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(54) **APPARATUS AND METHOD OF PROVIDING CONCENTRATED PRODUCT GAS**

VORRICHTUNG UND VERFAHREN ZUR BEREITSTELLUNG VON KONZENTRIERTEM
PRODUKTGAS

APPAREIL ET PROCÉDÉ POUR L'OBTENTION DE GAZ DE PRODUIT CONCENTRÉ

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(73) Proprietor: **INVACARE CORPORATION**
Elyria, OH 44036-2125 (US)

(72) Inventor: **SPRINKLE, Thomas**
Rocky River, OH 44116 (US)

(74) Representative: **Ganguillet, Cyril**
ABREMA
Agence Brevets & Marques Ganguillet
Avenue du Théâtre 16
P.O. Box 5027
1002 Lausanne (CH)

(56) References cited:
EP-A- 1 661 596 US-A- 4 561 287
US-A1- 2006 086 251

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DescriptionBackground

[0001] Various applications exist for the separation of gaseous mixtures. For example, the separation of nitrogen from atmospheric air can provide a highly concentrated source of oxygen. These various applications include the provision of elevated concentrations of oxygen for medical patients and flight personnel. Hence, it is desirable to provide systems that separate gaseous mixtures to provide a concentrated product gas, such as a breathing gas with a concentration of oxygen.

[0002] Several existing product gas or oxygen concentrators, for example, are disclosed in U.S. Pat. Nos. 4,449,990, 5,906,672, 5,917,135, and 5,988,165 and U.S. Patent Application No. 2006/086251, which are commonly assigned to Invacare Corporation of Elyria, Ohio. In general, these concentrators produce concentrated oxygen by passing pressurized ambient air through one of a pair of pressure swing adsorption sieve beds. The sieve beds contain Zeolite media. Zeolite is a clay-like substance that is processed to form small holes in the media pellets. As ambient air passes over the Zeolite, nitrogen atoms are trapped in the holes leaving oxygen mixed with small amounts of other gases found in the air such as argon, neon, and xenon. Typically the oxygen content of air produced by a concentrator consists of about 95% oxygen. As more air is treated by the sieve bed the holes in the media pellets become clogged with nitrogen atoms and eventually will no longer effectively remove nitrogen from the air. Prior to this exhaustion of Zeolite, the concentrator switches operation to the other sieve bed and flushes the exhausted bed with concentrated gas from the newly activated bed. This cycling of active sieve beds continues during operation of the concentrator.

[0003] US 4, 561, 287 discloses an oxygen concentrator wherein product gas flow is measured by monitoring the changing pressure in a reservoir.

Summary

[0004] Methods and apparatuses for providing a concentrator product gas according to the appended claims are provided. In one embodiment, component gas is separated from atmospheric air. Component gas flow rate, or demand, is determined. One or more gas separator operating parameters is changed based on the component gas flow rate. For example, gas flow rate can be approximated by measuring a rate of pressure decay of a product tank during a time period in which the tank is not being replenished by the separating system. When it is determined that the flow rate is relatively low, operating parameters of the separating system are changed to improve system performance with the lower demand. For example, a target product tank pressure at which sieve beds are switched can be lowered when demand

is lower.

Brief Description of the Drawings**[0005]**

Figure 1 is a schematic diagram of an oxygen concentrator constructed in accordance with an embodiment of the present invention.

Figure 2 is a timing diagram that shows the operation of valve components of the oxygen concentrator shown in Figure 1.

Figure 3 is a flowchart that outlines a procedure for operation of the oxygen concentrator of Figure 1.

Figure 4 is a flowchart that outlines a procedure for adjusting parameters of component gas separation based on component gas demand according to an embodiment of the present invention.

Figure 5 is a block diagram of a gas separation system that adjusts operating parameters based on component gas demand.

Description

[0006] Prior to discussing the various embodiments, a review of the definitions of some exemplary terms used throughout the disclosure is appropriate. Both singular and plural forms of all terms fall within each meaning:

[0007] "Logic," as used herein, includes but is not limited to hardware, firmware, software and/or combinations of each to perform a function(s) or an action(s), and/or to cause a function or action from another component. For example, based on a desired application or needs, logic may include a software controlled microprocessor, discrete logic such as an application specific integrated circuit (ASIC), or other programmed logic device. Logic may also be fully embodied as software.

[0008] "Software," as used herein, includes but is not limited to one or more computer readable and/or executable instructions that cause a computer or other electronic device to perform functions, actions, and/or behave in a desire manner. The instructions may be embodied in various forms such as routines, algorithms, modules or programs including separate applications or code from dynamically linked libraries. Software may also be implemented in various forms such as a stand-alone program, a function call, a servlet, an applet, instructions stored in a memory, part of an operating system or other type of executable instructions. It will be appreciated by one of ordinary skill in the art that the form of software is dependent on, for example, requirements of a desired application, the environment it runs on, and/or the desires of a designer/programmer or the like.

[0009] Industry standard home oxygen concentrators

utilize Pressure Swing Adsorption (PSA) technology to separate oxygen from the other constituents of room air - the most prevalent being nitrogen. Room air is pumped through a pneumatic network by an air compressor. The air compressor is generally AC powered and lacks speed control. Some commercially available home oxygen concentrators utilize time-based control while others utilized pressure based control. The home oxygen concentrators with AC powered compressors all operate independent of oxygen demand or output. The concentrators are controlled in a manner that is optimized for the best oxygen production at the maximum rated flow for the unit. The most common maximum rated flow rate for a home oxygen concentrator is five liters per minute. However, the majority of patients using concentrators are on prescriptions of three liters per minute or less. Therefore, concentrators that operate to provide the maximum rated flow rate at all times regardless of the actual flow rate are usually over-working the compressor and pneumatic components. For example, when the concentrator is operated to provide five liters per minute, the compressor is required to pressurize the product tank to a level (21 psi in standard concentrators) to provide the maximum rated flow rate even though a lower product tank pressure would be adequate to supply the actual flow rate required by the patient. This in turn results in elevated energy consumption, heat generation, noise, and component wear.

[0010] Figure 1 is a schematic diagram of an exemplary oxygen concentrator 10. The oxygen concentrator 10 that is described herein is just one example of an oxygen concentrator and all of the components described below need not be present in all embodiments of the present invention. Air comes into the concentrator through an air inlet 11 and is filtered by a cabinet filter 12 that removes large particles and a compressor inlet filter 14 that removes smaller particles such as dust. An air compressor 20 compresses the air to pressurize it. A pressure relief valve 21 is placed downstream from the compressor to reduce the risk of damage to the compressor in the event the concentrator air flow pathway becomes obstructed. A heat exchanger 23 cools the air that has been heated due to compression.

