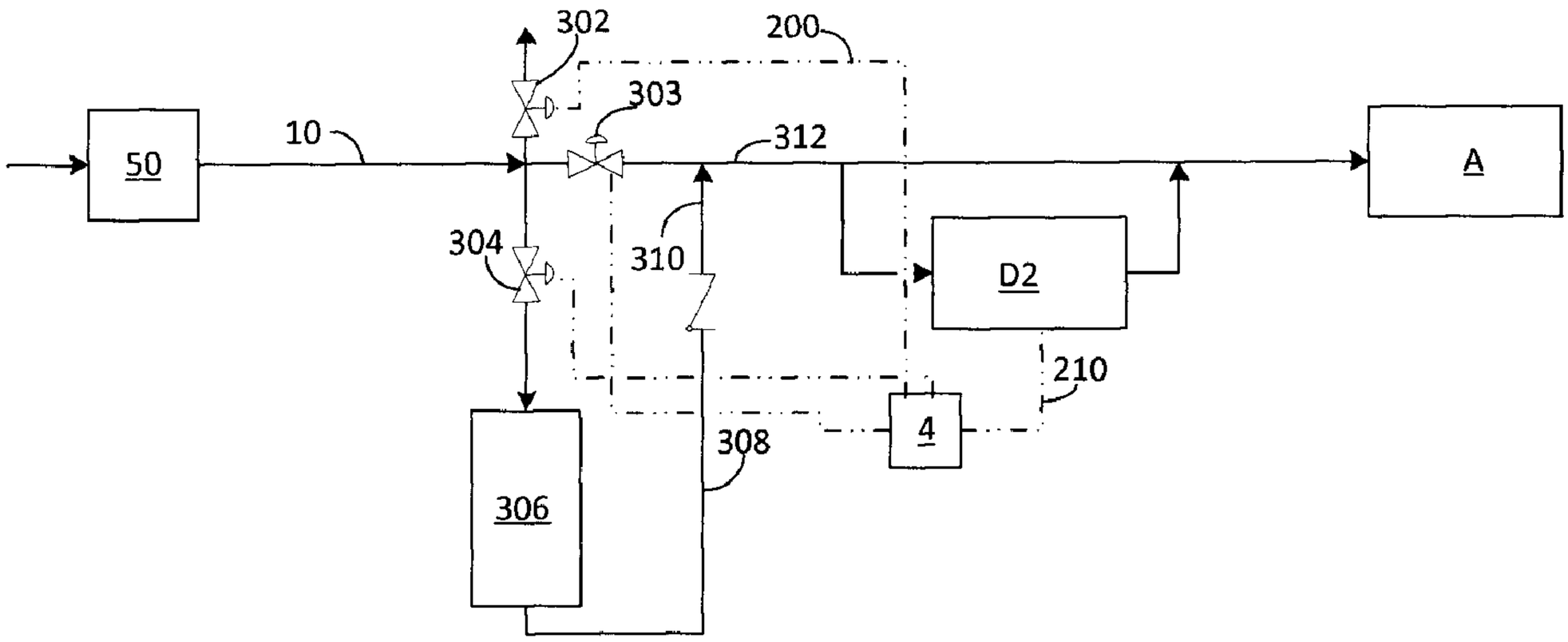

(57) Abrégé/Abstract:
The invention relates to an on-site medical gas production plant (100) comprising a unit (50) for purifying gas, such as air, a first compartment (A) for storing purified gas, and a main gas line (10) fluidically connecting the gas purification unit (50) to the said first storage compartment (A). It furthermore comprises an actuated valve (304) arranged on the main gas line (10) upstream of the first storage compartment (A), and furthermore connected to the secondary purifying device (306), as well as an operating device (4) which controls at least the actuated valve (304), and at least a gas analysis device (D2) in fluid communication with the main line (10), and which is in communication with said operating device (4).

ABSTRACT

The invention relates to an on-site medical gas production plant (100) comprising a unit (50) for purifying gas, such as air, a first compartment (A) for storing purified gas, and a main gas line (10) fluidically connecting the gas purification unit (50) to the said first storage compartment (A). It furthermore comprises an actuated valve (304) arranged on the main gas line (10) upstream of the first storage compartment (A), and furthermore connected to the secondary purifying device (306), as well as an operating device (4) which controls at least the actuated valve (304), and at least a gas analysis device (D2) in fluid communication with the main line (10), and which is in communication with said operating device (4).

ON-SITE MEDICAL GAS PRODUCTION PLANT AND ASSOCIATED OPERATING METHOD

Background

Embodiments of the invention relate to a plant for medical air production on-site, that is to say in a hospital building or the like, employing a three-way solenoid valve adapted to discharge product gas contaminated by impurities to the atmosphere via a purge line connected to one of the ports of the solenoid valve and/or to send the produced gas contaminated by the impurities to an in-line filter or purifier for removal of said impurities, and to a method for controlling or operating such a plant.

The medical air used in hospitals, clinics, treatment centres, emergency or incident units, or the like, for patients' respiration is a medicament whose composition is specified by recognized Pharmacopoeia.

For example, European Pharmacopoeia standards typically define medical air as ambient air that has been compressed to a pressure above atmospheric pressure, typically several bars, or to tens or even hundreds of bars and contains (by volume) from 20.4% to 21.4% oxygen, at most 500 ppm CO_2, at most 5 ppm CO, at most 1 ppm SO_2, at most 2 ppm NO and NO_2, at most 67 ppm water and at most 0.1 mg/m^3 oil; the oil vapours possibly present essentially come from the compression of the air. For medical oxygen, U.S. Pharmacopeia standards require oxygen of not less than 90% and not more than 96% by volume, max 10 ppm CO, and max 300 ppm CO2.

It should be noted that, other than oxygen, the components mentioned above (i.e. COx, NOx, water, or oil etc.) are in fact impurities whose presence is tolerated within the limits of the Pharmacopoeia but which ideally are not present therein.

Medical air furthermore contains nitrogen, and may also contain other compounds, such as argon.

Currently, medical air is delivered to hospitals or the like in three forms, namely, depending on the case:

- direct delivery in the form of compressed air, for example at an absolute pressure of from 200 to 300 bar, in cylinders, that is to say bottles or canisters of gas, or containers comprising a plurality of bottles;

- production on-site by mixing oxygen and nitrogen so as to create nitrogen/oxygen mixtures, and

- direct production on-site from ambient air treated, in particular, by compressors and filtration/purification systems.

Of these, the production of air directly on-site by compressors and filtration systems is the most widespread solution. Such a method is described, for example, in the document EP-A-864818.

The ambient air is taken in and compressed by compressors to a pressure range extending from 1 bar to 80 bar relative. This compressed air is then filtered, that is to say purified, by means of one or more treatment steps, for example by a set of filters and/or by employing a pressure swing adsorption method (PSA).

The medical air produced in this way may be stored in one or more intermediate buffer compartments, then sent through the network of pipes which passes through the hospital building in order to provision the treatment rooms, bedrooms or the like with medical air. It is quite clearly possible, and even indispensable in certain cases, to carry out intermediate expansion of the gas, for example in order to change from a pressure of about 10 bar in the storage compartment to a pressure of 5 or 8 bar in the network.

In general, any break in medical air provision is overcome by using medical air taken from a reserve or backup source in which the air is kept in gaseous form.

The other medical gases used in hospitals or treatment centres, such as oxygen, are also delivered in a similar way to the air. The compositions of these other gases are also specified by the European or US Pharmacopoeia.

Thus, oxygen may also be produced on-site by a PSA method by using specific adsorbents, such as lithium-exchanged zeolites X, making it possible to retain the nitrogen contained in the air and thus produce gaseous oxygen having a purity typically greater than 90%, or even 93% by volume, as is known from the document EP-A-297542.

However, the methods for producing medical air or other medical gases used on-site (also referred to as on-site methods) present certain drawbacks.

First, these methods do not permit easy monitoring of the reliability of the manufacturing process.

Thus, when an on-site medical air production unit is operating autonomously, the manufacturing process is not overseen continuously and the interventions on the plant take

place on the basis of planning, that is to say preventive maintenance, or when an error or a problem arises in the plant, that is to say curative maintenance.

These interventions are therefore carried out independently of the status of the plant and its reliability, which is not optimal because they are carried out either too soon, and therefore without actual need, or too late, and therefore with an impact on the production process and possibly on the final product.

Next, pollutant blockages in the main pipe occur when the gas produced is not compliant. This is because in existing plants, the control solenoid valve is a so called "2-way" solenoid valve which is arranged on the main line.

Although it makes it possible to stop possible pollution upstream of the valve, this pollution nevertheless remains blocked in the main line and necessitates a total purge of the system upstream of the valve. This is not ideal because it entails a shutdown of the gas production and manual intervention.

