IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

First Inventor:	Theodore W. Jagger
Serial No.:	11/054,615
Filed:	February 9, 2005
Group Art Unit:	3771
Examiner:	DOUGLAS, STEVEN O.
Confirmation:	8238
Title:	ADSORBENT CARTRIDGE FOR OXYGEN CONCENTRATO

NOTIFICATION OF LOSS OF SMALL ENTITY STATUS

Pursuant to 37 CFR § 1.27(g)(2), VBOX, INCORPORATED hereby submits this Notification of Loss of Entitlement to Small Entity Status. The status as a small entity was established in good faith. However, VBOX, INCORPORATED ceased to be eligible for small entity status on or about February 20, 2023.

Respectfully Submitted,

CARLSON, GASKEY & OLDS, P.C.

/Timothy J. Murphy/

Timothy J. Murphy
Registration No. 64,613
400 West Maple, Suite 350
Birmingham, MI 48009
Telephone: (248) 283-0732

GCE - Exhibit 1075, Page 1
GCE Gas Control Equipment Inc. v. VBOX, Inc.
IPR2023-00326

Electronic Acknowledgement Receipt	
EFS ID:	47624153
Application Number:	11054615
International Application Number:	
Confirmation Number:	8238
Title of Invention:	ADSORBENT CARTRIDGE FOR OXYGEN CONCENTRATOR
First Named Inventor/Applicant Name:	Theodore W. Jagger
Customer Number:	26096
Filer:	Timothy J. Murphy/Molly Anderson
Filer Authorized By:	Timothy J. Murphy
Attorney Docket Number:	67853-016 PUS1
Receipt Date:	03-MAR-2023
Filing Date:	09-FEB-2005
Time Stamp:	10:41:21
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Notification of loss of entitlement to small entity status	Loss_of_Small_Entity_Status_016PUS1.pdf	16041 44f1c8d0bc898f64dbbe1f22b7ba749f927f44d1	no	1

Warnings:

Information:	
Total Files Size (in bytes):	16041

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
11/054,615	02/09/2005	Theodore W. Jagger	V180.12-0006

CONFIRMATION NO. 8238

164
KINNEY & LANGE, P.A.
THE KINNEY & LANGE BUILDING
312 SOUTH THIRD STREET
MINNEAPOLIS, MN 55415-1002

POWER OF ATTORNEY NOTICE

OC000000099206504

Date Mailed: 05/02/2018

NOTICE REGARDING CHANGE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 04/19/2018.

- The Power of Attorney to you in this application has been revoked by the assignee who has intervened as provided by 37 CFR 3.71. Future correspondence will be mailed to the new address of record(37 CFR 1.33).

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at **(571) 272-4000** or **(571) 272-4200** or **1-888-786-0101**.

/atesfai/

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
11/054,615	02/09/2005	Theodore W. Jagger	67853-016 PUS1

CONFIRMATION NO. 8238

26096
CARLSON, GASKEY & OLDS, P.C.
400 WEST MAPLE ROAD
SUITE 350
BIRMINGHAM, MI 48009

POA ACCEPTANCE LETTER

OC000000099206540

Date Mailed: 05/02/2018

NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 04/19/2018.

The Power of Attorney in this application is accepted. Correspondence in this application will be mailed to the above address as provided by 37 CFR 1.33.

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at **(571) 272-4000** or **(571) 272-4200** or **1-888-786-0101**.

/atesfai/

Doc Code: PA..

Document Description: Power of Attorney

PTO/AIA/82A (07-12)
Approved for use through 11/30/2014. OMB 0651-0035
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

TRANSMITTAL FOR POWER OF ATTORNEY TO ONE OR MORE REGISTERED PRACTITIONERS

NOTE: This form is to be submitted with the Power of Attorney by Applicant form (PTO/AIA/82B or equivalent) to identify the application to which the Power of Attorney is directed, in accordance with 37 CFR 1.5. If the Power of Attorney by Applicant form is not accompanied by this transmittal form or an equivalent, the Power of Attorney will not be recognized in the application.

Application Number	11/054615
Filing Date	02/09/2005
First Named Inventor	Theodore W. Jagger
Title	ADSORBENT CARTRIDGE FOR OXYGEN CONCENTRATOR
Art Unit	3771
Examiner Name	Douglas, Steven O.
Attorney Docket Number	67853-016 PUS1

SIGNATURE of Applicant or Patent Practitioner

Signature	/DRAFT/	Date	04/19/2018
Name	Timothy J. Murphy	Telephone	248 988 8360
Registration Number	64,613		

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4(d) for signature requirements and certifications.

■ *Total of 1 forms are submitted.

This collection of information is required by 37 CFR 1.31, 1.32 and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

PTO/AIA/80 (07-17)
Approved for use through 01/31/2018. OMB 0651-0035
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no person is required to respond to a collection of information unless it displays a valid OMB control number

POWER OF ATTORNEY TO PROSECUTE APPLICATIONS BEFORE THE USPTO

I hereby revoke all previous powers of attorney given in the application identified in the attached statement under 37 CFR 3.73(c).

I hereby appoint:

[X] Practitioners associated with Customer Number: 26096

OR

[ ] Practitioner(s) named below (if more than ten patent practitioners are to be named, then a customer number must be used):

Name	Registration Number	Name	Registration Number

As attorney(s) or agent(s) to represent the undersigned before the United States Patent and Trademark Office (USPTO) in connection with any and all patent applications assigned only to the undersigned according to the USPTO assignment records or assignment documents attached to this form in accordance with 37 CFR 3.73(c).

Please change the correspondence address for the application identified in the attached statement under 37 CFR 3.73(c) to:

[X] The address associated with Customer Number: 26096

OR

[ ]

Firm or individual name		
Address		
City	State	Zip
Country		
Telephone	Email	

Assignee name and address: VBOX, INCORPORATED

A copy of this form, together with a statement under 37 CFR 3.73(c) (Form PTO/AIA/96 or equivalent) is required to be filed in each application in which this form is used. The statement under 37 CFR 3.73(c) may be completed by one of the practitioners appointed in this form, and must identify the application in which this Power of Attorney is to be filed.

SIGNATURE of Assignee of Record

The individual whose signature and title is supplied below is authorized to act on behalf of the assignee.

Signature	Date 4/11/18
Name Robert J Folkes	Telephone 612 355 5202
Title CFO	

This collection of information is required by 37 CFR 1.31, 1.32, and 1.33. The information is required to obtain or retain a benefit by the public, which is to update (and by the USPTO to process) the file of a patent or reexamination proceeding. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 18 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

PTO/AIA/96 (08-12)
Approved for use through 01/31/2013. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

STATEMENT UNDER 37 CFR 3.73(c)

Applicant/Patent Owner: Theodore W. Jagger

Application No./Patent No.: 11/054615 Filed/Issue Date: 02/09/2005

Titled: ADSORBENT CARTRIDGE FOR OXYGEN CONCENTRATOR

VBOX, Incorporated, a corporation

(Name of Assignee) (Type of Assignee, e.g., corporation, partnership, university, government agency, etc.)

states that, for the patent application/patent identified above, it is (choose **one** of options 1, 2, 3 or 4 below):

1. ☑ The assignee of the entire right, title, and interest.

2. ☐ An assignee of less than the entire right, title, and interest (check applicable box):

   ☐ The extent (by percentage) of its ownership interest is _____%. Additional Statement(s) by the owners holding the balance of the interest must be submitted to account for 100% of the ownership interest.

   ☐ There are unspecified percentages of ownership. The other parties, including inventors, who together own the entire right, title and interest are:

   Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

3. ☐ The assignee of an undivided interest in the entirety (a complete assignment from one of the joint inventors was made). The other parties, including inventors, who together own the entire right, title, and interest are:

   Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

4. ☐ The recipient, via a court proceeding or the like (*e.g.*, bankruptcy, probate), of an undivided interest in the entirety (a complete transfer of ownership interest was made). The certified document(s) showing the transfer is attached.

The interest identified in option 1, 2 or 3 above (not option 4) is evidenced by either (choose **one** of options A or B below):

A. ☐ An assignment from the inventor(s) of the patent application/patent identified above. The assignment was recorded in the United States Patent and Trademark Office at Reel _____, Frame _____, or for which a copy thereof is attached.

B. ☑ A chain of title from the inventor(s), of the patent application/patent identified above, to the current assignee as follows:

   1. From: Jagger, Van Brunt, Kivisto, and Lonnes To: VBOX, Incorporated

      The document was recorded in the United States Patent and Trademark Office at

      Reel 016387, Frame 0051, or for which a copy thereof is attached.

   2. From: _____ To: _____

      The document was recorded in the United States Patent and Trademark Office at

      Reel _____, Frame _____, or for which a copy thereof is attached.

This collection of information is required by 37 CFR 3.73(b). The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450**.

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

PTO/AIA/96 (08-12)
Approved for use through 01/31/2013. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

STATEMENT UNDER 37 CFR 3.73(c)

3. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at

Reel _____, Frame _____, or for which a copy thereof is attached.

4. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at

Reel _____, Frame _____, or for which a copy thereof is attached.

5. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at

Reel _____, Frame _____, or for which a copy thereof is attached.

6. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at

Reel _____, Frame _____, or for which a copy thereof is attached.

☐ Additional documents in the chain of title are listed on a supplemental sheet(s).

☐ As required by 37 CFR 3.73(c)(1)(i), the documentary evidence of the chain of title from the original owner to the assignee was, or concurrently is being, submitted for recordation pursuant to 37 CFR 3.11.

[NOTE: A separate copy (i.e., a true copy of the original assignment document(s)) must be submitted to Assignment Division in accordance with 37 CFR Part 3, to record the assignment in the records of the USPTO. See MPEP 302.08]

The undersigned (whose title is supplied below) is authorized to act on behalf of the assignee.

/Timothy J. Murphy/	04/19/2018
Signature	Date
Timothy J. Murphy	64613
Printed or Typed Name	Title or Registration Number

Electronic Acknowledgement Receipt	
EFS ID:	32386079
Application Number:	11054615
International Application Number:	
Confirmation Number:	8238
Title of Invention:	ADSORBENT CARTRIDGE FOR OXYGEN CONCENTRATOR
First Named Inventor/Applicant Name:	Theodore W. Jagger
Customer Number:	164
Filer:	Timothy J. Murphy/Carolyn Hannenberg
Filer Authorized By:	Timothy J. Murphy
Attorney Docket Number:	V180.12-0006
Receipt Date:	19-APR-2018
Filing Date:	09-FEB-2005
Time Stamp:	14:25:17
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Power of Attorney	Power_of_Attorney_016PUS1.pdf	281947 68b33d28c3a802d08bf85b1c84b9cec7d8a27292	no	4
Warnings:					

Information:	
Total Files Size (in bytes):	281947

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PETITION TO ACCEPT UNINTENTIONALLY DELAYED PAYMENT OF MAINTENANCE FEE IN AN EXPIRED PATENT (37 CFR 1.378(c))

Patent Number	Issue Date	Application Number	Filing Date	Docket Number (if applicable)
7604005	20-Oct-2009	11054615	09-Feb-2005	

CAUTION: Maintenance fee (and surcharge, if any) payment must correctly identify: (1) the patent number and (2) the application number of the actual U.S. application leading to issuance of that patent to ensure the fee(s) is/are associated with the correct patent. 37 CFR 1.366(c) and (d).

Applicants claims the following fee status:

- (•) Small Entity
- ( ) Micro Entity
- ( ) Regular Undiscounted

Applicants selects the following :

(•) 3 1/2	( ) 7 1/2	( ) 11 1/2

SURCHARGE
The surcharge required by 37 CFR 1.20(i)(2) (Fee Code 1558/2558/3558) must be paid as a condition of accepting unintentionally delayed payment of the maintenance fee.

MAINTENANCE FEE (37 CFR 1.20(e)-(g))
The appropriate maintenance fee must be submitted with this petition.

STATEMENT
THE UNDERSIGNED CERTIFIES THAT THE DELAY IN PAYMENT OF THE MAINTENANCE FEE TO THIS PATENT WAS UNINTENTIONAL

PETITIONER(S) REQUEST THAT THE DELAYED PAYMENT OF THE MAINTENANCE FEE BE ACCEPTED AND THE PATENT REINSTATED

THIS PORTION MUST BE COMPLETED BY THE SIGNATORY OR SIGNATORIES

37 CFR 1.378(d) states: "Any petition under this section must be signed by an attorney or agent registered to practice before the Patent and Trademark Office, or by the patentee, the assignee, or other party in interest."

I certify, in accordance with 37 CFR 1.4(d)(4) that I am

- (•) An attorney or agent registered to practice before the Patent and Trademark Office who has been given power of attorney in this application.
- ( ) An attorney or agent registered to practice before the Patent and Trademark Office
- ( ) A sole patentee
- ( ) A joint patentee; I certify that I am authorized to sign this submission on behalf of all the other patentees.
- ( ) A joint patentee; all of whom are signing this e-petition
- ( ) The assignee of record of the entire interest

Attorney			
A signature of the applicant or representative is required in accordance with 37 CFR 1.33 and 10.18. Please see 37 CFR 1.4(d) for the form of the signature			
Signature	/Larrin Bergman/		
Name	Larrin Bergman	Registration Number	57153

Electronic Patent Application Fee Transmittal

Application Number:	11054615
Filing Date:	09-Feb-2005
Title of Invention:	ADSORBENT CARTRIDGE FOR OXYGEN CONCENTRATOR
First Named Inventor/Applicant Name:	Theodore W. Jagger
Filer:	Larrin Bergman
Attorney Docket Number:	V180.12-0006

Filed as Small Entity

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Maintenance Fee Due at 3.5 years	2551	1	800	800
Surcharge after Expiration-Unintentional	2558	1	820	820
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**1620**

UNITED STATES PATENT AND TRADEMARK OFFICE

Commissioner for Patents
United States Patent and Trademark Office
P.O. Box 1450
Alexandria, VA 22313-1450
www.uspto.gov

In re Patent No. 7604005
Issue Date: October 20,2009
Application No. 11054615
Filed: February 9,2005
Attorney Docket No. V180.12-0006

:
:DECISION GRANTING PETITION
:UNDER 37 CFR 1.378(c)
:

This is a decision on the electronic petition, filed December 13,2013 ,under 37 CFR 1.378(c) to accept the unintentionally delayed payment of the 3.5 year maintenance fee for the above-identified patent.

The petition is **GRANTED**.

The maintenance fee is accepted, and the above-identified patent reinstated as of December 13,2013 . This decision also constitutes notice that the fee has been accepted. An electronic copy of the petition and this decision has been created as an entry in the Image File Wrapper. Nevertheless, petitioner should print and retain an independent copy.

Telephone inquiries related to this electronic decision should be directed to the Electronic Business Center at 1-866-217-9197.

Electronic Acknowledgement Receipt	
EFS ID:	17652162
Application Number:	11054615
Patent Number:	7604005
Confirmation Number:	8238
Petition Issued Date:	December 13,2013
Title of Invention:	ADSORBENT CARTRIDGE FOR OXYGEN CONCENTRATOR
First Named Inventor/Applicant Name:	Theodore W. Jagger
Customer Number:	164
Filer:	Larrin Bergman
Filer Authorized By:	
Attorney Docket Number:	V180.12-0006
Receipt Date:	13-DEC-2013
Filing Date:	09-FEB-2005
Time Stamp:	11:58:40
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$1620
RAM confirmation Number	11707
Deposit Account	110982
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:	

Charge any Additional Fees required under 37 C.F.R. Section 1.16 (National application filing, search, and examination fees)
Charge any Additional Fees required under 37 C.F.R. Section 1.17 (Patent application and reexamination processing fees)
Charge any Additional Fees required under 37 C.F.R. Section 1.19 (Document supply fees)
Charge any Additional Fees required under 37 C.F.R. Section 1.20 (Post Issuance fees)
Charge any Additional Fees required under 37 C.F.R. Section 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Petition automatically granted by EFS	petition-request.pdf	32487 769221d0854a909f8db54af437153360697 69616	no	2
Warnings:					
Information:					
2	Fee Worksheet (SB06)	fee-info.pdf	32256 52cb01fe244ecdc1d49188ada350963b3a1f 2fc3	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	64743		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO.	: 7,604,005 B2
APPLICATION NO.	: 11/054615
DATED	: October 20, 2009
INVENTOR(S)	: Theodore W. Jagger et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Col. 26, Line 44 Claim 2
Insert --inlet-- after "means for connecting the"

Col. 26, Line 63 Claim 7
Insert --each of-- after "claim 1 wherein"

Signed and Sealed this
Twelfth Day of April, 2011

David J. Kappos

David J. Kappos
Director of the United States Patent and Trademark Office

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

First Named Patentee	:	Theodore W. Jagger
Appln. No.	:	11/054,615
Filed	:	February 9, 2005
Title	:	ADSORBENT CARTRIDGE FOR OXYGEN CONCENTRATOR
Patent No.	:	7,604,005
Issued	:	October 20, 2009
Docket No.	:	V180.12-0006

REQUEST FOR CERTIFICATE OF CORRECTION

Commissioner for Patents
Attn: Certificate of Correction Branch
P.O. Box 1450
Alexandria, VA 22313-1450

FILED VIA EFS-WEB

March 9, 2011

Applicant respectfully requests that the enclosed Certificate of Correction form PTO/SB/44 setting out errors in the above-identified patent be approved and signed by an Attesting Officer, and that a copy be returned for attachment to the original Certificate of Letters Patent. All of the errors appear to have occurred in the printing of the patent and no fee is required under 37 C.F.R. § 1.322.

Respectfully submitted,

KINNEY & LANGE, P.A.

Date: March 9, 2011

by: /Larrin Bergman/
Larrin Bergman, Reg. No. 57,153
THE KINNEY & LANGE BUILDING
312 South Third Street
Minneapolis, MN 55415-1002
Telephone: (612) 339-1863
Fax: (612) 339-6580

LB:adj

PTO/SB/44 (09-07)
Approved for use through 08/31/2010. OMB 0651-0033
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.
(Also Form PTO-1050)

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 7,604,005
APPLICATION NO. : 11/054,615
ISSUE DATE : October 20, 2009
INVENTOR(S) : Theodore W. Jagger, Nicholas P. Van Brunt, John A. Kivisto, Perry B. Lonnes

It is certified that an error appears or errors appear in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Col. 26, Line 44
Insert --inlet-- after "means for connecting the"

Col. 26, Line 63
Insert --each of-- after "claim 1 wherein"

MAILING ADDRESS OF SENDER (Please do not use customer number below):
Kinney & Lange, P.A.
312 South Third Street
Minneapolis, MN 55415-1028

This collection of information is required by 37 CFR 1.322, 1.323, and 1.324. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1.0 hour to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Attention Certificate of Corrections Branch, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Electronic Acknowledgement Receipt	
EFS ID:	9619431
Application Number:	11054615
International Application Number:	
Confirmation Number:	8238
Title of Invention:	ADSORBENT CARTRIDGE FOR OXYGEN CONCENTRATOR
First Named Inventor/Applicant Name:	Theodore W. Jagger
Customer Number:	00164
Filer:	Larrin Bergman
Filer Authorized By:	
Attorney Docket Number:	V180.12-0006
Receipt Date:	09-MAR-2011
Filing Date:	09-FEB-2005
Time Stamp:	15:00:08
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Request for Certificate of Correction	2011-03-09-ReqCertCorr-V180-12-6.pdf	14041 f502aaedeec2d4699fa4e9e43042813f6a114543	no	1
Warnings:					
Information:					

2	Request for Certificate of Correction	2011-03-09-CertCorr-V180-12-6.pdf	19096 68e080bbc6eb490691fda0a74cc87cab59cb35eb	no	1
Warnings:					
Information:					
			Total Files Size (in bytes):	33137	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 7,604,005 B2
APPLICATION NO. : 11/054615
DATED : October 20, 2009
INVENTOR(S) : Jagger et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

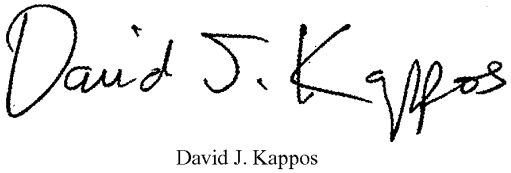
On the Title Page:

The first or sole Notice should read --

Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 884 days.

Signed and Sealed this

Fifth Day of October, 2010



David J. Kappos
Director of the United States Patent and Trademark Office

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
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Alexandria, Virginia 22313-1450
www.uspto.gov

KINNEY & LANGE, P.A.
THE KINNEY & LANGE BUILDING
312 SOUTH THIRD STREET
MINNEAPOLIS, MN 55415-1002

Mail Date: 04/21/2010

Applicant	: Theodore W. Jagger	: DECISION ON REQUEST FOR
Patent Number	: 7604005	: RECALCULATION of PATENT
Issue Date	: 10/20/2009	: TERM ADJUSTMENT IN VIEW
Appliction No	: 11/054,615	: OF WYETH AND NOTICE OF INTENT TO
Filed	: 02/09/2005	: ISSUE CERTIFICATE OF CORRECTION
		:

The Request for Recalculation is **GRANTED** to the extent indicated.

The patent term adjustment has been determined to be **884** days. The USPTO will *sua sponte* issue a certificate of correction reflecting the amount of PTA days determined by the recalculation.

Prior to the issuance of the certificate of correction, the USPTO will afford patentee an opportunity to be heard and request reconsideration. Accordingly, patentee has **one month or thirty (30) days**, whichever is longer, to file a request for reconsideration of this patent term adjustment calculation. See 35 U.S.C. 154(b)(3)(B)(ii) and 37 CFR 1.322(a)(4). No extensions of time will be granted under 37 CFR 1.136.

Patentee should use document code PET.OP if electronically filing a request for reconsideration of this patent term adjustment calculation. The patentee must also include the information required by 37 CFR 1.705(b)(2) and the fee required by 37 CFR 1.18(e). If patentee does not file a timely request for reconsideration of this patent term adjustment calculation including the information required by 37 CFR 1.705(b)(2) and the fee required by 37 CFR 1.18(e), the USPTO will issue a certificate of correction reflecting the PTA determination noted above.

Patentee should be aware that in order to preserve the right to review in the United States District Court for the District of Columbia of the USPTO patent term adjustment determination, patentee must ensure that he or she also take the steps required under 35 U.S.C. 154(b)(4)(A) in a timely manner. Nothing in the request for recalculation should be construed as providing an alternative time frame for commencing a civil action under 35 U.S.C. 154(b)(4)(A).

Any questions concerning this decision should be directed to the Office of Patent Legal Administration at 571-272-7702.

GCE - Exhibit 1075, Page 25
GCE Gas Control Equipment Inc. v. VBOX, Inc.
IPR2023-00326

Doc Code: PET.PTA.RCAL
Document Description: Request for Recalculation in view of Wyeth

PTO/SB/131 (01-10)
Approved for use through 02/28/2011. OMB 0651-0020
U.S. Patent and Trademark Office; U. S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

REQUEST FOR RECALCULATION OF PATENT TERM ADJUSTMENT IN VIEW OF *WYETH**

Attorney Docket Number: V180.12-0006	Patent Number: 7,604,005
Filing Date (or 371(b) or (f) Date): February 9, 2005	Issue Date: October 20, 2009
First Named Inventor: Theodore W. Jagger	
Title: ADSORBENT CARTRIDGE FOR OXYGEN CONCENTRATOR	

PATENTEE HEREBY REQUESTS RECALCULATION OF THE PATENT TERM ADJUSTMENT (PTA) UNDER 35 USC 154(b) INDICATED ON THE ABOVE-IDENTIFIED PATENT. THE PATENTEE'S SOLE BASIS FOR REQUESTING THE RECALCULATION IS THE USPTO'S PRE-*WYETH* INTERPRETATION OF 35 U.S.C. 154(b)(2)(A).

Note: This form is only for requesting a recalculation of PTA for patents issued before March 2, 2010, if the sole basis for requesting the recalculation is the USPTO's pre-*Wyeth* interpretation of 35 U.S.C. 154(b)(2)(A). See Instruction Sheet on page 2 for more information.

Patentees are reminded that to preserve the right to review in the United States District Court for the District of Columbia of the USPTO's patent term adjustment determination, a patentee must ensure that he or she also takes the steps required under 35 U.S.C. 154(b)(3) and (b)(4) and 37 CFR 1.705 in a timely manner.

**Wyeth v. Kappos*, No. 2009-1120 (Fed. Cir., Jan. 7, 2010).

Signature /Larrin Bergman/	Date February 15, 2010
Name (Print/Typed) Larrin Bergman	Registration Number 57,153

Note: *Signatures of all the inventors or assignees of record of the entire interest or their representative(s) are required in accordance with 37 CFR 1.33 and 11.18. Please see 37 CFR 1.4(d) for the form of the signature. If necessary, submit multiple forms for more than one signature, see below**.

☑ *Total of 1 forms are submitted.

The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 12 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

PTO/SB/131 (01-10)
Approved for use through 02/28/2011. OMB 0651-0020
U.S. Patent and Trademark Office; U. S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Instruction Sheet for: REQUEST FOR RECALCULATION OF PATENT TERM ADJUSTMENT IN VIEW OF *WYETH**

(Not to be Submitted to the USPTO)

This form is only for requesting a recalculation of PTA for patents issued before March 2, 2010, if the sole basis for requesting the recalculation is the USPTO's pre-*Wyeth* interpretation of 35 U.S.C. 154(b)(2)(A).

This form must be filed within 180 days of the day the patent was granted, with the following exception:

> Patentees who received a decision from the USPTO under the USPTO's pre-Wyeth interpretation of 35 U.S.C. 154(b)(2)(A) may file a request for reconsideration of that decision if such a request for reconsideration is filed within **two months** of the date of the decision (37 CFR 1.181(f)). If the patentee's sole basis for requesting reconsideration of the decision is the USPTO's pre-Wyeth interpretation of 35 U.S.C. 154(b)(2)(A), the request for reconsideration need only state that reconsideration is being requested in view of Wyeth (this form may be used for this purpose if it is filed within **two months** of the date of the decision from the USPTO).

Do not use this form if the application has been allowed, but not yet issued as a patent.

1. **For patents issued before March 2, 2010:** A request for reconsideration under 37 CFR 1.705(d) and the fee set forth in 37 CFR 1.18(e) are not required, provided that the patentee's sole basis for requesting recalculation of the PTA in the patent is the USPTO's pre-*Wyeth* interpretation of 35 U.S.C. 154(b)(2)(A) and this form is filed within 180 days of the day the patent was granted.

2. **For patents issued on or after March 2, 2010 (do not use this form):** Patentees seeking a revised PTA in a patent issued on or after March 2, 2010, must file a request for reconsideration under 37 CFR 1.705(d) that complies with the requirements of 37 CFR 1.705(b)(1) and (b)(2) within two months of the day the patent issued.

For more information, see "Notice Concerning Calculation of the Patent Term Adjustment With Respect to the Overlapping Delay Provision of 35 U.S.C. 154(b)(2)(A)" available on the USPTO Web site at http://www.uspto.gov/patents/law/notices/2010.jsp.

**Wyeth v. Kappos*, No. 2009-1120 (Fed. Cir., Jan. 7, 2010).

Privacy Act Statement

The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (*i.e.*, GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Electronic Acknowledgement Receipt	
EFS ID:	7012314
Application Number:	11054615
International Application Number:	
Confirmation Number:	8238
Title of Invention:	ADSORBENT CARTRIDGE FOR OXYGEN CONCENTRATOR
First Named Inventor/Applicant Name:	Theodore W. Jagger
Customer Number:	00164
Filer:	Larrin Bergman
Filer Authorized By:	
Attorney Docket Number:	V180.12-0006
Receipt Date:	15-FEB-2010
Filing Date:	09-FEB-2005
Time Stamp:	17:52:55
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Request for PTA recalculation in view of Wyeth	RequestForRecalculationTermAdjustment.pdf	150565 43d55aff64dab6099fbbb7a49851eacdc4de1d56	no	3
Warnings:					
Information:					

Total Files Size (in bytes):	150565

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/054,615	10/20/2009	7604005	V180.12-0006	8238

164 7590 09/30/2009

KINNEY & LANGE, P.A.
THE KINNEY & LANGE BUILDING
312 SOUTH THIRD STREET
MINNEAPOLIS, MN 55415-1002

ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment is 468 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at (571)-272-4200.

APPLICANT(s) (Please see PAIR WEB site http://pair.uspto.gov for additional applicants):

Theodore W. Jagger, White Bear Lake, MN;
Nicholas P. Van Brunt, White Bear Lake, MN;
John A. Kivisto, Oak Grove, MN;
Perry B. Lonnes, White Bear Lake, MN;

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

164 7590 08/26/2009

KINNEY & LANGE, P.A.
THE KINNEY & LANGE BUILDING
312 SOUTH THIRD STREET
MINNEAPOLIS, MN 55415-1002

FILED VIA EFS-WEB

(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/054,615	02/09/2005	Theodore W. Jagger	V180.12-0006	8238

TITLE OF INVENTION: ADSORBENT CARTRIDGE FOR OXYGEN CONCENTRATOR

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	YES	$755	$300	$0	$1055	11/27/2009

EXAMINER	ART UNIT	CLASS-SUBCLASS
DOUGLAS, STEVEN O	3771	128-202260

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

☒ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) the names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 Kinney & Lange P.A.
2
3

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE: Vbox Incorporated

(B) RESIDENCE: (CITY and STATE OR COUNTRY): White Bear Lake, MN, USA

Please check the appropriate assignee category or categories (will not be printed on the patent) : ☐ Individual ☒ Corporation or other private group entity ☐ Government

4a. The following fee(s) are submitted:
☒ Issue Fee
☒ Publication Fee (No small entity discount permitted)
☐ Advance Order - # of Copies _____

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**
☐ A check is enclosed.
☐ Payment by credit card. Form PTO-2038 is attached.
☒ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account Number 11-0982 (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)
☐ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27.
☐ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature /Larrin Bergman/ Date September 11, 2009

Typed or printed name Larrin Bergman Registration No. 57153

This collection of information is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

GCE - Exhibit 1075, Page 32
GCE Gas Control Equipment Inc. v. VBOX, Inc.
IPR2023-00326

Electronic Patent Application Fee Transmittal

Application Number:	11054615
Filing Date:	09-Feb-2005
Title of Invention:	ADSORBENT CARTRIDGE FOR OXYGEN CONCENTRATOR
First Named Inventor/Applicant Name:	Theodore W. Jagger
Filer:	Larrin Bergman
Attorney Docket Number:	V180.12-0006

Filed as Small Entity

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Utility Appl issue fee	2501	1	755	755
Publ. Fee- early, voluntary, or normal	1504	1	300	300

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**1055**

Electronic Acknowledgement Receipt	
EFS ID:	6052823
Application Number:	11054615
International Application Number:	
Confirmation Number:	8238
Title of Invention:	ADSORBENT CARTRIDGE FOR OXYGEN CONCENTRATOR
First Named Inventor/Applicant Name:	Theodore W. Jagger
Customer Number:	00164
Filer:	Larrin Bergman
Filer Authorized By:	
Attorney Docket Number:	V180.12-0006
Receipt Date:	11-SEP-2009
Filing Date:	09-FEB-2005
Time Stamp:	11:11:07
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$1055
RAM confirmation Number	8274
Deposit Account	110982
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: Charge any Additional Fees required under 37 C.F.R. Section 1.16 (National application filing, search, and examination fees) Charge any Additional Fees required under 37 C.F.R. Section 1.17 (Patent application and reexamination processing fees)	

Charge any Additional Fees required under 37 C.F.R. Section 1.19 (Document supply fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.20 (Post Issuance fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Miscellaneous Incoming Letter	Fee_Address_Indication_Form_V180-12-6.pdf	11000 ac122679ac7a97aea0cacb5228ff652c44cf5fa6	no	1
Warnings:					
Information:					
2	Issue Fee Payment (PTO-85B)	PartB_Fee_Transmittal_V180-12-6.pdf	100834 dc0d65940f70c610040f7aaf0e40fbe97dbbd6a5	no	1
Warnings:					
Information:					
3	Fee Worksheet (PTO-875)	fee-info.pdf	31987 e2e05e8be5b1880326455927facff0ca5101178a	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	143821		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

<u>New Applications Under 35 U.S.C. 111</u>
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

<u>National Stage of an International Application under 35 U.S.C. 371</u>
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

<u>New International Application Filed with the USPTO as a Receiving Office</u>
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

"FEE ADDRESS" INDICATION FORM

Address to:

Commissioner of Patents and Trademarks
Mail Stop M. Fee
P.O. Box 1450
Alexandria, VA 22313-1450

Please recognize as the "Fee Address" under the provisions of 37 C.F.R. 1.363 the following address. Please delete the previous payor number and fee address and send all future correspondence and notification to the last known mailing address of:

Kinney & Lange, P.A.
THE KINNEY & LANGE BUILDING
312 South Third Street
Minneapolis, MN 55415-1002
Payor Number: 00164

---

in the following listed application(s) or patent(s) for which the issue fee has been paid.

Patent Number (if known)	Serial Number	Patent Date (if known)	U.S. Filing Date
	11/054615		February 9, 2005

Typed name of person signing : Larrin Bergman

Signed : /Larrin Bergman/

(check one) __ Owner of record

_X_ Owner's attorney or agent of record

Form PTO-1537 United States Patent and Trademark Office

11/054,675

FORM PTO-1449	Atty. Docket No.: V180.12-0006	Application No.:
LIST OF PATENTS AND PUBLICATIONS FOR APPLICANT'S INFORMATION DISCLOSURE STATEMENT	First Named Inventor: Theodore W. Jagger	
	Filing Date: Herewith	Group Art:

U.S. PATENT DOCUMENTS

Examiner Initials		Document No.	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Documents
/S.A./	AA	Re. 35,099	11-28-1995	Hill
	AB	4,491,459	01-01-1985	Pinkerton
	AC	4,648,888	03-10-1987	Rowland
	AD	4,813,977	03-21-~~1898~~ 1989	Schmidt et al.
	AE	4,826,510	05-02-1989	McCombs
	AF	4,925,464	05-15-1990	Rabenau et al.
	AG	4,971,609	11-20-1990	Pawlos
	AH	5,531,807	07-02-1996	McCombs
	AI	5,593,478	01-14-1997	Hill et al.
	AJ	5,730,778	03-24-1998	Hill et al.
	AK	5,827,358	10-27-1998	Kulish et al.
	AL	5,858,062	01-12-1999	McCulloh et al.
	AM	5,893,275	04-13-1999	Henry
	AN	5,893,944	04-13-1999	Dong
	AO	5,928,189	07-27-1999	Phillips et al.
	AP	5,979,440	11-09-1999	Honkonen et al.
	AQ	6,212,904	04-10-2001	Arkharov et al.
	AR	6,287,366	09-11-2001	Derive et al.
	AS	6,302,107	10-16-2001	Richey, II et al.
	AT	6,311,719	11-06-2001	Hill et al.
	AU	6,314,957	11-13-2001	Boissin et al.
	AV	6,346,139	02-12-2002	Czabala
	AW	6,446,630	09-10-2002	Todd, Jr.
	AX	6,457,485	10-01-2002	Hill et al.
/S.A./	AY	6,471,744	10-29-2002	Hill

DP 5/9/05

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

NOTICE OF ALLOWANCE AND FEE(S) DUE

164 7590 08/26/2009

KINNEY & LANGE, P.A.
THE KINNEY & LANGE BUILDING
312 SOUTH THIRD STREET
MINNEAPOLIS, MN 55415-1002

EXAMINER	
DOUGLAS, STEVEN O	
ART UNIT	PAPER NUMBER
3771	

DATE MAILED: 08/26/2009

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/054,615	02/09/2005	Theodore W. Jagger	V180.12-0006	8238

TITLE OF INVENTION: ADSORBENT CARTRIDGE FOR OXYGEN CONCENTRATOR

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	YES	$755	$300	$0	$1055	11/27/2009

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the SMALL ENTITY status shown above.

If the SMALL ENTITY is shown as YES, verify your current SMALL ENTITY status:

A. If the status is the same, pay the TOTAL FEE(S) DUE shown above.

B. If the status above is to be removed, check box 5b on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and twice the amount of the ISSUE FEE shown above, or

If the SMALL ENTITY is shown as NO:

A. Pay TOTAL FEE(S) DUE shown above, or

B. If applicant claimed SMALL ENTITY status before, or is now claiming SMALL ENTITY status, check box 5a on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and 1/2 the ISSUE FEE shown above.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.

PTOL-85 (Rev. 08/07) Approved for use through 08/31/2010.

GCE - Exhibit 1075, Page 39
GCE Gas Control Equipment Inc. v. VBOX, Inc.
IPR2023-00326

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

164 7590 08/26/2009

KINNEY & LANGE, P.A.
THE KINNEY & LANGE BUILDING
312 SOUTH THIRD STREET
MINNEAPOLIS, MN 55415-1002

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)

(Signature)

(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/054,615	02/09/2005	Theodore W. Jagger	V180.12-0006	8238

TITLE OF INVENTION: ADSORBENT CARTRIDGE FOR OXYGEN CONCENTRATOR

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	YES	$755	$300	$0	$1055	11/27/2009

EXAMINER	ART UNIT	CLASS-SUBCLASS
DOUGLAS, STEVEN O	3771	128-202260

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

❑ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

❑ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list

(1) the names of up to 3 registered patent attorneys or agents OR, alternatively,

(2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 _____

2 _____

3 _____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE (B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ❑ Corporation or other private group entity ❑ Government

4a. The following fee(s) are submitted:

❑ Issue Fee

❑ Publication Fee (No small entity discount permitted)

❑ Advance Order - # of Copies _____

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**

❑ A check is enclosed.

❑ Payment by credit card. Form PTO-2038 is attached.

❑ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account Number _____ (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)

❑ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27.

❑ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature _____ Date _____

Typed or printed name _____ Registration No. _____

This collection of information is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

GCE - Exhibit 1075, Page 40
GCE Gas Control Equipment Inc. v. VBOX, Inc.
IPR2023-00326

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/054,615	02/09/2005	Theodore W. Jagger	V180.12-0006	8238

164 7590 08/26/2009

KINNEY & LANGE, P.A.
THE KINNEY & LANGE BUILDING
312 SOUTH THIRD STREET
MINNEAPOLIS, MN 55415-1002

EXAMINER	
DOUGLAS, STEVEN O	
ART UNIT	PAPER NUMBER
3771	

DATE MAILED: 08/26/2009

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment to date is 468 day(s). If the issue fee is paid on the date that is three months after the mailing date of this notice and the patent issues on the Tuesday before the date that is 28 weeks (six and a half months) after the mailing date of this notice, the Patent Term Adjustment will be 468 day(s).

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

PTOL-85 (Rev. 08/07) Approved for use through 08/31/2010.

Notice of Allowability	Application No.	Applicant(s)	
	11/054,615	JAGGER ET AL.	
	Examiner	Art Unit	
	/Steven O. Douglas/	3771	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to *papers filed 4/28/09*.

2. ☒ The allowed claim(s) is/are *1-20*.

3. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
   a) ☐ All b) ☐ Some* c) ☐ None of the:
      1. ☐ Certified copies of the priority documents have been received.
      2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
      3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

4. ☐ A SUBSTITUTE OATH OR DECLARATION must be submitted. Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL PATENT APPLICATION (PTO-152) which gives reason(s) why the oath or declaration is deficient.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   (a) ☐ including changes required by the Notice of Draftsperson's Patent Drawing Review (PTO-948) attached
      1) ☐ hereto or 2) ☐ to Paper No./Mail Date _____.
   (b) ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892)
2. ☐ Notice of Draftperson's Patent Drawing Review (PTO-948)
3. ☒ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date 05262009, 02092005
4. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
5. ☐ Notice of Informal Patent Application
6. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____ .
7. ☐ Examiner's Amendment/Comment
8. ☐ Examiner's Statement of Reasons for Allowance
9. ☐ Other _____.

/Steven O. Douglas/
Primary Examiner
Art Unit: 3771

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	11054615	JAGGER ET AL.
	Examiner	**Art Unit**
	/Steven O Douglas/	3771

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☒ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	01/27/2009	08/20/2009							
	1	✓	=							
	2	O	=							
	3	O	=							
	4	✓	=							
	5	O	=							
	6	O	=							
	7	✓	=							
	8	✓	=							
	9	✓	=							
	10	=	=							
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	12	=	=							
	13	=	=							
	14	=	=							
	15	=	=							
	16	=	=							
	17		=							
	18		=							
	19		=							
	20		=							

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	11054615	JAGGER ET AL.
	Examiner	Art Unit
	/Steven O Douglas/	3771

ORIGINAL		INTERNATIONAL CLASSIFICATION	
CLASS	SUBCLASS	CLAIMED	NON-CLAIMED
128	202.26	A 6 1 M 11 / 00 (2006.01.01)	

CROSS REFERENCE(S)

CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)				
128	205.18				
95	96				
55	356				

☒ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original

NONE		Total Claims Allowed:	
(Assistant Examiner)	(Date)	20	
/Steven O Douglas/ Primary Examiner.Art Unit 3771	8/20/09	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	7

GCE - Exhibit 1075, Page 44
GCE Gas Control Equipment Inc. v. VBOX, Inc.
IPR2023-00326

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L3	0	(oxygen adj1 concentrator) and (gas adj1 separation) and (absorbent adj1 column) and (housing or casing) and (inlet adj1 port) and (outlet adj1 port)	US-PGPUB	OR	OFF	2009/08/20 09:38
L4	0	(oxygen adj1 concentrator) and (gas adj1 separation) and (absorbent adj1 column) and (housing or casing) and (inlet adj1 port) and (outlet adj1 port)	US-PGPUB	OR	ON	2009/08/20 09:39
L5	0	(oxygen adj1 concentrator) and (gas adj1 separation) and (absorbent adj1 column) and (housing or casing) and (inlet) and (outlet)	US-PGPUB	OR	ON	2009/08/20 09:39
L6	0	(oxygen adj1 concentrat$4) and (gas adj1 separat $4) and (absorbent adj1 column) and (housing or casing) and (inlet) and (outlet)	US-PGPUB	OR	ON	2009/08/20 09:39

8/20/09 9:40:18 AM

GCE - Exhibit 1075, Page 45
GCE Gas Control Equipment Inc. v. VBOX, Inc.
IPR2023-00326

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GCE - Exhibit 1075, Page 46
GCE Gas Control Equipment Inc. v. VBOX, Inc.
IPR2023-00326

PTO/SB/08a (05-07)
Approved for use through 09/30/2007. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99**)		
	Application Number	11054615
	Filing Date	2005-02-09
	First Named Inventor	Theodore W. Jagger
	Art Unit	3771
	Examiner Name	Douglas, Steven O
	Attorney Docket Number	V180.12-0006

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
/SD/		6010555		2000-01-04	Smolarek et al.	