[0011] Cooled, compressed air passes to a four way valve 25 that is controlled by two solenoid operated pilot valves referred to as a first main valve 26 and a second main valve 27. The solenoid valves are actuated by a controller 35. The four way valve routes the cooled, compressed air through one of two PSA sieve beds 28, 29. From the beds, the concentrated gas flows to one of two check valves 32, 33 and to a product tank. The check valves prevent air from the tank from flowing back into the sieve beds and concentrated gas being supplied by the active bed must reach a threshold pressure to move through the check valve into the tank. A pressure regulator 43 controls the pressure at which concentrated oxygen is passed from the tanks. A pressure transducer 45 measures a tank pressure and feeds this information to the controller 35. A flow meter provides a visual indication

to the patient of the flow rate of concentrated gas from the concentrator.

[0012] During operation of the concentrator, the controller controls the actuation of the four way valve's solenoids 26, 27 and a pressure equalization valve 30 that selectively connects the outlets of the two sieve beds 28, 29 to one another. Figure 2 outlines the timing of the various valve actuations that are performed to pass room air alternately through one of the two sieve beds and to periodically purge and switch to an inactive sieve bed as will be described in more detail below. The operation of the valves is based on a product tank pressure. This product tank pressure is determined based on an expected flow rate, which in the past has been a single flow rate, the maximum rated flow rate.

[0013] Referring to Figure 2 in addition to Figure 1 the operation of concentrator, particularly with respect to the actuation of the first and second main valves and the pressure equalization valves, is outlined. Beginning at the left of the timing diagram in Figure 2, for the purposes of this discussion, the concentrator begins operation with the pressure equalization valve opening to connect the outlets of the sieve beds to one another. This allows product gas from the active sieve bed (in this case the second bed 29) to pressurize the inactive sieve bed (first bed 28). After a delay, the first main valve 26 (MV1) is opened to connect the pressurized air from the compressor to the first sieve bed 28. Simultaneously, the second main valve 27 is connected to an exhaust muffler 37 and vents to atmosphere through the muffler. The product gas flowing through the second sieve bed and out through the muffler collects trapped nitrogen atoms within the second sieve bed and carries them out of the sieve bed.

[0014] After a delay, the PE valve is closed and product gas begins to build pressure at check valve 32 until it overcomes the threshold pressure of the valve and enters the product tank. The first main valve remains open until pressure at the product tank reaches a "switch" pressure, for example 1,45 bar (21 psi). When the product pressure reaches the switch pressure, the PE valve is opened, connecting the inlet of the first sieve bed to the exhaust muffler 37 and out to ambient air. The first sieve bed is then pressurized with the product gas that was building up at the outlet of the second sieve bed due to the opening of the PE valve. After a delay, the second main valve is opened and connects the outlet of the second sieve bed to the check valve 33 and the product tank 40. After flushing the first sieve bed for a period of time, the PE valve closes. This cycling process repeats during operation of the concentrator.

[0015] As already discussed in the background the switch pressure is selected based on the maximum rated flow rate of, in this case, five liters per minute. Since the majority of the time, a concentrator will be called on to produce only about three liters per minute, it is possible to reduce the switch pressure to a lower value, for example, 0,69-1,38 bar (10-20 psi), and preferably 1,10 bar (16 psi) when the concentrator is experiencing this lower

demand. The concentrator can be placed in a "conservation mode" in which the bed switching cycle is triggered by the lower pressure of 1,10 bar (16 psi). In higher flow operating conditions, the concentrator transitions to a "high performance mode" in which the operation sequence of the concentrator does not change from that shown in Figure 2, but the switch pressure is set to a higher pressure such as 1,38-1,73 bar (20-25 psi), but preferably 1,45 bar (21 psi).

[0016] The flow rate of gas being consumed by the patient can be determined in a number of ways. For example, a flow meter capable of sending signals to the controller could monitor the gas leaving the tank. An ultrasonic oxygen sensor can be used to detect a flow rate. The method employed in the described concentrator measures pressure decay at the tank (with pressure transducer 45 in Figure 1) during the time in which the patient is consuming gas and the check valve has not yet allowed gas from the active sieve bed enter the tank. For example, pressure readings can be taken at points "A" and "B" on Figure 2. The first pressure reading A is immediately after the PE valve is opened at which time gas stops flowing into the product tank. The second reading B is taken after the PE valve is closed but prior to pressure of product gas from the newly activated sieve bed overcoming the threshold of the check valve. The pressure decay during this time is due to patient demand and therefore gives a good indication of the present demand. This method of detecting flow rate is also described in U.S. Patent Application No. 2006/086251 that is identified in the background.

[0017] Referring now to Figure 3, the operation of the concentrator will be described with reference to the flowchart illustrated therein. In the flowchart, the rectangular elements denote processing blocks and represent software instructions or groups of instructions. The quadrilateral elements denote data input/output processing blocks and represent software instructions or groups of instructions directed to the input or reading of data or the output or sending of data. The flow diagrams shown and described herein do not depict syntax of any particular programming language. Rather, the flow diagrams illustrate the functional information one skilled in the art may use to fabricate circuits or to generate software to perform the processing of the system. It should be noted that many routine program elements, such as initialization of loops and variables and the use of temporary variables are not shown.

[0018] Figure 3 outlines a procedure 300 for operating a concentrator to automatically place the concentrator in conservation mode when demand is relatively low, such as less than 2.0-3.0 liters per minute, and preferably less than 2.5 liters per minute. The concentrator is placed in high performance mode when the demand is relatively high, such as more than 3.5-4.5 liters per minute, and preferably 3.5 liters per minute. At 310, the product tank pressure is compared to the switch pressure, which is

set to either 1,45 or 1,10 bar (21 or 16 psi). Once the product pressure reaches the switch pressure at 320 the bed switch is initialized by opening the PE valve. Product pressure decay is measured during the time prior to opening of the check valve at 340 and at 350, the pressure decay is correlated to a flow rate, using, for example a look up table stored in the controller. At 360, the flow rate is compared to 3.5 liters per minute and if the flow rate is above 3.5 liters per minute, the switch pressure is set to 1,45 bar (21 psi). At 370 the flow rate is compared to 2.5 liters per minute and if it is less than 2.5 liters per minute, the switch pressure is set to 1,10 bar (16 psi). If the flow rate falls between 2.5 and 3.5 liters per minute, the switch pressure remains at its present value. This condition provides a hysteresis effect to prevent excessive changing of switch pressure.