Furthermore, in the event of short-term breaks in the air provision due, for example, to temporary contamination at the inlet, the backup source is resorted to directly. However, this poses a problem because the backup volume is limited and therefore, if the frequency of the breaks in provision is high, there is then a risk of draining the backup source. In other words, it would be highly beneficial to be able to avoid this drawback by reducing the extent to which the backup source is used, so as to increase its autonomy over time.

Lastly, the air produced by the current methods and plants is in general neither analyzed nor validated in pharmaceutical terms, which may raise obvious problems of compliance and quality. Furthermore, when it is analyzed, in the event of "noncompliance" this usually leads either to immediate interruption of the production and changeover to a backup source air, which may entail overuse of the backup air liable to cause a possible total break in the air provision, or to continuous provision of noncompliant air and parallel triggering of an alarm in order to warn the user, who then needs to intervene manually. It will be understood that these solutions are not ideal either.

In summary, there is currently no method of validating air produced on-site which makes it possible to ensure that the air produced is in fact compliant with the required specifications and which makes it possible to ensure effective and reliable provision of medical air.

In other words, the problem which arises is to provide a plant for continuous on-site production of a medicament gas, particular medical air, in accordance with good manufacturing practice (GMP) and a method for controlling or operating such a plant, which permit in particular:

- supervision of the reliability of the manufacturing process with rapid detection of any anomaly,
- monitoring of the various production steps and in particular the final production with, for each step, the possibility of a purge thus making it possible to stop any contamination or noncompliance of the gas produced, in particular medical air, and/or
- the use of the backup sources to be reduced to a minimal level.

Summary

The solution of the invention is a plant for on-site production of medical gas, in particular medical-quality air, comprising:

- a gas purification unit adapted to produce a purified gas from a supply gas,
- a first compartment for storing purified gas, and
- a main gas line fluidically connecting the gas purification unit to the said first storage compartment so as to supply the said first storage compartment with purified gas coming from the gas purification unit,

characterized in that it furthermore comprises:

- an actuated valve, preferably a three-way, more preferably a four-way actuated valve, arranged on the main gas line between the gas purification unit and the said first storage compartment, and furthermore connected to the secondary purifying device and optionally the atmosphere via a vent line,
- an operating device which controls at least one actuated valve,
- at least a first gas analysis device of which a first measurement line is fluidically connected to the main line, upstream of the actuated valve, and which is electrically connected to the said operating device,

and in which the operating device is designed and adapted to act on the actuated valve in response to a signal received from the gas analysis device, so as to allow the gas present in the main pipe to pass to the secondary purifying device and/or the vent line when the signal received from the gas analysis device corresponds to a “contamination”

signal of the main pipe, and simultaneously to prevent any gas being sent to the said first storage compartment.

Depending on the case, the plant of the invention may comprise one or more of the following technical characteristics:

- the gas compression unit supplies the gas purification unit with a gas to be purified, compressed to a pressure higher than 1 bar absolute.

- the gas compression unit supplies the gas purification unit with compressed ambient air.

- the gas compression unit comprises at least one screw, piston, scroll or diaphragm compressor.

- the gas compression unit comprises a plurality of compressors, in particular arranged in parallel.

- the gas purification unit comprises at least one adsorber, each containing at least one bed of at least one adsorbent material, preferably at least 2 adsorbers arranged in parallel.

- the gas purification unit comprises at least one adsorber operating in a cycle of the PSA type.

- the gas purification unit comprises at least two adsorbers operating alternately, and the operating device is designed and adapted to act on the gas purification unit and/or the gas compression unit so as to stop any production of gas by the adsorber which was in operation at the time when the gas analysis device transmitted the “contamination” signal of the main pipe to the operating device.

- the “contamination” signal corresponds to a given level of at least one impurity, in particular one or more impurities selected from water vapour, or oil vapours, SOx, COx and/or NOx.

- the “contamination” signal corresponds to a preset threshold level, for example corresponding to a maximum level set by the United States or European Pharmacopoeia as regards the aforementioned impurities (i.e. water and oil vapour, SOx, COx and/or NOx) or a maximum limit value lower than the said corrected maximum values (for example 80% or 90% of the maximum value in the Pharmacopoeia), which makes it possible to ensure an operational safety margin.

- the operating device is designed and adapted to act on the actuated valve(s), which can preferably be two or three-way or four-way, in response to a signal received

from the gas analysis device, so as to stop any gas present in the main pipe from passing to the vent line and/or the secondary purifying device when the signal received from the gas analysis device corresponds to a "compliant gas" signal of the main pipe, and simultaneously to allow gas to be sent to the said first storage compartment.

- the gas purification unit furthermore comprises one or more filters.

- the gas purification unit, in particular the adsorbers, makes it possible to eliminate all or some of the impurities which are possibly present in the ambient air to be purified or which have been introduced therein during the compression, in particular water vapour, oil vapours, SOx, COx and/or NOx, so as to produce a medical gas compliant with the Pharmacopoeia, in particular medical air compliant with the European Pharmacopoeia. The adsorbers may include desiccants and/or deliquescent dryers. Alternatives to adsorber based systems are refrigerant dryers or membrane dryers. Generally any suitable device for dehumidifying the air is compatible with the device and system described herein.

- the valve is a 3-way actuated valve, of which one of the ports is fluidically connected to the secondary purifying device and the other two ports are fluidically connected to the main line.

- the valve is a 4-way actuated valve, of which one of the ports is fluidically connected to the secondary purifying device, a second port is fluidically connected to the atmosphere via a vent line, and the other two ports are fluidically connected to the main line.

- the valve is an actuated valve controlled by an operating unit, preferably the operating unit electrically connected to the three-way actuated valve.

- The gas compression unit comprises one (or more) gas inlets supplied with atmospheric air.

- the main line connects the first compartment for storing purified gas to at least one gas consumer site, preferably a network of pipes in a hospital building.

- the main gas line comprises a second compartment for storing purified gas, located between the first storage compartment and the said at least one gas consumer site. The first and second compartments are therefore arranged in series on the main line.

- the main gas line branches downstream of the first storage compartment into a secondary line fluidically connected upstream to the said main line and downstream to at least one gas consumer site, that is to say directly or indirectly, for example by being connected to the main gas line, the said secondary gas line comprising a third

compartment for storing purified gas. The first and third compartments are therefore also arranged in series, whereas the second and third compartments are arranged in parallel on the main line and the secondary line, respectively.

- it furthermore comprises a backup line fluidically connecting a backup source, such as a reserve or store of medical air, to the said at least one gas consumer site, either directly or indirectly by being connected to the main gas line or the said secondary line.

- it furthermore comprises at least 2-way actuated valves, arranged on the main line or the secondary line, with a first actuated valve arranged between the first compartment and the second compartment for storing purified gas, and a second actuated valve arranged between the first compartment and the third compartment for storing purified gas,

- it furthermore comprises at least two-way actuated valves, arranged on the main line and the secondary line, with a third actuated valve arranged downstream of the second compartment and/or a fourth actuated valve arranged downstream of the third compartment,

- it furthermore comprises a first purge line, fluidically connected upstream to the main line and downstream to the vent line, the first purge line preferably being fluidically connected to the main line downstream of the second compartment.

- it furthermore comprises a second purge line fluidically connected upstream to the secondary line and downstream to the vent line, the second purge line preferably being fluidically connected to the secondary line downstream of the third compartment.

- the first purge line comprises a fifth actuated valve and/or the second purge line comprises a sixth actuated valve.

- it comprises at least a first gas analysis device, the first measurement line of which is fluidically connected to the main line, upstream of the actuated valve,

- it comprises a second gas analysis device, of which at least one second measurement line is fluidically connected to the main line and/or to the secondary line.

- the second measurement line comprises a seventh and/or an eighth actuated valve.

- the operating unit furthermore controls the gas purification unit, the gas compression unit, one or more of the actuated valves and the gas analysis device or devices.

- it comprises one or more non-return valves arranged on all or some of the pipes or lines conveying the gas.

The invention also relates to a method for operating an on-site medical gas production plant, in particular a plant according to the invention as described above, comprising the steps of:

a) producing a purified gas from a supply gas, in particular atmospheric air compressed to a pressure greater than atmospheric pressure (i.e. > 1 atm),

b) transporting the purified gas obtained in step a) by means of a main gas pipe,

c) storing at least a part of the purified gas in a first compartment the storing the gas supplied by the gas pipe,

characterized in that it furthermore comprises the steps of:

d) determining in the main gas pipe, upstream of the first storage compartment, an impurity level of at least one given impurity in the gas produced in step a), and

e) controlling an actuated valve arranged on the main gas line upstream of the first storage compartment, and furthermore connected to the atmosphere via a vent line, so as to divert the gas present in the main pipe, upstream of the actuated valve, to the secondary purifying device when the impurity level measured in step d) is greater than or equal to a preset threshold level.