If you wish to add additional U.S. Patent citation information please click the Add button. Add

U.S.PATENT APPLICATION PUBLICATIONS Remove

Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
/SD/	1	20020127442		2002-09-12	Connor et al.	

If you wish to add additional U.S. Published Application citation information please click the Add button. Add

FOREIGN PATENT DOCUMENTS Remove

Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
	1							☐

If you wish to add additional Foreign Patent Document citation information please click the Add button Add

NON-PATENT LITERATURE DOCUMENTS Remove

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	11054615
	Filing Date	2005-02-09
	First Named Inventor	Theodore W. Jagger
	Art Unit	3771
	Examiner Name	Douglas, Steven O
	Attorney Docket Number	V180.12-0006

	1		☐

If you wish to add additional non-patent literature document citation information please click the Add button Add

EXAMINER SIGNATURE

Examiner Signature	/Steven Douglas/	Date Considered	08/20/2009

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

Search Notes	Application/Control No.	Applicant(s)/Patent under Reexamination	
	11/054,615	JAGGER ET AL.	
	Examiner	Art Unit	
	/Steven O. Douglas/	3771	

SEARCHED			
Class	Subclass	Date	Examiner
update	previous	8/20/2009	SD

INTERFERENCE SEARCHED			
Class	Subclass	Date	Examiner
all	**previous**	8/20/2009	**SD**

SEARCH NOTES (INCLUDING SEARCH STRATEGY)		
	DATE	EXMR
PG PUB (see attached)	8/20/2009	SD

First Named Inventor	:	Theodore W. Jagger	
Appln. No.	:		
Filed	:	Herewith	Group Art Unit:
Title	:	ADSORBENT CARTRIDGE FOR OXYGEN CONCENTRATOR	Examiner:
Docket No.	:	V180.12-0006	

INFORMATION DISCLOSURE STATEMENT

Commissioner For Patents
P.O. Box 1450
Alexandria, VA 22313-1450

VIA EXPRESS MAIL NO.: EV 485708840 US

The enclosed PTO Form-1449 lists patents and publications submitted pursuant to 37 C.F.R. 1.97. Copies of the patents or publications are enclosed as necessary [if application filing date is after June 30, 2003, copies of U.S. patents and application publications are not required].

TIME OF FILING

The Information Disclosure Statement is being filed:

1. X with the application or within three months of the filing date of a national application (other than a continued prosecution application under 37 C.F.R. 1.53(d)) or date of entry into the national stage of an international application or, to the best of the undersigned's knowledge, before the mailing date of a first Office action on the merits or a first office action after the filing of a request for continued examination under 37 C.F.R. 1.114, whichever event occurs last. In accordance with 37 C.F.R. 1.97(b), no certification or fee is required.

Respectfully submitted,

KINNEY & LANGE, P.A.

By: _____

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DRF:LB:bmg

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /SD/

FORM PTO-1449	Atty. Docket No.: V180.12-0006	Application No.:
LIST OF PATENTS AND PUBLICATIONS FOR APPLICANT'S INFORMATION DISCLOSURE STATEMENT	First Named Inventor: Theodore W. Jagger	
	Filing Date: Herewith	Group Art:

U.S. PATENT DOCUMENTS

Examiner Initials		Document No.	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Documents
	AA	Re. 35,099	11-28-1995	Hill
	AB	4,491,459	01-01-1985	Pinkerton
	AC	4,648,888	03-10-1987	Rowland
	AD	4,813,977	03-21-1898	Schmidt et al.
	AE	4,826,510	05-02-1989	McCombs
	AF	4,925,464	05-15-1990	Rabenau et al.
	AG	4,971,609	11-20-1990	Pawlos
	AH	5,531,807	07-02-1996	McCombs
	AI	5,593,478	01-14-1997	Hill et al.
	AJ	5,730,778	03-24-1998	Hill et al.
	AK	5,827,358	10-27-1998	Kulish et al.
	AL	5,858,062	01-12-1999	McCulloh et al.
	AM	5,893,275	04-13-1999	Henry
	AN	5,893,944	04-13-1999	Dong
	AO	5,928,189	07-27-1999	Phillips et al.
	AP	5,979,440	11-09-1999	Honkonen et al.
	AQ	6,212,904	04-10-2001	Arkharov et al.
	AR	6,287,366	09-11-2001	Derive et al.
	AS	6,302,107	10-16-2001	Richey, II et al.
	AT	6,311,719	11--06-2001	Hill et al.
	AU	6,314,957	11-13-2001	Boissin et al.
	AV	6,346,139	02-12-2002	Czabala
	AW	6,446,630	09-10-2002	Todd, Jr.
	AX	6,457,485	10-01-2002	Hill et al.
	AY	6,471,744	10-29-2002	Hill

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /SD/

Examiner Initials		Document No.	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Documents
	AZ	6,478,857	11-12-2002	Czabala
	BA	6,511,526	01-28-2003	Jagger et al.
	BB	6,520,176	02-18-2003	Dubois et al.
	BC	6,551,384	04-22-2003	Ackley et al.
	BD	6,629,525	10-07-2003	Hill et al.
	BE	6,641,644	11-04-2003	Jagger et al.
	BF	6,651,653	11-25-2003	Honkonen et al.
	BG	6,651,658	11-25-2003	Hill et al.
	BH	6,681,764	01-27-2004	Honkonen et al.
	BI	6,691,702	02-17-2004	Appel et al.
	BJ	6,698,423	03-02-2004	Honkonen et al.
	BK	6,712,087	03-30-2004	Hill et al.
	BL	6,764,534	07-20-2004	McCombs et al.

FOREIGN PATENT DOCUMENTS

		Foreign Patent Document	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Documents	Translation Yes No
	BM	EP 0 860 646 A2	02-06-1998	McCulloh	Yes
	BN	WO 98/58219	12-23-1998	Honkonen	Yes
	BO	WO 03/092817	11-13-2003	Appel	Yes

OTHER ART (Including Author, Title, Date, Pertinent Pages, Etc.)

	BP	Recommendations of the Fifth Oxygen Consensus Conference, 1999
	BQ	"AirSep lowers boom", www.hmenews.com/2004.12/depts/vendors/vendors1.htm. , (no date).
	BR	

EXAMINER: /Steven Douglas/ DATE CONSIDERED: 08/20/2009

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP 609; draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /SD/

PTO/SB/08a (05-07)
Approved for use through 09/30/2007. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**		
	Application Number	11054615
	Filing Date	2005-02-09
	First Named Inventor	Theodore W. Jagger
	Art Unit	3771
	Examiner Name	Douglas, Steven O
	Attorney Docket Number	V180.12-0006

U.S.PATENTS						Remove
Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	6010555		2000-01-04	Smolarek et al.	
If you wish to add additional U.S. Patent citation information please click the Add button.						Add

U.S.PATENT APPLICATION PUBLICATIONS						Remove
Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	20020127442		2002-09-12	Connor et al.	
If you wish to add additional U.S. Published Application citation information please click the Add button.						Add

FOREIGN PATENT DOCUMENTS								Remove
Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
	1							☐
If you wish to add additional Foreign Patent Document citation information please click the Add button								Add

NON-PATENT LITERATURE DOCUMENTS			Remove
Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	11054615
	Filing Date	2005-02-09
	First Named Inventor	Theodore W. Jagger
	Art Unit	3771
	Examiner Name	Douglas, Steven O
	Attorney Docket Number	V180.12-0006

	1		☐

If you wish to add additional non-patent literature document citation information please click the Add button [Add]

EXAMINER SIGNATURE

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	11054615
	Filing Date	2005-02-09
	First Named Inventor	Theodore W. Jagger
	Art Unit	3771
	Examiner Name	Douglas, Steven O
	Attorney Docket Number	V180.12-0006

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☒ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

☐ See attached certification statement.

☐ Fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☐ None

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Larrin Bergman/	Date (YYYY-MM-DD)	2009-05-26
Name/Print	Larrin Bergman	Registration Number	57,153

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

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3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

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5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Electronic Acknowledgement Receipt

EFS ID:	5389339
Application Number:	11054615
International Application Number:	
Confirmation Number:	8238
Title of Invention:	Adsorbent cartridge for oxygen concentrator
First Named Inventor/Applicant Name:	Theodore W. Jagger
Customer Number:	00164
Filer:	Larrin Bergman
Filer Authorized By:	
Attorney Docket Number:	V180.12-0006
Receipt Date:	26-MAY-2009
Filing Date:	09-FEB-2005
Time Stamp:	09:27:33
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Information Disclosure Statement (IDS) Filed (SB/08)	Information_Disclosure_Statement.pdf	601821 a4fba9b3de760ff0a92f7ab3d7a9457f865f5173	no	4

Warnings:	
Information:	

Total Files Size (in bytes):	601821

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

First Named Inventor	:	Theodore W. Jagger	
Appln. No.	:	11/054,615	Confirmation No.: 8238
Filed	:	February 9, 2005	Group Art Unit: 3771
Title	:	ABSORBENT CARTRIDGE FOR OXYGEN CONCENTRATOR	Examiner: Douglas, Steven O.
Docket No.	:	V180.12-0006	

AMENDMENT

Mail Stop Amendment
Commissioner For Patents
P.O. Box 1450
Alexandria, VA 22313-1450

FILED VIA EFS-WEB

INTRODUCTION

This is in response to the Office Action mailed on January 29, 2009. Please amend the above-identified application as follows:

AMENDMENTS TO THE SPECIFICATION

Please delete the first paragraph on page 1 lines 3-18 and replace with the following paragraph:

Reference is hereby made to the following copending applications, which were filed on even date with the present application: "Ambulatory Oxygen Concentrator Containing a Power Pack", Theodore W. Jagger et al., Application No. 11/054,622; "Ambulatory Oxygen Concentrator Containing a Three Phase Vacuum Separation Process", Theodore W. Jagger et al., Application No. 11/054,340; "Personal Oxygen Concentrator", Theodore W. Jagger et al., Patent No. 7,121,276; "Method of Providing Ambulatory Oxygen", Theodore W. Jagger et al., Patent No. 7,475,234; "Low Power Ambulatory Oxygen Concentrator", Theodore W. Jagger et al., Patent No. 7,431,032; "Ambulatory Oxygen Concentrator With High Efficiency Adsorbent", Theodore W. Jagger et al., Application No. 11/054,367; "Portable Oxygen Concentrator With a Docking Station", Theodore W. Jagger et al., Application No. 11/054,714; "Method of Controlling the Rate of Oxygen Produced by an Oxygen Concentrator", Theodore W. Jagger et al., Application No. 11/054,342; "Product Pump for an Oxygen Concentrator", Theodore W. Jagger et al., Patent No. 7,171,963; and "Method and Apparatus for Controlling the Purity of Oxygen Produced by an Oxygen Concentrator", Theodore W. Jagger et al., Application No. 11/054,368.

AMENDMENTS TO THE CLAIMS

Please amend claims 1, such that the status of the claims is as follows:

1. (Currently Amended) A removable gas separation cartridge for use in an oxygen concentrator which separates oxygen from ambient air by using a vacuum swing absorption process, the gas separation cartridge comprising:

a first adsorbent column having an inlet, an outlet and a first bed of adsorbent material;

a second adsorbent column having an inlet, an outlet and a second bed of adsorbent material;

a third adsorbent column having an inlet, an outlet and a third bed of adsorbent material;

a housing for containing the first, second, and third adsorbent columns;

~~an~~ first, second, and third inlet ~~port~~ ports in the housing connected to ~~each of~~ the respective first, second, and third column inlets;

~~an~~ first, second, and third outlet ~~port~~ ports in the housing connected to ~~each of~~ the respective first, second, and third column outlets.

2. (Previously Presented) The gas separation cartridge of claim 1 further comprising:

an inlet air filter;

means for connecting the inlet air filter to the oxygen concentrator;

a product gas filter; and

means for connecting the product gas filter to the oxygen concentrator;

wherein the inlet air filter and product gas filter are contained within the housing.

3. (Original) The gas separation cartridge of claim 2 further comprising:

an outlet port connected to the product gas filter.

4. (Original) The gas separation cartridge of claim 1 wherein the adsorbent columns each further comprise a spring for retaining the adsorbent column in the housing.

5. (Previously Presented) The gas separation cartridge of claim 1 wherein each adsorbent columns further comprise spin inducers adjacent the inlet and outlet of the adsorption columns.

6. (Previously Presented) The gas separation cartridge of claim 5 wherein each adsorbent columns further comprise porous filters between the spin inducers and beds of adsorbent material.

7. (Previously Presented) The gas separation cartridge of claim 1 wherein each of the beds of adsorbent material comprise beds of zeolite which provide preferential adsorption of nitrogen.

8. (Original) The gas separation cartridge of claim 7 wherein the zeolite is an LiLSX adsorbent.

9. (Currently Amended) The gas separation cartridge of claim 1 wherein the first, second, and third inlet ports and first, second, and third outlet ports comprise quick connect couplings.

10. (Previously Presented) A removable cartridge for a portable oxygen concentrator, the cartridge comprising:

an outer casing;

a plurality of gas separation columns within the outer casing, each gas separation column containing an adsorbent material that preferentially adsorbs nitrogen, a first end, and a second end;

a plurality of inlet ports in the outer casing, each inlet port connect to the first end of one of the columns; and

a plurality of outlet ports in the outer casing, each outlet port connected to the second end of one of the columns.

11. (Previously Presented) The gas separation cartridge of claim 10 further comprising:
an inlet air filter within the outer casing;
a port for connecting the air filter to the oxygen concentrator;
a product gas filter within the outer casing; and
a port for connecting the product gas filter to the oxygen concentrator;

12. (Previously Presented) The gas separation cartridge of claim 10 wherein the adsorbent columns each further comprise a spring for retaining the adsorbent column in the housing.

13. (Previously Presented) The gas separation cartridge of claim 10 wherein the adsorbent columns further comprise spin inducers adjacent to the inlets of the adsorption columns.

14. (Previously Presented) The gas separation cartridge of claim 13 wherein the adsorbent columns further comprise porous filters between the spin inducers and beds of adsorbent material.

15. (Previously Presented) The gas separation cartridge of claim 10 wherein the beds of adsorbent material comprise beds of zeolite which provide preferential adsorption of nitrogen.

16. (Previously Presented) The gas separation cartridge of claim 15 wherein the zeolite is an LiLSX adsorbent.

17. (New) A removeable gas separation cartridge for use in an oxygen concentrator which separates oxygen from ambient air by using a vacuum swing absorption process, the gas separation cartridge comprising:

a first adsorbent column having an inlet, and outlet and a first bed of adsorbent material;

a second adsorbent column having an inlet, an outlet and a second bed of adsorbent material;

a third adsorbent column having an inlet, and outlet and a third bed of adsorbent material;

wherein each adsorbent column further comprise spin adjacent the inlet and outlet of the adsorption columns;

a housing for containing the first, second, and third adsorbent columns;

an inlet port in the housing connected to each of the respective first, second, and third column inlets; and

an outlet port in the housing connected to each of the respective first, second, and third column outlets.

18. (New) The gas separation cartridge of claim 17 wherein each adsorbent columns further comprise porous filters between the spin inducers and beds of adsorbent material.

19. (New) A removeable gas separation cartridge for use in an oxygen concentrator which separates oxygen from ambient air by using a vacuum swing absorption process, the gas separation cartridge comprising:

a first adsorbent column having an inlet, and outlet and a first bed of adsorbent material;

a second adsorbent column having an inlet, an outlet and a second bed of adsorbent material;

a third adsorbent column having an inlet, and outlet and a third bed of adsorbent material;

an inlet air filter;

means for connecting the inlet air filter to the oxygen concentrator;

a product gas filter;

means for connecting the product gas filter to the oxygen concentrator;

a housing for containing the first, second, and third adsorbent columns, the inlet filter, and the product gas filter;

an inlet port in the housing connected to each of the respective first, second, and third column inlets; and

an outlet port in the housing connected to each of the respective first, second, and third column outlets.

20. (New) The gas separation cartridge of claim 19 further comprising:

an outlet port connected to the product gas filter.

REMARKS

This is in response to the Office Action mailed on January 29, 2009, in which pending claims 1, 4, and 7-9 are rejected; claims 2, 3, 5, and 6 are objected to; and claims 10-16 are allowed. Specifically, claims 1, 4, 7, and 9 are rejected under 35 U.S.C. § 102(b) as being anticipated by Hill et al. (U.S. Patent No. 5,366,541), and claim 8 is rejected under 35 U.S.C. § 103(a) as being unpatentable over Hill et al. (U.S. Patent No. 5,366,541). In view of the above amendments and following remarks, reconsideration and allowance of all claims (1-20) is requested.

Objection to the Specification

The disclosure was objected to because of formalities. With this Amendment, applicant makes formal the amendment to the specification previously submitted. The objections to the specification have been overcome and notice to that effect is hereby requested.

Claim Objections

Claim 9 is objected to because of formalities. Claim 1 has been amended to include a plurality of ports, which now gives antecedent basis to all terms in Claim 9. The objection has been overcome and notice to that effect is hereby requested.

Claim Rejections Under 35 U.S.C. § 102(b)

Claims 1, 4, 7, and 9 are rejected under 35 U.S.C. § 102(b) as being anticipated by Hill et al. (U.S. Patent No. 5,366,541). Hill et al. discloses an apparatus for fractionating fluid mixture by pressure swing molecular adsorption employing a rotary distributor valve and an array of absorbent columns. The reference does not disclose a multiple or plurality of inlet ports and outlet ports in the housing. Applicant has amended Claim 1 to include limitation of first, second, and third inlet and outlet parts per the suggestion of the Examiner. As such, Claim 1 is now allowable, and notice thereof is hereby requested.

If an independent claim is allowable, then any claim depending therefrom is similarly allowable. *In re Fine*, 837 F.2d 107. Thus, dependent claims 4, 7, and 9 are also allowable as there is no disclosure of a plurality of inlet ports and outlet ports in the housing. Withdrawal of the rejections of the dependent claims pursuant to 35 U.S.C. § 102(b) is also requested.

Claim Rejections Under 35 U.S.C. § 102(b)

Claim 8 is rejected under 35 U.S.C. § 103(a) as being unpatentable over Hill et al. (U.S. Patent No. 5,366,541). Again, if an independent claim is allowable, then any claim depending therefrom is similarly allowable. *In re Fine*, 837 F.2d 107. Thus, dependent Claims 8 is allowable, as the claim depends from an allowable base claim that contains limitations that are not present in the prior art of record. Withdrawal of the rejections of the dependent claims pursuant to 35 U.S.C. § 103(a) is also requested.

Allowable Subject Matter

Claims 10-16 were allowed as presented. Claims 2, 3, 5, and 6 were objected to as being dependent upon a rejected base claim. Claim 1 has been amended and is now allowable. Claims 2, 3, 5, and 6 depend from Claim 1, and are thus now allowable as presented. Further, previously presented claims 2 and 5 have been rewritten into independent form as claims 17 and 19, including all the limitations of the base claim and all intervening claims. As such, claims 17 and 19 contain allowable subject matter, as do claims 18 and 20 that depend from claim 17 and 19, respectively.

Conclusion

In view of the foregoing, all pending claims 1-20 are in condition for allowance. A notice to that effect is respectfully requested.

The Examiner is cordially invited to contact the undersigned at the telephone number listed below if such a call would in any way facilitate the allowance of this application.

The Commissioner is hereby authorized to charge any additional fee required under 37 C.F.R. 1.16 and 1.17 and credit any overpayments to Deposit Account No. 11-0982.

Respectfully submitted,

KINNEY & LANGE, P.A.

Date: April 28, 2009 By: /Larrin Bergman/

Larrin Bergman, Reg. No. 57,153
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LB:mdh

Electronic Acknowledgement Receipt	
EFS ID:	5234716
Application Number:	11054615
International Application Number:	
Confirmation Number:	8238
Title of Invention:	Adsorbent cartridge for oxygen concentrator
First Named Inventor/Applicant Name:	Theodore W. Jagger
Customer Number:	00164
Filer:	Larrin Bergman
Filer Authorized By:	
Attorney Docket Number:	V180.12-0006
Receipt Date:	28-APR-2009
Filing Date:	09-FEB-2005
Time Stamp:	15:51:55
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		Amendment_V180-12-0006.pdf	294410 39ce837f0e62db516d462822966b4233783c5661	yes	10

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Amendment/Req. Reconsideration-After Non-Final Reject	1	1
	Specification	2	2
	Claims	3	7
	Applicant Arguments/Remarks Made in an Amendment	8	10
Warnings:			
Information:			
	Total Files Size (in bytes):	294410	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Electronic Patent Application Fee Transmittal

Application Number:	11054615
Filing Date:	09-Feb-2005
Title of Invention:	Adsorbent cartridge for oxygen concentrator
First Named Inventor/Applicant Name:	Theodore W. Jagger
Filer:	Larrin Bergman
Attorney Docket Number:	V180.12-0006

Filed as Large Entity

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Independent claims in excess of 3	1201	1	220	220
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
			Total in USD ($)	**220**

Electronic Acknowledgement Receipt	
EFS ID:	5234988
Application Number:	11054615
International Application Number:	
Confirmation Number:	8238
Title of Invention:	Adsorbent cartridge for oxygen concentrator
First Named Inventor/Applicant Name:	Theodore W. Jagger
Customer Number:	00164
Filer:	Larrin Bergman
Filer Authorized By:	
Attorney Docket Number:	V180.12-0006
Receipt Date:	28-APR-2009
Filing Date:	09-FEB-2005
Time Stamp:	15:57:22
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$220
RAM confirmation Number	2310
Deposit Account	110982
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: Charge any Additional Fees required under 37 C.F.R. Section 1.16 (National application filing, search, and examination fees) Charge any Additional Fees required under 37 C.F.R. Section 1.17 (Patent application and reexamination processing fees)	

Charge any Additional Fees required under 37 C.F.R. Section 1.19 (Document supply fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.20 (Post Issuance fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Fee Worksheet (PTO-875)	fee-info.pdf	29665 81409c5d3a15bd5027796b24d4bd3f673815163e	no	2

Warnings:

Information:

Total Files Size (in bytes):	29665

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

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PTO/SB/06 (07-06)
Approved for use through 1/31/2007. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number	Filing Date	☐ To be Mailed
11/054,615	02/09/2005	

APPLICATION AS FILED – PART I

	(Column 1)	(Column 2)	SMALL ENTITY ☒ RATE ($)	SMALL ENTITY ☒ FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY FEE ($)
FOR	NUMBER FILED	NUMBER EXTRA					
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =		OR	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =			X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $250 ($125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	

APPLICATION AS AMENDED – PART II

AMENDMENT 04/28/2009

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE ($)	SMALL ENTITY ADDITIONAL FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	* 16	Minus	** 20	= 0	X $26 =	0	OR	X $ =	
Independent (37 CFR 1.16(h))	* 2	Minus	***3	= 0	X $110 =	0	OR	X $ =	
☐ Application Size Fee (37 CFR 1.16(s))									
☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE	0	OR	TOTAL ADD'L FEE	

AMENDMENT

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)		RATE ($)	ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =		OR	X $ =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =		OR	X $ =	
☐ Application Size Fee (37 CFR 1.16(s))									
☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.

** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".

*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".

The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

Legal Instrument Examiner:
/PAMELA V. THERATT/

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/054,615	02/09/2005	Theodore W. Jagger	V180.12-0006	8238

164 7590 01/29/2009

KINNEY & LANGE, P.A.
THE KINNEY & LANGE BUILDING
312 SOUTH THIRD STREET
MINNEAPOLIS, MN 55415-1002

EXAMINER	
DOUGLAS, STEVEN O	
ART UNIT	PAPER NUMBER
3771	

MAIL DATE	DELIVERY MODE
01/29/2009	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No.	Applicant(s)	
	11/054,615	JAGGER ET AL.	
	Examiner	Art Unit	
	/Steven O. Douglas/	3771	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE *3* MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *10 March 2008*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-16* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☒ Claim(s) *10-16* is/are allowed.

6)☒ Claim(s) *1,4 and 7-9* is/are rejected.

7)☒ Claim(s) *2,3,5 and 6* is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

DETAILED ACTION

Specification

The disclosure is objected to because of the following informalities: it is noted that the first paragraph on page 1 of the specification contains a lengthy list of related applications that omit the required application numbers. A complete list is required. (Examiner notes that Applicant has faxed an informal amendment to the specification that cures such informality. A formal amendment should now be submitted).

Appropriate correction is required.

Claim Objections

Claim 9 is objected to because of the following informalities: "ports" (line 1 and 2) should be - - port - - . Appropriate correction is required.

Claim Rejections - 35 USC § 102

The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

Claims 1,4 and 7 are rejected under 35 U.S.C. 102(b) as being anticipated by Hill'541 et al.

The Hill et al. reference discloses a fluid fractionator comprising a first, second and third column 22 with respective inlets and outlets (see the open top and bottom of the columns 22 in Fig. 5), a housing 9 with an inlet port (proximate reference numeral 6 in Fig. 5) and an outlet port

(proximate reference numeral 8 in Fig. 5), wherein the inlet port is connected to the respective inlets via a rotary valve (proximate reference numeral 18 in Fig. 5) and the outlet port is connected to the respective outlets via vent 42 and a void defined by the rotary valve (see col. 5, lines 23-27).

In regard to claim 9, in as much structure defined by "quick connect" couplings, the threaded couplings associated with the inlet and outlet ports meet the claimed limitations.

Claim Rejections - 35 USC § 103

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

Claim 8 is rejected under 35 U.S.C. 103(a) as being unpatentable over Hill'541 et al.

The Hill et al. reference discloses a device (supra) including an absorbent material including a zeolite, but fails to disclose the zeolite as being LiLSX. Examiner takes Official Notice that LiLSX is a well known or conventional absorbent used in oxygen concentrators. It would have been obvious to one of ordinary skill in the art at the time the invention was made to employ a known absorbent such as LiLSX for the zeolite in the Hill et al. system in view Examiner's Noticed observation of conventionality.

Response to Arguments

Applicant's arguments with respect to claims 1-9 have been considered but are moot in view of the new ground(s) of rejection.

Allowable Subject Matter

Claims 10-16 are allowed.

Claims 2,3,5 and 6 are objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.

Note: In order to overcome the above rejections, Examiner suggests amending claim 1 by incorporating language such as -- plural inlet and outlet ports in the housing - - in a similar fashion applied to claim 10.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to /Steven O. Douglas/ whose telephone number is (571) 272-4885. The examiner can normally be reached on Mon-Thurs 6:30-5:00.

The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/Steven O. Douglas/
Primary Examiner
Art Unit 3771

SD
1/27/09

Search Notes	Application/Control No.	Applicant(s)/Patent under Reexamination	
	11/054,615	JAGGER ET AL.	
	Examiner	Art Unit	
	/Steven O. Douglas/	3771	

SEARCHED			
Class	Subclass	Date	Examiner
update	previous	1/27/2009	SD

INTERFERENCE SEARCHED			
Class	Subclass	Date	Examiner

SEARCH NOTES (INCLUDING SEARCH STRATEGY)		
	DATE	EXMR

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	11054615	JAGGER ET AL.
	Examiner	**Art Unit**
	/Steven O Douglas/	3771

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	01/27/2009								
	1	✓								
	2	O								
	3	O								
	4	✓								
	5	O								
	6	O								
	7	✓								
	8	✓								
	9	✓								
	10	=								
	11	=								
	12	=								
	13	=								
	14	=								
	15	=								
	16	=								

GCE - Exhibit 1075, Page 83
GCE Gas Control Equipment Inc. v. VBOX, Inc.
IPR2023-00326

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

First Named Inventor	:	Theodore W. Jagger	
Appln. No.	:	11/054,615	Confirmation No.: 8238
Filed	:	February 9, 2005	Group Art Unit: 3771
Title	:	ADSORBENT CARTRIDGE FOR OXYGEN CONCENTRATOR	Examiner: Ali, Shumaya B
Docket No.	:	V180.12-0006	

SUPPLEMENTAL AMENDMENT

Commissioner For Patents
P.O. Box 1450
Alexandria, VA 22313-1450

FILED VIA EFS-WEB

INTRODUCTION

This Supplemental Amendment is submitted at the request of the Examiner. Please amend the application as follows:

AMENDMENTS TO THE SPECIFICATION

Please delete the first paragraph on page 1 lines 3-18 and replace with the following paragraph:

Reference is hereby made to the following copending applications, which were filed on even date with the present application: "Ambulatory Oxygen Concentrator Containing a Power Pack", Theodore W. Jagger et al., Application No. 11/054,622; "Ambulatory Oxygen Concentrator Containing a Three Phase Vacuum Separation Process", Theodore W. Jagger et al., Application No. 11/054,340; "Personal Oxygen Concentrator", Theodore W. Jagger et al., Patent No. 7,121,276; "Method of Providing Ambulatory Oxygen", Theodore W. Jagger et al., Patent No. 7,475,234; "Low Power Ambulatory Oxygen Concentrator", Theodore W. Jagger et al., Patent No. 7,431,032; "Ambulatory Oxygen Concentrator With High Efficiency Adsorbent", Theodore W. Jagger et al., Application No. 11/054,367; "Portable Oxygen Concentrator With a Docking Station", Theodore W. Jagger et al., Application No. 11/054,714; "Method of Controlling the Rate of Oxygen Produced by an Oxygen Concentrator", Theodore W. Jagger et al., Application No. 11/054,342; "Product Pump for an Oxygen Concentrator", Theodore W. Jagger et al., Patent No. 7,171,963; and "Method and Apparatus for Controlling the Purity of Oxygen Produced by an Oxygen Concentrator", Theodore W. Jagger et al., Application No. 11/054,368.

REMARKS

This Preliminary Amendment is submitted at the request of the Examiner. Consideration and allowance of all of the pending claims are respectfully requested.

The Commissioner is hereby authorized to charge any additional fee required under 37 C.F.R. 1.16 and 1.17 and credit any overpayments to Deposit Account No. 11-0982.

Respectfully submitted,

KINNEY & LANGE, P.A.

Date: January 22, 2009 By: /Larrin Bergman/

Larrin Bergman, Reg. No. 57,153
THE KINNEY & LANGE BUILDING
312 South Third Street
Minneapolis, MN 55415-1002
Telephone: (612) 339-1863
Fax: (612) 339-6580

LB:mdh

Electronic Acknowledgement Receipt

EFS ID:	4659938
Application Number:	11054615
International Application Number:	
Confirmation Number:	8238
Title of Invention:	Adsorbent cartridge for oxygen concentrator
First Named Inventor/Applicant Name:	Theodore W. Jagger
Customer Number:	00164
Filer:	Larrin Bergman
Filer Authorized By:	
Attorney Docket Number:	V180.12-0006
Receipt Date:	22-JAN-2009
Filing Date:	09-FEB-2005
Time Stamp:	17:15:52
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Supplemental Response or Supplemental Amendment	Supplemental_Amendment_V180-12-0006.pdf	67828 378174c82c443490f6dfb8d1c0cd829bea4bf4ed	no	3
Warnings:					
Information:					

Total Files Size (in bytes):	67828

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

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OIPE
MAR 1 0 2008
IAP34
PATENT & TRADEMARK OFFICE

3-11-08

IFW

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

First Named Inventor	:	Theodore W. Jagger	
Appln. No.	:	11/054,615	
Filed	:	February 9, 2005	Group Art Unit: 3771
Title	:	ADSORBENT CARTRIDGE FOR OXYGEN CONCENTRATOR	Examiner: Shumaya B Ali
Docket No.	:	V180.12-0006	

EXPRESS MAIL COVER SHEET

Mail Stop Amendment
Commissioner For Patents
P.O. Box 1450
Alexandria, VA 22313-1450

SENT VIA EXPRESS MAIL
Express Mail No.: EM 088203561 US

The following papers are being transmitted via **EXPRESS MAIL** to the U.S. Patent and Trademark Office on the date shown below:

1. Amendment
2. Fee Transmittal (in duplicate)
3. Postcard

Respectfully submitted,

KINNEY & LANGE, P.A.

Date: 3-10-08

By _____
Larrin Bergman, Reg. No. 57,153
THE KINNEY & LANGE BUILDING
312 South Third Street
Minneapolis, MN 55415-1002
Telephone: (612) 339-1863
Fax: (612) 339-6580

FEE TRANSMITTAL

USPTO MAR 10 2008 PATENT & TRADEMARK OFFICE

Complete if Known	
Application No.	11/054,615
Filing Date	February 9, 2005
First Named Inventor	Theodore W. Jagger
Group Art Unit	3771
Examiner Name	Shumaya B. Ali
Atty. Docket Number	V180.12-0006

Total Amount of Payment $0.00

METHOD OF PAYMENT (Check One)

1. [X] The Commissioner is hereby authorized to charge any additional fee required under 37 C.F.R. 1.16 and 1.17 and credit any over payments to Deposit Account No.11-0982. Deposit Account Name: Kinney & Lange, P.A. A duplicate copy of this communication is enclosed.

2. [] Check Enclosed

FEE CALCULATION

1. BASIC FILING FEE

Appn. Type PD.	FILING FEE FEE/SMALL	SEARCH FEES FEE/SMALL	EXAM FEES FEE/SMALL	FEES
Utility	310 / 155	510 / 255	210 / 105	_
Design	210 / 105	100 / 50	130 / 65	_
Reissue	310 / 155	510 / 255	620 / 310	_
Provisional	210 / 105	-0- / -0-	-0- / -0-	_

Subtotal (1) $0.00

2. EXTRA CLAIM FEES

	Number Claims		Prior		Extra		Fee from Fee Paid Below		
Total	16	-	20	=	0	x	50	=	0
Indep.	2	-	3	=	0	x	210	=	0
Multiple Dependent Claims							_	=	_

Insert 3 and 20, or number previously paid if greater; Reissue see below

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Description
1202	50	2202	25	Claims in excess of 20
1201	210	2201	105	Independent claims in excess of 3
1203	370	2203	185	Multiple Dependent Claim
1204	210	2204	105	Reissue Independent Claims Over Original Patent
1205	50	2205	25	Reissue claims in excess of 20 and over original patent

3. APPLICATION SIZE FEE

If the specification and drawings exceed 100 sheets of paper, the application size fee due is $260 ($130 small) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 C.F.R. 1.16(s). $0.00

Subtotal (2) $0.00

FEE CALCULATION (Continued)

3. ADDITIONAL FEES

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee paid
1051	130	2051	65	Surcharge - Late filing fee or oath	_
1052	50	2052	25	Surcharge - late provisional filing fee or cover sheet	_
1053	130	1053	130	Non-English specification	_
1812	2,520	1812	2,520	For Filing a Request for Reexamination	_
1251	120	2251	60	Extension for reply within first month	_
1252	460	2252	230	Extension for reply within second month	_
1253	1,050	2253	525	Extension for reply within third month	_
1254	1,640	2254	820	Extension for reply within fourth month	_
1255	2,230	2255	1,115	Extension for reply within fifth month	_
1402	510	2402	255	Filing a brief in support of an appeal	_
1403	1,030	2403	515	Request for oral hearing	_
1814	130	2814	65	Terminal Disclaimer Fee	_
1452	510	2452	255	Petition to revive - unavoidable	_
1453	1,540	2453	770	Petition to revive - unintentional	_
1501	1,440	2501	720	Utility/Reissue issue fee	_
1502	820	2502	410	Design issue fee	_
1464	130	1464	130	Petitions to the Commissioner	_
1807	50	1807	50	Petitions related to provisional applications	_
1806	180	1806	180	Submission of Information Disclosure Statement	_
8021	40	8021	40	Recording each patent assignment per property (times number of properties)	_
1801	810	2801	405	Request for Continued Examination (RCE)	_

Other fee (specify) _____ _

Subtotal (3) $0.00

Signature _____ Reg. No. 57,153

Larrin Bergman

Date 3-10-08 Deposit Account No. 11-0982

OIPE IAP34
MAR 1 0 2008
PATENT & TRADEMARK OFFICE

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

First Named Inventor	:	Theodore W. Jagger	
Appln. No.	:	11/054,615	
Filed	:	February 9, 2005	Group Art Unit: 3771
Title	:	ADSORBENT CARTRIDGE FOR OXYGEN CONCENTRATOR	Examiner: Ali, Shumaya B.
Docket No.	:	V180.12-0006	

AMENDMENT

Mail Stop Amendment
Commissioner For Patents
P.O. Box 1450
Alexandria, VA 22313-1450

SENT VIA EXPRESS MAIL

Express Mail No.: EM 088203561 US

INTRODUCTION

This is in response to the Office Action mailed on December 11, 2007. Please amend the above-identified application as follows:

AMENDMENTS TO THE CLAIMS

Please amend claims 1, 2, 5-7, and 9-16, such that the status of the claims is as follows:

1. (Currently Amended) A removable gas separation cartridge for use in an oxygen concentrator which separates oxygen from ambient air by using a vacuum swing absorption process, the gas separation cartridge comprising:

a first adsorbent column having an inlet, an outlet and a first bed of adsorbent material;

a second adsorbent column having an inlet, an outlet and a second bed of adsorbent material;

a third adsorbent column having an inlet, an outlet and a third bed of adsorbent material;

a housing for containing the first, second, and third adsorbent columns;

an inlet ports in the housing connected to each of the respective first, second, and third ~~the~~ column inlets;

an outlet ports in the housing connected to each of the respective first, second, and third ~~the~~ column outlets.

2. (Currently Amended) The gas separation cartridge of claim 1 further comprising:

an inlet air filter;

means for connecting the inlet air filter to the oxygen concentrator;

a product gas filter; and

means for connecting the product gas filter to the oxygen concentrator;

wherein the inlet air filter and product gas filter are contained within the housing.

3. (Original) The gas separation cartridge of claim 2 further comprising:

an outlet port connected to the product gas filter.

4. (Original) The gas separation cartridge of claim 1 wherein the adsorbent columns each further comprise a spring for retaining the adsorbent column in the housing.

5. (Currently Amended) The gas separation cartridge of claim 1 wherein ~~the~~ each adsorbent columns further comprise spin inducers adjacent the inlet and outlet of the adsorption columns.

6. (Currently Amended) The gas separation cartridge of claim 5 wherein ~~the~~ each adsorbent columns further comprise porous filters between the spin inducers and beds of adsorbent material.

7. (Currently Amended) The gas separation cartridge of claim 1 wherein ~~the~~ each of the beds of adsorbent material comprise beds of zeolite which provide preferential adsorption of nitrogen.

8. (Original) The gas separation cartridge of claim 7 wherein the zeolite is an LiLSX adsorbent.

~~8~~9. (Currently amended) The gas separation cartridge of claim 1 wherein the inlet ports and outlet ports comprise quick ~~dis~~connect couplings.

~~9~~10. (Currently amended) A removable cartridge for a portable oxygen concentrator, the cartridge comprising:

an outer casing;

a plurality of gas separation columns within the outer casing, each gas separation column containing an adsorbent material that preferentially adsorbs nitrogen, a first end, and a second end;

a plurality of inlet ports in the outer casing, each inlet port connect to the first end of one of the columns; and

a plurality of outlet ports in the outer casing, each outlet port connected to the second end of one of the columns.

~~10~~11. (Currently amended) The gas separation cartridge of claim ~~9~~10 further comprising:
an inlet air filter within the outer casing;
a port for connecting the air filter to the oxygen concentrator;
a product gas filter within the outer casing; and
a port for connecting the product gas filter to the oxygen concentrator;

~~11~~12. (Currently amended) The gas separation cartridge of claim ~~9~~10 wherein the adsorbent columns each further comprise a spring for retaining the adsorbent column in the housing.

~~12~~13. (Currently amended) The gas separation cartridge of claim ~~9~~10 wherein the adsorbent columns further comprise spin inducers adjacent to the inlets of the adsorption columns.

~~13~~14. (Currently amended) The gas separation cartridge of claim ~~12~~13 wherein the adsorbent columns further comprise porous filters between the spin inducers and beds of adsorbent material.

~~14~~15. (Currently amended) The gas separation cartridge of claim ~~9~~10 wherein the beds of adsorbent material comprise beds of zeolite which provide preferential adsorption of nitrogen.

~~15~~16. (Currently amended) The gas separation cartridge of claim ~~14~~15 wherein the zeolite is an LiLSX adsorbent.

REMARKS

This is in response to the Final Office Action mailed on December 11, 2007, in which pending claims 1-16 were rejected. Specifically, claims 2, 8, and 15, the specification, and the drawings were objected to; claims 1-16 were rejected under 35 U.S.C. § 112, first paragraph, as failing to comply with the enablement requirement; claims 1-9 were rejected under 35 U.S.C. § 112, second paragraph, as being indefinite; and claims 1-4, 7-12, 15, and 16 were rejected under 35 U.S.C. § 102(e) as being anticipated by Deane et al. (U.S. Patent No. 7,135,059). In view of the following remarks, reconsideration and allowance of all claims (1-25) is requested.