[0019] Figures 4 and 5 outline the function and components of a concentrator that adjusts its separating process based on patient demand. Figure 4 illustrates a procedure 400 in which at 410 component gas is separated from an incoming gas mixture according to separation process parameters, such as, for example, the bed switch pressure. The component gas can include a relatively large quantity of a desired product gas such as oxygen and smaller residual amounts of other gases such as argon, neon, and xenon. The component gas demand is determined at 420 and at 430 one or more separation process parameters is adjusted based on the demand. The concentrator 500 shown in Figure 5 includes a gas separation module 520 that is controlled by separation controller 510. Component gas flows through an outlet 530. The demand for the component gas is monitored by a demand monitor 540 and this demand is fed back to the controller 510 for use in controlling separation.

[0020] While the apparatus and method of providing a concentrated product gas has been illustrated by the description of embodiments thereof, and while the embodiments have been described in considerable detail, it is not the intention of this specification to restrict or in any way limit the scope of the appended claims to such detail. Therefore, the apparatus and method of providing a concentrated product gas, in its broader aspects, is not limited to the specific details, the representative apparatus, and illustrative examples shown and described. Accordingly, departures may be made from such details as long as not departing from the scope of claims 1 to 14.

Claims

1. A method of providing a breathing gas comprising:
 - separating a component gas comprising oxygen from atmospheric air;
 - wherein room air is alternately passed through one of two pressure swing adsorption sieve beds (28, 29);
 - checking the component gas pressure before

- the component gas moves into a component gas tank (40);
 preventing the component gas to move into the component gas tank (40) if the checked component gas pressure has not reached a threshold value;
 wherein the steps of checking the component gas pressure and preventing the component gas to move into the component gas tank (40) are performed by two check valves (32, 33);
 determining the rate of flow of the component gas to a patient, wherein this step comprises:
- measuring a pressure decay at the tank (40) during the time in which the patient is consuming gas and the check valves (32, 33) have not yet allowed gas from the pressure swing adsorption sieve beds (28, 29) enter the tank (40);
 correlating the pressure decay to a flow rate; and
- adjusting the separation of the component gas from atmospheric air based on the rate of flow of the component gas.
2. The method of claim 1 wherein the step of adjusting the separation of the component gas from atmospheric air is performed by adjusting a duration of time during which atmospheric air is passed through an active sieve.
 3. The method of claim 1 wherein the step of separating a component gas from atmospheric air is performed with a gas separating system that includes said pair of pressure swing adsorption sieve beds (28, 29) that alternately separate the component gas from atmospheric air, wherein an inlet of each sieve bed is selectively connected, via a crossover valve (25), to an exhaust port and a pressurized gas source, and wherein an outlet of each sieve bed is selectively connected to a component gas outlet and further wherein the outlet of each sieve bed is selectively connected to the outlet of the other sieve bed by a pressure equalization valve (30) and wherein the gas separating system periodically performs a sieve bed switching cycle comprising actuating the pressure equalization valve (30) for a pressure equalization actuation period such that output component gas from an active sieve bed is used to flush byproducts from an inactive sieve bed and actuating the crossover valve (25) to connect the inactive bed to the pressurized gas source and the active bed to the exhaust port;
 and wherein the step of adjusting the separation of the component gas is performed by commencing the switching cycle when the present pressure reaches a target component gas pressure.
 4. The method of claim 1 wherein the step of measuring a pressure decay comprises determining a rate of decay of component gas pressure during at least a portion of the pressure equalization valve actuation period.
 5. The method of claim 4 wherein the rate of decay of component gas pressure is determined by measuring a first and a second pressure associated with the output of the component gas tank (40) and comparing said first pressure measured just after opening of the pressure equalization valve (30) to said second pressure measured after closing of the pressure equalization valve (30).
 6. The method of claim 3 further comprising the step of selecting a target component gas pressure by selecting a first target component gas pressure when the present component gas pressure exceeds a first threshold component gas pressure and selecting a second target component gas pressure when the present component gas pressure is below a second threshold component gas pressure.
 7. The method of claim 6 wherein the first target component gas pressure is greater than the second target component gas pressure.
 8. A system for separating a component gas comprising oxygen from atmospheric air comprising:
 - an atmospheric air compressor (20) adapted to compress atmospheric air to pressurize it;
 - a component gas separator that separates the component gas from pressurized atmospheric air;
 - wherein the component gas separator comprises a pair of pressure swing adsorption sieve beds (28, 29);
 - a component gas tank (40) having an output;
 - two check valves (32, 33) adapted to check the component gas pressure before the component gas moves into the component gas tank (40) and prevent the component gas to move into the component gas tank (40) if the checked component gas pressure has not reached a threshold value;
 - a pressure sensor (45) associated with the output of the component gas tank (40);
 - a controller (35) comprising logic configured to:
 - measure a pressure decay at the tank (40) during the time in which the patient is consuming gas and the check valves (32, 33) have not yet allowed gas from the pressure swing adsorption sieve beds (28, 29) enter the tank (40);
 - correlate the pressure decay to a flow rate;

and
adjust at least one operation parameter of
the component gas separator based on the
rate of flow of component gas.

9. The system of claim 8 wherein said two pressure
swing adsorption sieves (28, 29) alternately sepa-
rate atmospheric air according to a sieve timing
scheme and wherein the controller comprises logic
configured to adjust the timing scheme of the gas
separator based on the component gas flow rate.

10. The system of claim 8 comprising:

a component gas outlet that supplies compo-
nent gas to a user;
wherein the component gas separator compris-
es:

said pair of pressure swing adsorption sieve
beds (28, 29) each having a sieve inlet that
is selectively connected to a source of pres-
surized atmospheric gas and an exhaust
vent and a sieve outlet that is selectively
connected to the component gas outlet;
a pressure equalization valve (30) disposed
between the sieve outlets that selectively
connects the outlets of the sieve beds to
one another during a pressure equalization
valve actuation period;
a crossover valve (25) disposed between
the sieve inlets that selectively connects
one of the sieve beds to the exhaust port
and the other of the sieve beds to the pres-
surized atmospheric gas source;
a sieve bed switching cycle controller (35)
adapted to actuate the pressure equaliza-
tion valve (30) to place the sieve outlets in
communication with one another when the
present component gas pressure reaches
a switch pressure and to actuate the cross-
over valve (25) to place an active sieve bed
in communication with the exhaust port and
an inactive sieve bed in communication with
the pressurized atmospheric gas source;
and
a target component gas pressure selector
that determines a rate of flow of component
gas out of the component gas outlet and
selects the target component gas pressure
based on the rate of flow.