Depending on the case, the method of the invention may comprise one or more of the following technical characteristics:

- in step e), the gas present in the main pipe, upstream of the actuated valve, is diverted to the secondary purifying device and gas is simultaneously stopped from being sent to the first storage compartment, when the impurity level measured in step d) is greater than or equal to a preset threshold level.

- in step a), a purified gas is produced from a supply gas treated in a gas purification unit comprising at least two adsorbers operating alternately, and when an impurity level greater than or equal to a preset threshold level is determined in the gas produced by one of the said adsorbers, the production of the gas by the said adsorber is stopped and the production of gas by the other or an other of the said adsorbers is started.

- gaseous flushing of the main pipe part containing an impurity level greater than or equal to the preset threshold level with purified gas is carried out and the gas flow thus generated is discharged to the atmosphere via the vent line and/or sent to the secondary purifying device for further purification.

- the gas to be purified is ambient air and the purified gas is medical air or medical oxygen, that is to say with the specifications of the European Pharmacopoeia, as explained above.

- the impurity or impurities are selected from NOx, SOx, COx, water vapour and hydrocarbon vapours, in particular oil vapours.

- the medical air produced contains (by volume) from 20.4% to 21.4% oxygen, at most 500 ppm CO_2, at most 5 ppm CO, at most 1 ppm SO_2, at most 2 ppm NO and NO_2, at most 67 ppm water, at most 0.1 mg/m^3 oil, and nitrogen.

- in step d), a gas analysis device is used in order to determine the impurity level in the main gas pipe.

- in step e), an operating device, such as a programmable automaton, is used in order to control the three-way actuated valve, the said operating device acting in response to the measurements taken by the gas analysis device.

In accordance with another aspect of the present invention, there is provided an on-site medical gas production plant, comprising:

- a gas purification unit configured to produce a purified gas from a less pure supply gas source,

- a first compartment for storing the purified gas;

- a main gas line fluidically connecting the gas purification unit to the first storage compartment so as to supply the said first storage compartment with the purified gas coming from the gas purification unit;

- a first actuated valve in fluid communication with the main gas line between the gas purification unit and the first storage compartment ;

- a gas analysis device in fluid communication with the main line , wherein the gas analysis device is configured to analyze the purified gas within the main line for impurities;

a secondary purifying device in fluid communication with the main gas line, the secondary purifying device configured to receive at least a portion of the purified gas and remove additional impurities from the purified gas;

an operating device configured to control the first actuated valve, wherein the operating device is in communication with the gas analysis device wherein the operating device is configured to act on the first actuated valve in response to a signal received from the gas analysis device , so as to divert a gas present in the main pipe to pass to the

secondary purifying device when the signal received from the gas analysis device corresponds to a contamination signal based on an analysis of the gas in the main pipe.

In accordance with another aspect of the present invention, there is provided the plant, wherein the gas analysis device is upstream of the first actuated valve.

In accordance with another aspect of the present invention, there is provided the plant, wherein the gas analysis device is downstream of the first actuated valve.

In accordance with another aspect of the present invention, there is provided the plant, wherein the first actuated valve, once opened, is configured to close after a set period of time.

In accordance with another aspect of the present invention, there is provided the plant, wherein the first actuated valve, once opened, is configured to close upon receiving a closing signal from the operating device, wherein the closing signal is based on a reading from the gas analysis device.

In accordance with another aspect of the present invention, there is provided the plant, wherein the operating device is configured to act on the first actuated valve in response to a signal received from the gas analysis device, so as allow gas to be sent to the first storage compartment without passing through the secondary purifying device.

In accordance with another aspect of the present invention, there is provided the plant, further comprising a vent line, wherein the vent line comprises a vent line valve configured to open and close the vent line to the atmosphere.

In accordance with another aspect of the present invention, there is provided the plant, wherein the vent line valve is an actuated valve.

In accordance with another aspect of the present invention, there is provided the plant, wherein the vent line valve is electrically connected to the operating device and in which

- the operating device is configured to further act on the vent line valve in response to a signal received from the gas analysis device so as to open the vent line valve to the atmosphere; when a second actuated valve is closed to prevent the gas present in the main pipe from being sent to the said first storage compartment and to further or alternatively divert a gas present in the main pipe to pass to the vent line when the signal received from the gas analysis device corresponds to a contamination signal based on an analysis of the gas in the main pipe.

In accordance with another aspect of the present invention, there is provided the plant, wherein the first actuated valve is a four-way value configured to open gas flow through main line to storage compartment A, divert gas flow to vent line, or divert gas flow to the secondary purifying device.

In accordance with another aspect of the present invention, there is provided the plant, further comprising a valve controlled bypass line arranged to allow the purified gas from the gas purification unit to bypass the main line first actuated valve and create a fluid communication directly from the gas purification unit to the first storage compartment.

In accordance with another aspect of the present invention, there is provided the plant, wherein the purified gas remains in fluid communication with a vent line and a vent line valve is open to the atmosphere such that first gas analysis device is capable of continued monitoring of the purified gas while the bypass line is open.

In accordance with another aspect of the present invention, there is provided a method for operating an on-site medical gas production plant, the plant comprising:

a gas purification unit configured to produce a purified gas from a less pure supply gas source,

a first compartment for storing the purified gas, and

a main gas line fluidically connecting the gas purification unit to the first storage compartment so as to supply the said first storage compartment with the purified gas coming from the gas purification unit,

a first actuated valve arranged on the main gas line between the gas purification unit and the first storage compartment, and furthermore connected to a secondary purifying device,

an operating device which controls at least one first actuated valve,

a gas analysis device in fluid communication with the main line, the gas analysis device is in communication with the operating device,

a secondary purifying device in fluid communication with the main gas line via the first actuated valve, the secondary purifying device configured to receive at least a portion of the purified gas and remove additional impurities from the purified gas;

and in which the operating device is configured to act on the first actuated valve in response to a signal received from the gas analysis device, so as to divert a gas present in the main pipe to pass to the secondary purifying device when the

signal received from the gas analysis device corresponds to a contamination signal based on an analysis of the gas in the main pipe;

the method comprising the steps of:

a) producing a purified gas from a less pure supply gas source,

b) transporting the purified gas obtained in step a) in the main gas pipe,

c) storing at least a part of the purified gas in a first compartment for storing gas supplied by the main gas pipe,

d) determining in the main gas pipe, upstream of the first storage compartment, an impurity level of at least one given impurity in the gas produced in step a), and

e) controlling the first actuated valve, so as to divert the gas present in the main pipe, upstream of the first actuated valve, to the secondary purifying device when the impurity level measured in step d) is greater than or equal to a preset threshold level.

In accordance with another aspect of the present invention, there is provided the method, wherein in step e), the gas present in the main pipe, upstream of the first actuated valve, is diverted to the secondary purifying device and gas is simultaneously stopped from being sent to the first storage compartment, when the impurity level measured in step d) is greater than or equal to a preset threshold level.

In accordance with another aspect of the present invention, there is provided the method, wherein the operating device monitors the signal received from the gas analysis device during a first defined period of a purge operation to determine if the contamination signal persists for longer than a specified period of time and wherein, if the contamination signal persists for less than the specified period, the operating device closes the first actuated valve to end the additional purification and reopens the main line to resume delivery of gas from the gas purification unit to the first storage compartment.

Brief Description of the Drawings

For a further understanding of the aspects of the present invention, reference should be made to the following detailed description, taken in conjunction with the accompanying drawings, in which like elements are given the same or analogous reference numbers and wherein:

Figure 1, which represents the block diagram of an embodiment of a plant **100** for on-site production of medical gases, controlled by the operating method according to the invention, which plant **100** is connected to the network of pipes **30** of a hospital building.

Figure 2 represents a second embodiment of the invention.

Figure 3 represents an additional embodiment of the invention.

Description of Preferred Embodiments

The present invention will now be described in more detail with reference to the appended Figures 1 and 2, which represent the block diagram of an embodiment of a plant **100** for on-site production of medical gases, controlled by the operating method according to the invention, which plant **100** is connected to the network of pipes **30** of a hospital building or the like.

The gas produced here is medical air, that is to say purified air satisfying the specifications of the European Pharmacopoeia mentioned above. Nevertheless, such a

plant **100** may be used for manufacturing other medical gases, for example medical oxygen from ambient air.

More precisely, in the embodiment illustrated in Figure 1, the on-site medical air production plant **100** comprises a gas purification unit **50** supplied by a gas compression unit **31**, that is to say one or more air compressors taking in ambient air at atmospheric pressure (i.e. 1 atm) through their supply inlet **32** and delivering compressed air at a pressure higher than atmospheric pressure, for example at a pressure of between 1 bar and 80 bar absolute. This compressor or these compressors **31** may be one or more screw, piston, scroll or diaphragm compressors.