Claim Objections

Claim 2 has been amended per examiners suggestion. Claims 8 and 15 (now claim 16) have not been amended. The term "LiLSX" is common in the art, and well known when referring to adsorbent materials and zeolites. See e.g. U.S. Patent No. 6,824,590 to Dee et al. (claiming LiLSX as an adsorbent), U.S. Patent No. 7,144,446 to Lessi (mentioning LiLSX in specification), and U.S. Patent No. 7,195,028 to Basset et al (claiming a LiLSX as a zeolite). Applicant is unaware of any other material that has the same designation "LiLSX", and as such has not amended the claims. As such, applicant requests that the claim objections be withdrawn.

Specification Objection

Examiner has objected to the specification as failing to provide proper antecedent basis for the claim term "quick disconnect couplings." Applicant has amended claim 9 to read "quick connect couplings," which has support at page 23, line 10, in the specification as filed. As such, the objection should be withdrawn.

Drawing Objections

Examiner has objected to the drawings. "Quick connect couplings" (amended from "quick disconnect couplings") are illustrated in Figures 9 and 13. "Means for connecting the air filter to the oxygen concentrator" and "means for connecting the product gas filter to the oxygen concentrator" are illustrated schematically in Figure 5, as well as structurally in Figures 7, 15 and 16 (the filters 136 and 138 are contained within casing 230 of separation cartridge 206). As such, applicant respectfully requests that the objections to the drawings be withdrawn.

Rejections under 35 U.S.C. § 112, First Paragraph

Examiner has rejected claims 1-16 under 35 U.S.C. § 112, first paragraph, as failing to comply with the enablement requirement. With respect to claim 1, Examiner states it is not clear what structure connects inlet ports to the column inlets and outlet ports to the column outlets. The inlet ports and outlet ports are the structures that connect fluid passages to the columns as described and illustrated in the application. The inlet and outlet of each column is for identifying an end of each column, similar to referring to a first end and a second end. However, applicant has chosen to use descriptive language in this claim rather than generic language. As such, the rejection of claim one should be withdrawn.

With respect to claim 2, lines 3 and 4, applicant directs Examiner to page 31, line 22 through page 33, line 2, as well as Figures 5, 15, and 16. The text and figures illustrate the claimed means. Similarly, claim 3 was also rejected as not clear which structure connects outlet ports to the gas filter. The same text and figures describe this feature.

Claim 10 was rejected as not being clear what structure connects inlet port to the first end of one of the columns. Again, Applicant refers Examiner to the aforementioned text and Figures, particularly Figure 16.

In view of these remarks, Applicant respectfully requests that the rejections pursuant to 35 U.S.C. § 112, first paragraph, be withdrawn.

Rejections under 35 U.S.C. § 112, First Paragraph

Claims 1-9 were rejected under 35 U.S.C. § 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. Particularly, claim 1 was cited as indefinite for lines 11 and 12. Applicant has amended the claim to require each column inlet port to a corresponding column inlet and outlet port to a corresponding outlet in the housing. Similarly, claims 5-7 have been amended to clarify that it is each of the adsorbent columns and beds, respectively. With the forgoing amendments, the rejections should be withdrawn.

Rejections under 35 U.S.C. § 102

Claims 1-4, 7-12, 15, and 16 were rejected under 35 U.S.C. § 102(e) as being anticipated by Deane et al. (U.S. Patent No. 7,135,059). Deane et al. (US 7,135,059) discloses a portable gas fractionalization apparatus that provides oxygen rich air to a patient. The apparatus utilizes and discloses a pressure swing adsorption (PSA) process, although it does mention that vacuum swing adsorption (VSA) or vacuum pressure swing adsorption (VPSA) may be used.

Claim 1 requires that the housing contain the first, second, and third adsorbent columns. With the amendments, the housing must contain the inlet and outlet ports. Deane et al. lacks such a teaching.

Deane et al. teaches a plurality of columns 508a and 508b. There is no mention of a third column. Examiner cites 510, which is stated to be a product gas storage column in the Deane et al. specification. See col. 8, lines 24-28. Thus, 510 can not be read as a third column. Deane et al. teaches that each column 508a and 508b has its own individual housing. See col. 9, line 45 to col. 10, line 58. The housing does not contain multiple columns.

Examiner cites to 204 as a housing that meets the claim limitations. The structure cited fails to meet the language of claim 1 also. 204 is a shell that houses all components of the gas fractionalization apparatus. This corresponds to the belt and modules 104, 106, 110, 112, and 116 of the present application (See Figures 2 and 7). Further, as amended, claim 1 requires the housing contain the inlet ports and outlet ports. There is no corresponding structure in shell 204 of Deane et

al. As such, Deane et al. does not meet the claim limitations of claim 1, and the rejection thereof should be withdrawn.

Claim 10 requires that an outer casing contain a plurality of gas separation columns, and have a plurality of inlet ports and outlet ports in the casing. As previously explained, there is no such structure disclosed in Deane et al. Deane et al. teaches that each column 508a and 508b has its own individual housing 602. See col. 9, line 45 to col. 10, line 58. The housing in Deane et al. does not contain multiple or a plurality of gas separation columns as required by claim 10. (Examiner cites to 616 as the casing, but this actually refers to a spring (616) or gasket (616a and 616b). Applicant presumes that Examiner is referring to adsorbent housing 602). Similarly, in Deane et al. the inlet ports and outlet ports are not part of the housing, but of gasket 616a and 616b. This does not meet the claim language requiring the inlet ports and outlet ports to be a part of the outer casing. As such, Deane et al. does not teach each and every limitation of claim 10.

Further, the invention as claimed in the application is directed to removable cartridge for an oxygen concentrator that contains the adsorption columns. The reason for stating that the cartridge is removable stems from the fact that the adsorbent may wear over time and become less efficient in the gas separation process. Deane et al. is silent as to replacement of the adsorbent columns, whereas the current invention is directed to allow the adsorbent columns to be replaced, and hence be removable.

Conclusion

The references of record do not disclose every limitation of the independent claims, and thus independent claims 1 and 9 are allowable. Because claims 2-8 and 10-16 depend from an allowable claim, the claims also are allowable. All objections have been overcome. The present application, including pending claims 1-16, is now in condition for allowance. Notice to that effect is respectfully requested.

The Commissioner is authorized to charge any additional fees associated with this paper or credit any overpayment to the deposit account number 11-0982.

Respectfully submitted,

KINNEY & LANGE, P.A.

Date: 3-10-08

By: _____

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LB:arm

PTO/SB/06 (07-06)
Approved for use through 1/31/2007. OMB 0651-0032
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Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number	Filing Date	☐ To be Mailed
11/054,615	02/09/2005	

APPLICATION AS FILED – PART I

	(Column 1)	(Column 2)	SMALL ENTITY ☒ RATE ($)	SMALL ENTITY ☒ FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY FEE ($)
FOR	NUMBER FILED	NUMBER EXTRA					
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =		OR	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =			X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $250 ($125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	

APPLICATION AS AMENDED – PART II

AMENDMENT 03/10/2008

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE ($)	SMALL ENTITY ADDITIONAL FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	* 16	Minus	** 20	= 0	X $25 =	0	OR	X $ =	
Independent (37 CFR 1.16(h))	* 2	Minus	***3	= 0	X $105 =	0	OR	X $ =	
☐ Application Size Fee (37 CFR 1.16(s))									
☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE	0	OR	TOTAL ADD'L FEE	

AMENDMENT

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)		RATE ($)	ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =		OR	X $ =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =		OR	X $ =	
☐ Application Size Fee (37 CFR 1.16(s))									
☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.

** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".

*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".

The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

Legal Instrument Examiner:
/JACKIE A. WHITE/

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/054,615	02/09/2005	Theodore W. Jagger	V180.12-0006	8238

164 7590 12/11/2007

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EXAMINER	
ALI, SHUMAYA B	
ART UNIT	**PAPER NUMBER**
3771	

MAIL DATE	DELIVERY MODE
12/11/2007	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No.	Applicant(s)	
	11/054,615	JAGGER ET AL.	
	Examiner	Art Unit	
	Shumaya B. Ali	3771	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on 2/9/05.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) 1-16 is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) 1-16 is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☒ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on 09 February 2005 is/are: a)☐ accepted or b)☒ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date See Continuation Sheet.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____.
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

Continuation of Attachment(s) 3). Information Disclosure Statement(s) (PTO/SB/08), Paper No(s)/Mail Date :2/22/07,11/20/06,9/21/05,2/9/05.

GCE - Exhibit 1075, Page 103
GCE Gas Control Equipment Inc. v. VBOX, Inc.
IPR2023-00326

DETAILED ACTION

Claim Objections

The numbering of claims is not in accordance with 37 CFR 1.126 which requires the original numbering of the claims to be preserved throughout the prosecution. When claims are canceled, the remaining claims must not be renumbered. When new claims are presented, they must be numbered consecutively beginning with the number next following the highest numbered claims previously presented (whether entered or not).

Misnumbered claim 8 been renumbered 9. Claims 9-15 have been renumbered as 10-16.

Claims 2, 8, and 15 are objected to because of the following informalities:

with respect to claim 2, line 3, consider inserting --inlet-- before air filter; **with respect to claims 8 and 15,** line 1, consider writing out what "LiLSX" stands for since other words with different means may have the same abbreviation.

Specification

The specification is objected to as failing to provide proper antecedent basis for the claimed subject matter. See 37 CFR 1.75(d)(1) and MPEP § 608.01(o). Correction of the following is required: **"quick disconnect couplings"**.

Drawings

The drawings are objected to under 37 CFR 1.83(a). The drawings must show every feature of the invention specified in the claims. Therefore, the **means for connecting the air filter to the oxygen concentrator, means for connecting the product gas filter to the oxygen concentrator, and quick disconnect couplings** must be shown or the feature(s) canceled from the claim(s). No new matter should be entered.

Corrected drawing sheets in compliance with 37 CFR 1.121(d) are required in reply to the Office action to avoid abandonment of the application. Any amended replacement drawing sheet should include all of the figures appearing on the immediate prior version of the sheet, even if only one figure is being amended. The figure or figure number of an amended drawing should not be labeled as "amended." If a drawing figure is to be canceled, the appropriate figure must be removed from the replacement sheet, and where necessary, the remaining figures must be renumbered and appropriate changes made to the brief description of the several views of the drawings for consistency. Additional replacement sheets may be necessary to show the renumbering of the remaining figures. Each drawing sheet submitted after the filing date of an application must be labeled in the top margin as either "Replacement Sheet" or "New Sheet" pursuant to 37 CFR 1.121(d). If the changes are not accepted by the examiner, the applicant will be notified and informed of any required corrective action in the next Office action. The objection to the drawings will not be held in abeyance.

Claim Rejections - 35 USC § 112

The following is a quotation of the first paragraph of 35 U.S.C. 112:

> The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same and shall set forth the best mode contemplated by the inventor of carrying out his invention.

Claim 1-16 are rejected under 35 U.S.C. 112, first paragraph, as failing to comply with the enablement requirement. The claim(s) contains subject matter which was not described in the specification in such a way as to enable one skilled in the art to which it pertains, or with which it is most nearly connected, to make and/or use the invention.

With respect to claim 1, lines 11 and 12, it is not clear what structure connects inlet ports to the column inlets and outlet ports to the column outlets; **with respect to claim 2**, lines 3 and 4, it is not clear what structure corresponds to means for connecting the air filter to the oxygen concentrator and means for connecting the product gas filter to the oxygen concentrator; **with respect to claim 3,** line 2, it is not clear what structure connects outlet port to the product gas filter; **with respect to claim 10,** lines 7 and 8, it is not clear what structure connect inlet port to the first end of one of the columns. In each instances, specification lacks description of claimed structure which does not enable one of ordinary skill in the art to make Applicant's invention.

The following is a quotation of the second paragraph of 35 U.S.C. 112:

> The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

Claims 1-9, are rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

In claim 1, lines 11 and 12, "inlet ports connected to the column inlets; outlet ports connected to the column outlets" is indefinite. It is not clear whether the inlet and outlet ports are with respect to the housing reciting in line 10. Furthermore, it is not clear whether the claim in limiting "each" inlet ports connected to "each" of the column inlets and "each" outlet ports connected to "each" of the column outlets.

In claim 5, line 1, "the adsorbent columns" is indefinite. It is not clear whether the recitation is referring to all three adsorbent columns.

In claim 7, line 1, "the beds" is indefinite. It is not clear whether the recitation is referring to all three beds.

Claim Rejections - 35 USC § 102

The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

A person shall be entitled to a patent unless –

(e) the invention was described in (1) an application for patent, published under section 122(b), by another filed in the United States before the invention by the applicant for patent or (2) a patent granted on an application for patent by another filed in the United States before the invention by the applicant for patent, except that an international application filed under the treaty defined in section 351(a) shall have the effects for purposes of this subsection of an application filed in the United States only if the international application designated the United States and was published under Article 21(2) of such treaty in the English language.

Claims 1-4,7-12, 15, and 16 are rejected under 35 U.S.C. 102(e) as being anticipated by Deane et al. US 7,135,059 B1.

As to claim 1, Deane (in figures 1-18B) discloses a removable gas separation cartridge for use in an oxygen concentrator which separates oxygen from ambient air by using a vacuum swing absorption process, the gas separation cartridge comprising: a first adsorbent column and a first bed (508a) of adsorbent material (612); a second adsorbent column (508b) and a second bed (612) of adsorbent material; a third adsorbent column (510) and a third bed of adsorbent material (612) (Deane teaches plurals absorbents, see col.2, line 65; each bed has an inlet connected to a 120 a/b and an outlet connected to 120e/f in fig.1); the inlet and outlets for each column respectively corresponds to the top and bottom openings of each column that draw air in and out; a housing (204) for containing the first, second, and third adsorbent columns; inlet ports (port

covered by filter 618a) connected to the column inlets; outlet ports (port covered by 618b) connected to the column outlets (see fig.6).

As to claim 2, Deane discloses an inlet air filter (104); means for connecting (see lines connecting filter to the oxygen concentrator in fig.1) the air filter to the oxygen concentrator; a product gas filter (130); and means for connecting (see lines connecting product gas filter to oxygen concentrator in fig.1) the product gas filter to the oxygen concentrator; wherein the inlet air filter and product gas filter are contained within the housing (see figs.2 and 3).

As to claim 3, Deane discloses an outlet port (see lines connecting 120e at the outlet of Deane to the 124 in fig.1) connected to the product gas filter.

As to claim 4, Deane discloses the adsorbent columns each further comprise a spring (616) for retaining the adsorbent column in the housing.

As to claim 7, Deane discloses the beds of adsorbent material comprise beds of zeolite which provide preferential adsorption of nitrogen (see col.8, lines 28-30).

As to claim 8, Deane discloses the zeolite is a LiLSX adsorbent (see col.10, line 48).

As to claim 9, Deane discloses the inlet ports and outlet ports comprise quick disconnect couplings (616a, b).

As to claim 10, Deane (in figures 1-18B) discloses a removable cartridge for a portable oxygen concentrator, the cartridge comprising: an outer casing (616); a plurality of gas separation columns (508a,b) within the outer casing (see fig.6), each gas separation column containing an adsorbent material (612) that preferentially adsorbs nitrogen, a first end (corresponding end to 618a), and a second end (corresponding end to 618b); a plurality of inlet ports in the outer casing (ports covered by 618a), each inlet port connect to the first end of one of

the columns (see fig.6); and a plurality of outlet ports (ports covered by 618b) in the outer casing, each outlet port connected to the second end of one of the columns (see fig.6).

As to claim 11, Deane discloses an inlet air filter (104) within the outer casing; a port for connecting the air filter to the oxygen concentrator (see lines connecting filter to the oxygen concentrator in fig.1); a product gas filter (130) within the outer casing; and a port for connecting the product gas filter to the oxygen concentrator (see lines connecting product gas filter to oxygen concentrator in fig.1)

As to claim 12, Deane discloses the adsorbent columns each further comprise a spring (616) for retaining the adsorbent column in the housing.

As to claim 15, Deane discloses the beds of adsorbent material comprise beds of zeolite which provide preferential adsorption of nitrogen (see col.8, lines 28-30).

As to claim 16, Deane discloses the zeolite is an LiLSX adsorbent (see col.10, line 48).

Allowable Subject Matter

Claims 5, 6, 13, and 14 would be allowable if rewritten to overcome the rejection(s) under 35 U.S.C. 112, 2nd paragraph, set forth in this Office action and to include all of the limitations of the base claim and any intervening claims.

The following is a statement of reasons for the indication of allowable subject matter: **with respect to claim 5,** the prior art made of record does not teach spin inducers adjacent the inlet and outlet of the adsorption columns. W**ith respect to claim 13,** the prior art made of record does not teach spin inducers adjacent to the inlets of the adsorption columns. Claim 6 is considered allowable since it depends from claim 5. Claim 14 is considered allowable since it depends from claim 13.

Conclusion

The prior art made of record and not relied upon is considered pertinent to applicant's disclosure. Jung (5,007,293) and Jung (4, 65,061) pertain to spin inducers.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Shumaya B. Ali whose telephone number is 571-272-6088. The examiner can normally be reached on M-W-F 8:30am-5:00 pm.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Justine Yu can be reached on 571-272-4835. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

Shumaya B. Ali 12/6/07
Shumaya B. Ali
Examiner
Art Unit 3771

JUSTINE R. YU
SUPERVISORY PATENT EXAMINER
TECHNOLOGY CENTER 3700
12/8/07

FORM PTO-1449	Atty. Docket No.: V180.12-0006	Application No.: 11/054,615
LIST OF PATENTS AND PUBLICATIONS FOR APPLICANT'S INFORMATION DISCLOSURE STATEMENT	First Named Inventor: Theodore W. Jagger	
	Filing Date: February 9, 2005	Group Art: 3743

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Examiner Initials		Document No.	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Documents
/S.A./	AA	4,194,890	03-25-1980	McCombs, et al.
	AB	4,472,177	09-18-1984	Sircar
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	Foreign Patent Document	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Documents	Translation Yes No
AS				

OTHER ART (Including Author, Title, Date, Pertinent Pages, Etc.)

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EXAMINER: /Shumaya Ali/ DATE CONSIDERED: /Shumaya Ali/

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP 609; draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

FORM PTO-1449	Atty. Docket No.: V180.12-0006	Application No.:
LIST OF PATENTS AND PUBLICATIONS FOR APPLICANT'S INFORMATION DISCLOSURE STATEMENT	First Named Inventor: Theodore W. Jagger	
	Filing Date: Herewith	Group Art:

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/S.A./	BN	WO 98/58219	12-23-1998	Honkonen	Yes
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EXAMINER: /Shumaya Ali/ DATE CONSIDERED: 12/07/2007

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FORM PTO-1449	Atty. Docket No.: V180.12-0006	Application No.: 11/054,615
LIST OF PATENTS AND PUBLICATIONS FOR APPLICANT'S INFORMATION DISCLOSURE STATEMENT	First Named Inventor: Theodore W. Jagger	
	Filing Date: February 9, 2005	Group Art: 3743

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Examiner Initials		Document No.	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Documents
/S.A./	AA	US 2005/0072426 A1	04-07-2005	Deane et al.
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		Foreign Patent Document	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Documents	Translation Yes No
	AL				
	AM				
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OTHER ART (Including Author, Title, Date, Pertinent Pages, Etc.)

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FORM PTO-1449	Atty. Docket No.: V180.12-0006	Application No.: 11/054,615
LIST OF PATENTS AND PUBLICATIONS FOR APPLICANT'S INFORMATION DISCLOSURE STATEMENT	First Named Inventor: Theodore W. Jagger	
	Filing Date: February 9, 2005	Group Art: 3743

U.S. PATENT DOCUMENTS

Examiner Initials		Document No.	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Documents
/S.A./	AA	5,084,075	01-28-1992	Sircar
/S.A./	AB	6,802,889	10-12-2004	Graham et al.
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		Foreign Patent Document	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Documents	Translation Yes No
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Notice of References Cited	Application/Control No. 11/054,615	Applicant(s)/Patent Under Reexamination JAGGER ET AL.	
	Examiner Shumaya B. Ali	Art Unit 3771	Page 1 of 1

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*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-5,007,293	04-1991	Jung, Douglas B.	73/861.04
*	B	US-4,654,061	03-1987	Jung, Douglas B.	55/452
	C	US-			
	D	US-			
	E	US-			
	F	US-			
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	N					
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NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
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*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

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Bib Data Sheet

CONFIRMATION NO. 8238

SERIAL NUMBER	FILING OR 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
11/054,615	02/09/2005 RULE	128	3771	V180.12-0006

APPLICANTS

Theodore W. Jagger, White Bear Lake, MN;
Nicholas P. Van Brunt, White Bear Lake, MN;
John A. Kivisto, Oak Grove, MN;
Perry B. Lonnes, White Bear Lake, MN;

** CONTINUING DATA **********

** FOREIGN APPLICATIONS **********

IF REQUIRED, FOREIGN FILING LICENSE GRANTED ** SMALL ENTITY **
** 03/11/2005

Foreign Priority claimed	STATE OR COUNTRY	SHEETS DRAWING	TOTAL CLAIMS	INDEPENDENT CLAIMS
☐ yes ☑ no	MN	19	16	2
35 USC 119 (a-d) conditions met: ☐ yes ☑ no ☐ Met after Allowance				
Verified and Acknowledged: Examiner's Signature SA Initials				

ADDRESS
164

TITLE

Adsorbent cartridge for oxygen concentrator

FILING FEE RECEIVED		
565	FEES: Authority has been given in Paper No. _____ to charge/credit DEPOSIT ACCOUNT No. _____ for following:	☐ All Fees ☐ 1.16 Fees (Filing) ☐ 1.17 Fees (Processing Ext. of time) ☐ 1.18 Fees (Issue) ☐ Other _____ ☐ Credit

GCE - Exhibit 1075, Page 117
GCE Gas Control Equipment Inc. v. VBOX, Inc.
IPR2023-00326

Index of Claims

Application/Control No.	Applicant(s)/Patent under Reexamination
11/054,615	JAGGER ET AL.
Examiner	**Art Unit**
Shumaya B. Ali	3771

√	Rejected	–	(Through numeral) Cancelled	N	Non-Elected	A	Appeal
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Claim		Date
Final	Original	12/7/07
	1	√
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IPR2023-00326

Search Notes	Application/Control No.	Applicant(s)/Patent under Reexamination
	11/054,615	JAGGER ET AL.
	Examiner	Art Unit
	Shumaya B. Ali	3771

SEARCHED			
Class	Subclass	Date	Examiner
95	96-106 130 115 128 133	12/5/2007	SA
95	144	12/5/2007	SA
95	145	12/5/2007	SA
95	147	12/5/2007	SA
55	356	8/13/2007	SA
55	357	8/13/2007	SA
55	516-518	8/13/2007	SA
128	201.25	8/13/2007	SA
128	202.26	8/13/2007	SA
128	204.17	8/13/2007	SA
128	204.22	8/13/2007	SA
128	205.11	8/13/2007	SA
128	205.12	8/13/2007	SA
128	205.18	8/13/2007	SA

INTERFERENCE SEARCHED			
Class	Subclass	Date	Examiner

SEARCH NOTES (INCLUDING SEARCH STRATEGY)		
	DATE	EXMR
performed EAST word search	8/13/2007	SA
performed inventor name search	8/13/2007	SA
consulted class 55 search with Examiner Joseph Drodge	8/13/2007	SA
consulted class 95 search with Examiner Robert Hopkins	12/5/2007	SA

Search Notes (continued)	Application/Control No.	Applicant(s)/Patent under Reexamination
	11/054,615	JAGGER ET AL.
	Examiner	Art Unit
	Shumaya B. Ali	3771

SEARCHED			
Class	Subclass	Date	Examiner
128	201.26	8/13/2007	SA

INTERFERENCE SEARCHED			
Class	Subclass	Date	Examiner

SEARCH NOTES (INCLUDING SEARCH STRATEGY)		
	DATE	EXMR

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GCE Gas Control Equipment Inc. v. VBOX, Inc.
IPR2023-00326

EAST Search History

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L9	1	"55"/$.ccls. and spin and inducer	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2007/12/06 18:44
L10	0	"95"/$.ccls. and spin and inducer	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2007/12/06 18:42
L11	10	spin adj inducer	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2007/12/06 18:44
S1	2	filter and cartidge and concentrator	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2007/08/13 12:29
S2	436	oxygen and filter and absor$3 and bed and column and concentrator	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2007/08/13 12:30
S3	10	"spin inducer"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2007/08/13 12:37
S4	6	removable same gas same oxygen same concentrator	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2007/08/13 12:32

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EAST Search History

S5	7	filter and cartidge and spin	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2007/08/13 12:39
S6	2	("6346139").PN.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2007/09/28 04:44
S7	3439	((95/130) or (96/115) or (96/128) or (96/130) or (96/133) or (96/144) or (96/147) or (55/356) or (55/357)).CCLS.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2007/08/13 12:42
S8	1280	S7 and adsorbent	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2007/08/13 12:43
S9	708	S7 and adsorbent and oxygen	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2007/08/13 12:58

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EAST Search History

S10	43	("20050072426" | "4491459" | "4648888" | "4813977" | "4826510" | "4925464" | "4971609" | "5366541" | "5531807" | "5593478" | "5730778" | "5827358" | "5858062" | "5893275" | "5893944" | "5928189" | "5979440" | "6162283" | "6212904" | "6217635" | "6287366" | "6302107" | "6311719" | "6314957" | "6346139" | "6446630" | "6457485" | "6471744" | "6478857" | "6511526" | "6520176" | "6551384" | "6629525" | "6641644" | "6651653" | "6651658" | "6681764" | "6691702" | "6698423" | "6712087" | "6764534" | "7066985" | "RE35099").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2007/12/05 18:20
S11	10586	((96/108) or (96/115) or (96/117) or (96/126-128) or (96/130-135) or (96/137) or (96/147) or (96/142-144) or (96/149) or (96/153) or (96/154) or (55/356) or (55/357) or (55/516-518) or (55/523) or (128/201.25) or (128/202.26) or (128/204.17) or (128/204.22) or (128/205.11) or (128/205.12) or (128/205.18) or (128/201.26)).CCLS.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2007/08/13 13:05
S12	2710	S11 and oxygen	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2007/08/13 13:05
S13	1228	S11 and oxygen and filter	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2007/08/13 13:15
S14	261	S11 and oxygen and filter and concentra$3	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2007/08/13 13:15

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GCE Gas Control Equipment Inc. v. VBOX, Inc.
IPR2023-00326

EAST Search History

S15	161	("20020053286" | "20020121191" | "20030024531" | "20030167924" | "20030192431" | "20040020366" | "20040074496" | "20050072298" | "20050072423" | "20050072426" | "2195565" | "2728407" | "2798718" | "2944627" | "3258899" | "3323292" | "3406501" | "3703068" | "3730158" | "3880616" | "3922149" | "3976050" | "4054133" | "4070164" | "4077779" | "4146277" | "4222750" | "4247311" | "4302224" | "4303419" | "4342573" | "4371384" | "4373938" | "4378982" | "4381002" | "4428372" | "4449990" | "4462398" | "4482361" | "4491459" | "4496376" | "4502873" | "4509959" | "4511377" | "4516424" | "4534346" | "4584996" | "4681099" | "4686974" | "4698075" | "4706664" | "4744803" | "4770678" | "4783205" | "4802899" | "4826510" | "4877429" | "4892566" | "4895808" | "4925464" | "4971609" | "5002591" | "5004485" | "5005570" | "5032150" | "5071453" | "5112367" | "5114441" | "5144945" | "5154737" | "5226933" | "5268021" | "5275642" | "5366541" | "5427609" | "5466134" | "5474595" | "5495848" | "5496388" | "5531807" | "5549736" | "5558086" | "5578115" | "5593478" | "5603315" | "5611845" | "5626131" | "5630411" | "5632612" | "5658371" | "5665316" | "5697364" | "5730778" | "5735268" | "5746806" | "5752816" | "5755224" | "5759020" | "5827358" | "5839434" | "5865174" | "5871564" | "5881725" | "5890490" | "5906672" | "5912426" | "5917135" | "5928189" | "5968236" | "5979440" | "5997617" | "6033457" | "6036754" | "6050792" | "6068680" | "6077331" | "6129530" | "6146447" | "6152134" | "6176897" | "6178772").PN. OR ("6186142" | "6190441" | "6192884" | "6220244" | "6269811" | "6299670" | "6311719" | "6342090" | "6346139" | "6348082" | "6371114" | "6372026" | "6395065" | "6427690" | "6439864" | "6457485" | "6478850" | "6497755" | "6511308" | "6520176" | "6532957" | "6532958" | "6551384" | "6558451"	US-PGPUB; USPAT; USOCR	OR	OFF	2007/08/13 13:18

EAST Search History

S16	161	("20020053286" | "20020121191" | "20030024531" | "20030167924" | "20030192431" | "20040020366" | "20040074496" | "20050072298" | "20050072423" | "20050072426" | "2195565" | "2728407" | "2798718" | "2944627" | "3258899" | "3323292" | "3406501" | "3703068" | "3730158" | "3880616" | "3922149" | "3976050" | "4054133" | "4070164" | "4077779" | "4146277" | "4222750" | "4247311" | "4302224" | "4303419" | "4342573" | "4371384" | "4373938" | "4378982" | "4381002" | "4428372" | "4449990" | "4462398" | "4482361" | "4491459" | "4496376" | "4502873" | "4509959" | "4511377" | "4516424" | "4534346" | "4584996" | "4681099" | "4686974" | "4698075" | "4706664" | "4744803" | "4770678" | "4783205" | "4802899" | "4826510" | "4877429" | "4892566" | "4895808" | "4925464" | "4971609" | "5002591" | "5004485" | "5005570" | "5032150" | "5071453" | "5112367" | "5114441" | "5144945" | "5154737" | "5226933" | "5268021" | "5275642" | "5366541" | "5427609" | "5466134" | "5474595" | "5495848" | "5496388" | "5531807" | "5549736" | "5558086" | "5578115" | "5593478" | "5603315" | "5611845" | "5626131" | "5630411" | "5632612" | "5658371" | "5665316" | "5697364" | "5730778" | "5735268" | "5746806" | "5752816" | "5755224" | "5759020" | "5827358" | "5839434" | "5865174" | "5871564" | "5881725" | "5890490" | "5906672" | "5912426" | "5917135" | "5928189" | "5968236" | "5979440" | "5997617" | "6033457" | "6036754" | "6050792" | "6068680" | "6077331" | "6129530" | "6146447" | "6152134" | "6176897" | "6178772").PN. OR ("6186142" | "6190441" | "6192884" | "6220244" | "6269811" | "6299670" | "6311719" | "6342090" | "6346139" | "6348082" | "6371114" | "6372026" | "6395065" | "6427690" | "6439864" | "6457485" | "6478850" | "6497755" | "6511308" | "6520176" | "6532957" | "6532958" | "6551384" | "6558451"	US-PGPUB; USPAT; USOCR	OR	OFF	2007/08/13 13:18

EAST Search History

S17	44	("0928978" | "1593137" | "2101555" | "2665816" | "3186148" | "3258899" | "3323288" | "3324631" | "3849089" | "4065272" | "4302224" | "4428372" | "4496376" | "4559065" | "4576616" | "4584001" | "4631073" | "4802899" | "4822384" | "4826510" | "4892566" | "4894072" | "4925464" | "4932546" | "4973339" | "5112367" | "5114441" | "5183483" | "5268021" | "5474595" | "5531807" | "5549736" | "5578115" | "5593480" | "5827354" | "5997617").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2007/08/13 13:20
S18	23	("2625237" | "3155471" | "3164452" | "3258899" | "3304623" | "3323291" | "3507097" | "3543482" | "3922149" | "4231768" | "4272265" | "4302224" | "4342573" | "4373938" | "4378982").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2007/08/13 13:28
S19	2621	((96/121) or (96/133) or (96/134) or (96/136) or (96/138) or (96/149) or (96/139,152) or (95/130)).CCLS.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2007/08/13 13:49
S20	1618	product and porous and filter and oxygen and absorbent and column	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2007/08/16 19:21
S21	830	concentra$3 and gas and separation and product and porous and filter and oxygen and absorbent and column	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2007/08/16 19:25
S22	0	"spin inducer" and filter and concentrator	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2007/09/28 04:21

EAST Search History

S23	10	"spin inducer"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2007/09/28 04:29
S24	25626	filter with fan	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2007/09/28 04:29
S25	0	filter with fan and absorbtion and bed and product adj filter	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2007/09/28 04:30
S26	19	zeolite and filter and LiLSX	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2007/09/28 04:32
S27	167	"oxygen concentrator" and fan	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2007/09/28 04:35
S28	4988	"96"/$.ccls. and fan	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2007/09/28 04:35
S29	2899	"96"/$.ccls. and fan and filter	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2007/09/28 04:35

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IPR2023-00326

EAST Search History

S30	1420	"96"/$.ccls. and fan with filter	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2007/09/28 04:36
S31	88	"96"/$.ccls. and fan with filter and absorbent	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2007/09/28 04:38
S32	1420	"96"/$.ccls. and filter with fan	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2007/09/28 04:39
S33	111	"96"/$.ccls. and filter with fan and adsorbent	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2007/09/28 04:40
S34	505	((96/139) or (96/152)).CCLS.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2007/09/28 04:47
S35	135	S34 and filter and gas	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2007/09/28 04:47
S36	118	S34 and filter and gas and air	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2007/09/28 04:47

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GCE Gas Control Equipment Inc. v. VBOX, Inc.
IPR2023-00326

EAST Search History

S37	1233	oxygen and concentrator and inlet and outlet	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2007/12/05 03:23
S38	731	oxygen and concentrator and inlet and outlet and filter	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2007/12/05 03:31
S39	0	oxygen and concentrator and inlet and outlet and filter and coloum	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2007/12/05 03:32
S40	53	oxygen and concentrator and inlet and outlet and filter and column and sieve	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2007/12/05 03:33
S41	3	"absorbent column" and housing and port	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2007/12/05 03:34
S42	264	"absorbent column"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2007/12/05 03:37
S43	67	oxygen and concentrator and absorbent and bed and inlet and outlet	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2007/12/05 03:40

GCE - Exhibit 1075, Page 129
GCE Gas Control Equipment Inc. v. VBOX, Inc.
IPR2023-00326

EAST Search History

S44	460	((96/109,128/205.12,128/205.27, 55/356,96/115,96/121) or (,96/147, 96/384)).CCLS.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2007/12/05 03:40
S45	24	("20020066371" | "20030213368" | "20050166921" | "20050204923" | "2184481" | "2572009" | "3736074" | "4302224" | "4342573" | "4511377" | "4560395" | "4786299" | "4810269" | "5871564" | "6174342" | "6447586" | "6494940" | "6558451" | "6764534" | "6866700" | "6908503" | "6949133").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2007/12/05 03:41
S46	46	("20020053286" | "20040020366" | "20040149133" | "20050072426" | "4491459" | "4648888" | "4813977" | "4826510" | "4925464" | "4971609" | "5531807" | "5593478" | "5730778" | "5827358" | "5858062" | "5893275" | "5893944" | "5928189" | "5979440" | "6212904" | "6287366" | "6302107" | "6311719" | "6314957" | "6346139" | "6446630" | "6457485" | "6471744" | "6478857" | "6511526" | "6520176" | "6551384" | "6629525" | "6641644" | "6651653" | "6651658" | "6681764" | "6691702" | "6698423" | "6712087" | "6764534" | "6805729" | "6811590" | "6866041" | "7066985" | "RE35099").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2007/12/05 03:47
S47	4529	oxygen and concentrator	US-PGPUB; USPAT; USOCR	OR	OFF	2007/12/05 18:29
S48	36	oxygen and concentrator and housing and filter and swing and absorption	US-PGPUB; USPAT; USOCR	OR	OFF	2007/12/05 18:21
S49	793	oxygen and concentrator and absorption	USPAT	OR	OFF	2007/12/05 18:22
S50	2898	((95/96-106) or (95/130) or (96/115) or (96/128) or (96/130) or (96/133) or (96/144) or (96/145) or (96/147) or (55/356) or (55/357)). CCLS.	USPAT	OR	OFF	2007/12/05 18:30

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GCE Gas Control Equipment Inc. v. VBOX, Inc.
IPR2023-00326

EAST Search History

S51	161	("20020053286" | "20020121191" | "20030024531" | "20030167924" | "20030192431" | "20040020366" | "20040074496" | "20050072298" | "20050072423" | "20050072426" | "2195565" | "2728407" | "2798718" | "2944627" | "3258899" | "3323292" | "3406501" | "3703068" | "3730158" | "3880616" | "3922149" | "3976050" | "4054133" | "4070164" | "4077779" | "4146277" | "4222750" | "4247311" | "4302224" | "4303419" | "4342573" | "4371384" | "4373938" | "4378982" | "4381002" | "4428372" | "4449990" | "4462398" | "4482361" | "4491459" | "4496376" | "4502873" | "4509959" | "4511377" | "4516424" | "4534346" | "4584996" | "4681099" | "4686974" | "4698075" | "4706664" | "4744803" | "4770678" | "4783205" | "4802899" | "4826510" | "4877429" | "4892566" | "4895808" | "4925464" | "4971609" | "5002591" | "5004485" | "5005570" | "5032150" | "5071453" | "5112367" | "5114441" | "5144945" | "5154737" | "5226933" | "5268021" | "5275642" | "5366541" | "5427609" | "5466134" | "5474595" | "5495848" | "5496388" | "5531807" | "5549736" | "5558086" | "5578115" | "5593478" | "5603315" | "5611845" | "5626131" | "5630411" | "5632612" | "5658371" | "5665316" | "5697364" | "5730778" | "5735268" | "5746806" | "5752816" | "5755224" | "5759020" | "5827358" | "5839434" | "5865174" | "5871564" | "5881725" | "5890490" | "5906672" | "5912426" | "5917135" | "5928189" | "5968236" | "5979440" | "5997617" | "6033457" | "6036754" | "6050792" | "6068680" | "6077331" | "6129530" | "6146447" | "6152134" | "6176897" | "6178772").PN. OR ("6186142" | "6190441" | "6192884" | "6220244" | "6269811" | "6299670" | "6311719" | "6342090" | "6346139" | "6348082" | "6371114" | "6372026" | "6395065" | "6427690" | "6439864" | "6457485" | "6478850" | "6497755" | "6511308" | "6520176" | "6532957" | "6532958" | "6551384" | "6558451"	US-PGPUB; USPAT; USOCR	OR	OFF	2007/12/05 18:37

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GCE Gas Control Equipment Inc. v. VBOX, Inc.
IPR2023-00326

EAST Search History

S52	934	((95/96,128/205.12,128/205.27, 55/356,95/130,96/115) or (,96/130, 96/143,96/153)).CCLS.	USPAT	OR	OFF	2007/12/05 18:40

OIPE
FEB 22 2007
PATENT & TRADEMARK OFFICE
IAP19

IFW

First Named Inventor	:	Theodore W. Jagger	
Appln. No.	:	11/054,615	
Filed	:	February 9, 2005	Group Art Unit: 3743
Title	:	ABSORBENT CARTRIDGE FOR OXYGEN CONCENTRATOR	Examiner:
Docket No.	:	V180.12-0006	

THIRD SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT

Commissioner For Patents
P.O. Box 1450
Alexandria, VA 22313-1450

I CERTIFY THAT THIS PAPER IS BEING SENT BY U.S. MAIL, FIRST CLASS, TO THE COMMISSIONER FOR PATENTS, ALEXANDRIA, VA 22313, THIS 20th DAY OF February, 2007.

PATENT ATTORNEY

The enclosed PTO Form-1449 lists patents and publications submitted pursuant to 37 C.F.R. 1.97. Copies of the patents or publications are enclosed as necessary.

TIME OF FILING

The Information Disclosure Statement is being filed:

1. X with the application or within three months of the filing date of a national application (other than a continued prosecution application under 37 C.F.R. 1.53(d)) or date of entry into the national stage of an international application or, to the best of the undersigned's knowledge, before the mailing date of a first Office action on the merits or a first office action after the filing of a request for continued examination under 37 C.F.R. 1.114, whichever event occurs last. In accordance with 37 C.F.R. 1.97(b), no certification or fee is required.

Respectfully submitted,

KINNEY & LANGE, P.A.

By: _____
Larrin Bergman, Reg. No. 57,153
THE KINNEY & LANGE BUILDING
312 South Third Street
Minneapolis, MN 55415-1002
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LB:arm

OIPE
FEB 22 2007
PATENT & TRADEMARK OFFICE

FORM PTO-1449	Atty. Docket No.: V180.12-0006	Application No.: 11/054,615
LIST OF PATENTS AND PUBLICATIONS FOR APPLICANT'S INFORMATION DISCLOSURE STATEMENT	First Named Inventor: Theodore W. Jagger	
	Filing Date: February 9, 2005	Group Art: 3743

U.S. PATENT DOCUMENTS

Examiner Initials		Document No.	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Documents
	AA	5,084,075	01-28-1992	Sircar
	AB	6,802,889	10-12-2004	Graham et al.
	AC			
	AD			
	AE			
	AF			
	AG			
	AH			
	AI			
	AJ			
	AK			

FOREIGN PATENT DOCUMENTS

		Foreign Patent Document	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Documents	Translation Yes No
	AL				
	AM				
	AN				

OTHER ART (Including Author, Title, Date, Pertinent Pages, Etc.)