11. The system of claim 10 wherein the sieve bed switch-
ing cycle controller (35) comprises a microprocessor
having microprocessor-executable instructions
stored thereon for actuating the pressure equaliza-
tion valve (30) when the target component gas pres-
sure is reached.

12. The system of claim 10 wherein the target compo-
nent gas pressure selector comprises a microproc-
essor having microprocessor-executable instruc-
tions stored thereon for:

determining a rate of decay of component gas
outlet pressure during at least a portion of the
pressure equalization valve actuation period;
correlating the rate of decay to a rate of flow of
component gas out of the component gas outlet;
and
selecting a target component gas pressure
based on the rate of flow of component gas.

Patentansprüche

1. Verfahren zum Bereitstellen eines Atemgases, um-
fassend:

Trennen eines Komponentengases, das Sauer-
stoff umfasst, aus Atmosphärenluft;
wobei Raumlufte abwechselnd durch eines von
zwei Druckwechseladsorptionssiebbetten (28,
29) geleitet wird;
Prüfen des Drucks des Komponentengases, be-
vor das Komponentengas in einen Kompo-
nentengasbehälter (40) strömt;
Verhindern des Strömens des Komponentenga-
ses in den Komponentengasbehälter (40), wenn
der geprüfte Druck des Komponentengases ei-
nen Schwellenwert nicht erreicht hat;
wobei die Schritte des Prüfens des Drucks des
Komponentengases und des Verhinderns des
Strömens des Komponentengases in den Kom-
ponentengasbehälter (40) durch zwei Rück-
schlagventile (32, 33) ausgeführt werden;
Bestimmen der Durchflussmenge des Kompo-
nentengases zu einem Patienten, wobei dieser
Schritt Folgendes umfasst:

Messen eines Druckabfalls am Behälter
(40) während der Zeit, in der der Patient Gas
verbraucht und die Rückschlagventile (32,
33) noch nicht zugelassen haben, dass Gas
von den Druckwechseladsorptionssiebbet-
ten (28, 29) in den Behälter (40) eintritt;
Korrelieren des Druckabfalls mit einer
Durchflussmenge und

Einstellen der Trennung des Komponentenga-
ses aus Atmosphärenluft auf Grundlage der
Durchflussmenge des Komponentengases.

2. Verfahren nach Anspruch 1, wobei der Schritt des
Einstellens der Trennung des Komponentengases
aus Atmosphärenluft durch Einstellen einer Zeitdau-
er ausgeführt wird, während der Atmosphärenluft

durch ein aktives Sieb geleitet wird.

3. Verfahren nach Anspruch 1, wobei der Schritt des Trennens eines Komponentengases aus Atmosphärenluft mit einem Gastrennsystem ausgeführt wird, das das Paar Druckwechseladsorptionssiebbetten (28, 29) beinhaltet, die abwechselnd das Komponentengas aus Atmosphärenluft trennen, wobei ein Einlass jedes Siebbetts mittels eines Kreuzschaltventils (25) selektiv mit einer Abströmöffnung und einer Quelle druckbeaufschlagten Gases verbunden wird und wobei ein Auslass jedes Siebbetts selektiv mit einem Komponentengasauslass verbunden wird und wobei ferner der Auslass jedes Siebbetts durch ein Druckausgleichsventil (30) selektiv mit dem Auslass des anderen Siebbetts verbunden wird und wobei das Gastrennsystem in regelmäßigen Zeitabständen einen Siebbett-Umschaltzyklus ausführt, der das Betätigen des Druckausgleichsventils (30) für einen Druckausgleichsbetätigungszeitraum, so dass von einem aktiven Siebbett abgegebenes Komponentengas zum Spülen von Nebenprodukten aus einem inaktiven Siebbett verwendet wird, und das Betätigen des Kreuzschaltventils (25) umfasst, um das inaktive Bett mit der Quelle druckbeaufschlagten Gases und das aktive Bett mit der Abströmöffnung zu verbinden; und wobei der Schritt des Einstellens des Trennens des Komponentengases ausgeführt wird, indem der Umschaltzyklus begonnen wird, wenn der aktuelle Druck einen Komponentengassolldruck erreicht.
4. Verfahren nach Anspruch 1, wobei der Schritt des Messens eines Druckabfalls das Bestimmen einer Abfallrate des Komponentengasdrucks während mindestens eines Teils des Zeitraums der Betätigung des Druckausgleichsventils umfasst.
5. Verfahren nach Anspruch 4, wobei die Abfallrate des Komponentengasdrucks durch Messen eines ersten und eines zweiten Drucks, die mit dem Auslass des Komponentengasbehälters (40) in Verbindung stehen, und Vergleichen des ersten Drucks, der unmittelbar nach dem Öffnen des Druckausgleichsventils (30) gemessen wurde, mit dem zweiten Druck, der nach dem Schließen des Druckausgleichsventils (30) gemessen wurde, bestimmt wird.
6. Verfahren nach Anspruch 3, das ferner den Schritt des Wählens eines Komponentengassolldrucks durch Wählen eines ersten Komponentengassolldrucks, wenn der aktuelle Komponentengasdruck einen ersten Komponentengasdruckschwellenwert überschreitet, und Wählen eines zweiten Komponentengassolldrucks, wenn der aktuelle Komponentengasdruck unter einem zweiten Komponentengasdruckschwellenwert liegt, umfasst.

7. Verfahren nach Anspruch 6, wobei der erste Komponentengassolldruck höher als der zweite Komponentengassolldruck ist.

8. System zum Trennen eines Komponentengases, das Sauerstoff umfasst, aus Atmosphärenluft, umfassend:

einen Atmosphärenluftverdichter (20), der geeignet ist, Atmosphärenluft zu verdichten, um sie mit Druck zu beaufschlagen;
einen Komponentengasseparator, der das Komponentengas aus druckbeaufschlagter Atmosphärenluft trennt;
wobei der Komponentengasseparator ein Paar Druckwechseladsorptionssiebbetten (28, 29) umfasst;
einen Komponentengasbehälter (40) mit einem Auslass;
zwei Rückschlagventile (32, 33), die geeignet sind, den Komponentengasdruck zu prüfen, bevor das Komponentengas in den Komponentengasbehälter (40) strömt, und zu verhindern, dass das Komponentengas in den Komponentengasbehälter (40) strömt, wenn der geprüfte Komponentengasdruck einen Schwellenwert nicht erreicht hat;
einen Drucksensor (45), der mit dem Auslass des Komponentengasbehälters (40) in Verbindung steht;
einen Regler (35), der eine Logik umfasst, die zu Folgendem konfiguriert ist:

Messen eines Druckabfalls in dem Behälter (40) während der Zeit, in der der Patient Gas verbraucht und die Rückschlagventile (32, 33) noch nicht zugelassen haben, dass Gas von den Druckwechseladsorptionssiebbetten (28, 29) in den Behälter (40) eintritt;
Korrelieren des Druckabfalls mit einer Durchflussmenge und

Einstellen von mindestens einem Betriebsparameter des Komponentengas separators auf Grundlage der Durchflussmenge des Komponentengases.