The compressed air supplies the gas purification unit **50**, which here comprises two adsorbers **1**, **2** operating in parallel according to cycles of the PSA type (Pressure Swing Adsorption) or TSA type (Temperature Swing Adsorption), that is to say one is in production phase while the other is in regeneration phase, and vice versa. Typically, the duration of a production cycle is between 1 and 30 minutes, approximately, preferably from less than 10 to 15 minutes.

These adsorbers each contain at least one bed of at least one adsorbent material, for example adsorbent materials such as zeolites, aluminas, active carbon, silica gel or any other molecular sieve capable of stopping the impurities present in ambient air.

Depending on the embodiment in question, the gas purification unit **50** may also comprise a single adsorber or more than 2 adsorbers **1**, **2**, for example at least 3 adsorbers.

These types of adsorbers **1**, **2** and PSA or TSA cycle are well known and, in this regard, reference may furthermore be made for example to the documents EP-A-716274, EP-A-718024, EP-A-922482, GB-A-1551348, EP-A-930089.

In all cases, the adsorbers **1**, **2** make it possible to eliminate all or some of the impurities which are possibly present in the ambient air to be purified or which have been introduced therein during the compression (at 31), in particular water vapour, oil vapours, SOx, COx and/or NOx, so as to produce a medical gas compliant with the Pharmacopoeia, in particular medical air compliant with the European Pharmacopoeia.

Next, the purified air (or any other medical gas) produced by the gas purification unit **50** is recovered in outlet conduits **9** which supply a main line **10** conveying gas, that is to say a pipe or a tube delivering gas, which is adapted and designed to convey the purified air produced in this way to a first storage compartment **A**, that is defined as a buffer gas volume container such as a vessel, tank or discrete section of pipe in which the

purified medical air can be stored and/or homogenized before being sent to one or more consumer sites **30**, such as a network of gas pipes passing through a hospital building in order to convey the medical air to the various rooms in which it is to be used, such as treatment rooms, emergency rooms, recovery rooms, bedrooms or any other any other location.

Preferably the storage compartment **A** is in unidirectional fluid communication with the gas purification unit **50** via main line 10 such that gas entering the the storage compartment **A** cannot return upstream toward the gas purification unit **50**.

The main gas line **10** therefore fluidically connects the outlet (or outlets) **9** of the gas purification unit **50** to the said first storage compartment **A** so as to supply it with purified air coming from the two adsorbers **1**, **2** of the gas purification unit **50**.

The operation of the compressor or the compressors **31** and the purification cycles taking place in the gas purification unit **50** are controlled and monitored by an operating device **4**, for example a programmable automaton or the like, connected to the gas purification unit **50** by electrical connections **8**, such as electrical cables.

It should, however, be noted that communication between the various elements and devices of the plant, in particular with the automaton **4**, could in general also take place via wireless links, for example via one or more wireless transmitter devices or systems such as radiofrequency (RF), Bluetooth, Zigbee, wifi, GSM or GPRS, and one or more receiver antennas for carrying out wireless transmissions of data adapted to the type of transmitter used.

Preferably, the automaton **4** or the like is programmed according to the requirements of the hospital site in question and can be reprogrammed if the requirements of the site change, for example.

In order to regulate and monitor the conveyance of gas in the main gas line **10**, a actuated valve **VA** is arranged on the said main line **10** between the gas purification unit **50** and the first storage compartment **A**. The actuated valve **VA** is also controlled by the operating device **4** via an electrical connection **5**, such as an electrical cable.

According to one preferred embodiment shown in Figure 1, the valve **VA** is a three-way actuated valve such as a solenoid valve, one of the ports of which is fluidically connected via a vent line **11** to the ambient atmosphere (at 12) where there is preferably a device for venting to the atmosphere, such as a vent valve (not represented), and the other two ports of which are fluidically connected to the main line **10**.

The air produced by the gas purification unit **50** therefore passes through two of the ports of the actuated valve **VA**, that is to say the first and second ports of the actuated valve **VA**, when it passes normally through the said actuated valve **VA** in the direction of the buffer compartment **A** where the purified gas can be stored.

Conversely, in the event of contamination of the line **10** upstream of the valve **VA**, this pollution can be expelled easily and effectively from the contaminated conduit portion of the main line **10**, without the need for a total purge of the system upstream of the valve **VA**.

This is done conventionally by flushing the conduit portion polluted by impurities with pure air produced by the gas purification unit **50**. The gas flow entraining the impurities is then discharged via the third port of the actuated valve **VA** to the atmosphere, through the vent line **11** to the ambient atmosphere. In other words, the air produced by the gas purification unit **1**, **2** will then entrain the pollutants with it and these will be disposed of to the atmosphere (at 12).

The 3-way actuated valve **VA** therefore makes it possible not only to block any possible pollution on the main line **10** in order to confine it upstream of the actuated valve **VA**, but also subsequently to discharge this pollution of the main line **10** to the outside (at 12) and thus to purge the main line **10** upstream of the valve **VA**.

This solution makes it possible to avoid shutting down the production process entirely and resorting to the backup **3**, that is to say a reserve of pure gas, in the event of temporary pollution of the air taken in or created by the production line.

Furthermore, the first buffer compartment **A** makes it possible to take over the delivery of the purified gas, such as medical air, when the valve **VA** is in the vent position, that is to say when a purge of the line **10** is ongoing, so as here again to reduce the frequency of use of the backup source **3**.

The first compartment **A** also makes it possible to protect the production unit **50** from consumption peaks, that is to say peaks in demand from the consumer sites **30**, and to homogenize the air produced by the production unit.

The monitoring of the composition of the gas produced, such as purified air, delivered by the production unit **50** is carried out by means of a first gas analysis device **D1**, such as an analysis cabinet or any other suitable gas analyzer, the measurement line **29** of which is connected fluidically (at 28) to the main line **10**, upstream of the 3-way actuated valve **VA**.

This gas analysis device **D1** is connected to the operating device **4** via an electrical connection **7**, such as an electrical cable or the like, so as to transmit measurement signals and optionally other information thereto.

As a function of the signals received, the operating device **4** can retroact on the 3-way actuated valve **VA** and preferably the other elements of the plant, such as production unit **50**, compressor **31**, etc., in order to trigger a purge of the line **10** when pollution is detected.

More precisely, in order to evaluate the reliability of the method and of the production plant, the quality of the air produced is analyzed using the analysis cabinet **D1**, in particular the levels of O_2, H_2O, CO_2 and oil vapour. Complementary monitoring variables (for example temperature, pressure, vibrations, etc.) are furthermore collected from the plant.

The analysis results as well as the monitoring variables may also then be optionally processed by the operating device **4**, such as an automaton, on the basis of statistical process control (SPC) in order to define the reliability of the production process.

The processing of the data is carried out for each of the production lines, that is to say for each of the adsorbers **1**, **2** of the production unit **50** as well as the compressors **31**, on the basis of conventional control elements, such as aptitude indicators of the production process, control chart of the variables, average, control limits, trend analysis of the variables, etc.

On the basis of the results and the predefined parameters, it is then possible to determine whether or not the manufacturing process is reliable.

Thus, when the operating device **4** determines that the level of one or more impurities in the main gas pipe **10**, in particular upstream of the first storage compartment **A**, is greater than or equal to a preset threshold level, for example the maximum values set by the European Pharmacopoeia as regards the level of water vapour, or oil vapours, SOx, COx and/or NOx, the said operating device **4** controls the three-way actuated valve **VA** so as to divert the gas present in the main pipe **10**, in particular the gas present upstream of the three-way actuated valve **VA**, to the vent line **11** and thus purge the main line **10** of the impure, that is to say noncompliant, the gas contained therein.

In this case, i.e. when the manufacturing process is not reliable, or no longer reliable, the production line in question, that is to say the adsorbers **1** or **2** and the associated compressor **31**, is shut down and the second line takes over for producing

purified air, while the other line is regenerated, reinitialized and/or undergoes a maintenance operation.

In other words, in the event of excessive impurity levels, the gas present in the main pipe **10** is diverted to the vent line **11** and gas is simultaneously stopped being sent to the first storage compartment **A**.

At this time, the production of the gas by the adsorber **1** or **2** in question is stopped and production of gas by the other adsorber **1** or **2**, respectively, of the production unit **50** is started.

This gas produced by the other adsorber will then be used to carry out gaseous flushing of the part of the main pipe **10** containing the impurity level greater than or equal to the preset threshold level then will subsequently be discharged to the atmosphere as a result of the gas flow thus generated, via the vent line **11**.

When the pipe **10** has been purged and the impurity level has returned to normal, the operating device **4** will control the 3-way actuated valve **VA** in order to stop the purge and allow gas again to be sent to the compartments **A**, **B** and/or **C** located downstream.

The gas produced in this way is then subjected to monitoring as before.