	AO	
	AP	
	AQ	

EXAMINER: DATE CONSIDERED:

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP 609; draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

OIPE IAP95
NOV 20 2006
PATENT & TRADEMARK OFFICE

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

First Named Inventor	:	Theodore W. Jagger	
Appln. No.	:	11/054,615	
Filed	:	February 9, 2005	Group Art Unit: 3743
Title	:	ADSORBENT CARTRIDGE FOR OXYGEN CONCENTRATOR	Examiner:
Docket No.	:	V180.12-0006	

STATUS INQUIRY

Commissioner For Patents
P.O. Box 1450
Alexandria, VA 22313-1450

I CERTIFY THAT THIS PAPER IS BEING SENT BY U.S. MAIL, FIRST CLASS, TO THE ASSISTANT COMMISSIONER FOR PATENTS, ALEXANDRIA, VA 22313, **THIS 17TH DAY OF NOVEMBER, 2006.**

PATENT ATTORNEY

More than 21 months have passed since the filing of this application on February 9, 2005.

No further communication has been received from the Patent and Trademark Office. Kindly advise the undersigned of the present status of this application by checking the appropriate boxes below and providing the information requested.

STATUS INQUIRY REPLY

Application No. 11/054,615 is currently assigned to Group 3743

☐ Action by the Examiner is expected by _____

☐ An office action was mailed on _____

Respectfully submitted,
KINNEY & LANGE, P.A.

By: _____

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LB:kmm

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IAP95
NOV 20 2006
PATENT & TRADEMARK OFFICE

IFW

First Named Inventor	:	Theodore W. Jagger	
Appln. No.	:	11/054,615	
Filed	:	February 9, 2005	Group Art Unit: 3743
Title	:	ADSORBENT CARTRIDGE FOR OXYGEN CONCENTRATOR	Examiner:
Docket No.	:	V180.12-0006	

SECOND SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT

Commissioner For Patents
P.O. Box 1450
Alexandria, VA 22313-1450

I CERTIFY THAT THIS PAPER IS BEING SENT BY U.S. MAIL, FIRST CLASS, TO THE COMMISSIONER FOR PATENTS, ALEXANDRIA, VA 22313, **THIS 17TH DAY OF NOVEMBER, 2006.**

PATENT ATTORNEY

The enclosed PTO Form-1449 lists patents and publications submitted pursuant to 37 C.F.R. 1.97. Copies of the patents or publications are enclosed as necessary.

TIME OF FILING

The Information Disclosure Statement is being filed:

1. X with the application or within three months of the filing date of a national application (other than a continued prosecution application under 37 C.F.R. 1.53(d)) or date of entry into the national stage of an international application or, to the best of the undersigned's knowledge, before the mailing date of a first Office action on the merits or a first office action after the filing of a request for continued examination under 37 C.F.R. 1.114, whichever event occurs last. In accordance with 37 C.F.R. 1.97(b), no certification or fee is required.

Respectfully submitted,

KINNEY & LANGE, P.A.

By: _____

Larrin Bergman, Reg. No. 57,153
THE KINNEY & LANGE BUILDING
312 South Third Street
Minneapolis, MN 55415-1002
Telephone: (612) 339-1863
Fax: (612) 339-6580

LB:bmg

FORM PTO-1449	Atty. Docket No.: V180.12-0006	Application No.: 11/054,615
LIST OF PATENTS AND PUBLICATIONS FOR APPLICANT'S INFORMATION DISCLOSURE STATEMENT	First Named Inventor: Theodore W. Jagger	
	Filing Date: February 9, 2005	Group Art: 3743

OIPE NOV 20 2006 IAP9 PATENT & TRADEMARK OFFICE

U.S. PATENT DOCUMENTS

Examiner Initials		Document No.	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Documents
	AA	4,194,890	03-25-1980	McCombs, et al.
	AB	4,472,177	09-18-1984	Sircar
	AC	5,366,541	11-22-1994	Hill, et al.
	AD	5,429,666	07-04-1995	Agrawal, et al.
	AE	5,656,066	08-12-1997	Reiss, et al.
	AF	6,162,283	12-19-2000	Conrad, et al.
	AG	6,217,635	04-17-2001	Conrad, et al.
	AH	6,344,069	02-05-2002	Smolarek, et al.
	AI	6,544,318	04-08-2003	Dee, et al.
	AJ	6,712,886	03-30-2004	Kim
	AK	6,805,729	10-19-2004	Lim, et al.
	AL	6,811,590	11-02-2004	Lee, et al.
	AM	6,866,041	03-15-2005	Hardy, Jr. , et al.
	AN	7,066,985	06-27-2006	Deane, et al.
	AO	US 2002/053286 A1	05-09-2002	Czabala
	AP	US 2004/0020366 A1	02-05-2004	Walker, et al.
	AQ	US 2004/0149133 A1	08-05-2004	McCombs, et al.
	AR	US 2005/0081713 A1	04-21-2005	Lee, et al.

FOREIGN PATENT DOCUMENTS

		Foreign Patent Document	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Documents	Translation Yes No
	AS				

OTHER ART (Including Author, Title, Date, Pertinent Pages, Etc.)

	AT	

EXAMINER: DATE CONSIDERED:

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP 609; draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

OIPE IAP46
SEP 21 2005
PATENT & TRADEMARK OFFICE

IFW

First Named Inventor	:	Theodore W. Jagger	
Appln. No.	:	11/054,615	
Filed	:	February 9, 2005	Group Art Unit: 3743
Title	:	ADSORBENT CARTRIDGE FOR OXYGEN CONCENTRATOR	Examiner:
Docket No.	:	V180.12-0006	

SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT

Commissioner For Patents
P.O. Box 1450
Alexandria, VA 22313-1450

I CERTIFY THAT THIS PAPER IS BEING SENT BY U.S. MAIL, FIRST CLASS, TO THE COMMISSIONER FOR PATENTS, ALEXANDRIA, VA 22313, THIS 19th DAY OF September, 2005.

PATENT ATTORNEY

The enclosed PTO Form-1449 lists patents and publications submitted pursuant to 37 C.F.R. 1.97.

TIME OF FILING

The Information Disclosure Statement is being filed, to the best of the undersigned's knowledge, before the mailing date of a first Office action on the merits. In accordance with 37 C.F.R. 1.97(b), no certification or fee is required.

Respectfully submitted,

KINNEY & LANGE, P.A.

By: _____
Larrin Bergman, Reg. No. 57,153
THE KINNEY & LANGE BUILDING
312 South Third Street
Minneapolis, MN 55415-1002
Telephone: (612) 339-1863
Fax: (612) 339-6580

LB:bmg

OIPE IAP4
SEP 21 2005
PATENT & TRADEMARK OFFICE

FORM PTO-1449	Atty. Docket No.: V180.12-0006	Application No.: 11/054,615
LIST OF PATENTS AND PUBLICATIONS FOR APPLICANT'S INFORMATION DISCLOSURE STATEMENT	First Named Inventor: Theodore W. Jagger	
	Filing Date: February 9, 2005	Group Art: 3743

U.S. PATENT DOCUMENTS

Examiner Initials		Document No.	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Documents
	AA	US 2005/0072426 A1	04-07-2005	Deane et al.
	AB			
	AC			
	AD			
	AE			
	AF			
	AG			
	AH			
	AI			
	AJ			
	AK			

FOREIGN PATENT DOCUMENTS

		Foreign Patent Document	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Documents	Translation Yes No
	AL				
	AM				
	AN				

OTHER ART (Including Author, Title, Date, Pertinent Pages, Etc.)

	AO	
	AP	
	AQ	

EXAMINER:	DATE CONSIDERED:

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP 609; draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

03-22-05

IFW

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371 (c) DATE	FIRST NAMED APPLICANT	ATTORNEY DOCKET NUMBER
11/054,615	02/09/2005	Theodore W. Jagger	V180.12-0006

OC131
MAR 21 2005
PATENT & TRADEMARK OFFICE

CONFIRMATION NO. 8238

FORMALITIES LETTER

OC000000015457816

00164
KINNEY & LANGE, P.A.
THE KINNEY & LANGE BUILDING
312 SOUTH THIRD STREET
MINNEAPOLIS, MN 55415-1002

Date Mailed: 03/15/2005

NOTICE TO FILE MISSING PARTS OF NONPROVISIONAL APPLICATION

03/23/2005 MBERHE 00000069 11054615

01 FC:2011	150.00 OP
02 FC:2051	65.00 OP
03 FC:2111	250.00 OP
04 FC:2311	100.00 OP

FILED UNDER 37 CFR 1.53(b)

Filing Date Granted

Items Required To Avoid Abandonment:

An application number and filing date have been accorded to this application. The item(s) indicated below, however, are missing. Applicant is given **TWO MONTHS** from the date of this Notice within which to file all required items and pay any fees required below to avoid abandonment. Extensions of time may be obtained by filing a petition accompanied by the extension fee under the provisions of 37 CFR 1.136(a).

- The statutory basic filing fee is missing.
  Applicant must submit $ **150** *to complete the basic filing fee for a small entity.*
- The signature of the following inventor(s) is missing from the oath or declaration:
  Perry B. Lonnes
- To avoid abandonment, a late filing fee or oath or declaration surcharge as set forth in 37 CFR 1.16(e) of $65 for a small entity in compliance with 37 CFR 1.27, must be submitted with the missing items identified in this letter.

The applicant needs to satisfy supplemental fees problems indicated below.

The required item(s) identified below must be timely submitted to avoid abandonment:

SUMMARY OF FEES DUE:

Total additional fee(s) required for this application is **$565** for a Small Entity

- **$150** Statutory basic filing fee.
- **$65** Late oath or declaration Surcharge.

- The application search fee has not been paid. Applicant must submit **$250** to complete the search fee.
- The application examination fee has not been paid. Applicant must submit **$100** to complete the examination fee for a small entity in compliance with 37 CFR 1.27

Replies should be mailed to: Mail Stop Missing Parts
Commissioner for Patents
P.O. Box 1450
Alexandria VA 22313-1450

A copy of this notice MUST be returned with the reply.

Customer Service Center
Initial Patent Examination Division (703) 308-1202
PART 2 - COPY TO BE RETURNED WITH RESPONSE

OIPE JC131
MAR 2 1 2005
PATENT & TRADEMARK OFFICE

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

First Named Inventor	:	Theodore W. Jagger
Appln. No.	:	11/054,615
Filed	:	February 9, 2005
Title	:	ADSORBENT CARTRIDGE FOR OXYGEN CONCENTRATOR
Docket No.	:	V180.12-0006

RESPONSE TO NOTICE TO FILE MISSING PARTS OF APPLICATION - FILING DATE GRANTED UNDER 37 C.F.R. 1.53(f) AND 1.16(e)

Mail Stop Missing Parts
Commissioner For Patents
P.O. Box 1450
Alexandria, VA 22313-1450

SENT VIA EXPRESS MAIL
Express Mail No.: EV 485710790 US

In response to the Notice to File Missing Parts of Application - Filing Date Granted dated March 15, 2005, Applicant encloses the following documents to complete the above-identified patent application filed February 9, 2005:

1. A check in the amount of $565.00 to cover the filing fee of $500.00and surcharge fee of $65.00, and a check in the amount of $40.00 covering the recording fee;
2. Fee Transmittal (in duplicate);
3. Declaration executed by the inventor(s);
4. Power of Attorney;
5. Executed Assignment of the invention to Vbox, Incorporated , and Recordation Form Cover Sheet;
6. Submission Under 37 C.F.R.3.73(b) with copy of Assignment attached;
7. Notice to File Missing Parts of Application-Filing Date Granted;
8. Preliminary Amendment; and

9. Return receipt postcard.

The Commissioner is authorized to charge payment of any additional fees associated with this paper or credit any overpayment to Deposit Account No. 11-0982. A duplicate copy of this sheet is enclosed.

Respectfully submitted,

KINNEY & LANGE, P.A.

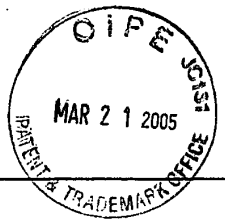
Date: 3/21/05

By: _____

David R. Fairbairn, Reg. No. 26,047
THE KINNEY & LANGE BUILDING
312 South Third Street
Minneapolis, MN 55415-1002
Telephone: (612) 339-1863
Fax: (612) 339-6580

DRF:LB:bmg

FEE TRANSMITTAL



Total Amount of Payment $605.00

Complete if Known	
Application No.	11/054,615
Filing Date	February 9, 2005
First Named Inventor	Theodore W. Jagger
Group Art Unit	
Examiner Name	
Atty. Docket Number	V180.12-0006

METHOD OF PAYMENT (Check One)

1. [X] The Commissioner is hereby authorized to charge any additional fee required under 37 C.F.R. 1.16 and 1.17 and credit any over payments to Deposit Account No.11-0982. Deposit Account Name: Kinney & Lange, P.A. A duplicate copy of this communication is enclosed.

2. [X] Check Enclosed

FEE CALCULATION

1. BASIC FILING FEE

Appn. Type PD.	FILING FEE FEE/SMALL	SEARCH FEES FEE/SMALL	EXAM FEES FEE/SMALL	FEES
Utility	300 / 150	500 / 250	200 / 100	500
Design	200 / 100	100 / 50	130 / 65	—
Reissue	300 / 150	500 / 250	600 / 300	—
Provisional	200 / 100	-0- / -0-	-0- / -0-	—

Subtotal (1) $500.00

2. EXTRA CLAIM FEES

	Number Claims		Prior**		Extra		Fee from Fee Paid Below
Total	15	-	20	=	0	x	25 = 0
Indep.	2	-	3	=	0	x	100 = 0
Multiple Dependent Claims							* = *

**Insert 3 and 20, or number previously paid if greater; Reissue see below

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Description
1202	50	2202	25	Claims in excess of 20
1201	200	2201	100	Independent claims in excess of 3
1203	360	2203	180	Multiple Dependent Claim
1204	200	2204	100	Reissue Independent Claims Over Original Patent
1205	50	2205	25	Reissue claims in excess of 20 and over original patent

Subtotal (2) $0.00

FEE CALCULATION (Continued)

3. ADDITIONAL FEES

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee paid
1051	130	2051	65	Surcharge - Late filing fee or oath	65
1052	50	2052	25	Surcharge - late provisional filing fee or cover sheet	*
1053	130	1053	130	Non-English specification	*
1812	2,520	1812	2,520	For Filing a Request for Reexamination	*
1251	120	2251	60	Extension for reply within first month	*
1252	450	2252	225	Extension for reply within second month	*
1253	1,020	2253	510	Extension for reply within third month	*
1254	1,590	2254	795	Extension for reply within fourth month	*
1255	2,160	2255	1,080	Extension for reply within fifth month	*
1402	500	2402	250	Filing a brief in support of an appeal	*
1403	1,000	2403	500	Request for oral hearing	*
1814	130	2814	65	Terminal Disclaimer Fee	*
1452	500	2452	250	Petition to revive - unavoidable	*
1453	1,500	2453	750	Petition to revive - unintentional	*
1501	1,400	2501	700	Utility/Reissue issue fee	*
1502	800	2502	400	Design issue fee	*
1460	130	1460	130	Petitions to the Commissioner	*
1807	50	1807	50	Petitions related to provisional applications	*
1806	180	1806	180	Submission of Information Disclosure Statement	*
8021	40	8021	40	Recording each patent assignment per property (times number of properties)	40
1801	790	2801	395	Request for Continued Examination (RCE)	*
Other fee (specify) _____					*

Subtotal (3) $105.00

Signature _____ Reg. No. 26,047

David R. Fairbairn

Date 3/21/05 Deposit Account No. 11-0982

OIPE JC131
MAR 2 1 2005
PATENT & TRADEMARK OFFICE

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

First Named Inventor	:	Theodore W. Jagger	
Appln. No.	:	11/054,615	
Filed	:	February 9, 2005	Group Art Unit: 3743
Title	:	ADSORBENT CARTRIDGE FOR OXYGEN CONCENTRATOR	Examiner:
Docket No.	:	V180.12-0006	

PRELIMINARY AMENDMENT

Mail Stop Amendment
Commissioner For Patents
P.O. Box 1450
Alexandria, VA 22313-1450

SENT VIA EXPRESS MAIL

Express Mail No.: EV 485710790 US

INTRODUCTION

Prior to an Examiner's first Action in the above-identified application, please enter the following amendments:

AMENDMENTS TO THE SPECIFICATION

Please replace the paragraph at page 1, lines 3-18 with the following paragraph:

Reference is hereby made to the following co-pending applications, which were filed on even date with the present application: "Ambulatory Oxygen Concentrator Containing a Power Pack", Theodore W. Jagger et al., Application No. 11/054,622; "Ambulatory Oxygen Concentrator Containing a Three Phase Vacuum Separation Process", Theodore W. Jagger et al., Application No. 11/054,340; "Personal Oxygen Concentrator", Theodore W. Jagger et al., Application No. 11/054,713; "Method of Providing Ambulatory Oxygen", Theodore W. Jagger et al., Application No. 11/054,341; "Low Power Ambulatory Oxygen Concentrator", Theodore W. Jagger et al., Application No. 11/054,716; "Ambulatory Oxygen Concentrator With High Efficiency Adsorbent", Theodore W. Jagger et al., Application No. 11/054,367; "Portable Oxygen Concentrator With a Docking Station", Theodore W. Jagger et al., Application No. 11/054,714; "Method of Controlling the Rate of Oxygen Produced by an Oxygen Concentrator", Theodore W. Jagger et al., Application No. 11/054,342; "Product Pump for an Oxygen Concentrator", Theodore W. Jagger et al., Application No. 11/054,512; and "Method and Apparatus for Controlling the Purity of Oxygen Produced by an Oxygen Concentrator", Theodore W. Jagger et al., Application No. 11/054,368.



DECLARATION FOR UTILITY PATENT APPLICATION (37 C.F.R. 1.63)		Attorney Docket No.	V180.12-0006
		First Named Inventor	Theodore W. Jagger
		COMPLETE IF KNOWN	
X Declaration Submitted with Initial Filing	Declaration Submitted after Initial Filing (Surcharge (37 C.F.R. 1.16(e)) Required)	Application Number	
		Filing Date	Herewith
		Group Art Unit	
		Examiner Name	

As a below named inventor, I hereby declare that my residence, post office address, and citizenship are as stated below.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:
ADSORBENT CARTRIDGE FOR OXYGEN CONCENTRATOR

the specification of which:

X is attached hereto OR

was filed on as United States Application Number or PCT International Application Number and was amended on (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment specifically referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 C.F.R. 1.56.

I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or of any PCT international application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application Number(s)	Country	Foreign Filing Date (MM/DD/YYYY)	Certified Copy Attached? Yes No

I hereby claim the benefit under 35 U.S.C. 119(e) of any United States provisional application(s) listed below.

Application Number(s)	Filing Date (MM/DD/YYYY)

I hereby claim the benefit under 35 U.S.C. 120 of any United States application(s), or 365(c) of any PCT international application designating the United States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT international application in the manner provided by the first paragraph of 35 U.S.C. 112, I acknowledge the duty to disclose information which is material to patentability as defined in 37 C.F.R. 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application.

GCE - Exhibit 1075, Page 147
GCE Gas Control Equipment Inc. v. VBOX, Inc.
IPR2023-00326

U.S. Parent Application or PCT Parent Number	Parent Filing Date (MM/DD/YYYY)	Parent Patent Number (*if applicable*)

DIRECT ALL CORRESPONDENCE TO:

Customer Number	00164
Attention	David R. Fairbairn
Telephone	(612) 339-1863
Fax	(612) 339-6580

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Sole or First Inventor:		
Given Name (First and middle (if any))		Family Name or Surname
Theodore W.		Jagger
Inventor's signature	Date:	
Residence	White Bear Lake, MN	Citizenship: U.S.A.
Mailing Address	5743 Birch Road	
City, State, Country	White Bear Lake, MN 55110, U.S.A.	

Second Inventor:		
Given Name (First and middle (if any))		Family Name or Surname
Nicholas P.		Van Brunt
Inventor's signature	Date:	
Residence	White Bear Lake, MN	Citizenship: U.S.A.
Mailing Address	One Bald Eagle Island	
City, State, Country	White Bear Lake, MN 55110, U.S.A.	

GCE - Exhibit 1075, Page 148
GCE Gas Control Equipment Inc. v. VBOX, Inc.
IPR2023-00326

Third Inventor:		
Given Name (First and middle (if any))		Family Name or Surname
John A.		Kivisto
Inventor's signature	Date:	
Residence	Oak Grove, MN	Citizenship: U.S.A.
Mailing Address	3367 221st Avenue NW	
City, State, Country	Oak Grove, MN 55303, U.S.A.	

Fourth Inventor:		
Given Name (First and middle (if any))		Family Name or Surname
Perry B.		Lonnes
Inventor's signature	Perry B Lonnes	Date: 2-11-05
Residence	White Bear Lake, MN	Citizenship: U.S.A.
Mailing Address	5300 East Bald Eagle Blvd.	
City, State, Country	White Bear Lake, MN 55110, U.S.A.	

GCE - Exhibit 1075, Page 149
GCE Gas Control Equipment Inc. v. VBOX, Inc.
IPR2023-00326

POWER OF ATTORNEY

Attorney Docket No.

V180.12-0006



First Named Inventor : Theodore W. Jagger

Title : ADSORBENT CARTRIDGE FOR OXYGEN CONCENTRATOR

In the patent application:

X identified above (and submitted to the Patent and Trademark Office herewith).

_ filed on _____ as Application No. _____.

I appoint the attorneys and agents associated with Customer Number 00164 to prosecute the patent application identified above and to transact all business in the Patent and Trademark Office connected therewith, including full power of association, substitution and revocation.

I ratify all prior actions taken by Kinney & Lange, P.A. or the attorneys and agents mentioned above in connection with the prosecution of the above-mentioned patent application.

I authorize Kinney & Lange, P.A. to mark the appropriate space above and to insert the filing date and application number of the application, as appropriate.

I authorize the attorneys and agents named herein to accept and follow instructions from David R. Fairbairn as to any action to be taken in the Patent and Trademark Office regarding this application without direct communication between the attorneys and agents and the undersigned. In the event of a change in the persons from whom instructions may be taken, the attorneys and agents named herein will be so notified by the undersigned.

Please address all correspondence and telephone calls to **Customer Number 00164**, attention David R. Fairbairn, Telephone (612) 339-1863, Fax (612) 339-6580.

VBOX, INCORPORATED

Signature: Nicholas P. Van Brunt Dated: 2-28-05

Nicholas P. Van Brunt

Title: President

OIPE JC131
MAR 21 2005
PATENT & TRADEMARK OFFICE

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

First Named Inventor	:	Theodore W. Jagger	
Appln. No.	:		
Filed	:	Herewith	Group Art Unit:
Title	:	ADSORBENT CARTRIDGE FOR OXYGEN CONCENTRATOR	Examiner:
Docket No.	:	V180.12-0006	

SUBMISSION UNDER 37 C.F.R. 3.73(b)

Commissioner For Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Vbox, Incorporated, a Minnesota company, is an owner of the patent application identified above by virtue of either:

A. [X] An assignment from the inventor(s) of the patent application identified above. The assignment was recorded in the Patent and Trademark Office at Reel _, Frame __, or a copy of which is attached.

OR

B. [ ] A chain of title from the inventor(s), of the patent application identified above, to the current assignee as shown below:

1. From:_____ To:_____
The document was recorded in the Patent and Trademark Office at Reel_____, Frame_____, or a copy of which is attached.

2. From:_____ To:_____
The document was recorded in the Patent and Trademark Office at Reel_____, Frame_____, or a copy of which is attached.

3. From:_____ To:_____
The document was recorded in the Patent and Trademark Office at Reel_____, Frame_____, or a copy of which is attached.

The undersigned (whose title is supplied below) is authorized to act on behalf of the assignee.

Signature: Nicholas P. Van Brunt Date: 2-28-05

Nicholas P. Van Brunt

Title: President

ASSIGNMENT

Attorney Docket No.

V180.12-0006

First Named Inventor : Theodore W. Jagger

Title : ADSORBENT CARTRIDGE FOR OXYGEN CONCENTRATOR

WHEREAS, we, Theodore W. Jagger, of White Bear Lake, MN, Nicholas P. Van Brunt, of White Bear Lake, MN, John A. Kivisto, of Oak Grove, MN, and Perry B. Lonnes, of White Bear Lake, MN have invented certain new and useful improvements as described in an application entitled ADSORBENT CARTRIDGE FOR OXYGEN CONCENTRATOR for Letters Patent of the United States, the application having been executed on even date herewith, and/or being identifiable in the United States Patent and Trademark Office by Application No. _____, filed _____; and

WHEREAS, Vbox, Incorporated, a corporation organized and existing under the laws of the State of Minnesota, and having offices at 2342 East County Road J, White Bear Lake, MN 55110, ("Assignee") is desirous of acquiring the entire right, title and interest in and to the invention, the application, and any and all Letters Patent or similar legal protection, foreign or domestic, to be obtained therefor;

NOW, THEREFORE, for good and valuable consideration, the receipt and adequacy of which is hereby acknowledged, we transfer to Assignee, its successors and assigns, my entire right, title and interest in and to the invention, the above-identified application, corresponding domestic and foreign applications, all Letters Patent or similar legal protection issuing thereon, and all rights and benefits under any applicable treaty or convention; and we authorize the Commissioner of Patents and Trademarks of the United States or foreign equivalent thereof to issue the Letters Patent or similar legal protection to the Assignee.

We authorize the Assignee, its successors and assigns, to insert in this instrument the filing date and application number of the application when ascertained.

We authorize the Assignee, its successors and assigns, or anyone it may properly designate, to apply for Letters Patent or similar legal protection, in its own name if desired, in any and all foreign countries.

We represent to the Assignee, its successors and assigns, that we have not and shall not execute any writing or do any act whatsoever conflicting with this Assignment. We, our executors or administrators, will at any time upon request, without additional consideration, but at the expense of the Assignee, its successors and assigns, execute such additional writings and do such additional acts as the Assignee, its successors and assigns, may deem desirable to perfect its enjoyment of this grant, and render all assistance in making application for and obtaining, maintaining, and enforcing the Letters Patent or similar legal protection on the invention in any and all countries.

Theodore W. Jagger

STATE OF MINNESOTA)
) ss.
COUNTY OF Hennepin)

Subscribed and sworn to before me, a Notary Public, this 9 day of February, 2005.

LARRIN P BERGMAN
NOTARY PUBLIC—MINNESOTA
My Commission Expires JAN. 31, 2006

Notary Public

(SEAL)

GCE - Exhibit 1075, Page 153
GCE Gas Control Equipment Inc. v. VBOX, Inc.
IPR2023-00326

Nicholas P. Van Brunt

STATE OF MINNESOTA)
) ss.
COUNTY OF Hennepin)

Subscribed and sworn to before me, a Notary Public, this 9 day of February, 2005.

LARRIN P BERGMAN
NOTARY PUBLIC—MINNESOTA
My Commission Expires JAN. 31, 2006
(SEAL)

Notary Public

John A. Kivisto

STATE OF MINNESOTA)
) ss.
COUNTY OF Hennepin)

Subscribed and sworn to before me, a Notary Public, this 9 day of Febry, 2005.

LARRIN P BERGMAN
NOTARY PUBLIC—MINNESOTA
My Commission Expires JAN. 31, 2006
(SEAL)

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Perry B. Lonnes

STATE OF ~~MINNESOTA~~ FLORIDA)
) ss.
COUNTY OF LEE)

Subscribed and sworn to before me, a Notary Public, this 11 day of feb, 2005.

Notary Public

(SEAL)

SUZANNE K. ADKINS
MY COMMISSION # DD 062951
EXPIRES: October 7, 2005

GCE - Exhibit 1075, Page 154
GCE Gas Control Equipment Inc. v. VBOX, Inc.
IPR2023-00326

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APPLICATION NUMBER	FILING OR 371 (c) DATE	FIRST NAMED APPLICANT	ATTORNEY DOCKET NUMBER
11/054,615	02/09/2005	Theodore W. Jagger	V180.12-0006

CONFIRMATION NO. 8238

00164
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FORMALITIES LETTER

OC000000015457816

Date Mailed: 03/15/2005

NOTICE TO FILE MISSING PARTS OF NONPROVISIONAL APPLICATION

FILED UNDER 37 CFR 1.53(b)

Filing Date Granted

Items Required To Avoid Abandonment:

An application number and filing date have been accorded to this application. The item(s) indicated below, however, are missing. Applicant is given **TWO MONTHS** from the date of this Notice within which to file all required items and pay any fees required below to avoid abandonment. Extensions of time may be obtained by filing a petition accompanied by the extension fee under the provisions of 37 CFR 1.136(a).

- The statutory basic filing fee is missing.
  Applicant must submit $ **150** *to complete the basic filing fee for a small entity.*
- The signature of the following inventor(s) is missing from the oath or declaration:
  Perry B. Lonnes
- To avoid abandonment, a late filing fee or oath or declaration surcharge as set forth in 37 CFR 1.16(e) of $65 for a small entity in compliance with 37 CFR 1.27, must be submitted with the missing items identified in this letter.

The applicant needs to satisfy supplemental fees problems indicated below.

The required item(s) identified below must be timely submitted to avoid abandonment:

SUMMARY OF FEES DUE:

Total additional fee(s) required for this application is **$565** for a Small Entity

- **$150** Statutory basic filing fee.
- **$65** Late oath or declaration Surcharge.

- The application search fee has not been paid. Applicant must submit **$250** to complete the search fee.
- The application examination fee has not been paid. Applicant must submit **$100** to complete the examination fee for a small entity in compliance with 37 CFR 1.27

Replies should be mailed to: Mail Stop Missing Parts
Commissioner for Patents
P.O. Box 1450
Alexandria VA 22313-1450

A copy of this notice MUST be returned with the reply.

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11324 U.S. PTO 020905

UTILITY PATENT APPLICATION TRANSMITTAL

Our Docket No.: **V180.12-0006**	Date: **February 9, 2005**
First Named Inventor: **Theodore W. Jagger**	
Title: **ADSORBENT CARTRIDGE FOR OXYGEN CONCENTRATOR**	
Express Mail No.: **EV 485708840 US**	

11263 U.S. PTO 11054615 020905

APPLICATION ELEMENTS

ADDRESS TO: **Commissioner for Patents**
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Alexandria, VA 22313-1450

1. [] Fee Calculation Sheet
   (Submit an original and a duplicate for fee processing)
2. [X] Applicant claims small entity status
3. [X] Specification Total Pages **[49]**
   - Descriptive title of the invention
   - Cross References to Related Applications
   - Statement Regarding Fed. Sponsored R&D
   - Reference to Microfiche Appendix
   - Background of the Invention
   - Brief Summary of the Invention
   - Brief Description of the Drawings (if filed)
   - Detailed Description
   - Claims
   - Abstract of the Disclosure
4. [X] Drawings (35 U.S.C. 113) Total Sheets **[19]**
5. [X] Oath or Declaration Total Pages **[3]**
   a. [X] Newly Executed (original or copy)
   b. [] Copy from a prior application (37 C.F.R. 1.63(d) - for continuation/divisional with Box 18 completed)
   [Mark Box 5 below]
   I. [] DELETION OF INVENTOR(S)
   Signed statement attached deleting inventor(s) named in the prior application, see 37 C.F.R. 1.63(d)(2) and 1.33(b)
6. [X] Application Data Sheet. See 37 CFR 1.76.
7. [] CD-ROM or CD-R in duplicate, large table or Computer Program (*Appendix*)
8. Nucleotide and/or Amino Acid Sequence Submission (*If applicable, all necessary*)
   a. [] Computer Readable Copy (CRF)
   b. Specification Sequence Listing on:
      i. [] CD-ROM or CD-R (2 copies; or
      ii. [] Paper
   c. [] Statements verifying identify of above copies

ACCOMPANYING APPLICATION PARTS

9. [] Assignment Papers (cover sheet & document(s))
10. [] 37 C.F.R. 3.73(b) Submission
    [X] Power of Attorney
11. [] English Translation Document (*if applicable*)
12. [X] Information Disclosure Statement with copies of Citations as necessary
13. [] Preliminary Amendment Total Pages []
14. [X] Return Receipt Postcard (*Should be specifically itemized*)
15. [] Certified Copy of Priority document(s) (*If foreign priority is claimed*)
16. [] Nonpublication Request under 35 U.S.C. 122(b)(2)(B)(i). Application must attach form PTO/SB/35 or its equivalent
17. [] Other

18. **If a CONTINUING APPLICATION,** *check appropriate box and supply the requisite information below and in a preliminary amendment, or in an Application Data Sheet under 37 CFR 1.76:*
[] Continuation [] Division [] Continuation-in-part (CIP) of prior Application No.

Prior Application Information: Examiner _ Group Art Unit __

For CONTINUATION OR DIVISIONAL APPS only: The entire disclosure of the prior application, from which an oath or declaration is supplied under Box 5b is considered a part of the disclosure of the accompanying continuation or divisional application and is hereby incorporated by reference. The incorporation can only be relied upon when a portion has been inadvertently omitted from the submitted application parts.

19. **CORRESPONDENCE ADDRESS**

ATTY NAME AND REG. NO.	**David R. Fairbairn** 26,047 SIGNATURE:
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ADSORBENT CARTRIDGE FOR OXYGEN CONCENTRATOR

CROSS-REFERENCE TO RELATED APPLICATION(S)

Reference is hereby made to the following copending applications, which were filed on even date with the present application: "Ambulatory Oxygen Concentrator Containing a Power Pack", Theodore W. Jagger et al., Application No. _____; "Ambulatory Oxygen Concentrator Containing a Three Phase Vacuum Separation Process", Theodore W. Jagger et al., Application No. _____; "Personal Oxygen Concentrator", Theodore W. Jagger et al., Application No. _____; "Method of Providing Ambulatory Oxygen", Theodore W. Jagger et al., Application No. _____; "Low Power Ambulatory Oxygen Concentrator", Theodore W. Jagger et al., Application No. _____; "Ambulatory Oxygen Concentrator With High Efficiency Adsorbent", Theodore W. Jagger et al., Application No. _____; "Portable Oxygen Concentrator With a Docking Station", Theodore W. Jagger et al., Application No. _____; "Method of Controlling the Rate of Oxygen Produced by an Oxygen Concentrator", Theodore W. Jagger et al., Application No. _____; "Product Pump for an Oxygen Concentrator", Theodore W. Jagger et al., Application No. _____; and "Method and Apparatus for Controlling the Purity of Oxygen Produced by an Oxygen Concentrator", Theodore W. Jagger et al., Application No. _____.

BACKGROUND OF THE INVENTION

The field of this invention relates to oxygen concentrators. In particular, the invention relates to wearable oxygen concentration systems utilizing vacuum swing adsorption for creating an oxygen stream for ambulatory respiratory patients.

There is a need for home and ambulatory oxygen systems for use by patients. Supplemental oxygen is required for patients exhibiting symptoms from certain diseases and lung disorders; for example, pulmonary fibrosis, sarcoidosis, or occupational lung disease. For such patients, oxygen therapy is an increasingly beneficial prescription to help the patients live normal and productive lives. While not a cure for

lung disease, prescriptive supplemental oxygen increases blood oxygenation, which reverses hypoxemia. Oxygen prescriptions prevent long-term effects of oxygen deficiency on organ systems, the heart, brain and kidneys. Oxygen treatment is also prescribed for Chronic Obstructive Pulmonary Disease (COPD), heart disease, AIDS, asthma, and emphysema.

Currently, supplemental medical oxygen for therapy is provided to a patient from high pressure gas cylinders; cryogenic liquid in vacuum-insulated containers or thermos bottles commonly called "dewars", and oxygen concentrators. Some patients require in-home oxygen only, while others require in-home as well as ambulatory oxygen depending on the prescription. The three systems are all used for in-home use. However, oxygen concentrators provide a special beneficial advantage because they do not require refilling of dewars or exchange of empty cylinders with full ones. Home oxygen concentrators, however, do have drawbacks. They consume relatively large amounts of electricity; are relatively large and heavy; emit excessive heat and are relatively noisy.

There has been a need for an improved portable device for supplying oxygen to a patient. Only small high pressure gas bottles and small liquid dewars are truly portable enough to be used for ambulatory needs. Either system may be used for both in-home and ambulatory use. A patient using a stationary oxygen system at home (or even a portable system which cannot be readily transported), who travels must opt for small cylinders towed in a wheeled stroller or for portable containers that they carry, typically on a shoulder sling. Both of these options have significant drawbacks.

A major drawback of the cylinder option is that small cylinders only provide oxygen for a short duration. Moreover, these cylinders are maintained at a high pressure, and thus their use is restricted due to safety considerations. Another drawback of the cylinders is the refill requirement after depletion of the contents of the cylinder. Empty cylinders must be refilled at specialized facilities, or in the patient's home using a

commercial oxygen concentrator which extracts oxygen from the air. The latter option requires an on-site compressor to boost the output pressure of the concentrator to meet cylinder refill pressure requirements. Filling of cylinders with oxygen in the home is potentially dangerous due to the physics involved with compressing gas. Another detriment to cylinder usage is fire hazards associated with storage of large volumes of oxygen in the home environment.

Convenience and safety issues are not the only drawbacks associated with the use of cylinders. Another drawback is the cost associated with cylinders. Cylinders require special care, and specialized materials are required for high pressure oxygen compatibility, which in turn drives up the cost of cylinder-based systems.

The liquid oxygen storage system also has drawbacks. The primary drawback is the requirement of a base reservoir which necessitates refilling once a week or more from an outside source. Liquid oxygen is transferred from the base unit to a portable dewar, which is used by an ambulatory patient. However, there is substantial waste, as a certain amount of oxygen is lost during the transfer to the portable containers and from evaporation. Up to twenty percent of the contents of the base cylinder is lost in the course of two weeks because of losses in transfers and normal evaporation. Even without withdrawal by the patient, the base reservoir will typically boil dry over a period of one to two months.

The aforementioned systems all require a refilling station. When the patient is out in public, such stations are not readily available. Upon running low (or out) of oxygen, the patient must return home to a specified place that can refill the system. Such a requirement detracts from the ambulatory usefulness of the systems.

The industry has developed a set of recommendations for systems targeted to provide portable oxygen for ambulatory patients. The Fifth Oxygen Consensus Conference set forth the following standards for long-term oxygen therapy ambulatory equipment: 1) equipment must weigh less than 10 lbs., 2) equipment must

provide the equivalent of 2 liter/min of continuous flow O_2, and 3) the flow rate must be maintained for four hours or more. Thus, ambulatory equipment, or personal oxygen systems (POS), are to be inconspicuous to the public as well as unrestricting to the patient. Cylinders and other liquid oxygen systems tend to be bulky, which interferes with normal daily activities. Similarly, cylinders and liquid oxygen systems are difficult to conceal from public view. Ideally, a POS is small, lightweight, quiet, and flexible which allows the device to be concealed from the public. The present invention, whereby oxygen rich gas is provided to a patient from a wearable oxygen concentrator, meets and exceeds these standards.

BRIEF SUMMARY OF THE INVENTION

A removable gas separation cartridge includes a housing containing three columns, each having an inlet port, an outlet port, and a bed of adsorbent material. The cartridge is removable from an oxygen concentrator which separates oxygen from ambient air by using a vacuum swing absorption process.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a front view of a patient carrying the oxygen concentrator of the present invention.

FIG. 2 is a front perspective view of the oxygen concentrator.

FIG. 3 is a rear perspective view of the oxygen concentrator.

FIG. 4 is a front perspective view of the oxygen concentrator and a docking station.

FIG. 5 is a block diagram showing the components and connections of the oxygen concentrator.

FIG. 6 is a diagram showing rotary valve timing.

FIG. 7 is an exploded view of the oxygen concentrator in which the power pack and the adsorbent cartridge have been removed.

FIG. 8 is a perspective view of the oxygen concentrator with a portion

of the belt removed.

FIG. 9 is a perspective view of the components of the oxygen concentrator without the belt.

FIG. 10 is a perspective view of the components contained within the case portions of the modules and their associated pneumatic and electrical connections of the oxygen concentrator.

FIG. 11 is a perspective view of the components contained within a battery module.

FIG. 12a is a perspective view of an accumulator.

FIG. 12b is a top view of the accumulator.

FIG. 12c is a sectional view of the accumulator.

FIG. 12d is another sectional view of the accumulator.

FIG.13 is a perspective view of a control module.

FIG. 14 is a front view of the interior components of the control module.

FIG. 15 is a perspective view of the cartridge contained within a cartridge module.

FIG. 16 is an exploded view of columns and filters within the cartridge.

FIG. 17 is a rear perspective view of the oxygen concentrator and the docking station.

FIG. 18 is a front perspective view of the docking station.

FIG. 19 is a chart showing the adsorption isotherms for two different adsorbent materials.

DETAILED DESCRIPTION

The current invention relates to separation of gases using vacuum swing adsorption. Specifically, disclosed is an oxygen concentrator for a patient who requires a source of oxygen. The present invention is further explained with reference to the drawn figures in which like structures are referred to by like numerals throughout the

several views.

Overview - Oxygen Concentrator 100 (FIGS. 1-4)

FIG. 1 is a front view showing patient P with oxygen concentrator 100 and oxygen delivery tube 102. Oxygen concentrator 100 is a small unit which utilizes vacuum swing adsorption to separate oxygen from the ambient air around patient P. Oxygen concentrator 100 is compact and light so as not to interfere with the ambulatory movement of patient P, and can produce a product stream of gas containing a range of eighty-five to ninety-five percent oxygen.