9. System nach Anspruch 8, wobei die zwei Druckwechseladsorptionssiebe (28, 29) abwechselnd Atmosphärenluft nach einem Siebzeitsteuerschema trennen und wobei der Regler eine Logik umfasst, die dazu konfiguriert ist, das Zeitsteuerschema des Gasseparators auf Grundlage der Komponentengas-Durchflussmenge einzustellen.

10. System nach Anspruch 8, umfassend:

einen Komponentengasauslass, der einen Be-

nutzer mit Komponentengas versorgt;
wobei der Komponentengasseparator Folgendes umfasst:

das Paar Druckwechseladsorptionssieb-
betten (28, 29), von denen jedes einen Sie-
beinlass, der selektiv mit einer Quelle
druckbeaufschlagten Atmosphärgases
und einer Abströmöffnung verbunden wird,
und einen Siebauslass hat, der selektiv mit
dem Komponentengasauslass verbunden
wird;
ein zwischen den Siebauslässen angeord-
netes Druckausgleichsventil (30), das wäh-
rend eines Zeitraums der Betätigung des
Druckausgleichsventils die Auslässe der
Siebbetten selektiv miteinander verbindet;
ein zwischen den Siebeinlässen angeord-
netes Kreuzschaltventil (25), das selektiv
eines der Siebbetten mit der Abströmöff-
nung und das andere der Siebbetten mit der
Quelle druckbeaufschlagten Atmosphären-
gases verbindet;
einen Siebbett-Umschaltzyklus-Regler
(35), der geeignet ist, das Druckausgleichs-
ventil (30) zu betätigen, um die Siebausläs-
se miteinander in Verbindung zu setzen,
wenn der aktuelle Komponentengasdruck
einen Umschaltdruck erreicht, und das
Kreuzschaltventil (25) zu betätigen, um ein
aktives Siebbett mit der Abströmöffnung in
Verbindung zu setzen und ein inaktives
Siebbett mit der Quelle druckbeaufschlag-
ten Atmosphärgases in Verbindung zu
setzen; und
eine Komponentengassolldruck-Wählvor-
richtung, die eine Durchflussmenge des
Komponentengases aus dem Komponen-
tengasauslass bestimmt und den Kompo-
nentengassolldruck auf Grundlage der
Durchflussmenge wählt.

11. System nach Anspruch 10, wobei der Siebbett-Umschaltzyklus-Regler (35) einen Mikroprozessor umfasst, der darauf gespeichert von einem Mikroprozessor ausführbare Anweisungen zum Betätigen des Druckausgleichsventils (30) aufweist, wenn der Komponentengassolldruck erreicht ist.
12. System nach Anspruch 10, bei dem die Komponenten-gassolldruck-Wählvorrichtung einen Mikroprozessor umfasst, der darauf gespeichert von einem Mikroprozessor ausführbare Anweisungen für Folgendes aufweist:

Bestimmen einer Abfallrate des Komponenten-gasauslassdrucks während mindestens eines Teils des Zeitraums der Betätigung des Druck-

ausgleichsventils;

Korrelieren der Abfallrate mit einer Durchflussmenge des Komponentengases aus dem Komponentengasauslass; und

Wählen eines Komponentengassolldrucks auf Grundlage der Durchflussmenge des Komponentengases.

10 Revendications

1. Procédé de fourniture de gaz respiratoire comprenant :

- la séparation d'un composant gazeux comprenant de l'oxygène provenant de l'air atmosphérique, l'air ambiant passant en alternance à travers un de deux lits de tamis d'adsorption modulés en pression (28, 29) ;
le contrôle de la pression du composant gazeux avant le déplacement du composant gazeux dans une cuve de composant gazeux (40) ;
l'empêchement du déplacement du composant gazeux dans la cuve de composant gazeux (40) si la pression du composant gazeux contrôlée n'a pas atteint une valeur seuil ;
dans lequel les étapes de contrôle de la pression du composant gazeux et d'empêchement du déplacement du composant gazeux dans la cuve de composant gazeux (40) sont réalisées par deux soupapes de contrôle (32, 33) ;
la détermination du débit du composant gazeux vers un patient, cette étape comprenant :
la mesure d'une diminution de pression au niveau de la cuve (40) pendant le temps au cours duquel le patient consomme du gaz et les soupapes de contrôle (32, 33) n'ont pas encore permis l'entrée du gaz provenant des lits de tamis d'adsorption modulés en pression (28, 29) dans la cuve (40) ;
la corrélation de la diminution de pression à un débit ; et
l'ajustement de la séparation du composant gazeux provenant de l'air atmosphérique sur base du débit du composant gazeux.

2. Procédé selon la revendication 1, l'étape d'ajustement de la séparation du composant gazeux provenant de l'air atmosphérique étant réalisée par ajustement d'un laps de temps durant lequel l'air atmosphérique passe à travers un tamis actif.

3. Procédé selon la revendication 1, l'étape de séparation d'un composant gazeux de l'air atmosphérique étant réalisée par un système de séparation de gaz qui inclut ladite paire de lits de tamis d'adsorption