In the event of unreliability of the second line as well, the system then switches to the backup source **3**. Specifically, the plant also comprises a backup line **40** fluidically connecting a backup source **3**, such as a backup reservoir containing medical air, to the gas consumer sites **30**, directly or indirectly, that is to say by being connected at **23** to the main gas line **10** or to a secondary line **20**.

The secondary line **20** is in fact another gas line arranged in parallel with the main line **10** and used as an alternative passage for the gas coming from the compartment **A**, for example, and/or from the production unit **50**, when the main line **10** is out of use, for example contaminated and/or undergoing a maintenance operation.

In other words, the main gas line **10** branches (at 21) downstream of the first compartment **A** into a secondary line **20**. The latter **20** is therefore fluidically connected on its upstream side (at 21) to the said main line **10** and, by its downstream end, to at least one gas consumer site (30), directly or indirectly, that is to say by being connected (at 22) to the main gas line **10**.

Furthermore line **10** also comprises a second buffer compartment **B** for storing purified gas, located between the first compartment **A** and the gas consumer site or sites,

such as a network of pipes **30** of a hospital building, and the secondary line **20** in turn comprises a third compartment **C** for storing purified gas.

The compartments **B**, **C** are used to supply the consumer site or sites **30** with respiratory gas. In fact, the compartments **B** and **C** are used to provide medical air in alternation, that is to say while one compartment (for example B) is being filled or analyzed for compliance, the second (respectively C) delivers the gas to the hospital network **30**, or vice versa.

In general, maintenance of the plant **100** is triggered by the automaton **4** on an anticipatory basis when the production parameters of one or both production units **1**, **2** reach a predetermined threshold.

It will furthermore be noted that 2-way actuated valves are arranged on the main line **10** and the secondary line **20**. More precisely, a first actuated valve **V1** is arranged between the first compartment **A** and the second compartment **B**, and a second actuated valve **V3** is arranged between the first compartment **A** and the third compartment **C** for storing purified gas.

Furthermore, a third actuated valve **V2** is arranged downstream of the second compartment **B** and a fourth actuated valve **V4** is arranged downstream of the third compartment **C**. These 2-way actuated valves are controlled by the operating device **4** via electrical connections **6**, **37**, such as cables or the like, and make it possible to control the passage of the gas through the lines **10** and **20** and therefore to divide the pipes **10**, **20** into well-determined sections, and also to manage and/or operate the gas inlets and/or outlets of the compartments **B** and **C**.

The plant **100** furthermore comprises a first purge line **13** fluidically connected by its upstream end **24** to the main line **10**, preferably downstream of the second compartment **B**, and by its downstream end **25** to the vent line **11**, as well as a second purge line **14** fluidically connected by its upstream end **26** to the secondary line **20**, preferably downstream of the third compartment **C**, and by its downstream end **27** to the vent line **11**.

The first purge line **13** comprises a fifth actuated valve **V7** and the second purge line **14** comprises a sixth actuated valve **V8** used to control the passage of the gas to the vent line **11**. The operating device **4** also controls the actuated valves **V7**, **V8** via electrical connections **37**.

These purge lines **13**, **14** make it possible to purge the portions of lines **10**, **20** as well as the compartments **B** and **C**, respectively, located upstream of the actuated valves **V2** and **V4**, respectively.

A second gas analysis device **D2**, such as an analysis cabinet or the like, is provided and includes at least one second measurement line **36**, branching into two subsections **36a**, **36b**, which is fluidically connected (at 34, 35) to the main line **10** and to the secondary line **20**, in particular by means of the subsections **36a**, **36b**. Preferably, the second measurement line **36**, **36a**, **36b** comprises a seventh **V5** and/or an eighth **V6** actuated valve.

This second gas analysis device **D2** makes it possible to determine the composition of the gas circulating in the main **10** and secondary **20** lines, downstream of the compartments **B**, **C**, that is to say it makes it possible to analyze discontinuously the gas taken from the compartments **B** and **C**. As before, this second gas analysis device **D2** cooperates with the operating device **4**, which itself controls the actuated valves **V5**, **V6** via electrical connections **37**.

The electrical supply of the plant **100** is carried out conventionally by current from the mains, for example at a voltage of between 1 and 600 V, typically 24 V, 230 V or 400 V.

If need be, measurement means (not shown) may be provided in order to determine the pressure of the medical air contained in the compartments **A**, **B**, **C** for storage and homogenization of the gas and optionally retroact via the operating device **4** on the compression unit **31** and/or the production unit **50** so as to regulate the production of the gas, such as air, by taking into account the pressure (or pressures) thus measured. For example, the operating means **4** may be programmed in order to cause shutdown of the flow source **31** and/or triggering of an audio and/or visual alarm, when a pressure sensor arranged at the buffer compartment **A** detects a pressure or a pressure difference greater than or, conversely, less than a preset threshold value. This type of pressure regulation is well known and will not be described in detail here.

Furthermore, in order to ensure even more effective purification of the air taken in by the compressor **31**, one (or more) mechanical filtration devices (not represented in detail) may be provided, arranged at one or more sites between the air source **31** and the hospital network **30**. For example, the compression unit may comprise one or more filters at the inlet **32** and/or outlet **33** in order to retain the dust contained in the ambient air and

the condensates due to the compression, for example cyclone filters or separators, micron filters or the like.

Figure 2 illustrates and alternative arrangement of the invention having a single storage compartment **A**. The basic elements are the same as Figure 1, namely the medical air production unit **50** fed by compressor **31** directing medical via main line **10** to a point of use **30** such as a hospital piping network. Storage compartment **A** in this example is a discrete section of pipe which is fluidically isolated from the preceding main line **10** such as by a one way check valve. In Figure 2, each valve **VA**, **VB** and **110** may all be two way actuated valves under a common operating device **4** control **200** or one or more may be also, or exclusively manually operated. In one preferred embodiment, VA and VB are under operating device **4** control **200**, but bypass valve **110** is a manual only valve. Figure 2's design includes a backup medical air supply **140** which may be a tank or cylinder of medical air.

Medical air production unit **50** may, instead of being the air purification systems of Figures 1 and 2, be a synthetic air production system wherein oxygen and nitrogen gases are blended to form a respiratory gas substitute for air (synthetic air). The nitrogen and oxygen can be medical grade gases or can be purified to medical grade standards pre- or post-blending using an air purification system such as those described in Figures 1 and 2. The nitrogen and oxygen sources may be for example bulk storage tanks of cryogenic liquids that are vaporized and temperature adjusted pre- or post-blending. Other sources of gases for the synthetic air could include direct pipelines from an Air Separation plant or other means for storing or delivering the nitrogen and oxygen to the medical air production unit **50**.

In general, the plant **100** of the invention for production of medical air on-site, that is to say in a hospital building or the like, therefore employs a three-way actuated valve adapted to discharge product gas contaminated by impurities to the atmosphere via a purge line connected to one of the ports of the actuated valve **VA**, in response to detection of the said contamination by an analysis device **D1** cooperating with the operating device **4**.

The medical air production plant **100** of the invention may be used directly on the site where the gas is used, that is to say directly in a hospital building or the like. It may therefore be installed directly in a room of the hospital building or outside the said building or in containers, and connected to the network **30** of pipes conveying the gas inside the building.

Figure 3 represents an alternative embodiment of the present invention. As noted previously, in many instances, medical air is produced on-site. In these types of set-ups, the air is compressed and then filtered to remove various contaminants, for example, NOx, CO, CO2, moisture, etc... Under normal conditions, the concentration of these contaminants in the feed air remain relatively constant. As such, the filters employed at the front end are typically sized to remove the required amount in order to produce the proper quality of air. However, it has been discovered that the concentrations of these contaminants can vary depending on local atmospheric conditions (e.g., prevailing winds), traffic conditions, temperatures, and humidity. Consequently, there are times when the filtered air could exceed acceptable levels of contaminants.

Instead of sizing the front end filter to accommodate any and all concentrations of contaminants, the inventors have discovered a much more cost effective solution to this problem. Figure 3 provides one such solution. In one embodiment, purified gas within main gas line (10) coming from the gas purification unit (not shown) can be further monitored for additional impurities (e.g., NO_x, SO_2, CO, CO_2, and moisture via second gas analysis device D2, and if the concentration of any of these contaminants approaches or exceeds a certain value, rather than venting all of the gas to the atmosphere (via valve 302), all or at least a portion of the contaminated gas can be introduced to secondary purifying device 306 by closing valve 303 and opening valve 304.

After filtering, filtered gas 308 passes through check valve 310 and re-enters main gas line 312, where it can be sent to first storage compartment A. In another embodiment, at least a portion of filtered gas 308 gas pass through gas analysis device D2 prior to being sent to first storage compartment A. While the embodiment shown in Figure 3 has secondary purifying device 306 located upstream of second gas analysis device D2, those of ordinary skill in the art will understand that the invention should not be so limited. As such, in another embodiment, secondary purifying device 306 can be located downstream of second gas analysis device D2. In an additional embodiment, secondary purifying device 306 can be located both upstream and downstream of second gas analysis device D2. For example, this would occur in embodiments (not shown) where the gas is recycled from gas analysis device D2 back to a point upstream of secondary purifying device 306.