Oxygen delivery tube 102 is a polymer tube or similar oxidation resistant structure, which extends from oxygen concentrator 100 to the nose, mouth, or port into the upper airway of patient P. Tube 102 allows delivery of oxygen to patient P for inhalation. In FIG. 1, patient P is about six foot tall to illustrate an approximation of the relative size of oxygen concentrator 100.

FIG. 2 is a perspective view of oxygen concentrator 100. Oxygen concentrator 100 is comprised of belt 104, power module 106 containing power pack 108, reservoir module 110, control module 112 containing user interface 114, and separation cartridge module 116. Oxygen concentrator 100 is a portable oxygen separator used to provide an oxygen rich gas stream to patient P. Belt 104 connects and carries the modules 106, 110, 112, and 116 of oxygen concentrator 100. Belt 104 may contain belt loops (not illustrated), clips, or a pair of straps that contain a buckle and holes or like fastening device for securing oxygen concentrator 100 to patient P. Alternatively, oxygen concentrator 100 may be placed in a purse, fanny pack, or similar personal carrying device for transport with patient P.

Power module 106 provides the necessary power to operate the systems of oxygen concentrator 100. In the embodiment illustrated, power module 106 contains replaceable power pack 108. Reservoir module 110 stores oxygen rich gas that has been separated from ambient air by cartridge module 116. Control module 112 pilots

and regulates the interaction of the power module 106, reservoir module 110, and separation cartridge module 116 of oxygen concentrator 100. User interface 114 on control module 112 is a console which allows patient P to adjust and monitor oxygen concentrator 100.

FIG. 3 is a perspective view of the opposite side of oxygen concentrator 100 as shown in FIG. 2. Illustrated in FIG. 3 are belt 104, power module 106, reservoir module 110, control module 112, and separation cartridge module 116. Belt 104 is constructed to contain belt segments 120 formed by serrations 118. This allows the belt 104 to be flexible and conform to patient P's body while wearing oxygen concentrator 100. Belt 104 is fabricated from a flexible material, such as textile or plastic and contains an inner padding such as foam. Belt 104 also houses the electrical and pneumatic connections of oxygen concentrator 100.

FIG. 4 is a perspective view of the front side of the oxygen concentrator 100 on docking station 122. Illustrated are oxygen concentrator 100 comprising belt 104, power module 106, reservoir module 110, control module 112, and separation cartridge module 116, along with docking station 122 containing power pack chargers 124a and 124b. Belt 104 is flexible and thus rests on the arc shaped docking station 122. Docking station 122 contains power pack chargers 124a (with power pack 108a inserted therein) and 124b, as well as concentrator dock 126 which supports the oxygen concentrator 100 while on the docking station 122. Docking station 122 converts AC power to recharge power packs 108.

Oxygen Concentrator 100 System Components and Connections (FIG. 5)

FIG. 5 is a block diagram of oxygen concentrator 100 illustrating power module 106, reservoir module 110, control module 112, and separation cartridge module 116, along with docking station 122 and showing the components and connections among the modules and docking station 122. Oxygen concentrator 100 components includes product gas outlet port 103, adsorbent columns 130a-130c (each

containing a respective inlet port 132a-132c and a respective outlet port 134a-134c), air inlet port 135, air inlet filter 136, product gas final filter 138, main valve 140, drive reducer 142, vacuum pump 144, drive 146, electric control module (ECM) 148, breakthrough flow sensor 150, valve position sensor 152, product control pump 154, check valve 156, main storage reservoir 158 containing pressure sensor 159, dispensing valve 160, as well as previously identified components tubing 102, power pack 108, user interface 114, and docking station 122.

As shown in FIG. 5, adsorbent cartridge module 116 includes adsorbent columns 130a-130c each containing respective inlet ports 132a-132c and outlet ports 134a-134c, air inlet filter 136, and product gas final filter 138. Ambient air enters air inlet port 135, passes through air inlet filter 136, and enters valve 140 for distribution to adsorbent columns 130a-130c. Product gas passes through final filter 138 and product gas outlet port 103 into tubing 102 for delivery to patient P. Inlet ports 132a-132c of adsorbent columns 130a-130c connect to valve 140 through inlet lines 164a-164c. Similarly, outlet ports 134a-134c connect to valve 140 through outlet lines 166a-166c.

Control module 112 houses main valve 140, drive reducer 142, vacuum pump 144, drive 146, electric control module (ECM) 148, breakthrough flow sensor 150, valve position sensor 152, and contains user interface 114. Main valve 140 is pneumatically connected to adsorbent columns 130a-130c, as well as inlet filter 136 via inlet line 168, vacuum pump 144 via vacuum inlet line 170, product control pump 154 via vacuum line 172 and product gas line 174, and main reservoir 158 via product gas line 176. Valve 140 is actuated by drive 146 through a motor speed reducer 142. Also, valve 140 connects to breakthrough flow sensor 150 and valve position sensor 152 which send electrical inputs 178 and 180 to ECM 148.

ECM 148 is a logic control, such as a PLC (programmable logic controller), microprocessor, or similar structure which controls operation of oxygen concentrator 100. ECM 148 contains the set of inputs and outputs associated with the

modules for regulating oxygen concentrator 100. ECM 148 also receives control setting inputs182 and 184 from user interface 114, and docking station 122, respectively, power pack management input 186 from power pack 108, reservoir pressure input 188 from pressure sensor 159 in main reservoir 158, and nasal pressure input 190 from dispensing valve 160. ECM 148 provides interface output 192 to the user interface114, interface output 194 to docking station 122, power management output 196 to power pack 108, dispensing valve time open output 198 to dispensing valve 160, and motor drive output 200 to drive 146.

User interface 114 contains physical controls such as dials, toggle switches, push button switches, and similar controls, for operating oxygen concentrator 100. The physical controls provide electrical control settings to ECM 148. ECM 148 reads these settings as inputs 182 and provides output 192 to the user interface 114. The status is converted from electric signals to physical output by indicator lights, status display, and similar structures of user interface 114.

Power pack management input 186 and output 196 control the charge and discharge of voltage from power pack 108 to drive 146 via ECM 148. Drive 146 will activate vacuum pump 144, valve 140 through drive speed reducer 142, and any other systems requiring power. Power pack management output 196 will also supply power to indicator lights, status display, audible alarm (if included), and other passive electrical system requirements on user interface 114 through ECM 148.

ECM 148 controls and coordinates the steps of the vacuum swing adsorption cycle through its inputs and outputs. In one embodiment, breakthrough flow sensor 150 provides an input 178 into ECM 148 by measuring air flow rates. The position of valve 140 is detected by valve position sensor 152 to produce input 180. Reservoir 158 contains a sensor to produce reservoir pressure input 188. Dispensing valve 160 also contains a pressure sensor which provides nasal pressure input 190 in response to differential pressure. ECM 148 reads these inputs to control the cycle by

changing outputs, such as motor drive output 200 for drive 146. Drive 146 propels vacuum pump 144. Vacuum pump 144 creates a vacuum that is communicated to valve 140 through vacuum input line 170, while dispelling nitrogen rich gas as exhaust 177. Another output 198 controls the time that dispensing valve 160 is open. In this embodiment, the inputs and outputs are connected to a PLC within ECM 148 which is programmed to control the cycle of oxygen concentrator 100.

Contained within reservoir module 110 is an oxygen-rich gas accumulator comprising reservoir 158, check valve 156, product control pump 154, and check valve 153. Reservoir 158 receives oxygen-rich gas produced by oxygen concentrator 100 and stores it at a low pressure above ambient until it is required for use. A portion of the stored oxygen-rich gas is delivered back to valve 140 by product gas line 176 for use in ordering the nitrogen content in adsorbent columns 130a-130c by moving much of the residual nitrogen held after evacuation near the outlets134a-134c toward inlets 132a-132c of the columns 130a-130c. Reservoir 158 is in communication with dispensing valve 160 through product gas line 202. Check valve 156 opens to allow oxygen into reservoir 158 and closes to prevent backflow of oxygen upon reaching the desired pressure in reservoir 158.

Product control pump 154 is driven by vacuum provided by the vacuum pump 144 through valve 140 via vacuum line 172. Product line 174 is in communication from separation cartridge module 116 to check valve 153, which opens to allow product control pump 154 to transport separated oxygen-rich gas to reservoir 158. Product control pump 154 delivers the product gas to main reservoir 158 through check valve 156.

Dispensing valve 160 and power pack 108 are contained within power module 106. Dispensing valve 160 is used to feed the flow of oxygen-rich gas to the patient P by delivery of the product gas through final product gas line 205 to product final filter 138. The product gas is obtained from the main reservoir 158 through product gas

line 202. Power pack 108 provides the power supply for oxygen concentrator 100 as previously described. Power pack 108 is rechargeable through docking station 122 as represented by power connection 204.

Vacuum Swing Adsorption (VSA) Process- Overview

Oxygen concentrator 100 operates using a vacuum swing adsorption process, which involves a series of cycles that include a feed step or phase, an evacuation step or phase, and a repressurization step or phase. Each of these three phases takes place in one of the three columns 130a-130c at any given time. Each column 130a-130c is in a different phase. For purposes of explanation, the VSA process will be described in reference to "column 130", which is representative of each of the three columns 130a-130c.

In the feed phase, a gas stream of ambient air 162 enters inlet end 132 of column 130 while product gas containing concentrated oxygen is delivered from outlet end 134 of column 130. The slight vacuum in column 130 draws air 162 into column 130 and through an adsorbent material (typically a zeolite) which preferentially retains specific components of air (nitrogen), allowing the desired product (oxygen) to pass through. A mass transfer zone (MTZ), which is a small region in which nitrogen is being adsorbed, is passing through the adsorbent material. The MTZ divides the column 130 into two segments: a nitrogen-rich segment where the MTZ has passed through, and an oxygen-rich segment ahead of the moving MTZ. The MTZ forms at the inlet 132 at the start of the process and gradually moves through the column to the outlet 134 as the process proceeds. Outlet end 134 of column 130 is connected to main reservoir 158 through main valve 140, check valve 153, and product control pump 154, so that oxygen-rich product gas from column 130 is pumped into reservoir 158.

In the evacuation phase, column 130 is brought to a stronger vacuum by vacuum pump 144, causing the adsorbed component, i.e. nitrogen, to be desorbed. The nitrogen is evacuated from column 130 through main valve 140, and is discharged by

vacuum pump 144 as waste exhaust 177.

In the repressurization phase, the previously evacuated column 130 is returned to near 1 atm. Ambient air 162 enters column 130 through inlet end 132, and recycled product gas from product line 176 enters column 130 through outlet end 134. The gases replace the vacuum that was previously drawn in column 130 during the evacuation phase. Just prior to column 130 reaching about 1 atm, the repressurization phase ends and the feed phase of the cycle begins again.

This constitutes the general principles of vacuum swing adsorption (VSA) for gas separation. All phases can be accomplished with a single column, or with a plurality of columns. If a plurality of columns are used, it is preferable to have a multiple of three (illustrated as 130a-130c in FIG. 5) that are sequenced out of phase for the different cycle phases in order to maintain constant product flow.

The Feed Phase- Breakthrough Detection

During the feed phase of the separation cycle, the position of the MTZ within adsorbent column 130 is monitored, determined, and beneficially used to control the termination of the feed phase. The control results in improvements in product purity and recovery with concomitant decrease in energy consumed, as well as system size and system weight for a given volume of product produced.

Breakthrough is defined as the point when the MTZ reaches outlet 134 of adsorbent column 130. At this point, feed gas begins to flow into the separated product gas stream. This is undesirable because the purity of the product stream is reduced by the feed stream gas if the feed is allowed to continue past this point. Conversely, if the feed phase is terminated before the MTZ nears outlet 134 of column 130, product recovery will be reduced because product gas contained in column 130 between the MTZ and outlet 134 of column 130 will be subjected to the evacuation phase that follows the feed phase in the separation cycle, and much of this remaining product gas will be lost with the desorbed gas in the waste stream.

For a particular column geometry, temperature, adsorbent type and condition, and cycle vacuum levels, there is an optimal time during the feed phase of the cycle to terminate the feed -- before purity requirements are compromised, but after the maximum possible product has been recovered from column 130. This optimal time is determined by the detection of the passage of the mass transfer zone through a specific position relative to outlet end 134 of column 130.

For some combinations of system variables, the optimum feed termination time corresponds to the beginning of breakthrough when the leading edge of the MTZ has just reached outlet end 134 of column 130. This event can be detected by monitoring either or both of the gas flow rates at inlet 132 or outlet 134 to column 130. Before breakthrough, the outlet flow rate is less than the inlet flow rate by an amount equal to the rate of nitrogen gas adsorption of column 130 from the feed gas flow. After breakthrough, column 130 is no longer adsorbing nitrogen from the feed gas, so the inflow and outflow rates of column 130 become equal. Any method of measuring gas flow rates to determine the point in time when these flow rates begin the transition toward equality can be used to detect this beginning of breakthrough.

It has been determined that if the inflow rate of air to column 130 is maintained constant, a simple detection of a significant rise in slope of the outflow rate marks breakthrough. Conversely, if the outflow rate is held fairly steady, then a falling slope of the inflow rate marks the breakthrough. Monitoring the ratio of flow for the inlet and outlet and detecting a significant change in the ratio of flows toward a ratio of 1:1 can mark breakthrough in systems where inflow or outflow may not be steady enough to detect breakthrough by monitoring just one of the flow rates.

For other combinations of system variables, the optimum feed termination time may correspond to the MTZ position prior to breakthrough. In these cases, it is beneficial for a specific amount of product to be intentionally left in column 130 at the end of a feed phase. Detecting the position of the MTZ before breakthrough

can be accomplished by additional methods.

One method used determines the volume of gas passed into or out of adsorbent column 130 up to the point of breakthrough by integrating the flow rate during the time interval between an initial feed and breakthrough while using some breakthrough detection method as previously described. Volume of flow may also be directly measured by physical equivalent methods using displacements of known volumes. Once the volume of gas that passes the column up to the point of breakthrough is determined, the volume of gas flow can be monitored during subsequent feed phases and the feed terminated when the volume reaches a specific value less than that for breakthrough. At any time during the feed phase, the volume of gas passed through column 130 since the beginning of feed divided by the volume of gas at breakthrough will be the same ratio as the position of the mass transfer zone divided by the length of column 130 (assuming a constant cross sectional area along the length). Using this relationship, the position of the MTZ within column 130 can be adequately determined during the feed phase.

The components of oxygen concentrator 100 as previously described are used to complete the cyclical phases of VSA to separate gases. The feed phase operates at a slight vacuum just below ambient (in the range of 0.9 to 1 atm). This provides just enough driving force to pull ambient air 162 into adsorbent column 130 through inlet filter 136. The vacuum is caused by product control pump 154, which is driven by the vacuum drawn by vacuum pump 144. Product control pump 154 is a piston pump or similar structure that meters a volume of gas. Product control pump 154 connects with a volume much greater than the piston displacement volume, such as main reservoir 158.

The feed phase is allowed to proceed until breakthrough is detected. Up to this point, the outflow gas from adsorbent column 130 has been a high purity oxygen/argon, low percent nitrogen mixture. The MTZ position is controlled to minimize nitrogen into the product gas mixture. The MTZ position is monitored by breakthrough

flow sensor 150, which detects a large increase in flow rate associated with breakthrough when the nitrogen no longer is preferentially adsorbed by adsorbent column 130. Breakthrough flow sensor is located near the column inlet 132, column outlet 134, or similar place where the flow rate being measured is accessible. When the increase MTZ flow is detected, a signal is sent to ECM 148, which also receives valve position signal 180 from the valve position sensor 152. The ECM 148 compares the timing of the MTZ breakthrough signal and the valve position signal and makes a minor adjustment to motor speed 200 based on lead, lag, or on-time status to keep the breakthrough time near the end of each feed phase. Alternately, ECM 148 receives a signal from breakthrough flow sensor 150 and immediately terminates the current feed phase in column 130 by signaling valve 140 to rotate to start the next phase. In yet another embodiment, the separation system contains a shut off valve that is signaled to close the feed of ambient air 162 into column 130, or the delivery of product gas from the column upon breakthrough detection.

In another embodiment, the method for determining the position of the mass transfer zone prior to breakthrough is accomplished by placing a small amount of non-adsorbing material within adsorbent column 130 at a particular position. When the mass transfer zone passes through this position, a flow change is detectable as the adsorption of gas is briefly interrupted by the non-adsorbing segment of column 130. The resulting flow change is detectable using the same methods for breakthrough detection previously described.

With larger columns and slower feed phases, the position of the mass transfer zone has been established by measuring temperature rise at positions of interest within column 130. Significant temperature increases result from the heat of adsorption at the MTZ and can be detected by thermistors or similar devices placed within column 130.

The Evacuation Phase

The evacuation phase brings the gas in adsorbent column 130 that was just in the feed phase to a vacuum state. At the end of the feed phase, the adsorbent column 130 is in equilibrium with the air infeed mixture near 1 atm from column inlet 132 up to the MTZ. Hence, if the ending position of the MTZ is established, and the nitrogen, oxygen, and argon isotherms for the chosen adsorbent mass are known, then the quantity of these gases present in adsorbent column 130 at the end of each feed phase is known. Vacuum pump 144 draws a vacuum on adsorbent column 130. This vacuum level is determined and set to a state that will remove a large portion of the gas left in column 130. In one embodiment, this is 0.2 to 0.3 atm. By percentage, the vast majority of gas discharged is nitrogen. The evacuated gas is discharged as waste from exhaust 177 of vacuum pump 144. The preferred embodiment uses a fixed displacement type of vacuum pump 144. During each evacuation phase, the adsorbed gas in column 130 is expanded into a much larger volume made up of the column volume plus the fixed displacement volume of pump 144.

The evacuate phase creates a self regulating effect that compensates for reductions in the amount of nitrogen adsorbed by adsorbent column 130 as the adsorbent degrades (ages). If the adsorbent loses efficiency, less nitrogen will be present in column 130 at the end of the phase, but the volume of the pump that the nitrogen expands into remains the same. A stronger vacuum will result that will remove more nitrogen and therefore allow more air to be fed during the next feed phase. A more constant breakthrough time results and provides a more robust product cycle.

The evacuation is provided by vacuum pump 144, which is controlled and activated by drive 146. The volume removed for each cycle of the vacuum pump 144 will remain constant, but the motor drive output 200 will be controlled by the rate of product gas used by patient P. The amount of oxygen used by patient P depends on the patient P's on-demand respiratory rate, which is sensed by the device and from a variable position switch which sends an input 192 from user interface 114 to ECM 148,

which in turn provides motor drive output 200 to drive 146. This determines the speed of each successive phase and, therefore, the oxygen production rate.

In one embodiment, a purge is applied at the very end of an evacuation phase. While still in the evacuation phase, a purge of product gas (mostly oxygen) introduced through outlet 134 effectively drives out a portion of nitrogen in column 130 through inlet 132. Adding the purge gas of high purity oxygen/argon through outlet 134 desorbs more nitrogen from outlet 134 of column 130, and pushes the nitrogen toward inlet 132 of adsorbent column 130 and creates an ordering of the gases. The purge volume is a function of vacuum level and adsorbent characteristics. A purge portion of the evacuation phase is not a necessary phase for a functioning device, but allows high oxygen purity to be maintained with weaker vacuum levels.

The Repressurization Phase

The repressurization phase brings adsorbent column 130 (just previously evacuated and purged) up to the feed pressure. In one embodiment, the gas used for repressurization is from both the infeed ambient air 162 and a counter stream from the (oxygen-rich) product gas line 176 from the main reservoir 158. Alternately, the repressurization of product gas can be accomplished through valve design negating the need for a separate line. The product gas is dispensed from a stream of product gas from the adsorbent column that is in the feed phase through a vacuum break valve used during repressurization. Repressurization with product gas can be done before, simultaneously, or after partial pressurization with ambient air. Repressurization with product gas is done at the opposite end of column 130 as repressurization with ambient air 162.

The effect of adding the repressurization gas of high purity oxygen/argon through outlet 134 creates a cleaning zone at outlet 134 of adsorbent column 130 where, during the feed phase that follows next, any stray nitrogen can be preferentially adsorbed and not discharged as product gas. This improves the ordering of gases in the adsorbent

column 130. By repeating this phase during successive cycles, the purity will continue to increase in the product output. Weaker vacuums require more oxygen volume returned to column 130 during repressurization if high purity is desired. That is, a stronger vacuum must be drawn on the column 130 to effectuate the same purity of oxygen absent the use of oxygen-rich gas as a back flush for repressurization at the outlet 134 of column 130. At the end of repressurization, the feed phase will proceed.

Valve 140 Timing (FIG. 6)

The VSA cycle comprises three phases: evacuation, repressurization, and feed, which occur sequentially in each column 130a-130c. For clarity, only column 130a will be discussed, although each phase is performed (at different times during a complete cycle) in each of columns 130a-130c.

Starting with the evacuation phase of the cycle, a small amount of oxygen (not illustrated) may flow into outlet 134a of adsorption column 130a to purge adsorption column 130a, while vacuum pump 144 withdraws gas present at inlet 134a of the column, i.e. nitrogen-rich gas.

During the repressurization phase, an amount of previously separated oxygen flows into outlet 134a of adsorption column 130a for a short time, and then air is allowed to enter inlet 132a of column 130a that has been previously evacuated. There may be a slight overlap of the oxygen flow into outlet 134a of adsorption column 130a and the air flow in the opposite direction into inlet 132a. Air freely flows into inlet 132a of adsorption column 130a upon opening of valve 140 as adsorption column 130a has been previously evacuated during the evacuation phase.

During the feed phase, air continues to flow into inlet 132a of adsorption column 130a while oxygen is removed from outlet 134a of column 130a by a pressure differential created by product control pump 154. As the MTZ passes through the adsorption column and reaches a position at or near outlet 134a, vacuum pump 144 will again begin to evacuate adsorbent column 130a and restart with the evacuation phase.

In the embodiment illustrated in FIG. 6, these phases are controlled by main valve 140.

FIG. 6 is a diagram showing timing for main valve 140, which is a rotary valve that moves 360°(one full revolution about a central axis) for each complete cycle of the VSA process. In the embodiment with three columns 130a-130c, the timing for each phase of the cycle is 120°. Each column 130a-130c is present in a different phase for each 120° of rotation of valve 140 that is different from the other two columns to obtain a sequence that creates a steady flow of oxygen as valve 140 keeps rotating.

As shown in the timing diagram, adsorption column 130a is in the feed phase of the cycle at a start point of zero degrees. Air is being let in through inlet filter 136 and column inlet 132a while separated gas consisting of highly concentrated oxygen is being removed through column outlet 134a. A portion of the oxygen-rich product gas is used in the repressurization of column 130b. Adsorption column 130b is in the repressurization phase at a point of rotary valve 140 being in initial position zero degrees. As valve 140 is turned, column outlet 134b is fed with the oxygen-rich gas for a portion of the valve's rotation, preferably less than 120°. After the flow of oxygen-rich gas enters column 130b through the column outlet 134b, air repressurization through the opening of column inlet 132b begins. In the embodiment shown, this takes place at a point after valve 140 has begun its rotation and ends before it reaches a third of its rotation, or a 120° rotation.

While column 130a is in feed phase and column 130b is in the repressurization phase, column 130c is in the evacuation phase. During the evacuation phase, a vacuum is drawn to remove adsorbed gas through inlet 132c, thereby regenerating it for the following feed phase.

In the embodiment shown, each column 130a, 130b, and 130c, is in a different phase of the cycle as one moves vertically down the diagram in FIG. 6. During the first one hundred twenty degrees of rotation of the rotary valve, column 130a is in the feed phase. Simultaneously, from zero to one hundred twenty degrees of rotation, column

130b is being repressurized, while column 130c is being evacuated.

For the next one hundred twenty degrees of rotation of valve 140 (i.e., from 120° to 240°), adsorption column 130a is in the evacuation phase. At this same time, column 130b is in the feed phase, and column 130c is in the repressurization phase.

Moving horizontally across the diagram for column 130a, during the final one hundred twenty degrees of rotation of valve 140 (i.e., from 240° to 360°), column 130a is repressurized first using separated gas, and then ambient air. Separated gas and ambient air are introduced to the column 130a through column inlet 132a and column outlet 174a at opposite ends of column 130a. During the final one hundred twenty degrees of rotation (i.e. from 240° to 360°) of main valve 140, column 130b is in the evacuation phase, and column 130c is in the feed phase. Upon reaching three hundred sixty degrees, valve 140 is back at its starting position (zero degrees), and the cycles for each column 130a-130c restart from the zero degree position.

Oxygen Concentrator 100 Physical Components (FIGS. 7-16)

FIG. 7 shows an exploded view of the oxygen concentrator 100, which includes belt 104, power module 106 containing removable power pack 108, reservoir module 110, control module 112, and separation cartridge module 116 containing adsorbent cartridge 206. Power pack 108 has been removed from receptacle 210 of power module 106. Adsorbent cartridge 206 has been removed from receptacle 208 of cartridge module 116. Adsorbent cartridge 206 and power pack 108 are easily removable to facilitate replacement.

In this embodiment, power pack 108 is a rechargeable battery. Receptacle 210 contains electrical contacts (not illustrated) for connection to power pack 108. Cartridge 206 contains a quick-connect attachment (not illustrated) for inlet lines 164a-164c, outlet lines 166a-166c, inlet air line 168, and final product gas line 205 (not illustrated) within receptacle 208. Also present on cartridge 206 are air inlet ports 135 which receive ambient air 162 for separation. Adsorbent cartridge 206 contains

adsorbent material that deteriorates in efficiency as it is used and ages.

FIG. 8 is a perspective view of oxygen concentrator 100. A portion of belt 104 has been removed revealing back interior surface 211 and inner connections amongst the modules, including utility tubes 212, tube pathways 214, module apertures 216a-216d, and module sockets 218a-218d.

Utility tubes 212 run between the adjacent modules and contain either electrical wiring or pneumatic lines, or comprise pneumatic lines and electrical wiring and associated connections. Tubes 212 are constructed to be flexible and bend as belt 104 is manipulated. If the tubes 212 contain electrical lines, the tubes are constructed from a dielectric material to insulate electrical wires, or similar material commonly used in electrical connections. If the tubes 212 comprise pneumatic lines, they may be air tight, small diameter polyvinyl or PVC tubes to connect the various gas input, gas separation, and gas removal systems of the oxygen concentrator 100. Tubes 212 contain openings or connections as required for electrical and pneumatic communication with each module. The back interior surface 211 of belt 104 contains tube pathways 214. Pathways 214 fabricated on the interior surface 211 of belt 104 allow the utility tubes 212 to extend between the modules 106, 110, 112, and 116. Tube pathways 214 create a semi-partitioned area on back interior surface 211 of belt 104 which support tubes 212.

Belt 104 is fabricated to contain apertures 216a-216d which allow modules 106, 110, 112, and 116 to connect utility tubes 212 of belt 104 through sockets 218a-218d. Apertures 216a-216d and sockets 218a-218d are fabricated as part of modules 106, 110, 112, and 116. Serrations 118 can be seen between the upper and lower edges 220 and 222 of belt 104. When fabrication of belt 104 is completed, padding will be inserted between edges 220 and 222, and material will be wrapped around creating serrations 118 and belt segments 120 to complete belt 104 as illustrated in FIG. 3. The padding is fabricated over the top of tubes 212 and tube pathways 214, or separately fabricated and fastened to back interior surface 211 during assembly of

belt 104. Individual modules allow the device to flex when mounted about a curved surface, such as a belt around patient P's waist. The construction of belt 104 with tubes 212 allows patient P to manipulate the oxygen concentrator 100, such as by bending belt 104 to wear around the waist, place on docking station 122, or folding concentrator 100 in half for transport in a carryall.

FIG. 9 is a perspective view of modules 106, 110, 112, and 116 of oxygen concentrator 100. In this view, belt 104 has been removed to illustrate the positions of sockets 218a-218d containing apertures 216a-216d on each respective module 106, 110, 112, and 116. Each respective module 106, 110, 112, and 116 is constructed from a thermoplastic material such as acrylanitrile butadine styrene (ABS) or high density polyethylene (HDPE), or a lightweight metal or a similar rigid material that is oxidation resistant.

Each module 106, 110, 112, and 116, comprises a case portion 224, 226, 228, and 230, defining the outer volume of each respectively. Bottom padding 232, 234, 236, and 238, covers the lower base portion of each module 106, 110, 112, and 116, respectively. Similarly, top padding 240 extends around the top perimeter of power module 106, while top padding 242 and 244 covers the top portions of modules 110 and 112. Power pack top padding 246 covers the top portion of power pack 108 and cartridge top padding 248 covers the top of separation cartridge 206. Padding 222-248 is a foam or similar lightweight material that adds protection to the modules as well as acts to reduce vibration of oxygen concentrator 100 felt by patient P. Alternately, oxygen concentrator 100 is enclosed in soft, flexible material to further increase comfort and maintain flexibility. In one embodiment, padding 232-248 is fabricated separately from the modules 106, 110, 112, and 116, power pack 108 and cartridge 206. In assembling the oxygen concentrator 100, padding 232-248 and case portions 224, 226, 228, and 230, are merged and secured either using fasteners, adhesives, or a manufacturing process such as ultrasonic welding.

Case portions 224, 226, 228, and 230, of each of the modules 106, 110, 112, and 116, contain sockets 218a-218d fabricated on the surface that contacts belt 104. Socket 218a-218d for each module is constructed to have support paths 250 for electrical wiring and pneumatic tubing similar to those contained within belt 104 represented by tube pathways 214. Sockets 218a-218d are constructed so that support paths 250 on sockets 218a-218d align with tube pathways 214 in belt 104 when each individual module 106, 110 ,112, and 116, is connected to belt 104. In one embodiment, sockets 218a-218d are constructed to allow each individual module 106, 110, 112, and 116, to snap onto belt 104 or attach in a similar quick connect fashion. Utility tubes 212 comprise quick connects at module apertures 216a-216d. Apertures 216a-216d are openings in the case portions 224, 226, 228, and 230, provided for connection of utility tubes 212 to components contained within each module 106, 110, 112, and 116. This allows for removal of a single module 106, 110, 112, or 116 should a specific component require maintenance or replacement. Sockets 218a-218d are constructed from the same material as the case portions 224, 226, 228, and 230.

FIG. 10 is a perspective view of the components contained within modules 106, 110, 112, and 116, and the associated pneumatic and electrical connections of oxygen concentrator 100. Illustrated are power pack 108, valve 140, drive reducer 142, vacuum pump 144, drive 146, oxygen accumulator 252 (comprising product control pump 154, check valves 153 and 156, and reservoir 158), dispensing valve 160 connected to nasal pressure sensor line 190 and dispensing valve open line 198, column inlet lines 164a-164c, column outlet lines 166a-166c, product control pump vacuum line 172, product control pump inlet line 174, product gas line 202, final product gas line 205, adsorbent cartridge 206, and main electrical cable 254.

Main electrical cable 254 contains a set of electrical wires that carry inputs 178, 180, 182, 188, and 190, outputs 192 and 198, and power lines 186, 198, and 200 shown in FIG. 5. Main electrical cable 254 extends from power pack 108 to

ECM 148 (not visible in FIG. 10). Dispensing valve time open output 198 and nasal pressure sensor input 190 are wires that extend between ECM 148 and dispensing valve 160. Similarly, the other inputs and outputs are wired to the appropriate system components as illustrated in FIG 5 (although not specifically illustrated in FIG 10.)

Product gas line 202 connects dispensing valve 160 with reservoir 158 of accumulator 252. Final product gas line 205 connects dispensing valve 160 to product gas outlet port 103 for connection to delivery tube 102 after passing through final filter 136 located in adsorbent cartridge 206 to provide patient P with oxygen rich product gas. Product control pump inlet line 174 extends from main valve 140 to product control pump154, which pumps separated oxygen rich gas into reservoir 158. Vacuum line 172 connects product control pump 154 through valve 140 to a vacuum drawn by vacuum pump 144, and provides the actuation for product control pump 154. Column inlet lines 164a-164c and column outlet lines 166a-166c connect main valve 140 with column inlet ports 132a-132c and column outlet ports 134a-134c of columns 130a-130c, respectively (not illustrated). Inlet air line 168 transports ambient air 162 from separation cartridge 206 to main valve 140, while vacuum inlet line 170 connects vacuum pump 144 to main valve 140. All lines 164a-164c, 166a-166c, 168, 170, 172, 174, 176, 202, and 205, are pneumatic lines or similar structures that allow for the isolated flow of gases between system components.

FIG. 11 is a perspective view of the components contained within power module 106: power pack 108 (comprising cells 256, outer wall 258, and power pack life indicator 260) and dispensing valve 160. In the embodiment illustrated, power pack 108 is a lithium-ion battery pack comprised of five cells 256. Individual cells 256 are contained within outer wall 258, part of which has been removed to show cell 256. Power pack 108 is a battery that is rechargeable and removable from power module 106. Although illustrated as a trapezoid containing five cylindrical cells, the shape and number of cells will vary depending on the shape of power module 106 and power

requirements of oxygen concentrator 100.

Power pack 108 is a lithium based battery pack capable of being recharged in a recharging socket or station that connects to an external power supply. Alternatively, power pack 108 comprises a battery or fuel cell. In one embodiment, power pack 108 is a lithium ion battery pack that is constructed from several interconnected lithium-ion batteries. Oxygen concentrator 100 uses a maximum of fifteen watts of power. This results in a battery weight of less than 0.7 pounds (0.3 kg). In this embodiment, patient P taking twenty breaths per minute at a setting of 2 liters per minute equivalent can use oxygen concentrator 100 for a minimum of four hours on a fully charged battery. Power pack 108 is easily exchanged with another similar battery pack, and can be removed with a simple pulling or tugging motion. In another embodiment (not illustrated), oxygen concentrator 100 contains a jack for receiving a power cord which can then be plugged into either a 110 volt wall outlet or a 12 volt power supply system (such as a car utility plug) so that power pack 108 can be charged in place in oxygen concentrator 100.

Power pack life indicator 260 displays the amount of time left that the power pack will operate the oxygen concentrator 100. As illustrated, power pack life indicator 260 is a display, such as a liquid-crystal display (LCD) or light emitting diode (LED) screen, with numeric output of expected life in hours. The LCD or LED screen may also contain a series of bars that act as indicators. Alternately, power pack life indicator 260 is a light or series of lights.

Dispensing valve 160 is contained within power module 106 and is used to feed the flow of oxygen to patient P. Dispensing valve 160 is a valve activated by a change in pressure, such as that caused when a person is inhaling. A sensor in the dispensing valve circuit monitors pressure, and opens dispensing valve 160 when a drop in pressure is sensed. ECM 148 communicates with dispensing valve 160 through input 190 and output 198 (see FIG. 5). Dispensing valve 160 is in communication with

reservoir 158 through product gas line 202. Reservoir 158 is kept at a slight pressure above ambient. Thus, when dispensing valve 160 is opened, oxygen rich gas will flow from reservoir 158 through final product gas line 205, final product filter 138, and product gas outlet port 103 for delivery to patient P through tubing 102. The flow of gas is further assisted by the pressure drop created by patient P's inhaling. Dispensing valve 160 can be set to deliver oxygen rich gas to patient P for the beginning portion of a breath when patient P first inhales rather than the whole breath.

Dispensing valve 160 provides for operating oxygen concentrator 100 in one of two possible modes: pulse flow or continuous flow. When patient P is using the oxygen concentrator 100 in the pulse flow mode, dispensing valve 160 will open intermittently in response to inhalation and will stay open for a pulse time according to the setting of the controls as set by patient P. If continuous flow is desired, dispensing valve 160 is maintained at an open or partially opened state. The product is dispensed to patient P though oxygen delivery tube 102 at a continuous rate, typically in the range of 1-1.5 lpm (liters per minute). The pressure difference corresponding to a dispensing orifice in delivery tube 102 will accommodate the flow rate from the reservoir 158.

FIGS. 12a-12d are various views of components contained inside of reservoir module 110. FIG. 12a is a perspective view of accumulator 252. FIG. 12b is a top view of accumulator 12b. FIGS. 12c and 12d are sectional views corresponding to the section lines in 12b. Contained within reservoir module 110 is oxygen accumulator 252 (comprising reservoir 158, check valves 153 and 156, and product control pump 154), inlet port 261, and outlet port 263. Accumulator 252 receives separated product gas through inlet port 261. Product inlet line 174 (shown in FIG. 10) is connected to inlet port 261 and links product control pump 154 to separation cartridge 206 through main valve 140 to transport oxygen rich gas separated by cartridge 206. Inlet port 261 connects to check valve 153 which allows product gas into product control pump 154.

Product control pump 154 includes piston 262, actuated by spring 264

within pump chamber 265, which pushes separated oxygen-rich product gas into reservoir 158. Check valve 156 opens to allow oxygen into the reservoir 158 and closes to prevent back flow of oxygen-rich gas when the desired pressure in reservoir 158 is attained. The low pressure of reservoir 158 exerts a force on check valve 156 to keep valve 156 closed. Reservoir 158 takes oxygen-rich gas produced by oxygen concentrator 100 and stores it at a low pressure above ambient until the product is required for use by patient P.

Product control pump 154 is driven by vacuum. Product control pump vacuum line 174 is connected to the vacuum drawn by vacuum pump 144 through main valve 140. When a vacuum is drawn, the force draws piston 262 down to compress spring 264 which expands pump chamber 265, and causes check valve 153 to open. Oxygen-rich gas from separation cartridge 206 flows through check valve 153 and enters pump chamber 265 in the volume created by the displacement of piston 262. At the appropriate time in the cycle, valve 140 will interrupt the vacuum to product control pump 154, and spring 264 will force piston 262 upwards. The movement of piston 262 will force oxygen rich gas in pump chamber 265 through check valve 156 and into reservoir 158. At the same time, check valve 153 closes to prevent more gas from entering pump 154. With this embodiment, no additional drive (other than the vacuum to pull piston 262 down and the spring force to move it up) is required for product control pump 154 which adds to the overall efficiency of the system.

In one embodiment, reservoir 158 has a capacity that is about four times larger than the size of the largest pulse provided by oxygen concentrator 100. In one embodiment, extra volume is included to account for separated oxygen used as a back flow in adsorbent columns 130a-130c. Specifically, main storage reservoir 158 for oxygen concentrator 100 can be designed according to the flow rates listed in Table 1. Storage reservoir 158 is 100cc (cubic centimeters) to 400cc in volume. Main storage reservoir 158 is maintained at a low pressure to provide delivery of the product gas to

patient P through outlet 263 which is connected to final product dispensing line 202. In one embodiment, the pressure is between 1 atm (ambient) and 1.5 atm. Also acceptable are pressures less than eight psi (55,158 Pa), with a pressure of two and one half to five psi (17,236 to 34,473 Pa) preferred. The low pressure of reservoir 158 allows oxygen concentrator 100 to be used in most areas where high pressure oxygen is banned. Also, low pressure requires less energy to fill reservoir 158, which adds to the efficiency of the system by requiring a simpler pressurizing mechanism compared to high pressure systems.

Reservoir 158 contains pressure sensor 159 (such as a piezoresistive or capacitive sensor) that sends reservoir pressure signal 188 to ECM 148 (see FIG. 5). ECM 148 adjusts the speed of the motor of drive 146 based on reservoir pressure signal 188 in combination with the current settings on user interface 114. As patient P's respiratory rate increases for the current setting, more oxygen-rich gas from reservoir 158 is dispensed thus lowering the pressure of reservoir 158. The drop in pressure is sensed and the system will react by increasing the production of product gas. Similarly, a decrease in the respiratory rate of patient P at the current setting of oxygen concentrator 100 raises the pressure in reservoir 158. The rise in pressure is sensed and ECM 148 adjusts drive 146 accordingly to maintain a preset pressure range in reservoir 158. Thus, only the amount of oxygen used by patient P is produced by oxygen concentrator 100.

FIG. 13 is a perspective view of the control module 112. Illustrated are the case 228 containing aperture 216c and socket 218c, and padding 236 and 234. Control module 112 contains user interface 114 comprising power switch 266, flow level indicator lights 268, flow setting switches 270a and 270b, boost switch 272, and indicator lights 274 and 276. Power switch 266 is an ordinary toggle or push button switch capable of turning oxygen concentrator 100 on and off.

Flow settings are dually controlled by patient P utilizing flow setting

switches 270. First, continuous or pulse mode is selected by patient P. In a continuous flow mode, oxygen is dispensed at a continuous flow rate such as one to one and a half liters per minute. If oxygen concentrator 100 is set in a pulse mode for controlling flow, oxygen concentrator 100 utilizes dispensing valve 160 to provide pulse dispensing of product gas. The pulse mode is set to meet patient P's needs for the equivalent of one to five liters per minute of continuous oxygen flow. In one embodiment, a dial containing settings of one to five is utilized. In the embodiment illustrated in FIG. 13, flow setting switches are used to adjust the flow rate between various stepped levels. Each setting corresponds to the specific value for continuous flow, or a corresponding pulse volume. For example, settings for a pulse mode are contained in the table below.

TABLE 1

Setting	Total Volume Pulse Range (cc/pulse)	Trigger Time (sec)	Pulse Flow Ramp Rate (sec)	Pulse Duration Max (sec)	Peak Pulse Flow (LPM)
1	10 to 12	.001 to .02	.03 to .07	.15	14
2	20 to 24	.001to .02	.03 to .07	.20	14
3	30 to 36	.001 to .02	.03 to .07	.25	15
4	40 to 48	.001 to .02	.03 to .07	.30	16
5	50 to 60	.001 to .02	.03 to .07	.35	17

When the unit is set in pulse mode, product gas is dispensed only at the beginning of inhalation. In one embodiment, product dispensing valve 160 is only opened between zero and 0.4 seconds of the beginning of a breath of patient P. This controls the amount of oxygen removed from reservoir 158. In another embodiment, oxygen concentrator 100 is shut off if no pressure drop is sensed by nasal pressure sensor 190 for a set amount of time, such as two minutes, which in turn closes dispensing valve 160.