- modulés en pression (28, 29) qui séparent en alternance le composant gazeux de l'air atmosphérique, une entrée de chaque lit de tamis étant connectée de manière sélective, via une vanne d'intercommunication (25), à un orifice d'échappement et à une source de gaz pressurisé, et une sortie de chaque lit de tamis étant connectée de manière sélective à une sortie de composant gazeux et, en outre, la sortie de chaque lit de tamis étant connectée de manière sélective à la sortie de l'autre lit de tamis par une soupape d'équilibrage de pression (30) et le système de séparation de gaz réalisant périodiquement un cycle de commutation des lits de tamis comprenant l'actionnement de la soupape d'équilibrage de pression (30), pendant une période d'actionnement de l'équilibrage de la pression, de sorte que le composant gazeux sortant provenant d'un lit de tamis actif est utilisé pour évacuer les sous-produits provenant d'un lit de tamis inactif, et l'actionnement de la vanne d'intercommunication (25) pour connecter le lit inactif à la source de gaz pressurisé et le lit actif à l'orifice d'échappement ;
et dans lequel l'étape d'ajustement de la séparation du composant gazeux est réalisée en commençant le cycle de commutation lorsque la pression actuelle atteint une pression cible de composant gazeux.
4. Procédé selon la revendication 1, l'étape de mesure d'une diminution de la pression comprenant la détermination d'une vitesse de diminution de la pression du composant gazeux pendant au moins une partie de la période d'actionnement de la soupape d'équilibrage de pression.
5. Procédé selon la revendication 4, la vitesse de diminution de la pression du composant gazeux étant déterminée par mesure d'une première et d'une deuxième pression associées à la sortie de la cuve du composant gazeux (40) et comparaison de ladite première pression mesurée juste après l'ouverture de la soupape d'équilibrage de pression (30) à ladite deuxième pression mesurée après la fermeture de la soupape d'équilibrage de pression (30).
6. Procédé selon la revendication 3, comprenant en outre l'étape de sélection d'une pression cible de composant gazeux par sélection d'une première pression cible de composant gazeux lorsque la pression actuelle du composant gazeux dépasse une première pression seuil de composant gazeux et de sélection d'une deuxième pression cible de composant gazeux lorsque la pression actuelle du composant gazeux est inférieure à une deuxième pression seuil de composant gazeux.
7. Procédé selon la revendication 6, la première pression cible du composant gazeux étant supérieure à la deuxième pression cible du composant gazeux.
8. Système de séparation d'un composant gazeux comprenant de l'oxygène de l'air atmosphérique comprenant :
- un compresseur d'air atmosphérique (20) conçu pour comprimer de l'air atmosphérique en vue de le pressuriser ;
 - un séparateur de composant gazeux qui sépare le composant gazeux de l'air atmosphérique pressurisé ;
 - dans lequel le séparateur de composant gazeux comprend une paire de lits de tamis d'adsorption modulés en pression (28, 29) ;
 - une cuve de composant gazeux (40) dotée d'une sortie ;
 - deux soupapes de contrôle (32, 33) conçues pour contrôler la pression du composant gazeux avant le déplacement du composant gazeux dans la cuve de composant gazeux (40) et pour empêcher le déplacement du composant gazeux dans la cuve de composant gazeux (40) si la pression de composant gazeux contrôlée n'a pas atteint une valeur seuil ;
 - un capteur de pression (45) associé à la sortie de la cuve de composant gazeux (40) ;
 - un dispositif de commande (35) comprenant une logique configurée pour :
 - mesurer une diminution de pression au niveau de la cuve (40) pendant le temps au cours duquel le patient consomme le gaz et les soupapes de contrôle (32, 33) n'ont pas encore permis l'entrée du gaz provenant des lits de tamis d'adsorption modulés en pression (28, 29) dans la cuve (40) ;
 - corrélérer la diminution de pression à un débit ; et
 - ajuster au moins un paramètre de fonctionnement du séparateur de composant gazeux sur base du débit du composant gazeux.
9. Système selon la revendication 8, lesdits deux lits de tamis d'adsorption modulés en pression (28, 29) séparant en alternance l'air atmosphérique selon un schéma du timing de tamisage et dans lequel le dispositif de commande comprenant une logique configurée pour ajuster le schéma du timing du séparateur de gaz sur base du débit du composant gazeux.
10. Système selon la revendication 8 comprenant :
- une sortie de composant gazeux qui fournit un composant gazeux à un utilisateur ;
 - dans lequel le séparateur de composant gazeux comprend :
 - ladite paire de lits de tamis d'adsorption mo-

dulés en pression (28, 29) présentant chacun une entrée de tamis qui est connectée de manière sélective à une source de gaz atmosphérique pressurisé et à un évent d'échappement et une sortie de tamis qui est connectée de manière sélective à la sortie du composant gazeux ;
 une soupape d'équilibrage de pression (30) disposée entre les sorties des tamis qui connecte de manière sélective les sorties des lits de tamis l'une à l'autre pendant une période d'actionnement de la soupape d'équilibrage de pression ;
 une vanne d'intercommunication (25), disposée entre les entrées des tamis, qui connecte de manière sélective un des lits de tamis à l'orifice d'échappement et l'autre des lits de tamis à la source de gaz atmosphérique pressurisé ;
 un dispositif de commande (35) de cycle de commutation de lits de tamis conçu pour actionner la soupape d'équilibrage de pression (30) en vue de placer les sorties des tamis en communication l'une avec l'autre lorsque la pression actuelle du composant gazeux atteint une pression de commutation et pour actionner la vanne d'intercommunication (25) en vue de placer un lit de tamis actif en communication avec l'orifice d'échappement et un lit de tamis inactif en communication avec la source de gaz atmosphérique pressurisé ; et
 un sélecteur de pression cible de composant gazeux qui détermine un débit de composant gazeux hors de la sortie de composant gazeux et sélectionne la pression cible de composant gazeux sur base du débit.

11. Système selon la revendication 10, le dispositif de contrôle (35) de cycle de commutation de lit de tamis comprenant un microprocesseur, sur lequel des instructions exécutables par le microprocesseur sont enregistrées, destiné à actionner la soupape d'équilibrage de pression (30) lorsque la pression cible du composant gazeux est atteinte.
12. Système selon la revendication 10, le sélecteur de pression cible du composant gazeux comprenant un microprocesseur, dans lequel des instructions exécutables par le microprocesseur sont enregistrées, destiné à :

déterminer une vitesse de diminution de la pression de sortie du composant gazeux pendant au moins une partie de la période d'actionnement de la soupape d'équilibrage de pression ;
 corrélérer la vitesse de diminution à un débit du composant gazeux hors de la sortie de compo-

sant gazeux ; et
 sélectionner une pression cible de composant gazeux sur base du débit de composant gazeux.