In one embodiment, first gas analysis device is a separate device from second gas analysis device. In another embodiment, second gas analysis device is the same or part of first gas analysis device. In one embodiment, second gas analysis device D2 is in

communication with valve 304 and valve 303, such that second gas analysis device D2 can send, or cause to be sent, a signal to open and close valve 304 and valve 303. Valve 304 and valve 303 are preferably actuated remediation control valves. In one embodiment, an acceptable secondary purifying device 306 can be Breathing STAR BSP-MT 10-95 or an equivalent.

In another embodiment, valve 304 is configured such that once it has been opened, it will close after a user-specified amount of time (e.g., 30 minutes). Similarly, the opening and closing of valve 303 would be configured to operate in concert with valve 304. In another embodiment, valve 304, once opened, is configured to close when the impurity level measured falls below a specified level.

In another embodiment, valves 302, 303 and 304 can be combined into a single four-way actuated valve that is configured to send flow to the atmosphere, to the secondary purifying device (306) or to the main line (312).

In another embodiment not shown, another venting valve can be included downstream second gas analysis device D2 and is configured to vent gas downstream secondary purifying device 306 that exceeds acceptable impurity levels, thereby preventing contamination of gas within first storage compartment A.

While the invention has been described in conjunction with specific embodiments thereof, it is evident that many alternatives, modifications, and variations will be apparent to those skilled in the art in light of the foregoing description. Accordingly, the scope of the claims should not be limited by the preferred embodiments, but should be given the broadest interpretation consistent with the specification as a whole. The present invention may suitably comprise, consist or consist essentially of the elements disclosed and may be practiced in the absence of an element not disclosed. Furthermore, if there is language referring to order, such as first and second, it should be understood in an exemplary sense and not in a limiting sense. For example, it can be recognized by those skilled in the art that certain steps can be combined into a single step.

The singular forms "a", "an" and "the" include plural referents, unless the context clearly dictates otherwise.

"Comprising" in a claim is an open transitional term which means the subsequently identified claim elements are a nonexclusive listing (i.e., anything else may be additionally included and remain within the scope of "comprising"). "Comprising" as used herein may

be replaced by the more limited transitional terms "consisting essentially of" and "consisting of" unless otherwise indicated herein.

"Providing" in a claim is defined to mean furnishing, supplying, making available, or preparing something. The step may be performed by any actor in the absence of express language in the claim to the contrary a range is expressed, it is to be understood that another embodiment is from the one.

Optional or optionally means that the subsequently described event or circumstances may or may not occur. The description includes instances where the event or circumstance occurs and instances where it does not occur.

Ranges may be expressed herein as from about one particular value, and/or to about another particular value. When such particular value and/or to the other particular value, along with all combinations within said range.

All references identified herein are each hereby incorporated by reference into this application in their entireties, as well as for the specific information for which each is cited.

What is claimed is:

1. An on-site medical gas production plant, comprising:

- a gas purification unit configured to produce a purified gas from a less pure supply gas source,

- a first compartment for storing the purified gas;

- a main gas line fluidically connecting the gas purification unit to the first storage compartment so as to supply the said first storage compartment with the purified gas coming from the gas purification unit;

- a first actuated valve in fluid communication with the main gas line between the gas purification unit and the first storage compartment ;

- a gas analysis device in fluid communication with the main line , wherein the gas analysis device is configured to analyze the purified gas within the main line for impurities;

a secondary purifying device in fluid communication with the main gas line, the secondary purifying device configured to receive at least a portion of the purified gas and remove additional impurities from the purified gas;

an operating device configured to control the first actuated valve, wherein the operating device is in communication with the gas analysis device wherein the operating device is configured to act on the first actuated valve in response to a signal received from the gas analysis device , so as to divert a gas present in the main pipe to pass to the secondary purifying device when the signal received from the gas analysis device corresponds to a contamination signal based on an analysis of the gas in the main pipe .

2. The plant according to claim 1, wherein a gas compression unit is configured to supply the gas purification unit with a gas to be purified at a pressure of more than 1 bar absolute.

3. The plant according to claim 2, wherein the gas compression unit comprises at least one screw, piston, scroll, rotary, or diaphragm compressor.

4. The plant according to claim 1, wherein the gas analysis device is upstream of the first actuated valve.

5. The plant according to claim 1, wherein the gas analysis device is downstream of the first actuated valve.

6. The plant according to claim 1, wherein the first actuated valve, once opened, is configured to close after a set period of time.

7. The plant according to claim 1, wherein the first actuated valve, once opened, is configured to close upon receiving a closing signal from the operating device, wherein the closing signal is based on a reading from the gas analysis device.

8. The plant according to claim 1, wherein the gas purification unit comprises at least one dehumidifier device optionally selected from one or more of an adsorber containing at least one bed of at least one adsorbent material, a desiccant dryer, a deliquescent dryer, a refrigerant dryer or a membrane dryer.

9. The plant according to claim 1, wherein the gas purification unit comprises at least two adsorbers configured to operate alternately.

10. The plant according to claim 1, wherein the gas purification unit comprises at least two adsorbers configured to operate alternately, and the operating device is designed and adapted to act on the gas purification unit and/or the gas compression unit so as to stop any production of gas by the adsorber which was in operation at the time when the gas analysis device transmitted the contamination signal to the operating device.

11. The plant according to claim 1, wherein the gas purification unit comprises at least two adsorbers configured to operate alternately, and the operating device is designed and adapted to act on the gas purification unit and/or the gas compression unit so as to start production of gas by the adsorber which was not in operation at the time when the gas analysis device transmitted the contamination signal to the operating device.

12. The plant according to claim 1, wherein the operating device is configured to act on the first actuated valve in response to a signal received from the gas analysis device, so as allow gas to be sent to the first storage compartment without passing through the secondary purifying device.

13. The plant according to any one of claims 1-12, further comprising a vent line, wherein the vent line comprises a vent line valve configured to open and close the vent line to the atmosphere.

14. The plant according to claim 13, wherein the vent line valve is a manual valve.

15. The plant according to claim 13, wherein the vent line valve is an actuated valve.

16. The plant of claim 15, wherein the vent line valve is electrically connected to the operating device and in which

- the operating device is configured to further act on the vent line valve in response to a signal received from the gas analysis device so as to open the vent line valve to the atmosphere; when a second actuated valve is closed to prevent the gas present in the main pipe from being sent to the said first storage compartment and to further or alternatively divert a gas present in the main pipe to pass to the vent line when the signal received from the gas analysis device corresponds to a contamination signal based on an analysis of the gas in the main pipe.

17. The plant according to claim 13, wherein the first actuated valve is a four-way value configured to open gas flow through main line to storage compartment A, divert gas flow to vent line, or divert gas flow to the secondary purifying device.

18. The plant according to claim 16, wherein the operating device is further configured to monitor the signal received from the gas analysis device during a first defined period of a purge operation to determine if the contamination signal persists for longer than a specified period of time and wherein, if the contamination signal persists for less than the specified period, the operating device closes the vent line actuated valve to end the purge operation and

reopens a main line actuated valve to resume delivery of gas from the gas purification unit to the first storage compartment.

19. The plant according to any one of claims 1-18, wherein the purified gas is medical air meeting the following criteria:

- 19.5% to 23.5% oxygen, with predominant balance nitrogen
- Carbon monoxide: < 10 ppm
- Carbon dioxide: < 500 ppm
- Nitrogen dioxide: < 2.5 ppm
- Nitric oxide: < 2.5 ppm
- Sulfur dioxide: < 5 ppm.

20. The plant according to any one of claims 1-19, further comprising a second source of purified gas in fluid communication with the main line and configured to supply purified gas to the main line when the gas present in the main pipe is diverted to pass to the vent line.

21. The plant according to any one of claims 1-20, further comprising a valve controlled bypass line arranged to allow the purified gas from the gas purification unit to bypass the main line first actuated valve and create a fluid communication directly from the gas purification unit to the first storage compartment.

22. The plant according to claim 21, wherein the purified gas remains in fluid communication with a vent line and a vent line valve is open to the atmosphere such that first gas analysis device is capable of continued monitoring of the purified gas while the bypass line is open.