Patient P can temporarily increase (or "boost") the flow rate of oxygen by actuating boost control switch 272 on user interface 114. When boost switch 272

is activated, oxygen concentrator 100 increases the flow rate of oxygen for a set period of time, such as 10 minutes. After timing out, oxygen concentrator 100 returns to the previous setting. The boost function will not work if oxygen concentrator 100 is already operating at the maximum flow rate.

Indicator light 274 indicates power pack 108 is running low. Indicator light 276 indicates that there is a problem with separation cartridge 206, such as a bad connection with receptacle 208. In one embodiment, oxygen concentrator 100 contains three different colored lights: red, yellow, and green. The green light indicates that there are no problems detected with oxygen concentrator 100. A yellow flashing light or a yellow non-flashing light indicates a condition has been sensed that should be addressed. An example of such a condition is a low battery. A red flashing light indicates that a condition has been detected that requires an immediate response. A red non-flashing light indicates that oxygen concentrator 100 has failed, and has shut down. For example, if oxygen concentrator 100 fails to produce a stream of separated gas of eighty-five percent oxygen, oxygen concentrator 100 will detect this problem via breakthrough flow sensor 150. ECM 148 shuts off main valve 140 so no ambient air 162 is being submitted to the gas separation cartridge 206. Product gas is no longer being supplied to reservoir 158. After a few breaths, reservoir 158 will empty, triggering reservoir pressure sensor output 188 (shown in FIG. 5), which communicates to ECM 148 to shut down oxygen concentrator 100, and display the red warning light. This signals patient P that maintenance is needed. In addition to the aforementioned indicator lights, the unit may also contain a boost indicator light to indicate when a boost function is in operation. Similarly, an audible alarm may be included in oxygen concentrator 100 to indicate failure.

FIG. 14 is a front view of the interior components of control module 112. Illustrated are drive 146, vacuum pump 144, drive speed reducer 142, and valve 140. Drive 146 includes a DC motor, driven by battery power pack 108, which

supplies the necessary power to operate vacuum pump 144. The motor draws a maximum of 15 watts of power. Vacuum pump 144 is a positive displacement pump. In this embodiment, drive 146 runs both vacuum pump 144 and valve 140. Vacuum pump 144 is run by the motor at one speed, while valve 140 is run off the same motor but at a reduced speed. The reduction in speed is accomplished with gears that comprise drive speed reducer 142 between the motor of drive 146 and valve 140.

Valve 140 is a valve containing a minimum number of ports equal to two times the number of adsorbent beds (columns) in separation cartridge 206. Additionally, main valve 140 contains other ports for the inlet of ambient air 162, vacuum provided by vacuum pump 144, and recycling of product gas used to purge columns 130a-130c during repressurization. In the preferred embodiment, valve 140 is a rotary valve, but may also be a solenoid valve, directional control valve, or series of individual valves in communication with each other and each connected to an adsorbent column 130a-130c.

In an alternate embodiment, drive 146 may contain an independent motor for operating valve 140. If valve 140 is run by an independent motor, that motor is powered by power pack 108 and synchronized with the other motor(s) of drive 146 by ECM 148. As illustrated, drive 146 contains a single motor and valve 140 is connected to a system of gears that comprise drive speed reducer 142. Alternately, drive speed reducer 142 can be any common power transmission components such as pulley and belts, or gears and sprockets.

FIG. 15 is a perspective view of separation cartridge 206 contained within separation cartridge module 116. Illustrated are inlet ports 132a-132c, outlet ports 134a-134c, and casing 230. In the embodiment illustrated, three adsorption columns are contained within casing 230 with one inlet port 132a-132c, and one outlet port 134a-134c, for each adsorption column 130a-130c. Each adsorption column 130a-130c is a hermetically sealed container containing a bed of adsorption material,

preferably a zeolite capable of adsorbing nitrogen gas, such as lithium low silica 13X zeolite. Each bed contains between five and twenty-five cubic centimeters of material, and in one embodiment contains fifteen (plus or minus one) cubic centimeters of material. The adsorbent bead size is a thirty by sixty mesh, wherein thirty mesh is equal to 0.0234 inches (0.0594 cm) and sixty mesh is equal to 0.01 inches (0.0254 cm).

Column inlet ports 132a-134c are connected to receive either ambient air 162 or vacuum, while outlet ports 134a-134c expel product gas or receive purge gas. This arrangement promotes ordering of gases within the columns 130a-130c by having oxygen rich gas always present at one end of the column. This results in improved efficiency as air flow through the columns 130a-130c creates an oxygen rich zone continuously at one end, which allows the vacuum to evacuate and desorb the previously adsorbed nitrogen where it is contained in the greatest concentration.

FIG. 16 is a perspective view of the columns 130a-130c and the filters 136 and 138 within casing 230 of separation cartridge 206. Illustrated are final product filter 138 connected to product gas outlet port 103 which connects to tubing 102, inlet air filter 136, and adsorbent columns 130a-130c each comprising spin inducers 280a-280f, adsorbent material 282a-282c, porous filters 284a-284f, and springs 286a-286c. Springs 286a-286c are coil springs that hold each adsorbent column in compression 130a-130c in place within casing 230 of separation cartridge 206 to prevent movement of adsorbent beads. Spin inducers 280a-280f help force even distribution of gases through columns 130a-130c, which helps to keep the MTZ well defined for more accurate detection.

Adsorbent material 282a-282c is the same as that previously described. Filters 136 and 138 are constructed of common filtering materials and are used to remove dust and other large particulate matter from the air streams to assure that the flow of oxygen out to patient P is free of such materials. Porous filters 284a-284f are a small section of material commonly used as a particle filter provided at each end of columns

130a-130c. Porous filters 284a-284f act to prevent adsorbent particles from contacting the mechanisms and valving of concentrator 100.

Docking station 122 (FIGS. 17-18)

FIG. 17 is a perspective view of the back side of oxygen concentrator 100 on docking station 122. Illustrated are oxygen concentrator 100 comprising power module 106, reservoir module 110, control module 112, and separation cartridge module 116, belt 104, and docking station 122 containing status display 288. Status display 288 is an LED, LCD, or similar digital display used to provide information to patient P such as time of day, time the concentrator has been used, time of recharging for power pack 108, or similar information. Additionally, docking station 122 may contain other controls (not illustrated) including a boost setting while the concentrator is docked, a mode switch for switching between pulse and continuous flow of oxygen, and indicator lights to show expected battery life, adsorbent column life, gas input, gas output, or gas separation system malfunctions, or other similar items that were previously described as part of user interface 114.

FIG. 18 is a perspective view of the docking station 122 with oxygen concentrator 100 removed. Concentrator dock 126 is visible on docking station 122 with oxygen concentrator 100 removed. Concentrator dock 126 may optionally contain electrical connections (not illustrated) to charge power pack 108 contained within power module 106 while oxygen concentrator 100 is docked. Additionally, docking station 122 contains a power cord (not illustrated) available to connect to a wall socket or other power source such as a car utility plug. Docking station 122 uses power provided through the power cord to operate oxygen concentrator 100 and/or recharge power packs 108. Docking station 122 contains a flat bottom 290 to rest on a level surface and allow oxygen concentrator 100 to be in the docking station without moving. Alternately, docking station 122 is mountable to a wall in one embodiment, and is a free standing device that is set on a generally flat surface in another embodiment.

In one embodiment, docking station 122 comprises indicator lights and control power switch (not illustrated) in addition to status display 288, power pack chargers 124a and 124b, and concentrator dock 126. Indicator lights provide information to patient P utilizing oxygen concentrator 100. Indicator lights will indicate if oxygen concentrator 100 is functioning properly, requires maintenance, or has failed. Control switch is a master switch for supplying or terminating power or controlling the setting of flow for oxygen concentrator 100. Status display 128 is an LED, LCD or similar digital display that can be used to indicate various information to patient P such as time of day, time oxygen concentrator 100 has been docked, time of recharging for the power pack, or similar information.

Docking station 122 also contains power pack chargers 124a and 124b and concentrator dock 126. Docking station 122 contains a power cord (not illustrated) available to plug into a wall socket or a similar power pack. Docking station 122 converts AC power to recharge power pack 108 in power pack chargers 124a and 124b. Power pack chargers 124a and 124b contain contacts that are used to transfer power to power pack 108 while recharging. Alternatively, a power pack 108 placed in charger 124a or 124b is inductively coupled to recharge the power pack 108. Similarly, power is provided to oxygen concentrator 100 itself while on docking station 122, and to recharge of the power pack 108 (see FIG. 4) still attached to the oxygen concentrator 100. Concentrator dock 126 is shaped to provide a place to set oxygen concentrator 100 while docked, as well as facilitate easy removal of oxygen concentrator 100 for ambulatory use.

In one embodiment, docking station 122 performs several functions with oxygen concentrator 100 docked. First, oxygen concentrator 100 is allowed to run without utilizing power pack 108 while it is docked. Second, a boost setting is available to increase the delivery rate of oxygen while oxygen concentrator 100 is docked. Boost switch 272 is located on user interface 114 (See FIG. 13). In an alternate embodiment,

a boost switch is located on docking station 122. Upon removal of oxygen concentrator 100 from docking station 122, the boost setting is removed and oxygen concentrator 100 operates at a set delivery rate in either a continuous or pulse mode.

Oxygen concentrator 100 contains flow setting switch 270 (FIG. 13), and a mode switch (not illustrated). The mode switch allows patient P to select continuous or pulse flow. In one embodiment, patient P is allowed to adjust the setting of oxygen concentrator 100 only while docked. That is, patient P can reprogram by changing a pulse setting (e.g., from 2 to 3), or continuous flow mode (e.g., from 1.0 to 1.5 liters per minute), only while oxygen concentrator 100 is on docking station 122. Patient P wishing to adjust settings will be required to hold the control switch while adjusting the flow setting dial or mode switch. In another embodiment, docking station 122 contains a switch automatically activated by placing oxygen concentrator 100 in docking station 122 which allows patient P to adjust flow setting. The requirement that settings can only be changed during docking prevents accidental switching of the flow mode of oxygen concentrator 100 during ambulatory use. For example, there is no change in flow if flow setting switch 130 is bumped, which would normally increase oxygen flow. If oxygen concentrator 100 can only be reprogrammed in docking station 122, oxygen concentrator 100 will remain in the preset mode set at docking station 122 and will not increase or decrease flow by a change of the setting. In one embodiment, the flow setting switch and mode switch are located on a user interface located directly on docking station 122.

Another function of docking station 122 is to provide diagnostic features of the system. Docking station 122 may indicate expected battery life, adsorbent column life, or pump malfunctions through the use of indicator lights, or status display 128, or a combination of both. Alternatively, these items are located on user interface 114, or at a combination of locations of user interface 114 and docking station 122. For example, battery life indicator 142 is located directly on power pack 108 that comprises the

battery itself, and battery problem warning light 274 is on user interface 114 also. Similarly, adsorbent cartridge warning light 276 is located on user interface 114, but may also be on either the cartridge module 116 or docking station 122 as well.

Concentrator Efficiency

Oxygen concentrator 100 can produce a stream of product gas containing a range of 85-95 percent oxygen which provides up to 5 liters per minute pulsed equivalent of product gas. By utilizing vacuum swing adsorption, the separation process phases are all performed at less than 1 atm.

Utilizing a vacuum to exhaust unwanted gas from adsorbent columns 130a-130c improves efficiency of the oxygen concentrator 100. Less power is required than pressure swing adsorption (PSA) or vacuum-pressure swing adsorption (VPSA), which results in a smaller battery and thus a lighter weight product. Oxygen concentrator 100 as disclosed weighs less than 3 pounds (1.4kg) and occupies less than 1 liter of volume. Also, the efficiency of the system allows for oxygen concentrator 100 to operate for at least three hours while producing up to 5 liters per minute pulsed equivalent of product gas without requiring patient P to attend to the unit, e.g. changing the battery. Further, the low energy consumption causes less heat transfer. The product gas is discharged from the separation system at a temperature of $\pm$ six degrees Celsius from that of the ambient air. This eliminates the need for heat exchangers which add to the overall weight and reduces system efficiency. The amount of heat generated causes no discomfort to patient P wearing and utilizing the oxygen concentrator 100. Also, upon starting oxygen concentrator 100, the flow of product gas will increase from 21 percent oxygen (ambient) to 85 percent or more oxygen in under two minutes.

Improvements over the prior art are attained by regulating the device to only separate the amount of oxygen needed by patient P at any given time. The prior art separates a flow of oxygen and delivers that rate to patient P as a steady flow. Patient P is only inhaling this oxygen during about 1/3 of the normal breathing cycle. Within the

inhalation portion of the breathing cycle, the volume of gas inhaled last stays in the dead space of the airways and is not presented to the alveoli. Therefore if oxygen is dispensed to patient P only during the early part of inhalation, less than 1/3 the steady flow is actually required. Moreover, prior art devices do not adjust the flow based on a patient P's needs, but operate at the same steady flow. The present concentrator slows down its entire cycle rate producing only the amount of oxygen needed. Thus, oxygen concentrator 100 retains a high oxygen recovery percentage at all product flow rates while minimizing energy consumption and maximizing adsorbent life. Patient P's actual needs vary with real time changes in activity. This causes a corresponding variation in breathing rate. Oxygen concentrator 100 tracks patient P's breathing rate and adjusts oxygen separation and delivery rates proportionally. In combination, these two features allow oxygen concentrator 100 to separate oxygen only at the rate it is being consumed, resulting in a reduction in the amount of oxygen needing to be separated for patient P.

Another improvement over the prior art involves reducing the waste of separated oxygen in the various adsorb and desorb cycle phases. This is typically referred to as maximizing product recovery. The primary system components become larger or smaller as the amount of oxygen separated increases or decreases. Therefore, a dramatic reduction in size and weight of the concentrator requires use of as much separated oxygen as possible by delivering it to patient P rather than losing it to the waste stream. The prior art works by using the Skarstrom cycle well known to those skilled in the art.

During one phase of the Skarstrom cycle in PSA or VPSA, air is pumped into one end of a column of adsorbent pressurizing it above atmospheric pressure while oxygen is flowing out of the opposing end. Nitrogen is being adsorbed as the MTZ propagates toward the oxygen outlet end of the column. This phase is terminated before the MTZ breaks through into the oxygen stream so that oxygen purity is not diluted by the nitrogen rich air trailing the MTZ. If it is terminated earlier than

necessary to maintain purity there will be substantial separated oxygen left in the column in front of the MTZ that is not passed to the patient. During the next cycle phase the column pressure is reduced to a lower cycle pressure desorbing the nitrogen that was adsorbed during the separation phase and it is passed to the waste stream. Some of the oxygen left in the column at higher pressure will also be passed to the waste stream as gas flows from the column when pressure is reduced. Recovery of separated oxygen can therefore be maximized by stopping the previous separation phase just short of breakthrough, leaving minimal oxygen in the column to be lost to the waste stream during the reduced pressure evacuation phase. The position of the MTZ needs to be accurately known to terminate the separation phase for optimal recovery without compromising purity. This position cannot be accurately estimated because its propagation rate is a function of many variables including product oxygen flow rate, high and low cycle pressures, temperature, adsorbent water content and the amount of other contaminants accumulated in the adsorbent. Prior art systems stop the separation phase well short of breakthrough to encompass worst case operating conditions without sacrificing purity and thereby waste separated oxygen in the evacuation phases during most typical non-worst case operating conditions.

Oxygen concentrator 100 determines the position of the MTZ just prior to breakthrough and terminates the flow from outlet 134 for the remainder of the feed phase or adjusts the motor speed, as previously described. Additional oxygen is left in the column at the end of a feed phase and is wasted during the evacuation phases. This is oxygen adsorbed by the adsorbent combined with oxygen present in the interstitial and dead spaces of the adsorbent and column. All adsorbents used in oxygen separators adsorb nitrogen, and also oxygen to some extent. The adsorbent used in oxygen concentrator 100 presents a very high ratio of adsorbed nitrogen to adsorbed oxygen. As the amount of oxygen adsorbed is minimized through the choice of an adsorbent with a low affinity for oxygen, the amount of adsorbent needed to separate a given amount of

nitrogen during a separation phase will decrease as its affinity for nitrogen increases. The less adsorbent needed to adsorb a given amount of nitrogen, the less adsorbent there is to adsorb oxygen and the smaller the column can be with less interstitial and dead space.

For example, a LiLSX adsorbent referred to as Oxysiv MDX from UOP Corporation has a very high ratio of adsorbed nitrogen to adsorbed oxygen in the operating pressure range of oxygen concentrator 100. The Skarstrom cycle of the prior art uses a purge phase in which separated oxygen is fed back into the product end of the column while nitrogen rich gas is passing out of the opposing end of the column into the waste stream as the pressure transitions to the lower cycle pressure. While this purge can enhance product purity, some of the purge oxygen passes all the way through the column and is lost to the waste stream. Oxygen concentrator 100 using VSA achieves a measured 60% oxygen recovery rate, compared to a typical recovery rate of 30% for the prior art utilizing PSA.

Another improvement over the prior art concerns the choice of adsorbent and operating pressure range. The energy required by the separation process directly defines the weight and size of major components such as the battery, motor and gas pump of a concentrator. Minimizing the amount of adsorbent minimizes the amount of energy needed to separate a given amount of oxygen. Each adsorbent has a characteristic pair of isotherms that show the amount of oxygen and nitrogen a given mass of adsorbent will hold at equilibrium over a range of pressures and vacuums for these gasses at a constant temperature. The cycle phases of the system necessarily include the pumping of gas contained in volumes of adsorbent to produce a change in nitrogen partial pressure between a chosen higher pressure and a chosen lower pressure. The pneumatic energy a pump must deliver in the process of cycling a given volume of gas between a higher and a lower level is in direct proportion to the volume of gas pumped multiplied by the difference between the high and low vacuum levels. The isotherms for various adsorbent candidates specify the amount of nitrogen contained in

a fixed mass of adsorbent at a fixed temperature as a function of nitrogen partial pressure.

An example of the isotherm for the LiLSX adsorbent Oxysiv MDX along with the isotherm for a typical 13X type adsorbent used in the prior art is shown in FIG 19. Having minimized the amount of oxygen needed to be separated from air and having maximized the recovery percent of oxygen as previously disclosed, along with knowing the percentage of oxygen present in air prescribes a specific minimum amount of air that must be moved into the system to produce the needed oxygen. This minimum amount of air minus the maximized separated oxygen must pass out of the system as a minimized volume of waste gas. Oxygen concentrator 100 acts to minimize the flow rates of the air feed stream and the waste stream. This flow must be pumped across a pressure difference defined by the choice of high and low operating pressures requiring a pumping energy that is proportional to both the flow rate and the pressure difference. The gas streams are pumped into or out of the adsorbent during each complete cycle to produce the needed swing in pressure between high and low cycle pressure levels allowing the separation of nitrogen from oxygen. Minimizing the amount of gas being pumped through the system reduces the pumping energy in proportion to reductions in the difference between chosen high and low pressure points that the gas must be pumped across. The isotherm for nitrogen shows that nitrogen is transferred in or out of the adsorbent with the smallest change in pressure where the slope of the isotherm is the steepest. Using typical PSA, a ratio of high to low pressure levels in these systems needs to be 3:1 or greater to maintain the desired oxygen purity. Lower pressure ranges, i.e. sub-atmospheric or vacuum ranges used in VSA, allow this ratio to be maintained with less total difference between the high and low pressure levels.

For example, prior art operates between 1 and 3 atmospheres for a 3:1 ratio and a pressure difference between high and low levels of 2 atmospheres. Oxygen concentrator 100 using VSA operates between 0.3 atmospheres and 1 atmosphere. A

ratio of about 3.3:1 is achieved with a pressure difference of only 0.7 atmospheres. Operating on this range of the isotherm as seen in FIG. 19 allows just as much nitrogen to be passed in and out of the LiLSX adsorbent with a 0.7 atmosphere pressure range as a PSA system does with 13X adsorbent and a 2.0 atmosphere pressure range. The LiLSX adsorbent allows a cycle pressure range that is nearly 1/3 that of a PSA system with a proportional reduction in pumping energy.

Oxygen concentrator 100 is a quiet device. When oxygen concentrator 100 is running, it produces a noise level in the range of ten to thirty decibels. Further, with the compact size of the parts, vacuum pump 144 is running continuously and there is very little vibration to affect a person using it docked or wearing it as an ambulatory device. The device of the present invention with the described components weighs less than three pounds (1.36 kg). The compact size (less than about61 cu. in. (1000 cc)) allows for easy portability. Similarly, the small size does not disrupt counter space or storage when used at home. The device does give off some heat, however the outer case is less than 6 degrees Celsius higher than ambient when oxygen concentrator 100 is running on battery power. The device may emit more heat while it is docked and operating on AC power to charge the power pack 108, but is still less than 15 degrees Celsius above ambient.

Based on the foregoing embodiments, the efficiency of the concentrator can be determined. One measure of efficiency is the ratio of oxygen produced to the amount of adsorbent material used to obtain the oxygen, represented by the following:

$$Qp = \text{Liter/min } O_2 \text{ produced}$$

$$M_{adsorbent} = \text{Kg of Adsorbent Material}$$

for example, the disclosed embodiments include adsorbent columns 130a-130c, with each column containing 15 cubic centimeters (cc) of adsorbent material with a density of 0.66gm/cc. That is:

$$(3columns)\left(\frac{15cc}{column}\right)\left(\frac{0.66gm}{cc}\right) = 30gms \text{ for the system.}$$

The following flow rates (Qp) were obtained by the above disclosed concentrator:

Qp max = 1.5 L/min

Qp min = 0.14 L/min

This results in a range for kilograms of adsorbent material to oxygen flow rate of:

$$0.020 < \frac{Madsorbent}{Qp} < 0.214$$

Similarly, flow rates (Qp) were determined for a system that contains three adsorption columns, each column containing 15cc of adsorbent material. The separation completed in a range of .3 atm to .95 atm. Values were calculated for breakthrough time, work, battery life, and flow rate. The volume of gas contained in a column at the end of a feed phase was 150cc. These constants were used to determine the following measures of efficiency:

Work per evacuation cycle or pneumatic power requirements were determined based on the following calculations:

W (work) = (volume moved) * (vacuum differences);

The vacuum differences are calculated as the vacuum pump is continuously changing gas out, and as vacuum progresses to end point. From this:

V_H = Vacuum upper level

V_L = Vacuum lower level

Vol = Volume of gas in the column at end of feed phase

$W = Vol*(V_H-V_L)*(1+(V_H/(V_H-V_L))*\ln(V_L/V_H)+\ln(V_H/V_L))$

Inserting the above constants and converting to joules (multiply by 100.32 to get L*atm to joules) yields:

W = 4.81 joules

Thus, 4.81 joules is required to evacuate the gas which desorbs during the evacuation phase. From experimentation, the following flow rates (LPM is liters per minute) and cycle times were recorded:

Qp (flow rate)	Low = .14 LPM
	Med = .720 LPM
	High = 1.5 LPM
Cycle time	Low = 5.6 sec.
	Med = 1.12 sec.
	High = .54 sec.

Power consumption can be determined by calculating work divided by the time of the cycle.

Low flow power = 4.81 joule/5.6 sec = .85 watts

Medium Flow power = 4.81 joule/1.12 sec = 4.29 watts

High flow power = 4.81 joule/.54 sec = 8.9 watts

From the above, a measure of energy consumed to the flow rate can be made and used as an indicator of the system efficiency:

$$Low: \frac{.85w}{.14LPM} = 6.07w / LPM$$

$$Medium: \frac{4.29w}{.72LPM} = 5.95w / LPM$$

$$High: \frac{8.9w}{1.5LPM} = 5.93w / LPM$$

Another measure of efficiency is the ratio of mass of the power pack (Mpowerpack) compared to the amount of oxygen produced (Qp) over time:

$$\frac{Mpowerpack}{QpT(time)}$$

The following constants are used in the calculation: the battery cell is a type 18650 lithium ion battery with 7.4 watts-hrs, measuring 42 g; motor efficiency is 90 percent; and vacuum pump efficiency is 80 percent.

Pneumatic work = 6W/L/min. Thus,

$$\text{Electric power} = \frac{6W / LPM}{(.9)(.8)} = 8.3W / LPM$$

Battery mass compared to energy consumption is:

$$\frac{42g}{7.4(watt)(hr)}\left(\frac{1Kg}{1000g}\right)\frac{8.3watt}{LPM} = .047\frac{Kg}{LPM(HR)}$$

Total battery mass for the power pack can be determined from this equation. For example, if a patient requires the concentrator to run for four hours at setting of "3" and takes 20 breaths per minute (the medium flow rate):

$$(4hr)*\frac{.047kg}{LPM(hr)}.72LPM = .135kg$$

The mass of the batteries needed is 0.135 Kg. Assuming each battery cell is 42g as previously stated, the number of batteries for the power pack can be calculated:

$$.135kg\left(\frac{1000g}{1kg}\right)\frac{\text{battery cell}}{42g} = 3.2 battery\ cells$$

Although the present invention has been described with reference to preferred embodiments, workers skilled in the art will recognize that changes may be made in form and detail without departing from the spirit and scope of the invention. For example, larger flow rates may be achieved by scaling the concentrator components to achieve desired flow rates at the disclosed efficiencies.

CLAIMS:

1. A removable gas separation cartridge for use in an oxygen concentrator which separates oxygen from ambient air by using a vacuum swing absorption process, the gas separation cartridge comprising:

a first adsorbent column having an inlet, an outlet and a first bed of adsorbent material;

a second adsorbent column having an inlet, an outlet and a second bed of adsorbent material;

a third adsorbent column having an inlet, an outlet and a third bed of adsorbent material;

a housing for containing the first, second, and third adsorbent columns;

inlet ports connected to the column inlets;

outlet ports connected to the column outlets.

2. The gas separation cartridge of claim 1 further comprising:

an inlet air filter;

means for connecting the air filter to the oxygen concentrator;

a product gas filter; and

means for connecting the product gas filter to the oxygen concentrator;

wherein the inlet air filter and product gas filter are contained within the housing.

3. The gas separation cartridge of claim 2 further comprising:

an outlet port connected to the product gas filter.

4. The gas separation cartridge of claim 1 wherein the adsorbent columns each further comprise a spring for retaining the adsorbent column in the housing.

5. The gas separation cartridge of claim 1 wherein the adsorbent columns further comprise spin inducers adjacent the inlet and outlet of the adsorption columns.

6. The gas separation cartridge of claim 5 wherein the adsorbent columns further comprise porous filters between the spin inducers and beds of adsorbent material.

7. The gas separation cartridge of claim 1 wherein the beds of adsorbent material comprise beds of zeolite which provide preferential adsorption of nitrogen.

8. The gas separation cartridge of claim 7 wherein the zeolite is an LiLSX adsorbent.

8. The gas separation cartridge of claim 1 wherein the inlet ports and outlet ports comprise quick disconnect couplings.

9. A removable cartridge for a portable oxygen concentrator, the cartridge comprising:

an outer casing;

a plurality of gas separation columns within the outer casing, each gas separation column containing an adsorbent material that preferentially adsorbs nitrogen, a first end, and a second end;

a plurality of inlet ports in the outer casing, each inlet port connect to the first end of one of the columns; and

a plurality of outlet ports in the outer casing, each outlet port connected to the second end of one of the columns.

10. The gas separation cartridge of claim 9 further comprising:
an inlet air filter within the outer casing;
a port for connecting the air filter to the oxygen concentrator;
a product gas filter within the outer casing; and
a port for connecting the product gas filter to the oxygen concentrator;

11. The gas separation cartridge of claim 9 wherein the adsorbent columns each further comprise a spring for retaining the adsorbent column in the housing.

12. The gas separation cartridge of claim 9 wherein the adsorbent columns further comprise spin inducers adjacent to the inlets of the adsorption columns.

13. The gas separation cartridge of claim 12 wherein the adsorbent columns further comprise porous filters between the spin inducers and beds of adsorbent material.

14. The gas separation cartridge of claim 9 wherein the beds of adsorbent material comprise beds of zeolite which provide preferential adsorption of nitrogen.

15. The gas separation cartridge of claim 14 wherein the zeolite is an LiLSX adsorbent.

ADSORBENT CARTRIDGE FOR OXYGEN CONCENTRATOR

ABSTRACT OF THE DISCLOSURE

A removable gas separation cartridge which includes a housing containing three columns, each having an inlet port, an outlet port, and a bed of adsorbent material. The cartridge is removable from an oxygen concentrator which separates oxygen from ambient air by using a vacuum swing absorption process.

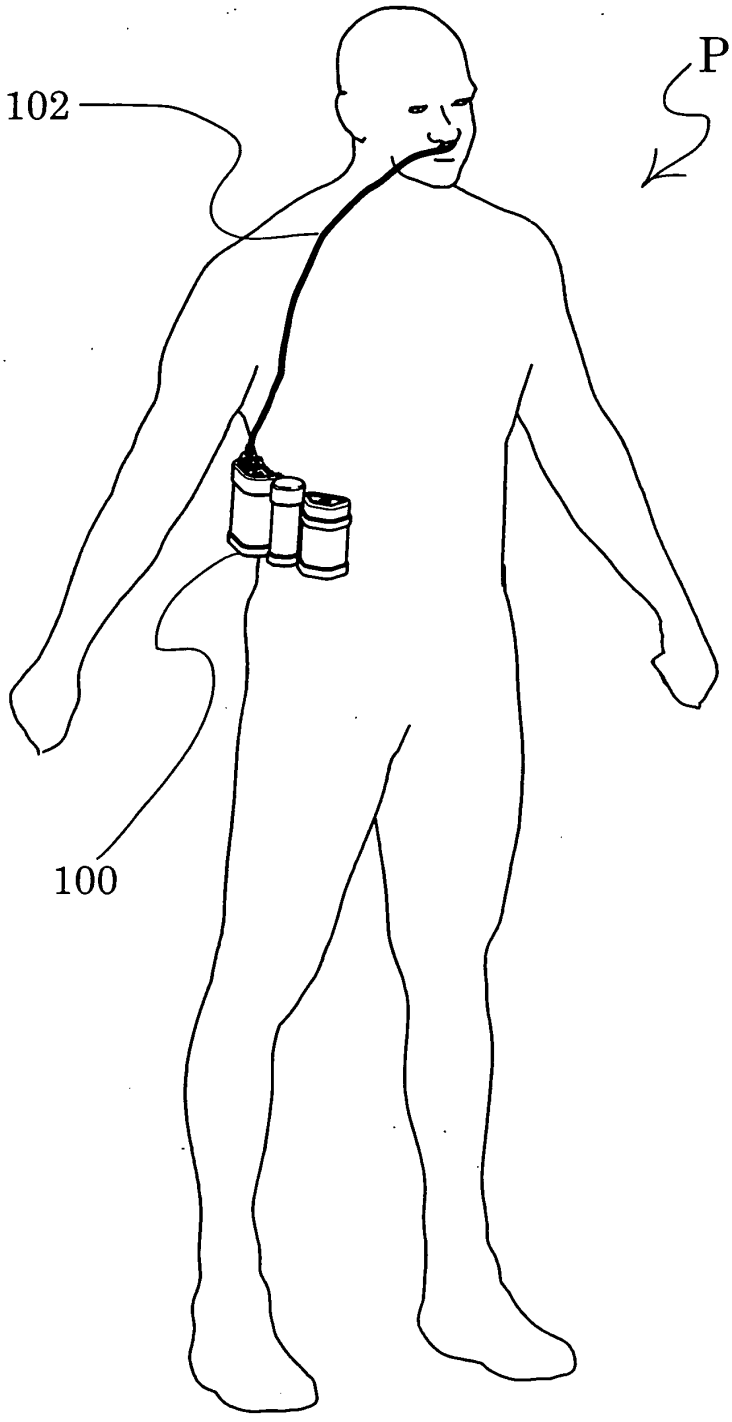


Fig 1

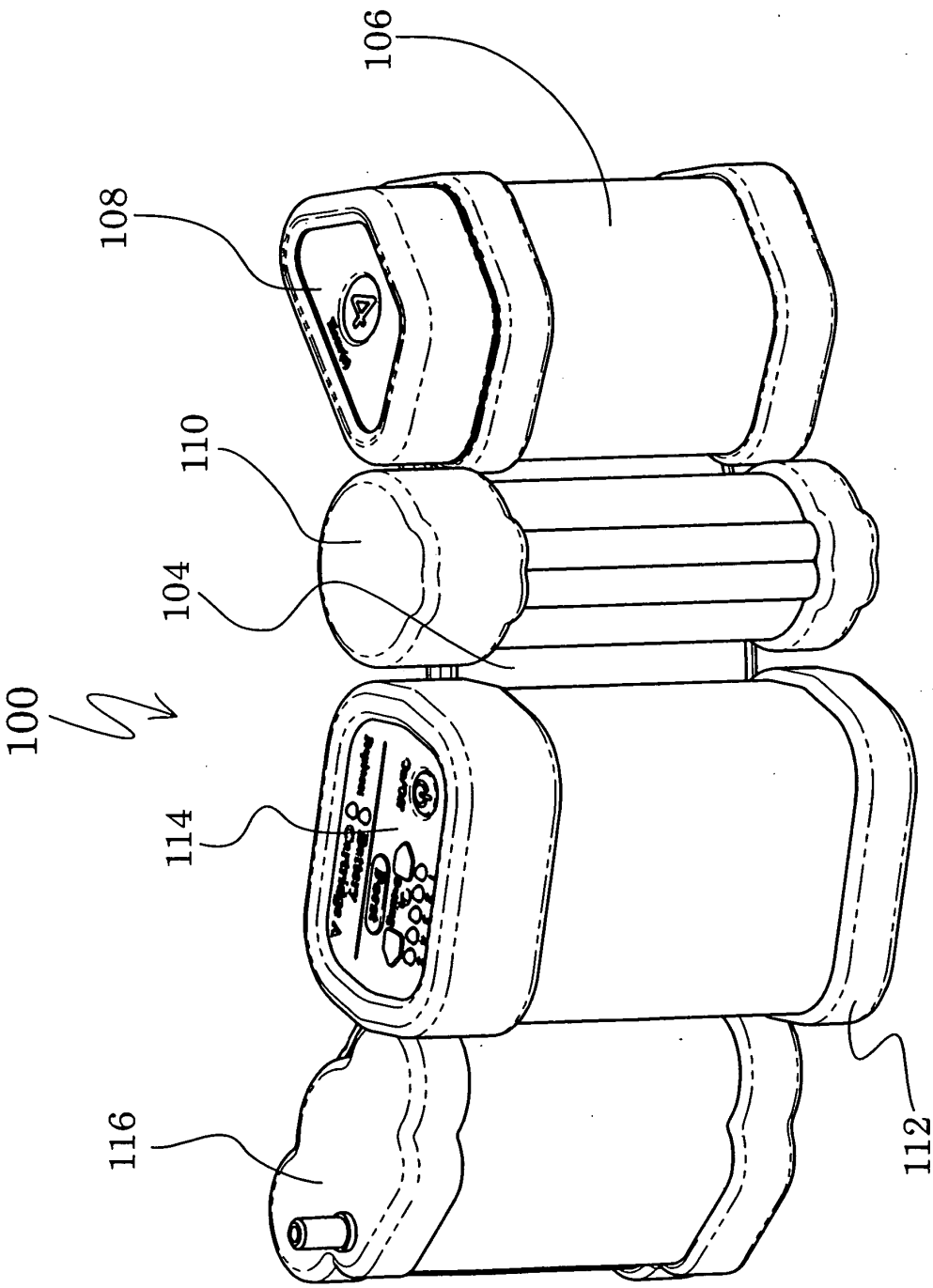


Fig 2

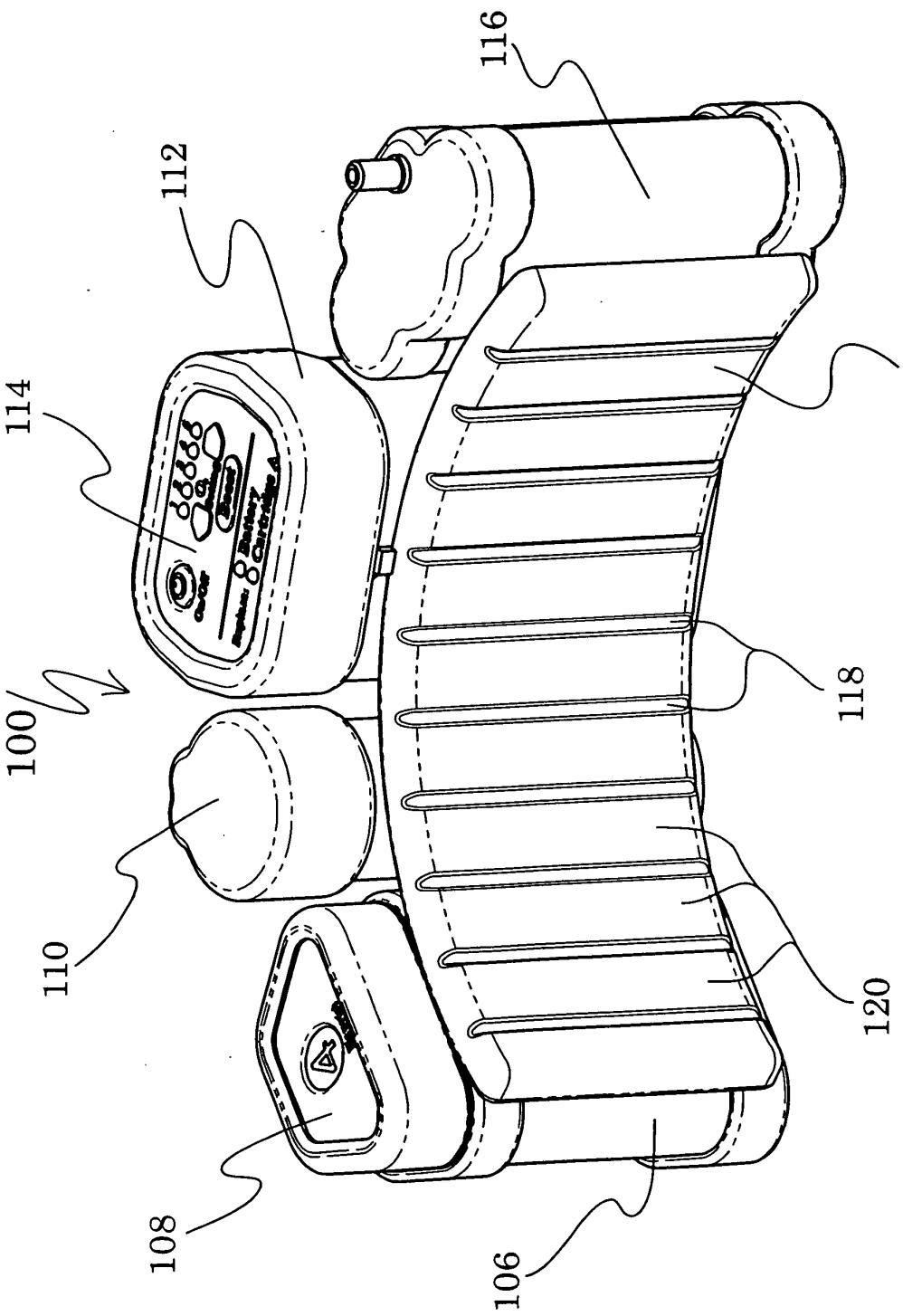


Fig 3

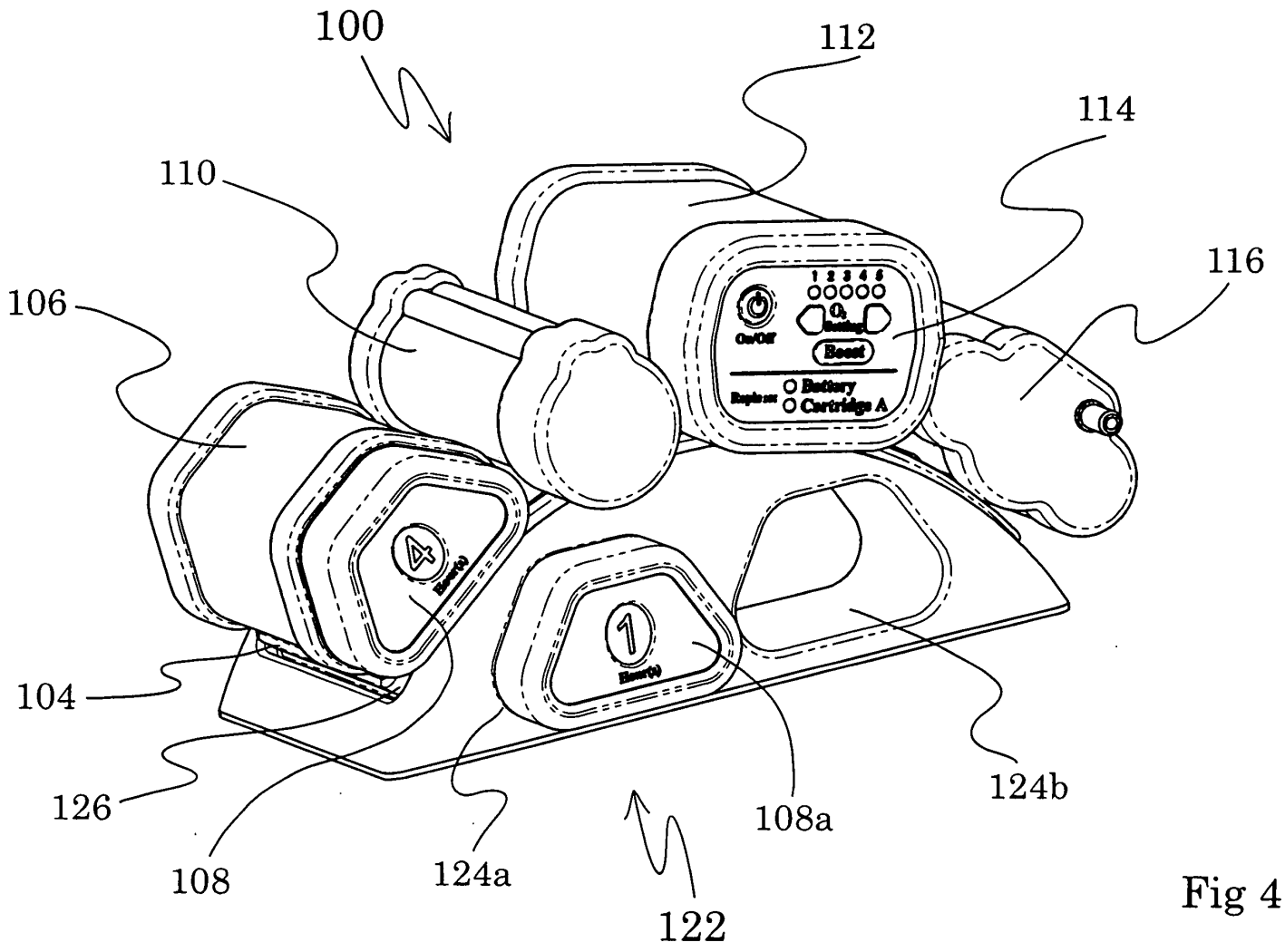


Fig 4

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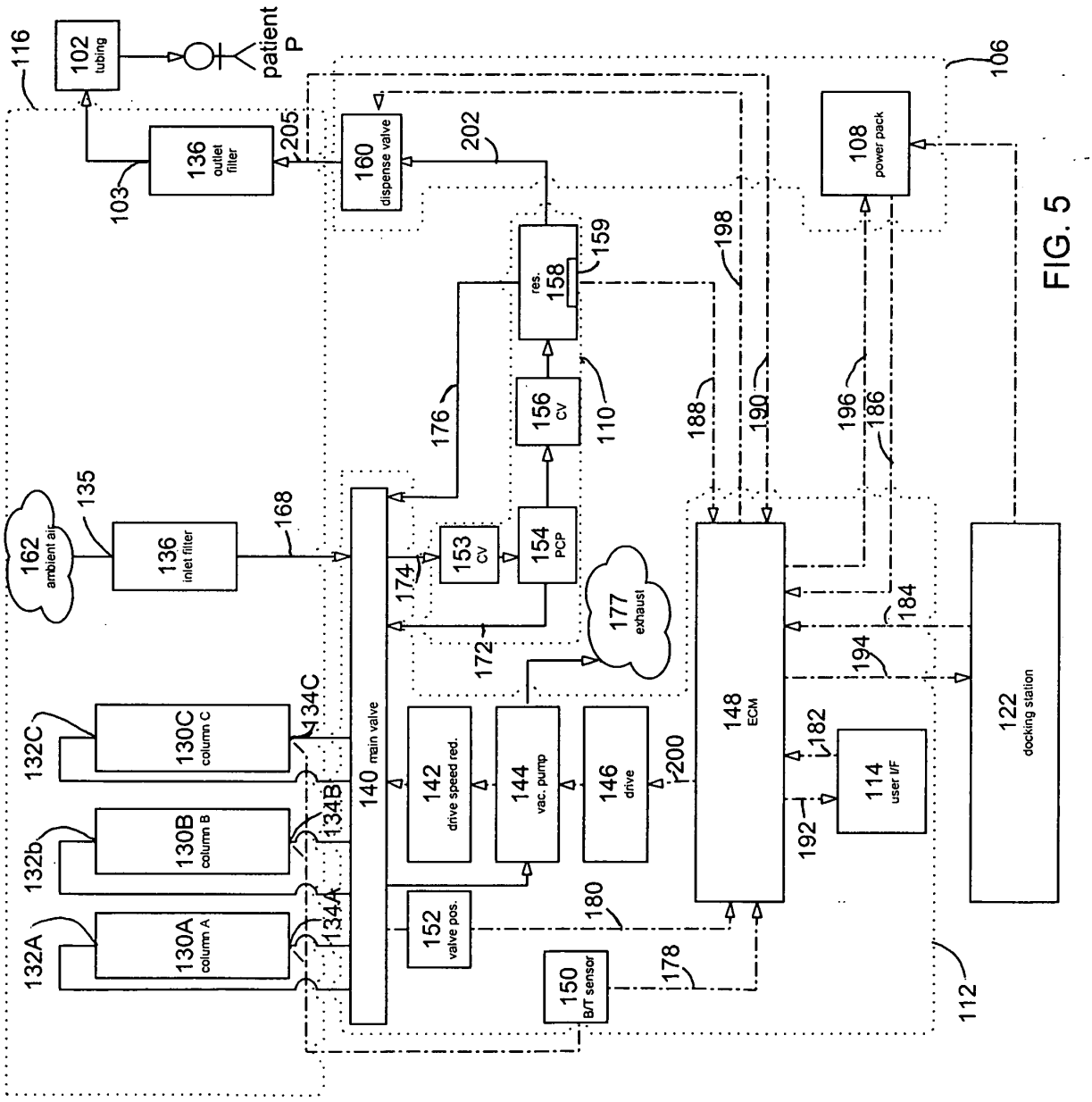