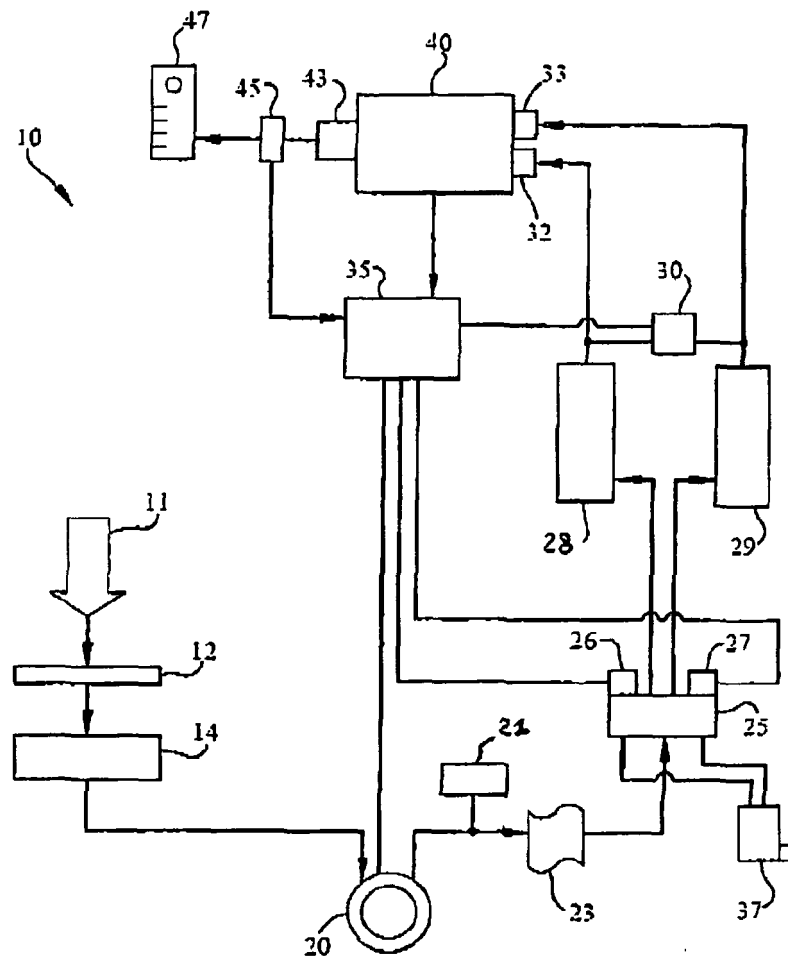


Figure 1

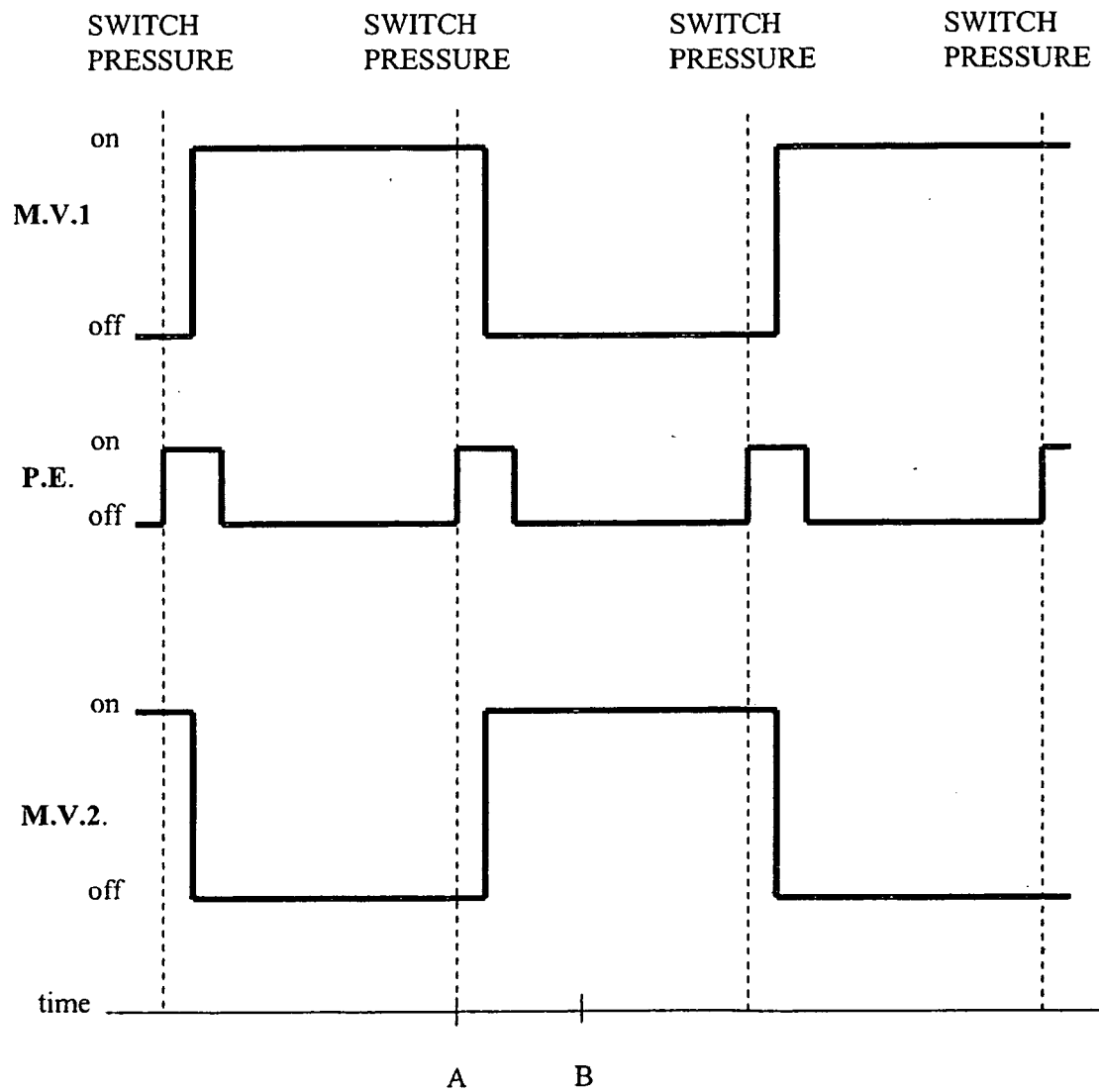


Figure 2

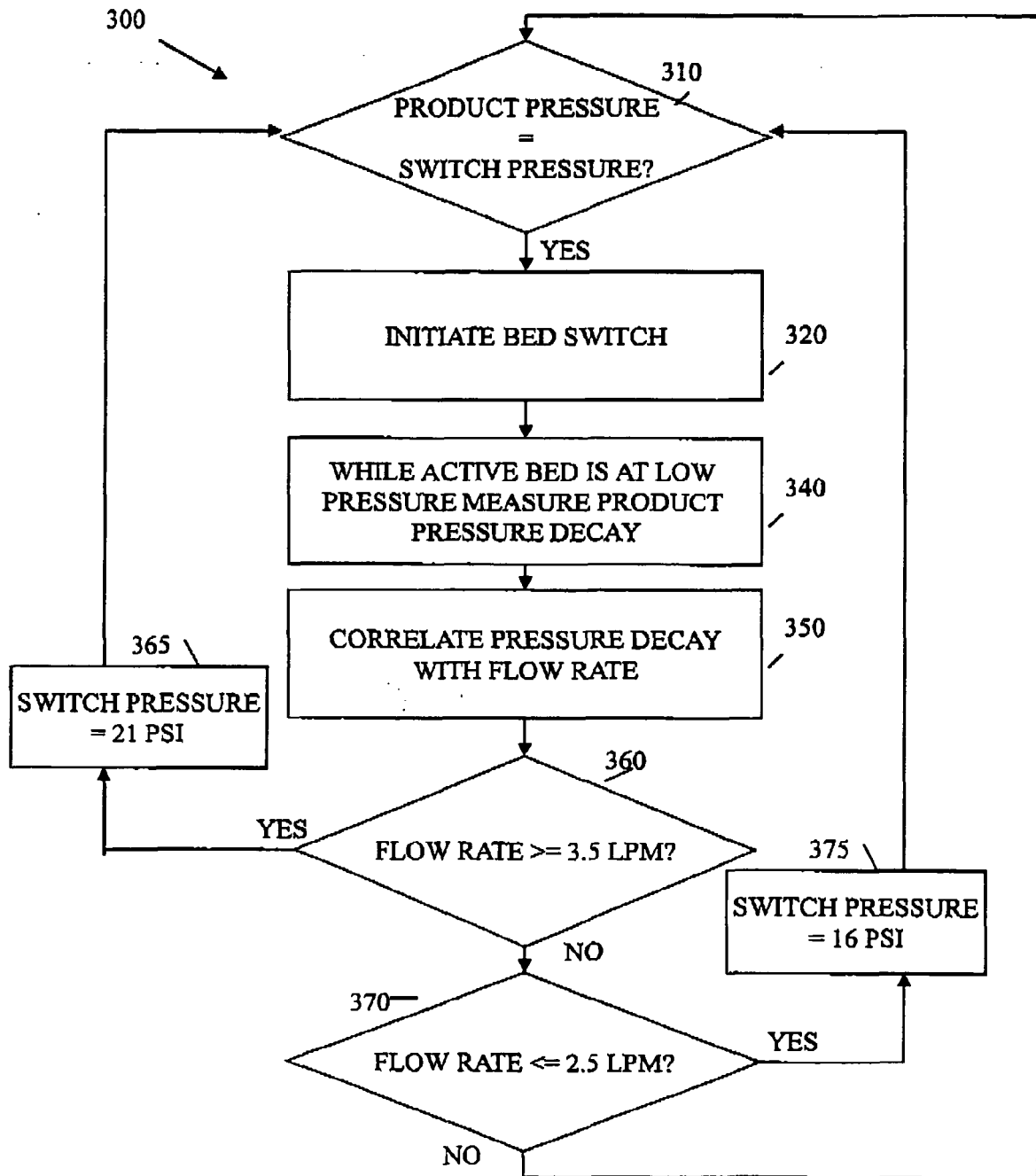


Figure 3

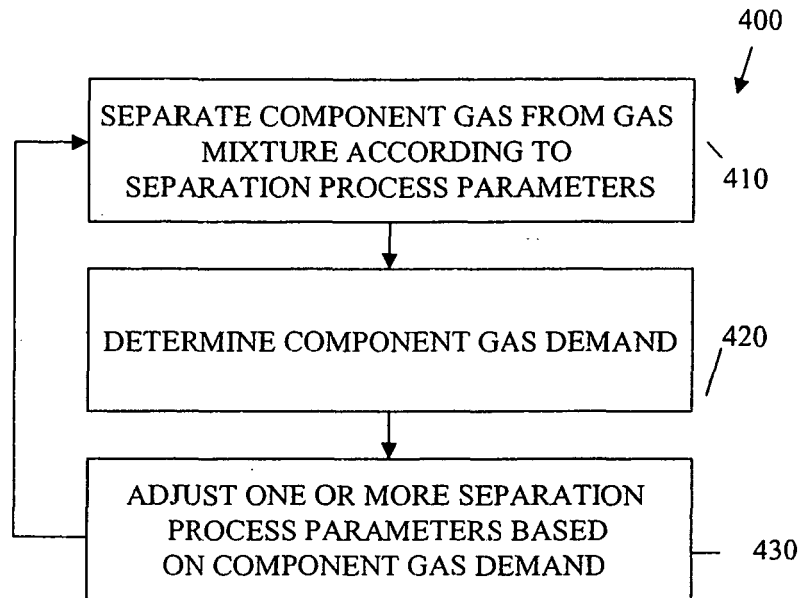


Figure 4