23. A method for operating an on-site medical gas production plant, the plant comprising:

a gas purification unit configured to produce a purified gas from a less pure supply gas source,

a first compartment for storing the purified gas, and

a main gas line fluidically connecting the gas purification unit to the first storage compartment so as to supply the said first storage compartment with the purified gas coming from the gas purification unit,

a first actuated valve arranged on the main gas line between the gas purification unit and the first storage compartment, and furthermore connected to a secondary purifying device,

an operating device which controls at least one first actuated valve,

a gas analysis device in fluid communication with the main line, the gas analysis device is in communication with the operating device,

a secondary purifying device in fluid communication with the main gas line via the first actuated valve, the secondary purifying device configured to receive at least a portion of the purified gas and remove additional impurities from the purified gas;

and in which the operating device is configured to act on the first actuated valve in response to a signal received from the gas analysis device, so as to divert a gas present in the main pipe to pass to the secondary purifying device when the signal received from the gas analysis device corresponds to a contamination signal based on an analysis of the gas in the main pipe;

the method comprising the steps of:

a) producing a purified gas from a less pure supply gas source,

b) transporting the purified gas obtained in step a) in the main gas pipe,

c) storing at least a part of the purified gas in a first compartment for storing gas supplied by the main gas pipe,

d) determining in the main gas pipe, upstream of the first storage compartment, an impurity level of at least one given impurity in the gas produced in step a), and

e) controlling the first actuated valve, so as to divert the gas present in the main pipe, upstream of the first actuated valve, to the secondary purifying device when the impurity level measured in step d) is greater than or equal to a preset threshold level.

24. The method according to claim 23, wherein in step e), the gas present in the main pipe, upstream of the first actuated valve, is diverted to the secondary purifying device and

gas is simultaneously stopped from being sent to the first storage compartment, when the impurity level measured in step d) is greater than or equal to a preset threshold level.

25. The method according to claim 24, wherein:

a. in step a), the gas purification unit comprises at least two adsorbers operating alternately, and

b. when an impurity level greater than or equal to a preset threshold level is determined in the gas produced by one of the adsorbers, the production of the gas by the adsorber is stopped and the production of purified gas by another of the adsorber(s) is started.

26. The method according to claim 24, wherein a gaseous flushing step of the main pipe containing an impurity level greater than or equal to the preset threshold level with purified gas is carried out and the gas flow thus generated is discharged to the atmosphere via a vent line.

27. The method of claim 23, wherein the impurity or impurities are selected from the group consisting of NOx, SOx, COx, water vapour, hydrocarbon vapours, and combinations thereof.

28. The method of claim 23, wherein less pure supply gas source to be purified is ambient air and the purified gas is medical air or medical oxygen.

29. The method of claim 28, wherein ambient air is purified to medical air meeting the following criteria:

- 19.5% to 23.5% oxygen, with predominant balance nitrogen
- Carbon monoxide: < 10 ppm
- Carbon dioxide: < 500 ppm
- Nitrogen dioxide: < 2.5 ppm

- Nitric oxide: < 2.5 ppm
- Sulfur dioxide: < 5 ppm.

30. The method of claim 28, wherein the medical air produced contains (by volume) from 20.4% to 21.4% oxygen, at most 500 ppm CO_2, at most 5 ppm CO, at most 1 ppm SO_2, at most 2 ppm NO and NO_2, at most 67 ppm water, at most 0.1 mg/m^3 oil, and nitrogen.

31. The method of claim 28, wherein in step d), the gas analysis device determines the impurity level in the gas in the main gas pipe.

32. The method of claim 31, wherein in step e), the operating device controls the first actuated valve, the operating device acting in response to the measurements taken by the gas analysis device.

33. The method of claim 32, wherein the operating device monitors the signal received from the gas analysis device during a first defined period of a purge operation to determine if the contamination signal persists for longer than a specified period of time and wherein, if the contamination signal persists for less than the specified period, the operating device closes the first actuated valve to end the additional purification and reopens the main line to resume delivery of gas from the gas purification unit to the first storage compartment.

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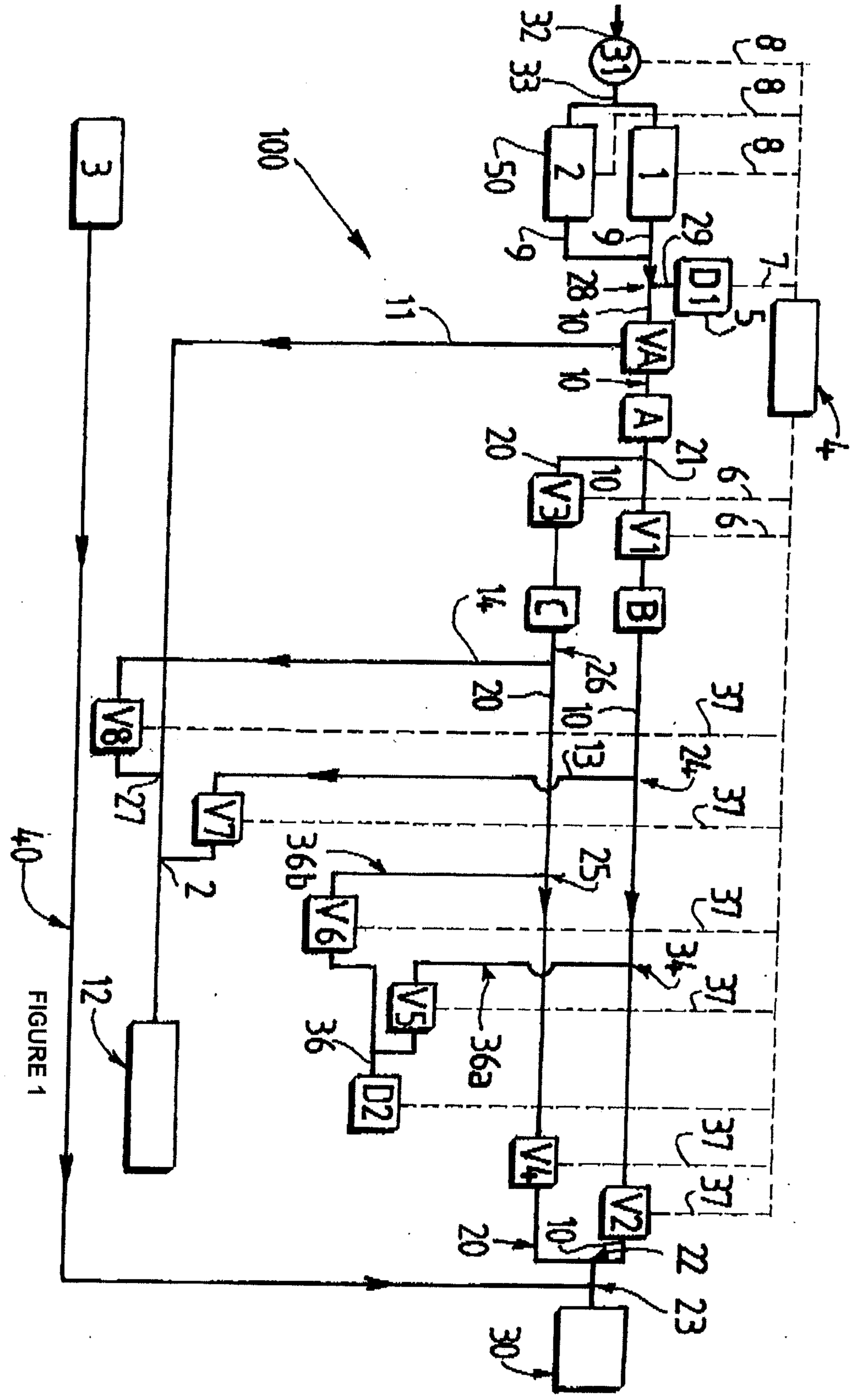