116
102
tubing
patient
P
106
136
outlet
filter
205
160
dispense valve
202
108
power pack
103
res.
158
159
198
176
156
CV
110
188
190
196
186
135
162
ambient air
136
inlet filter
168
153
CV
154
PCP
174
177
exhaust
184
172
194
134C
132C
130C
column C
140
main valve
142
drive speed red.
144
vac. pump
146
drive
148
ECM
182
122
docking station
132b
130B
column B
134B
200
114
user I/F
192
134A
132A
130A
column A
152
valve pos.
180
150
B/T sensor
178
112

FIG. 5

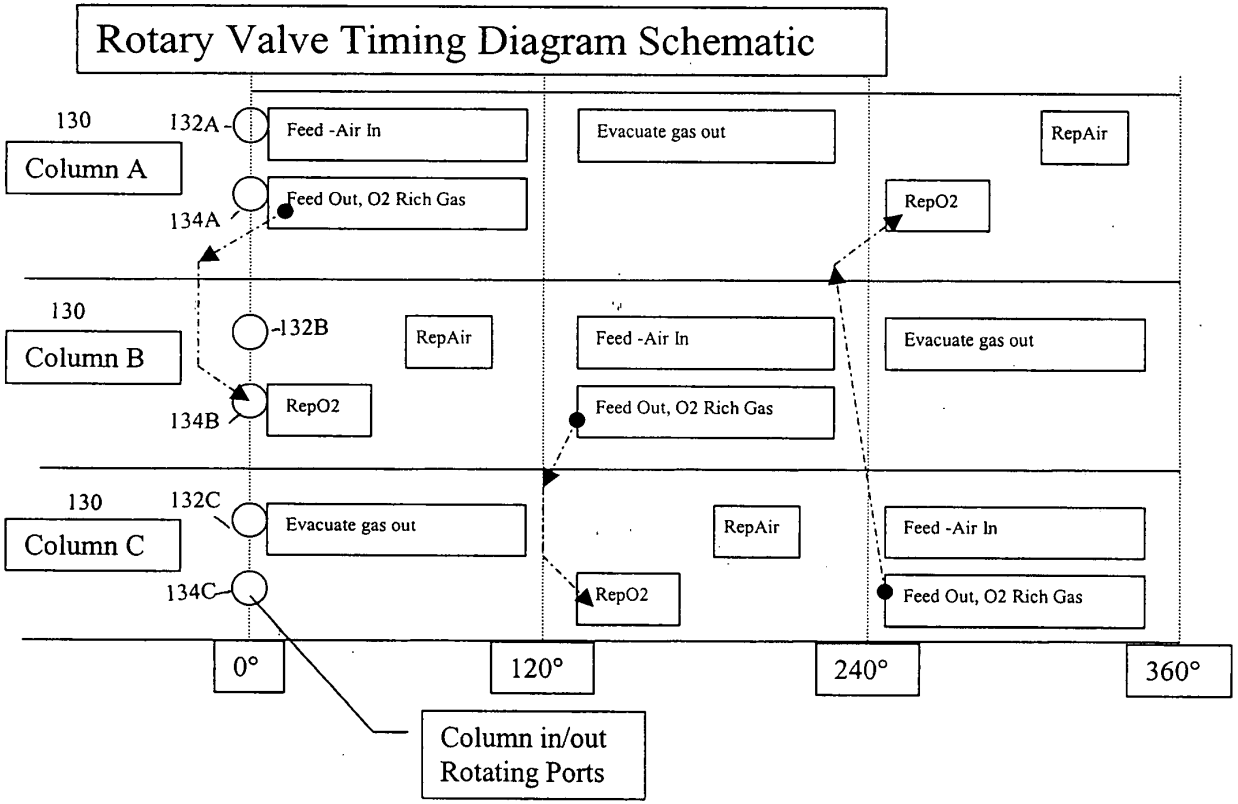


FIG. 6

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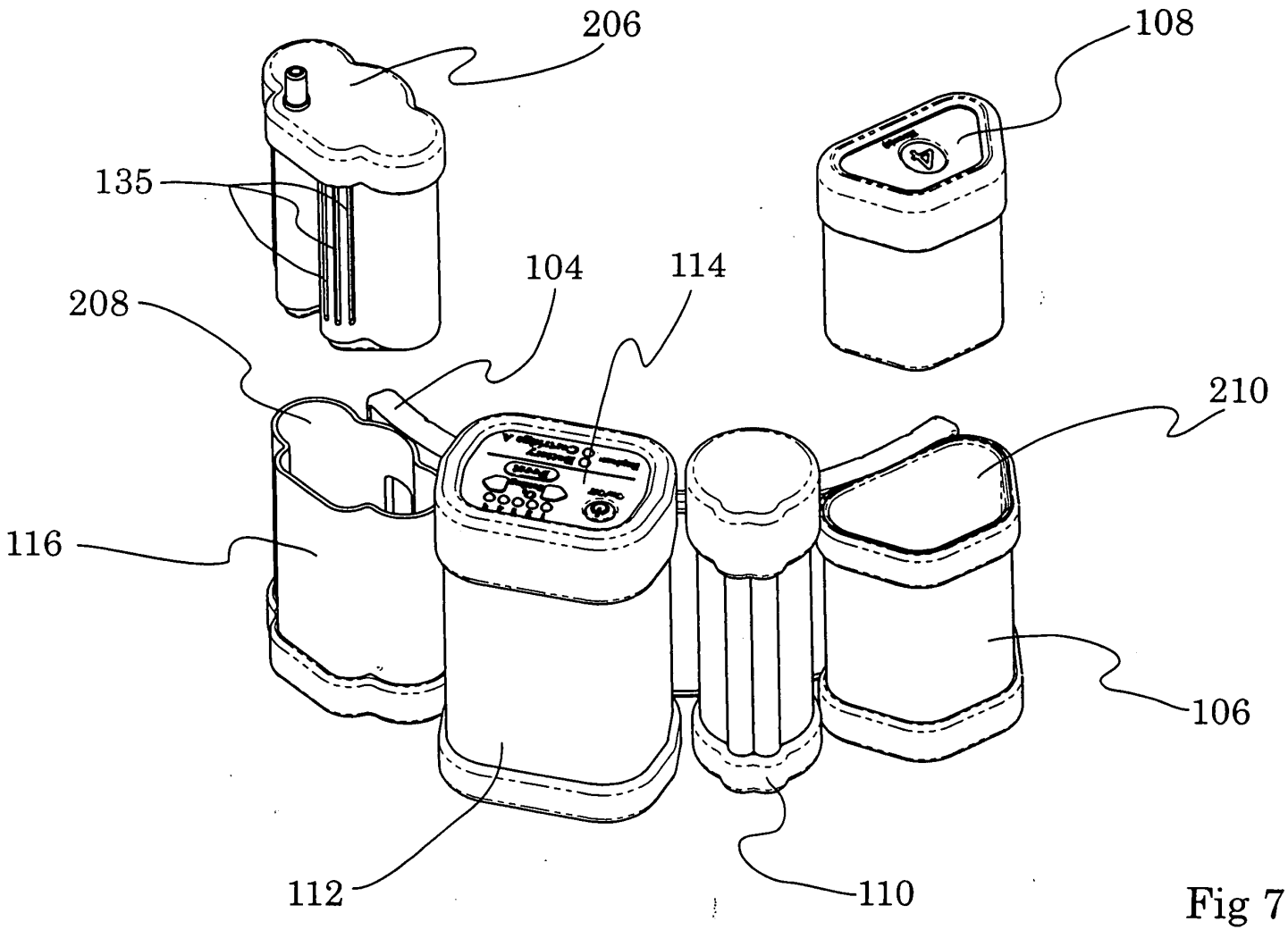


Fig 7

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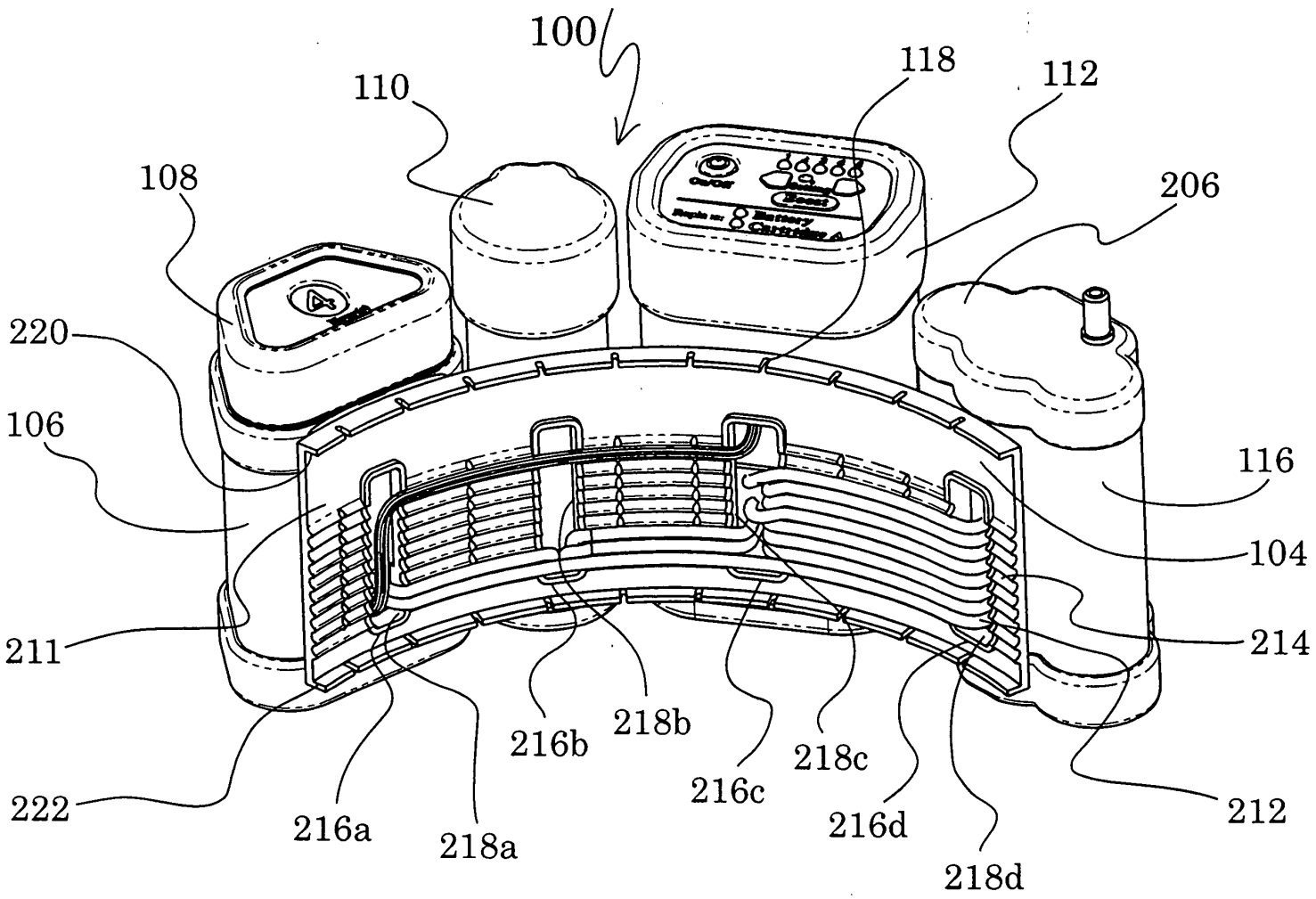


Fig 8

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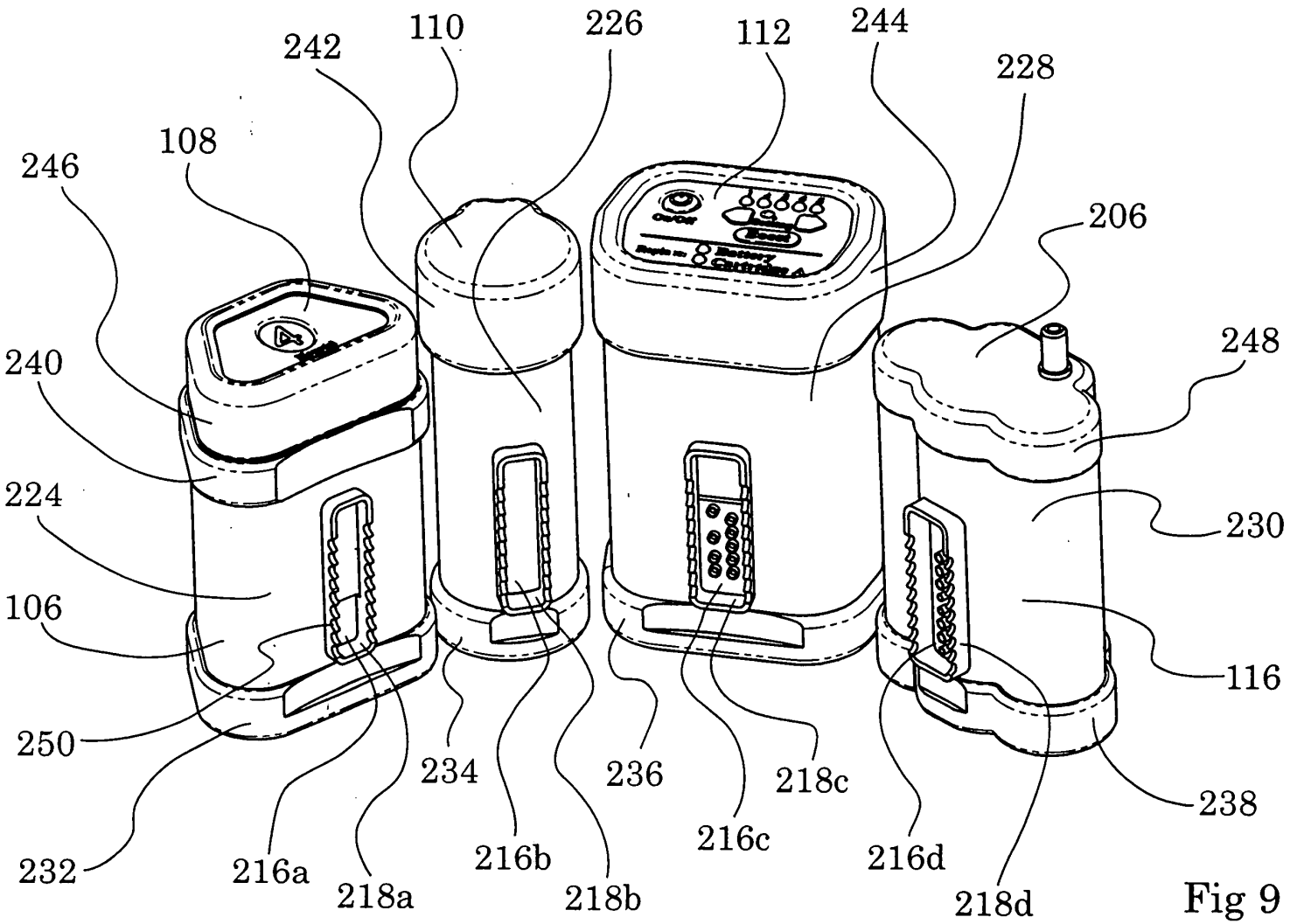


Fig 9

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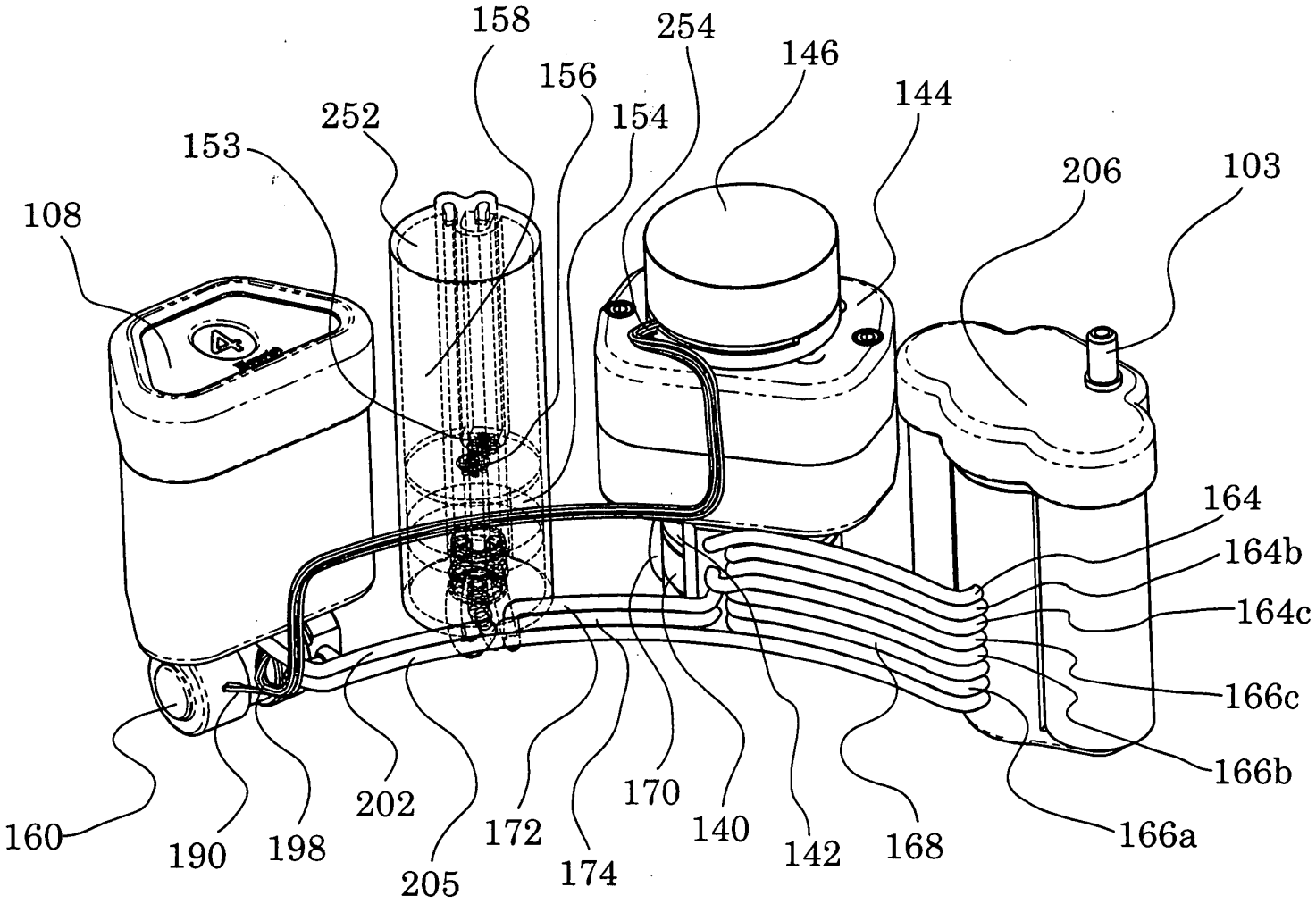


Fig 10

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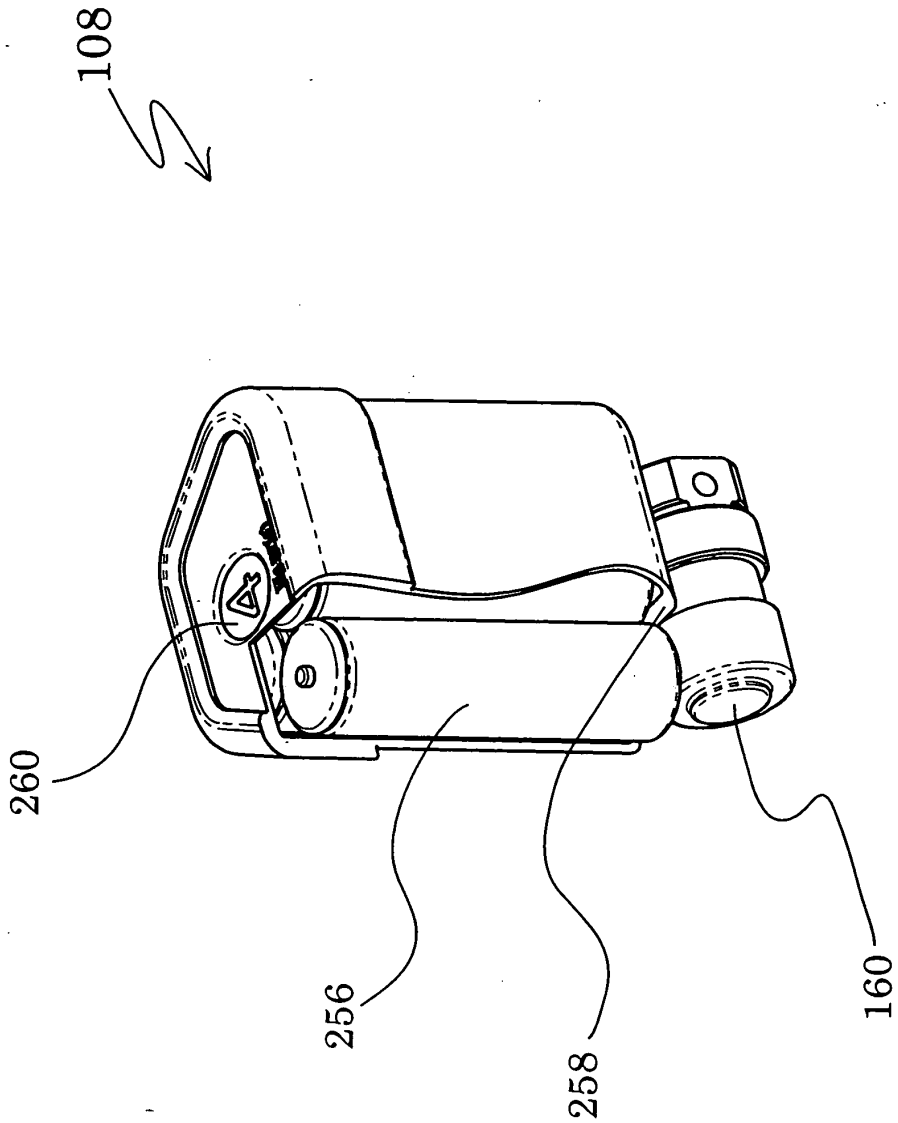


Fig 11

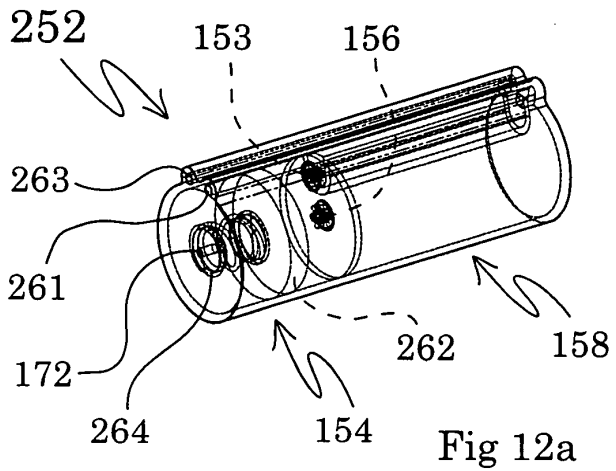
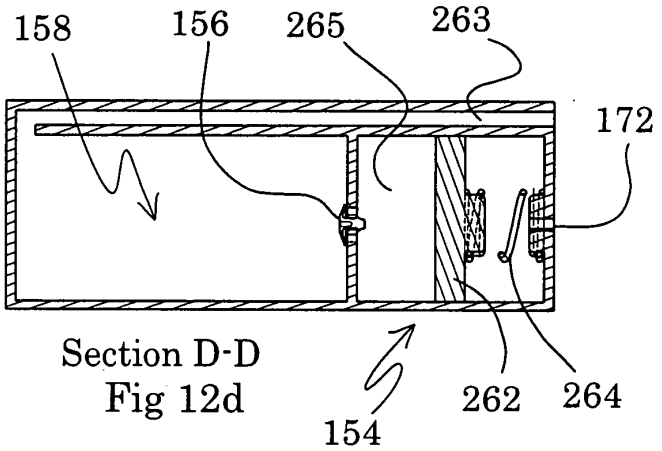


Fig 12a



Section D-D
Fig 12d

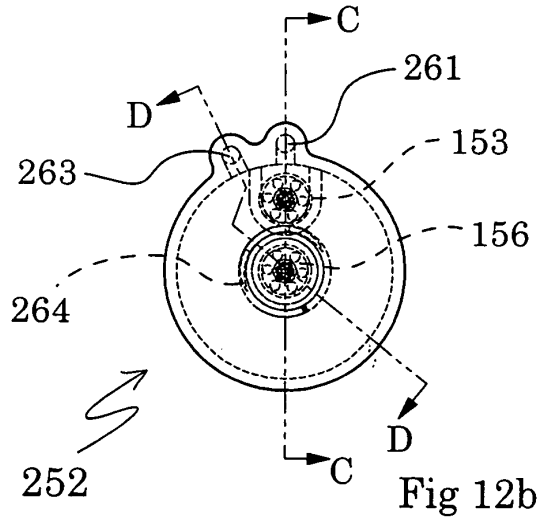
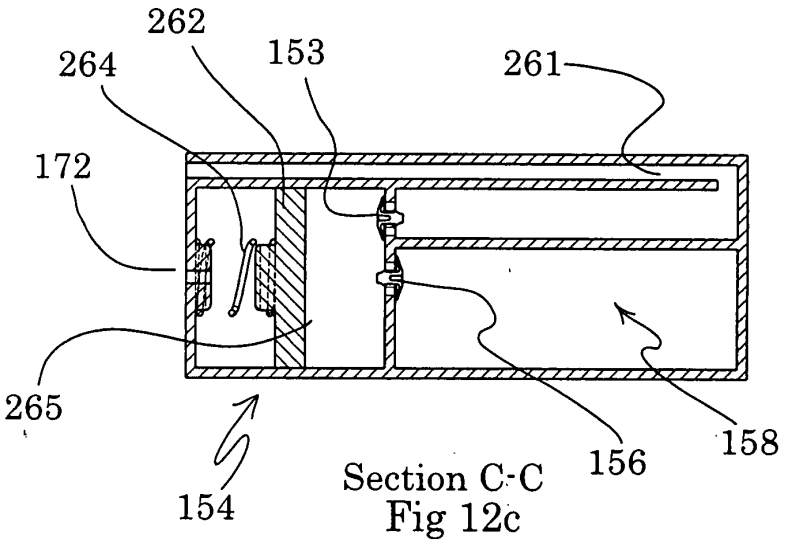


Fig 12b



Section C-C
Fig 12c

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GCE Gas Control Equipment Inc. v. VBOX, Inc.
IPR2023-00326

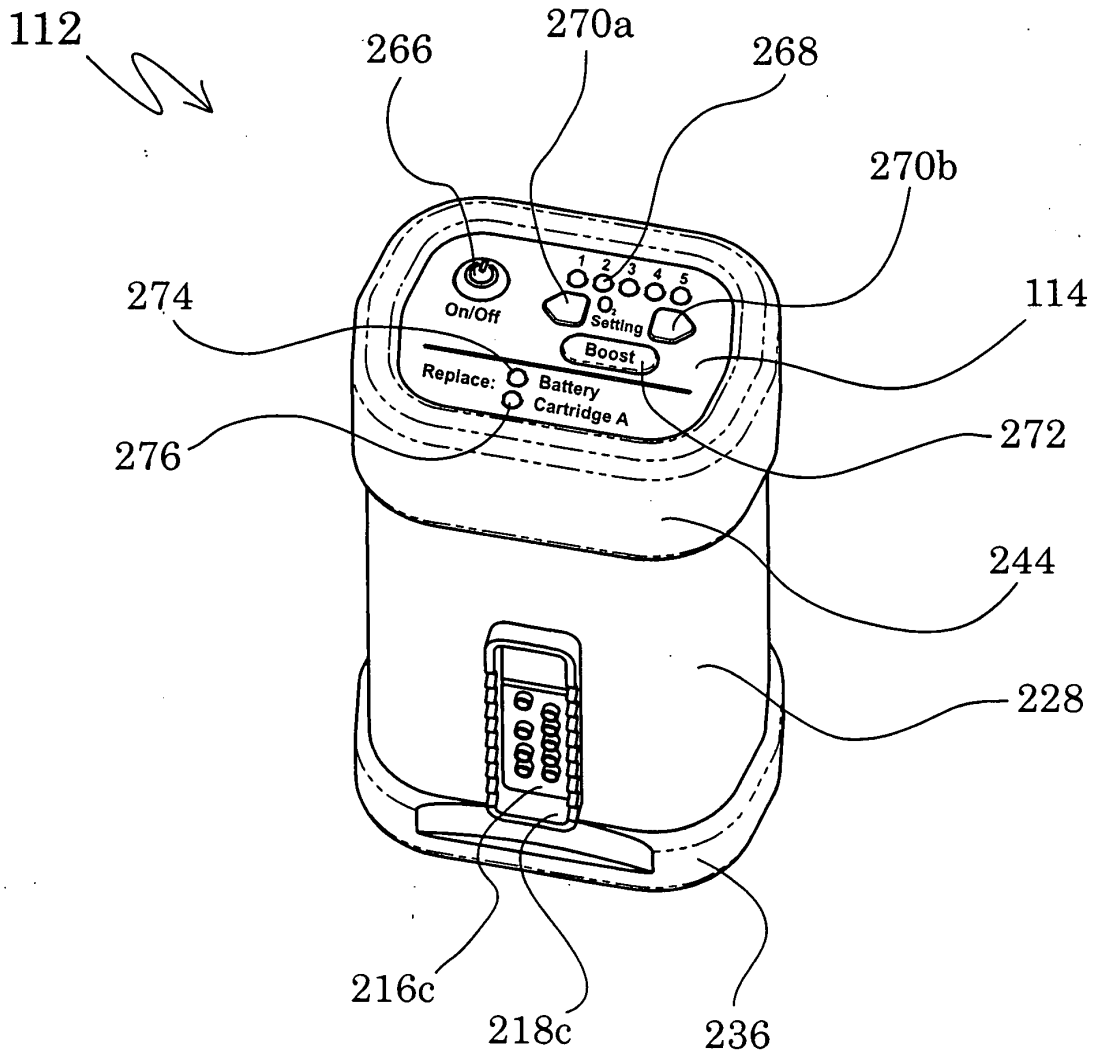


Fig 13

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GCE Gas Control Equipment Inc. v. VBOX, Inc.
IPR2023-00326

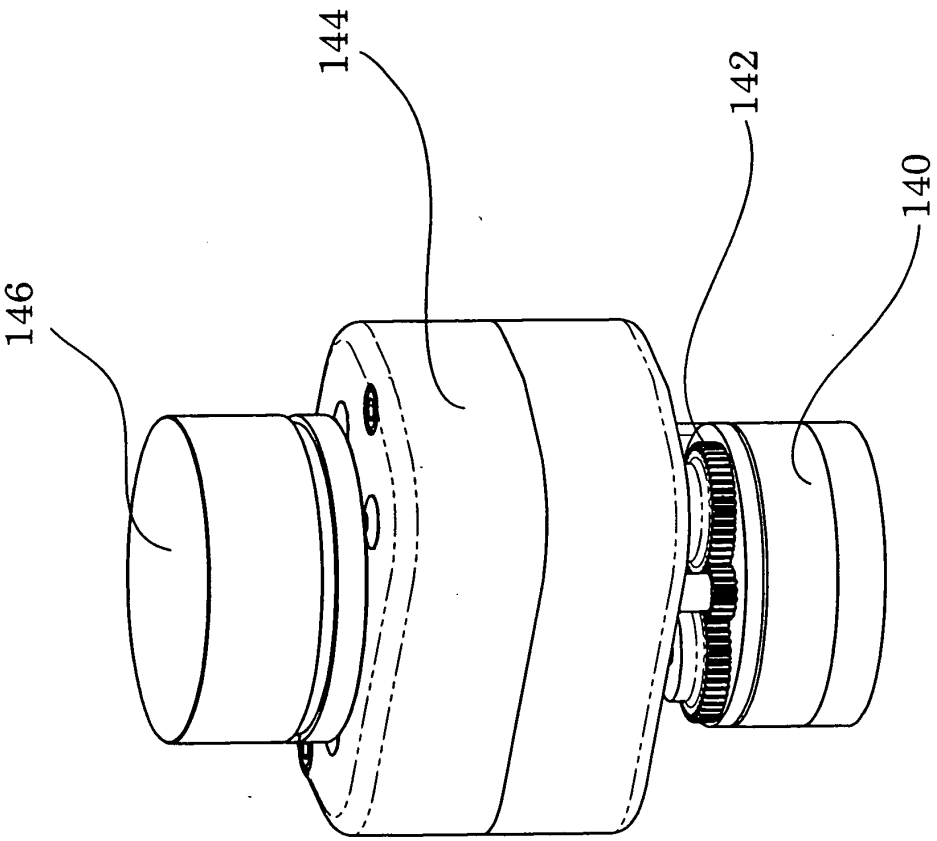


Fig 14

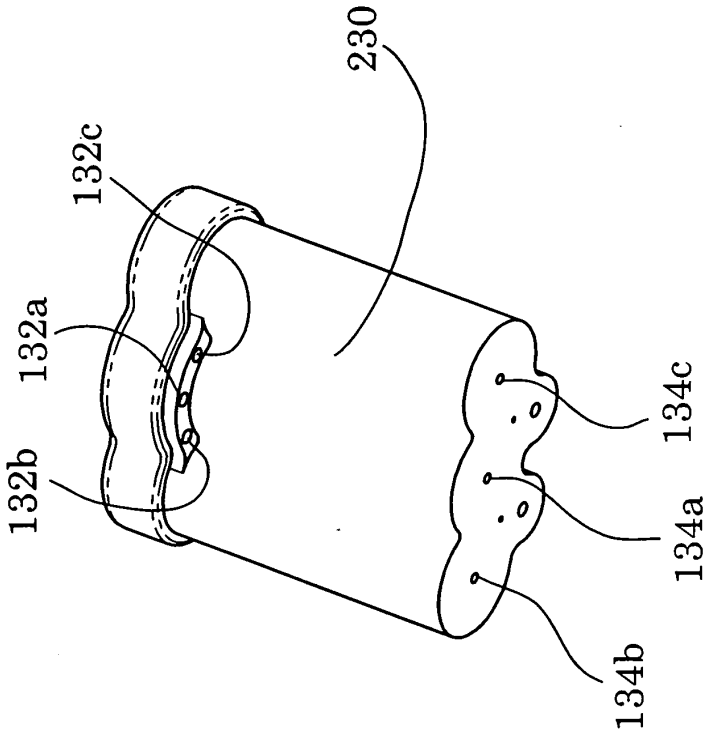


Fig 15

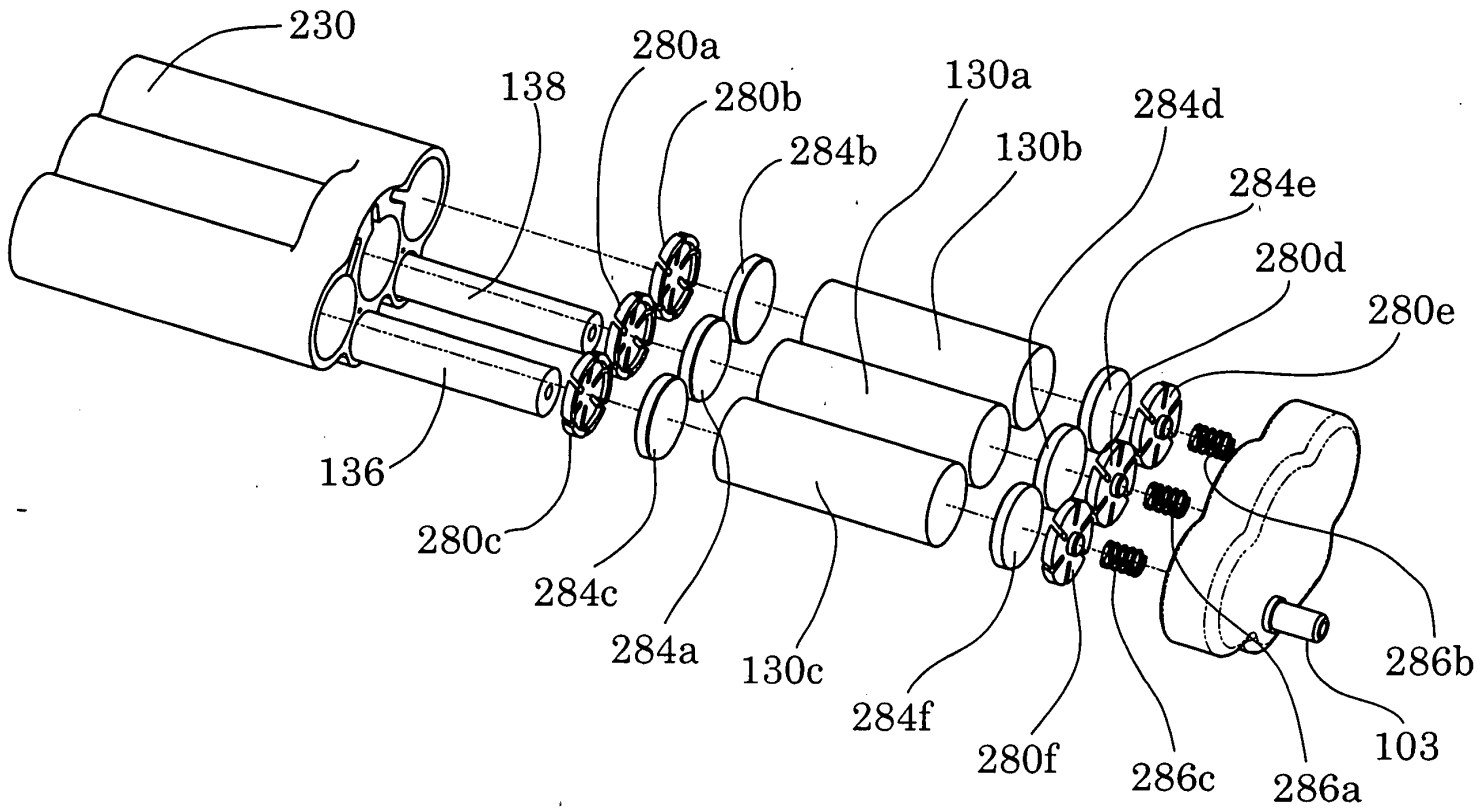


Fig 16

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GCE Gas Control Equipment Inc. v. VBOX, Inc.
IPR2023-00326