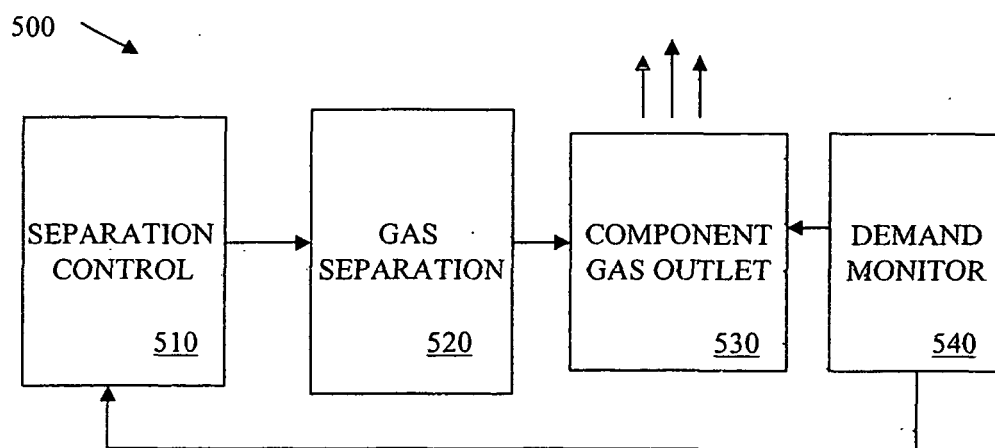


Figure 5

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 4449990 A [0002]
- US 5906672 A [0002]
- US 5917135 A [0002]
- US 5988165 A [0002]
- US 2006086251 A [0002] [0016]
- US 4561287 A [0003]