FIGURE 1

Figure 1

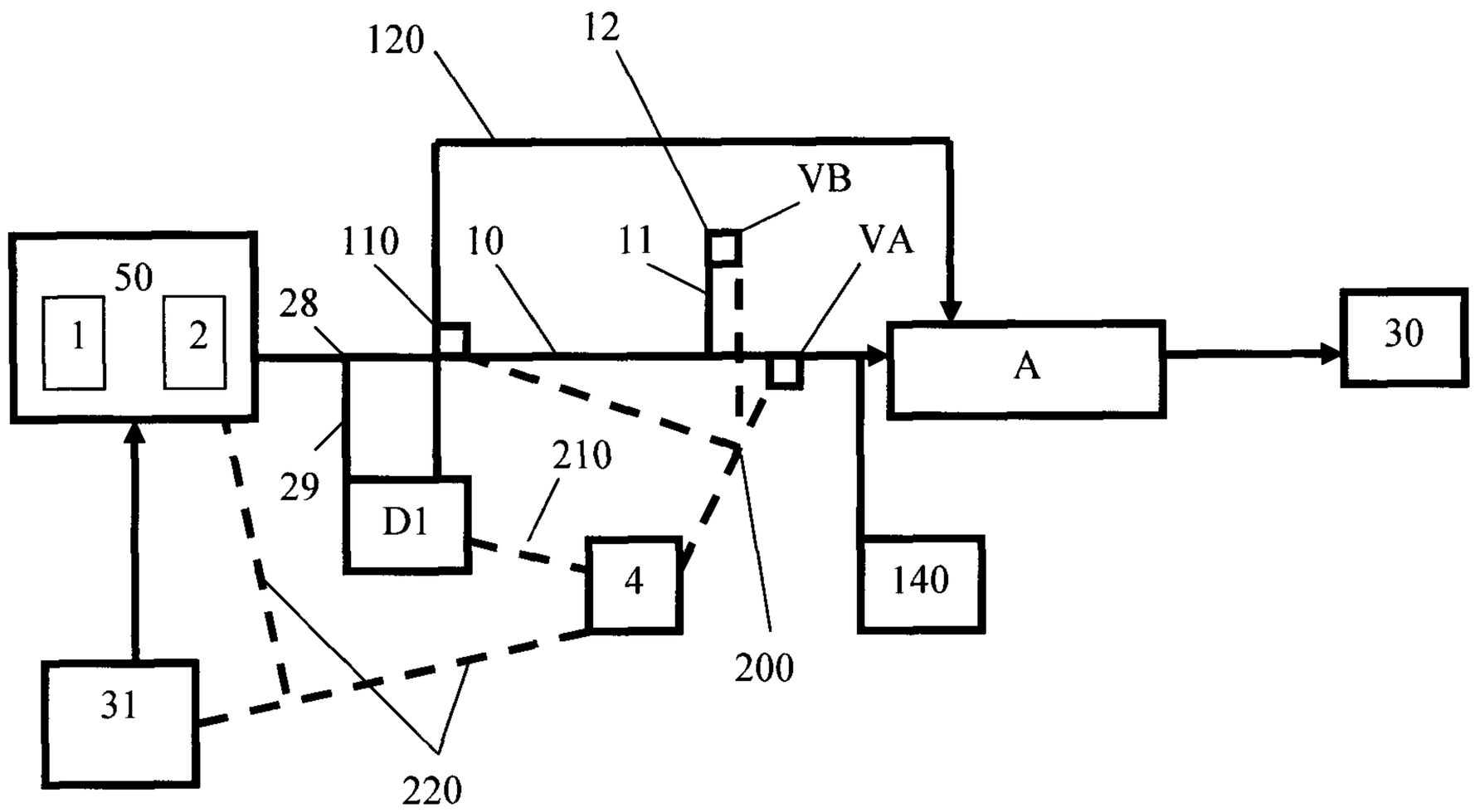


Figure 2

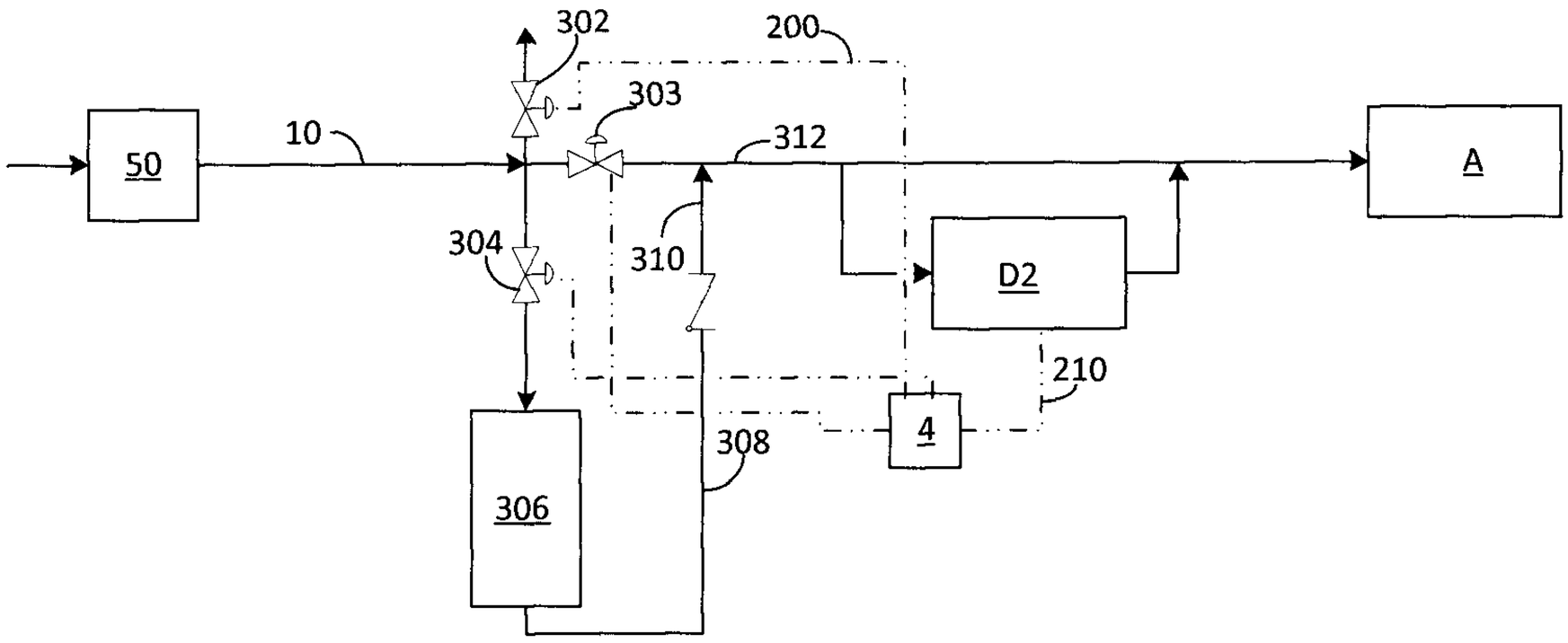
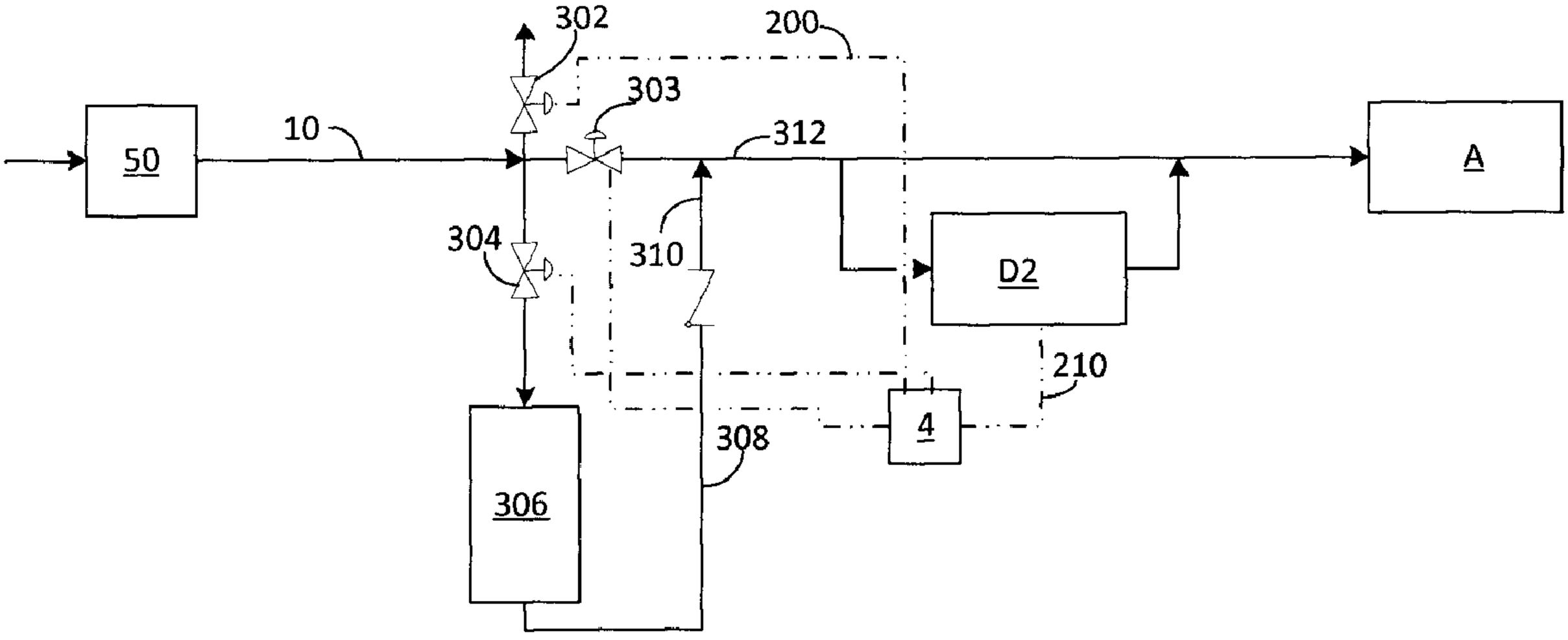


Figure 3


302
200
303
10
312
50
A
304
310
D2
210
4
308
306