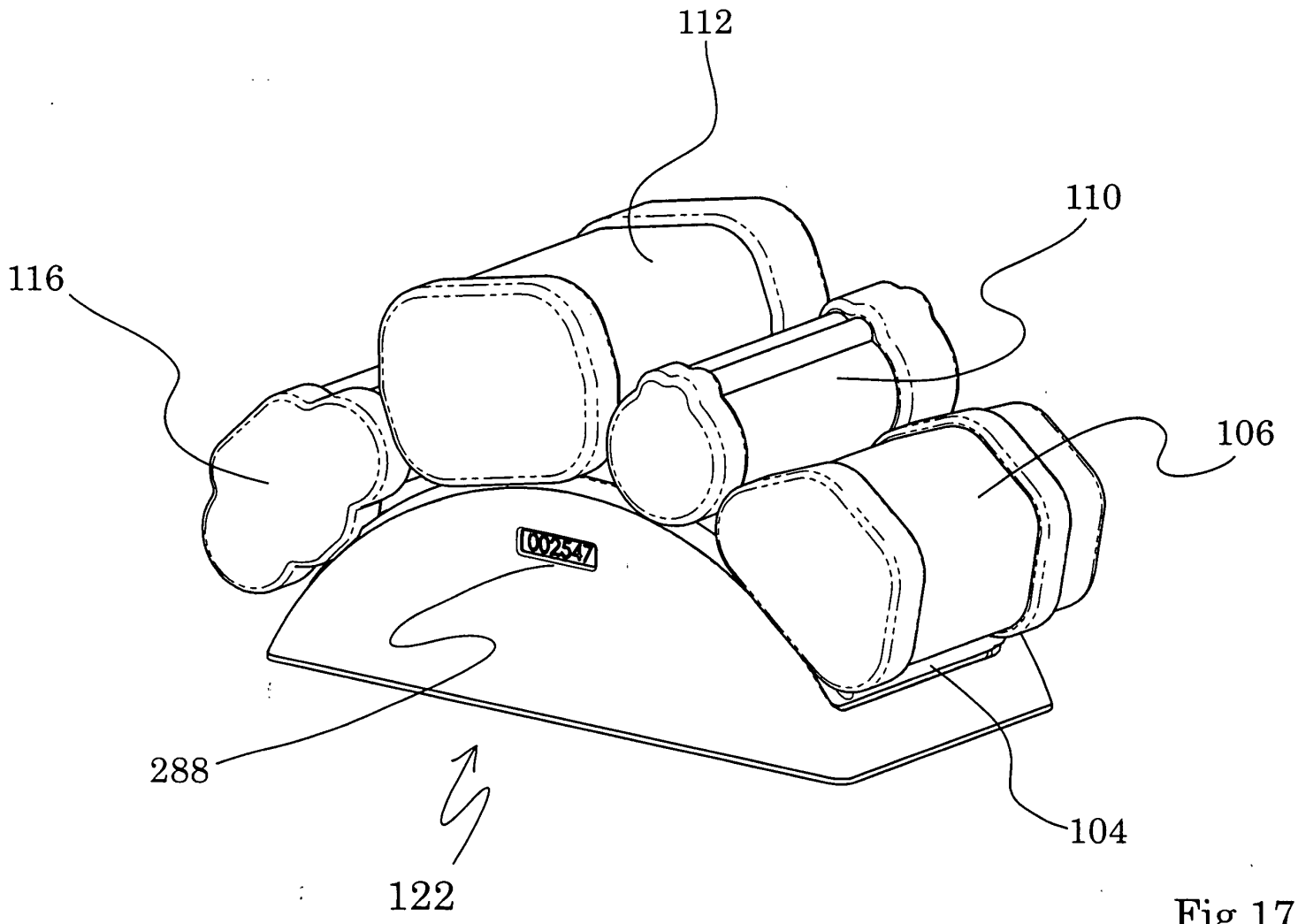


Fig 17

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GCE Gas Control Equipment Inc. v. VBOX, Inc.
IPR2023-00326

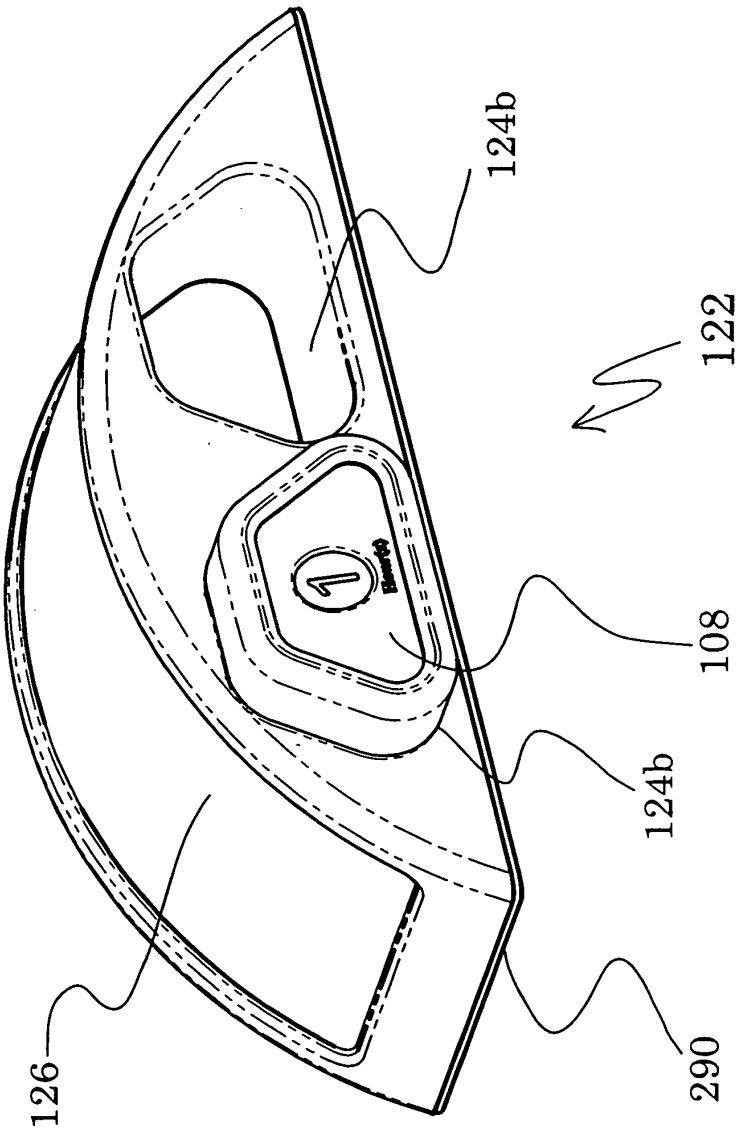


Fig 18

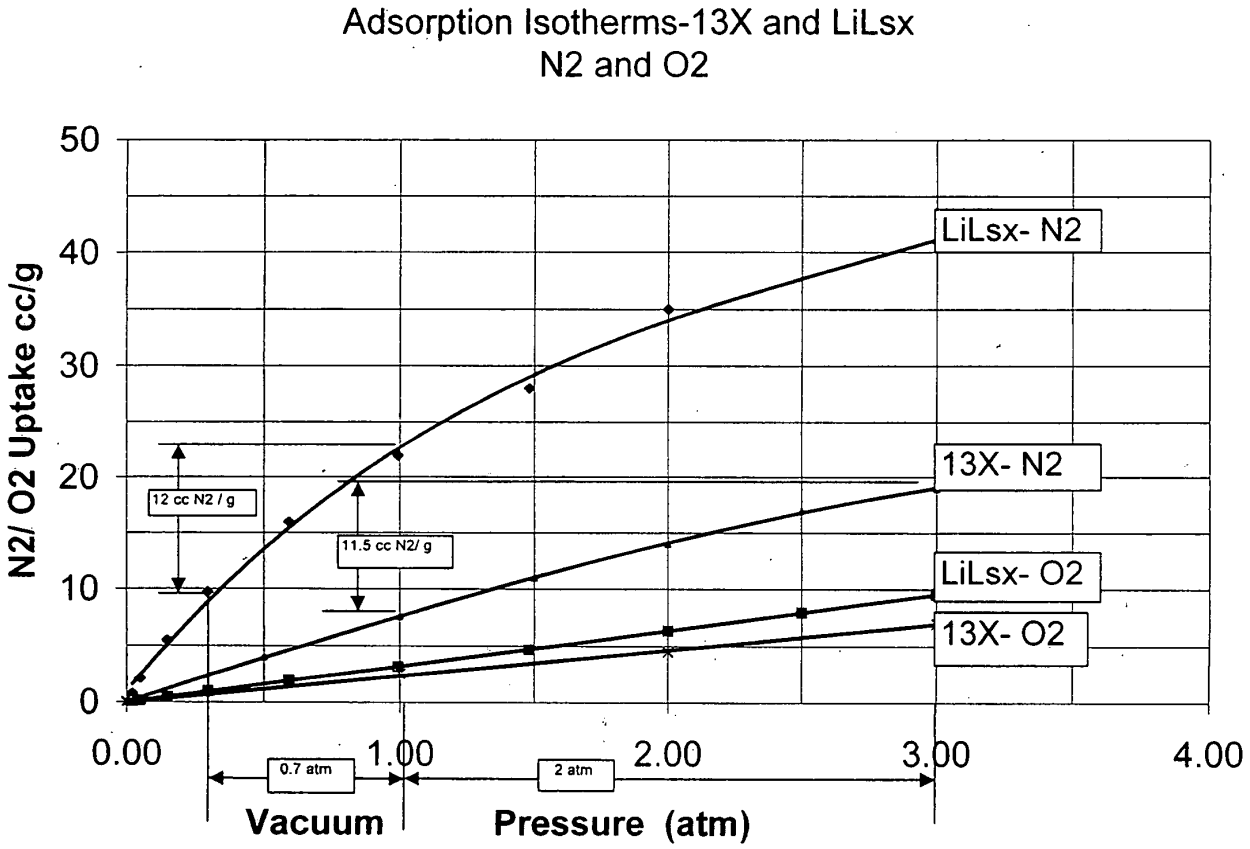


FIG. 19

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GCE Gas Control Equipment Inc. v. VBOX, Inc.
IPR2023-00326

DECLARATION FOR UTILITY PATENT APPLICATION (37 C.F.R. 1.63)		Attorney Docket No.	V180.12-0006
		First Named Inventor	Theodore W. Jagger
		COMPLETE IF KNOWN	
X Declaration Submitted with Initial Filing	Declaration Submitted after Initial Filing (Surcharge (37 C.F.R. 1.16(e)) Required)	Application Number	
		Filing Date	Herewith
		Group Art Unit	
		Examiner Name	

As a below named inventor, I hereby declare that my residence, post office address, and citizenship are as stated below.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:
ADSORBENT CARTRIDGE FOR OXYGEN CONCENTRATOR

the specification of which:

X is attached hereto OR

was filed on as United States Application Number or PCT International Application Number and was amended on (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment specifically referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 C.F.R. 1.56.

I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or of any PCT international application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application Number(s)	Country	Foreign Filing Date (MM/DD/YYYY)	Certified Copy Attached? Yes No

I hereby claim the benefit under 35 U.S.C. 119(e) of any United States provisional application(s) listed below.

Application Number(s)	Filing Date (MM/DD/YYYY)

I hereby claim the benefit under 35 U.S.C. 120 of any United States application(s), or 365(c) of any PCT international application designating the United States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT international application in the manner provided by the first paragraph of 35 U.S.C. 112, I acknowledge the duty to disclose information which is material to patentability as defined in 37 C.F.R. 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application.

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GCE Gas Control Equipment Inc. v. VBOX, Inc.
IPR2023-00326

U.S. Parent Application or PCT Parent Number	Parent Filing Date (MM/DD/YYYY)	Parent Patent Number (*if applicable*)

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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GCE Gas Control Equipment Inc. v. VBOX, Inc.
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GCE - Exhibit 1075, Page 228
GCE Gas Control Equipment Inc. v. VBOX, Inc.
IPR2023-00326

POWER OF ATTORNEY

Attorney Docket No.

V180.12-0006

First Named Inventor : Theodore W. Jagger

Title : ADSORBENT CARTRIDGE FOR OXYGEN CONCENTRATOR

In the patent application:

X identified above (and submitted to the Patent and Trademark Office herewith).

_ filed on _____ as Application No. _____.

I appoint the attorneys and agents associated with Customer Number 00164 to prosecute the patent application identified above and to transact all business in the Patent and Trademark Office connected therewith, including full power of association, substitution and revocation.

I ratify all prior actions taken by Kinney & Lange, P.A. or the attorneys and agents mentioned above in connection with the prosecution of the above-mentioned patent application.

I authorize Kinney & Lange, P.A. to mark the appropriate space above and to insert the filing date and application number of the application, as appropriate.

I authorize the attorneys and agents named herein to accept and follow instructions from David R. Fairbairn as to any action to be taken in the Patent and Trademark Office regarding this application without direct communication between the attorneys and agents and the undersigned. In the event of a change in the persons from whom instructions may be taken, the attorneys and agents named herein will be so notified by the undersigned.

Please address all correspondence and telephone calls to **Customer Number 00164**, attention David R. Fairbairn, Telephone (612) 339-1863, Fax (612) 339-6580.

VBOX, INCORPORATED

Signature: Nicholas P. Van Brunt Dated: 2/05/09

Nicholas P. Van Brunt

Title: President

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Application Information

Title Line One::	ADSORBENT CARTRIDGE FOR OXYGEN
Title Line Two::	CONCENTRATOR
Total Drawing Sheets::	Nineteen (19)
Formal Drawings?::	Yes
Application Type::	Utility
Docket Number::	V180.12-0006

Representative Information

Representative Customer Number:: 00164

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GCE Gas Control Equipment Inc. v. VBOX, Inc.
IPR2023-00326

First Named Inventor	:	Theodore W. Jagger	
Appln. No.	:		
Filed	:	Herewith	Group Art Unit:
Title	:	ADSORBENT CARTRIDGE FOR OXYGEN CONCENTRATOR	Examiner:
Docket No.	:	V180.12-0006	

INFORMATION DISCLOSURE STATEMENT

Commissioner For Patents
P.O. Box 1450
Alexandria, VA 22313-1450

VIA EXPRESS MAIL NO.: EV 485708840 US

The enclosed PTO Form-1449 lists patents and publications submitted pursuant to 37 C.F.R. 1.97. Copies of the patents or publications are enclosed as necessary [if application filing date is after June 30, 2003, copies of U.S. patents and application publications are not required].

TIME OF FILING

The Information Disclosure Statement is being filed:

1. X with the application or within three months of the filing date of a national application (other than a continued prosecution application under 37 C.F.R. 1.53(d)) or date of entry into the national stage of an international application or, to the best of the undersigned's knowledge, before the mailing date of a first Office action on the merits or a first office action after the filing of a request for continued examination under 37 C.F.R. 1.114, whichever event occurs last. In accordance with 37 C.F.R. 1.97(b), no certification or fee is required.

Respectfully submitted,

KINNEY & LANGE, P.A.

By: _____

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DRF:LB:bmg

FORM PTO-1449	Atty. Docket No.: V180.12-0006	Application No.:
LIST OF PATENTS AND PUBLICATIONS FOR APPLICANT'S INFORMATION DISCLOSURE STATEMENT	First Named Inventor: Theodore W. Jagger	
	Filing Date: Herewith	Group Art:

U.S. PATENT DOCUMENTS

Examiner Initials		Document No.	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Documents
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	AB	4,491,459	01-01-1985	Pinkerton
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	AZ	6,478,857	11-12-2002	Czabala
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		Foreign Patent Document	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Documents	Translation Yes No
	BM	EP 0 860 646 A2	02-06-1998	McCulloh	Yes
	BN	WO 98/58219	12-23-1998	Honkonen	Yes
	BO	WO 03/092817	11-13-2003	Appel	Yes

OTHER ART (Including Author, Title, Date, Pertinent Pages, Etc.)

	BP	Recommendations of the Fifth Oxygen Consensus Conference, 1999
	BQ	"AirSep lowers boom", www.hmenews.com/2004.12/depts/vendors/vendors1.htm.
	BR	

EXAMINER: DATE CONSIDERED:

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP 609; draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 860 646 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
26.08.1998 Bulletin 1998/35

(51) Int Cl.[6]: **F17C 5/06**

(21) Application number: **98300882.2**

(22) Date of filing: **06.02.1998**

(84) Designated Contracting States:
AT BE CH DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **10.02.1997 US 797828**

(71) Applicant: **LITTON SYSTEMS, INC.**
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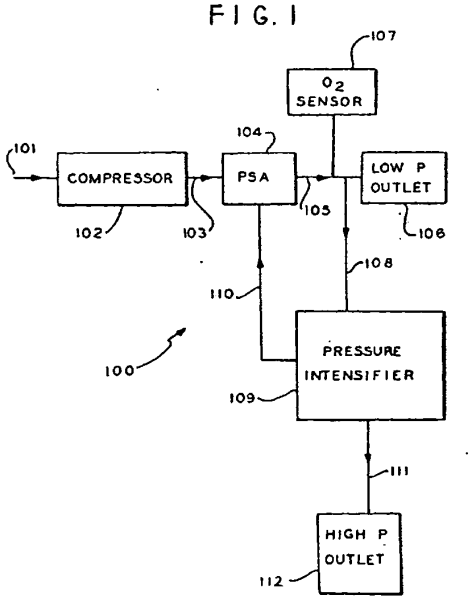
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(54) Oxygen concentrator

(57) An apparatus for providing oxygen-enriched air at a first pressure and at a second pressure, the second pressure being greater than the first pressure. The apparatus comprises, in combination, a pressure swing adsorption system (104) and a pressure intensifier (109). The pressure swing adsorption system (104) for enriching the oxygen content of air has a pressure of at least the first pressure. The pressure swing adsorption system (104) is adapted to provide oxygen-enriched air to a first outlet (106) at the first pressure and to provide oxygen-enriched air to a pressure intensifier (109) at the first pressure. The pressure intensifier (109) pressurizes the oxygen-enriched air and provides the oxygen-enriched air to a second outlet (112) at the second pressure.

FIG. 1



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EP 0 860 646 A2

Printed by Jouve, 75001 PARIS (FR)

Description

Field of the Invention

The present invention provides an oxygen concentrator and cylinder recharger and in particular provides a home health care oxygen concentrator and a cylinder recharger that is capable of simultaneously or independently providing oxygen-enriched air at a low pressure and at a high pressure. Such provision of oxygen-enriched air at two different pressures enables the apparatus to be utilized for the provision of oxygen-enriched air at a pressure suitable for use by a patient while at the same time providing oxygen-enriched air at a pressure suitable for recharging of a cylinder, thereby providing the patient with the option to be mobile.

Background of the Invention

There are a number of instances where the provision of oxygen-enriched air, sometimes referred to as oxygen, is required to be provided at a low pressure. One particular situation where such low pressure oxygen-enriched air is required is in the health care field, both in the health care field within various institutions as well as within a patient's home. In such situations, it may be necessary to provide a continuous flow of low pressure oxygen-enriched air to a patient on an on-going basis. While such patients may be able to withstand the absence of the flow of oxygen-enriched air for short periods of time, such patients frequently are unable to withstand the absence of such a flow of oxygen-enriched air for longer periods of time without suffering major health problems. In particular, such patients are normally not able to move from one location to another without oxygen-enriched air.

Systems for the provision of a flow of low pressure oxygen-enriched air include distillation processes, adsorption separation processes and membrane separation processes. One such process is a so-called pressure swing adsorption (PSA) process which has the advantage of being able to provide oxygen-enriched air in a short period of time after the supply of a suitable feed gas e.g. compressed air, to the apparatus. An example of a pressure swing adsorption process is described in U.S. Patent 4,948,391 of Y. Noguchi, which issued August 14, 1990.

A typical pressure swing adsorption process applied to the provision of oxygen-enriched air could comprise the following steps:

a) introducing air under pressure into a cylinder having an adsorption column of an adsorbent which selectively adsorbs nitrogen,
b) continuing the introduction of the air into the cylinder such that a zone of the adsorbed gas (nitrogen) moves forward through the cylinder,
c) collecting the desired gas (oxygen) that passes from the cylinder,
d) terminating the introduction of air to the cylinder,
e) terminating the collection of oxygen from the cylinder,
f) discharging a portion of the pressurized gas remaining in the cylinder, and
g) returning a portion of the oxygen back into the cylinder to flow through the column in the opposite direction to desorb the gas (nitrogen) adsorbed on the adsorbent and to purge the desorbed gas (nitrogen) from the cylinder.

Steps (a)-(e) effect the separation of nitrogen from the air so as to provide oxygen-enriched air, whereas steps (f) and (g) effect regeneration of the column used in the process. This permits continuous and long-term use of the pressure swing adsorption process to provide oxygen-enriched air.

One of the disadvantages of known processes for the supply of oxygen-enriched air at low pressure is that such processes lack the flexibility to allow the patient to be located at a fixed location but also to be able to move from that location with relative ease with an assurance that the source of oxygen-enriched air is sufficient. For instance, the patient may wish or need to be able to move from a bed or other similar location, e.g. to use toilet facilities, prepare meals, go to another room or change locations for other reasons. Such mobility with existing processes generally requires a patient to be disconnected from a first source of low pressure oxygen-enriched air and to be re-connected to a second system for provision of such air and which is mobile e.g. a cylinder of oxygen-enriched air. The patient would want an assurance that the source of oxygen-enriched air is sufficient, which would be of particular concern if the patient wished to be mobile for an extended period of time e.g. a day or weekend, without having to re-fill the mobile, or ambulatory, cylinder at a dealer or distributor.

Summary of the Invention

Apparatus has now been found that is capable of simultaneously providing low pressure oxygen-enriched air for use by a patient as well as high pressure oxygen-enriched air for the filling of a pressure cylinder.

Accordingly, one aspect of the present invention provides an apparatus for providing oxygen-enriched air comprising, in combination:

a low pressure oxygen enriched air separation system for enriching the oxygen content of inlet air, said air separation system adapted to provide oxygen-enriched air to a first outlet at a first pressure, said air separation system adapted to provide oxygen-enriched air to a second outlet at approximately said first pressure;
a pressure intensifier connected to said second outlet of the air separation system to pressurize said

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oxygen-enriched air and to provide said oxygen-enriched air to an outlet of the pressure intensifier at a second pressure; and

wherein said air separation system is capable of simultaneously providing oxygen-enriched air to said first outlet and said second outlet such that a flow of oxygen-enriched air can be supplied to said first outlet while said pressure intensifier is pressurizing said oxygen-enriched air to said second pressure.

In another aspect, the present invention provides a method for providing oxygen-enriched air at a first pressure and at a second pressure, said second pressure being greater than the first pressure, said method comprising:

feeding air to an air separation system;

providing oxygen-enriched air from said air separation system to a first outlet at said first pressure and controlling the flow of oxygen-enriched air at said first outlet;

providing oxygen-enriched air from said air separation system to a pressure intensifier at approximately said first pressure, increasing the pressure of said oxygen-enriched air to said second pressure using said pressure intensifier; and

wherein said air separation system is capable of simultaneously providing oxygen-enriched air to said first outlet and said second outlet such that a flow of oxygen-enriched air can be supplied to said first outlet while said pressure intensifier is pressurizing said oxygen-enriched air to said second pressure.

In a further aspect, the present invention provides apparatus for providing oxygen-enriched air comprising, in combination:

an air compressor, a low pressure oxygen-enriched air separation system and a pressure intensifier;

said air compressor being adapted to provide compressed air to said air separation system;

said air separation system being adapted to provide oxygen-enriched air to a first outlet at a first pressure, said first outlet having a controller to control the flow of oxygen-enriched air at a first outlet;

said air separation system further providing oxygen-enriched air to the pressure intensifier at said first pressure, said pressure intensifier being adapted to provide oxygen-enriched air at said second pressure;

wherein said air separation system is capable of simultaneously providing oxygen-enriched air to said first outlet and said second outlet such that a flow of oxygen-enriched air can be supplied to said first inlet while said pressure intensifier is pressurizing said oxygen-enriched air to said second pressure.

In embodiments of the apparatus and method of the present invention, the air separation system is a pressure swing absorption system, and the oxygen-enriched air from the pressure swing adsorption system is provided either simultaneously or independently to said pressure intensifier.

In another embodiment, the apparatus further comprises an air compressor for providing air to said pressure swing adsorption system, said air compressor having an inlet and exhaust air sound suppression system.

Brief Description of the Drawings

The present invention is illustrated by the embodiments shown in the drawings in which:

Figure 1 is a schematic representation in block format of apparatus of the invention;

Figure 2 is a schematic representation of the apparatus of Figure 1;

Figure 3 is a schematic representation of a fill port adaptor body;

Figure 4 is a schematic representation of a plan view of the fill port adaptor body;

Figure 5 is a schematic representation of a cross section of the fill port adaptor body through lines A-A of Figure 4;

Figure 6 is a schematic representation of a cross section of the fill port adaptor body through lines D-D of Figure 4;

Figure 7 is a schematic representation of a cross section of a part of the fill port adaptor of Figure 6, through B-B;

Figure 8 is a schematic representation of a perspective view of a flow controller body;

Figure 9 is a schematic representation of an end view of the flow controller body of Figure 8;

Figure 10 is a schematic representation of a cross section of the flow controller body of Figure 9 through line A-A;

Figure 11A is a schematic representation of a compressor system; and

Figure 11B is a schematic representation of a compressor sound suppression system, through line B-B of Figure 11A.

Detailed Description of the Invention

The low pressure oxygen-enriched air separation system may be an oxygen generator, a distiller, an air separator or a membrane separator, but it will be described herein with reference to the preferred embodiment in which it is a pressure swing absorption system.

Fig. 1 shows apparatus of the invention, generally indicated by 100, in block format. Ambient air 101 is connected to compressor 102. Outlet 103 from compressor 102 is connected to pressure swing adsorber (PSA) 104 and pressure intensifier 109 (see Fig. 2). Outlet 105 from pressure swing adsorber 104 is connected to oxygen

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sensor 107, low pressure outlet 106, and through tubing 108, to pressure intensifier 109. Pressure intensifier 109 is connected by tubing 111 to high pressure outlet 112, as well as being interconnected by tubing 110 to pressure swing adsorber 104.

In operation, ambient air enters air inlet 101 and is pressurized in compressor 102. The pressurized air is fed to pressure swing adsorber 104, as well as being fed to pressure intensifier 109 when the latter is energized (see Fig. 2). The oxygen-enriched air from pressure swing adsorber 104 is monitored by oxygen sensor 107, as well as fed to low pressure outlet 106 for use by a patient. In addition, oxygen-enriched air is fed to pressure intensifier 109. Pressurized oxygen-enriched air is fed from pressure intensifier 109 to high pressure outlet 112 where it may be used to re-charge a cylinder of oxygen-enriched air.

Fig. 2 shows an embodiment of an apparatus of the invention, generally indicated by 200, in greater detail. Apparatus 200 has inlet 101 connected in turn to particulate filter 201, tuned resonator 202 and to the inlet to compressor 203. Compressor 203 is driven by motor 204, and has relief valve 205. The outlet from compressor 203 is connected to a heat exchanger, generally indicated by 206, which has heat exchanger section 207 and cooling fan 208. Outlet tubing 209 from heat exchanger 207 is connected to two solenoid valves, 210 and 211, which are in a parallel relationship.

Solenoid valves 210 and 211 are connected to a tuned resonator 212. Each of solenoid valves 210 and 211 is connected to a sieve bed, 213 and 214 respectively, which are also in a parallel relationship. Sieve beds 213 and 214 are molecular sieve beds. Each of the outlets of sieve bed 213 and 214 is connected to a check valve, 215 and 216 respectively. In addition, sieve bed 213 and 214 are interconnected through orifice 217, the interconnection being located between the outlet of each of sieve bed 213 and 214 and each of check valves 215 and 216.

The outlets from each of check valves 215 and 216 are joined together, and connected to oxygen plenum 220. Oxygen plenum 220 is connected through orifice 221 to oxygen sensor 222 and filter 223, which is vented to the atmosphere. Oxygen plenum 220 is also connected to low pressure switch 237. The outlet of oxygen plenum 220 is connected in turn to pressure regulator 231, through orifice 232, filter 233, check valve 234, flow meter 235 to patient outlet 236. Patient outlet 236 is a low pressure outlet i.e. the pressure would normally be only a few inches of water, as will be understood by persons skilled in the art.

The outlet of the oxygen plenum 220 is also connected to a pressure intensifier generally indicated by 240. Pressure intensifier 240 has a first stage cylinder 241 and a second stage cylinder 242, with drive air cylinder 243 located therebetween. The opposed sides of drive cylinder 243 are connected through solenoid valves 244 and 245 to tubing between solenoid valve 210 and sieve bed 213, and tubing between solenoid valve 211 and sieve bed 214, respectively, of the pressure swing adsorber. Check valve 247 is located between oxygen plenum 220 and first stage cylinder 241. First stage cylinder 241 is also connected through check valve 248 and check valve 250 to second stage cylinder 242. Rupture disc 246 is attached to first stage cylinder 241 and rupture disc 251 is attached to second stage cylinder 242. Filters 252 and 253 are connected to first stage cylinder 241 and second stage cylinder 242, respectively, and vented to the atmosphere.

Check valve 249 is connected to filter 260, pressure switch 261 and pressure connection 262, which is the high pressure connection.

In an example of a typical operation of the embodiment of Figure 2, air enters air compressor 203 through inlet 101, particulate filter 201 and tuned resonator 202. Tuned resonator 202 is for sound suppression of compressor 203. The air is compressed to the operating pressure e.g. a pressure ranging from 20 to 30 psig. The compressed air obtained is routed through a fan cooled tube and fin heat exchanger 206 which cools the air before it enters the molecular sieve beds 213 and 214. The cooling of the air from the compressor optimizes performance of the molecular sieve beds as well as cooling the oxygen-enriched air obtained from the beds before it reaches the patient. Air flow into and out of the beds is controlled by two solenoid valves (valve 210 and valve 211) which allow compressed air to either enter the bed or to be vented from the bed to atmosphere.

A normal three phase cycle is (i) a first filling phase to fill bed 213 and exhaust bed 214, (ii) an intermediate overlap phase and (iii) a second filling phase to fill bed 214 and exhaust bed 213.

In phase (i), solenoid valve 210 allows compressed gas to enter bed 213 while valve 211 is venting gas from bed 214 to atmosphere. The molecular sieve in bed 213 adsorbs water vapour and nitrogen from the compressed air, allowing oxygen and argon to pass through the sieve. A portion of the gas is used as product gas which is delivered to the patient as low pressure oxygen-enriched air. The remainder of the oxygen-enriched air passes through an orifice, 217, and purges nitrogen and water vapour out of bed 214 as it is vented to atmosphere through solenoid valve 211. At the end of this phase, which in a typical embodiment of the invention lasts approximately 8 seconds, the pressure in bed 213 is typically approximately 30 psig and in bed 214 it is typically slightly above zero psig. At this time, bed 213 is almost saturated with nitrogen and continued flow through this bed without purging would result in nitrogen breakthrough and loss of purity in the product gas.

In overlap phase (ii), there is an overlap of approximately 1.6 seconds in which both solenoid valves 210 and 211 are switched to allow flow into both molecular sieve beds. This allows the air from sieve bed 213, initially at approximately 30 psig, as discussed above, to back flow through solenoid valve 210 into bed 214 which

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is initially at a low pressure. The crossflow of air in addition to the air from compressor provides a quick charge of bed 214, thereby reducing the compressor flow requirements and improving the efficiency of the system. At the end of the overlap cycle, the pressure in both beds is typically approximately 20 psig.

At the end of the overlap phase i.e. in phase (iii), solenoid valve 210 is switched to the vent position allowing bed 213 to vent to atmosphere until the pressure is only slightly above zero. Venting the bed to atmosphere plus back filling with product gas from bed 214 purges nitrogen and water vapour from bed 213 in preparation for the next cycle. At the same time bed 214 is providing product gas to the patient and purging bed 213. At the end of this phase, the entire cycle is repeated.

The oxygen-enriched air from the sieve beds passes through check valves 215 and 216 into the product storage (oxygen plenum 220). From oxygen plenum 220, the oxygen-enriched air passes into pressure regulator 231, through flow control orifice 232, HEPA filter 233 and check valve 234 to flow meter 235. Regulator 231 reduces the pressure from, for example, 30 psig in the oxygen storage plenum 220 to a constant pressure e.g. 6 psig, at the inlet of flow meter 235. Flow meter 235 is adjustable by the patient to provide the prescribed flow rate of oxygen at very low pressure.

A small amount of gas from the plenum e.g. typically less than 250 cc per minute, is continuously monitored by the oxygen sensor to ensure that the oxygen purity is above a predetermined value e.g. 90%. If the purity is below the predetermined or threshold value, a microprocessor energizes a warning light to alert the patient that an equipment malfunction has occurred and to prevent cycling of the pressure intensifier.

Pressure intensifier 240 may be standard two-stage device with a drive air cylinder and first and second stage product gas cylinders. The intensifier is turned on by opening solenoid valve 244 and 245 and which are either both open or both closed. A typical pressure intensifier cycle is as follows:

1. In the first step of the cycle, drive air enters drive air cylinder 243 through solenoid valve 244 beginning at the start of the overlap cycle of the molecular sieve beds discussed above, which occurs just before bed 213 starts charging, and continuing through the bed 213 charging cycle. This causes the piston to shuttle, drawing product gas into first stage cylinder 241 through check valve 247 and compressing the oxygen-enriched air in the second stage cylinder 242 which exits through check valve 249.
2. The drive air cylinder supply is common to the sieve bed supply and controlled by the sieve bed solenoid valves. Thus, the air in drive air cylinder 243 also helps precharge the sieve beds during the overlap phase which further increases the efficiency of the system. In this step during the overlap phase, the air in the drive air cylinder 243 back flows through solenoid valve 244, backflows through solenoid valve 210 and back into bed 214 through solenoid valve 211.
3. When the bed solenoid valves cycle, ambient air enters drive air cylinder 243 through solenoid valve 245 causing the piston to shuttle compressing the oxygen enriched air in the first stage cylinder 241. This gas then passes through check valves 248 and 250 and enters the second stage cylinder. The drive air, entering through solenoid valve 245 in this side of the drive air cylinder 243 aids in precharging bed 213 during the overlap cycle, as previously described.

After leaving the pressure intensifier, the gas passes through a filter 260 and the high pressure coupling 262 before entering a pressure vessel (not shown). The pressure intensifier will continue to operate until the pressure is high enough to activate a pressure switch 261 in the product line which signals the controller to close solenoid valves 244 and 245.

An example of apparatus for monitoring gaseous oxygen concentration is shown in U.S. Patent 5,402,665 of R.F. Hart et al, which issued April 4, 1995. An example of a pressure swing adsorber system having a pneumatically driven booster compressor is shown in U.S. Patent 5,354,361 of K.M. Coffield, which issued October 11, 1994.

In embodiments of the present invention, the first pressure is in the range of 5-10 psi and the second pressure is in the range of up to 3000 psi. The apparatus of the present invention is particularly adapted to be capable of providing both first and second pressures simultaneously.

The oxygen content of the oxygen-enriched air may be varied over a wide range but is preferably at least 85% by volume. In preferred embodiments, the oxygen content is at least 90% by volume, especially in the range of 92-94% by volume.

The oxygen concentrator described herein utilizes a pressure intensifier to raise the pressure of a portion of the oxygen-enriched air to a suitable pressure e.g. 2000 psig, for storage in pressure vessels e.g. a cylinder, for use by ambulatory patients. It will be understood that when the cylinder is empty, the pressure intensifier will provide oxygen-enriched air at a relatively low pressure, for instance, about the pressure in the storage plenum e.g. 30 psig, but that this pressure will rise as the cylinder fills e.g. to the aforementioned 2000 psig.

While the oxygen concentrator may be operated so as to produce oxygen-enriched air having a content of, for example, 93% oxygen, and thereby meet certain regulations relating to the provision of oxygen-enriched air for patients, such oxygen-enriched air may not meet the specifications for a medical-grade oxygen. Thus cylinders with adaptors meeting regulations for medical-

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grade oxygen may not be able to be used with the oxygen concentrator. Nonetheless, a unique integrated high pressure fitting and flow controller is preferred, that allows the patient to easily and safely fill their cylinders with oxygen-enriched air e.g. 93% oxygen, from the concentrator. Such a high pressure fitting and flow controller is shown in Figures 3-11.

Figure 3 shows a perspective view of a fill port adaptor body, generally indicated by 300. Fill port adaptor body 300 has a housing 301 with integral cradle 302, handle 303, locking clip 304 and adaptor housing 305. Cradle 302 of housing 301 is adapted to accept the flow controller body described herein below. Cradle 302 has fill port adaptor 306 therein, which is further shown in Figure 5. Fill port adaptor 306 is connected to handle 303, and is movable into cradle 302 using handle 303. Adaptor 307 extends from housing 301 from the opposed side thereof to fill port adaptor 306, and is interconnected therewith as shown in Figure 5.

Locking clip 304 is intended to retain the flow controller body within cradle 302, as described below. Latching of the flow controller body into cradle 302 occurs automatically when the flow controller body of a cylinder is placed in the cradle. However, an operator must manually move locking clip 304 into a release position to remove the cylinder. Similarly, handle 303 must be moved before the flow controller body of a cylinder may be placed in cradle 302 or removed therefrom, to reduce risk of damage to fill port adaptor 306.

Adaptor housing 305 is open on its upper face, as illustrated, and has housing window 308 on the opposed side thereof. The end of adaptor housing 305 opposed to cradle 302 has housing slot 309 therein.

Figure 4 is a plan view of fill port adaptor port 300. Handle 303 is located on housing 301, and is adjacent to cradle 302. Locking clip 304 is shown as extending into cradle 302. Cradle 302 has adaptor housing 305 extending therefrom and in an aligned relationship. Adaptor housing 305 has housing window 308 therein, with housing slot 309 in the end thereof. Figure 4 shows that adaptor 307 is connected to gear rack 401 which extends into housing 301.

Figure 5 shows a cross section of fill port adaptor body 300 through line A-A. Locking clip 304 is pivoted about locking clip pivot 501. Locking clip spring 504 located within housing 301 biases locking clip base 503 in an outwards direction so that locking clip lip 502 is biased into to cradle 302 to lock the flow controller body therein.

A fill port adaptor, generally indicated by 505 in Figure 5, is on the opposed side of cradle 302 to locking clip 304.

Fill port adaptor extends from adaptor 307 to adaptor pin 511. Adaptor 307 is connected to adaptor channel 506 which is located within adaptor channel housing 507 which in turn is located within adaptor housing 512. Gear rack 401, shown in Fig. 4 and Fig. 6 is machined into adaptor housing 512. As discussed herein, adaptor housing 512 is movable with respect to housing 301. Adaptor channel 506 connects with spring chamber 513 in which is located adaptor spring 508 and check valve base 509. Check valve base 509 extends through check valve seat 510 and terminates in adaptor pin 511. In the retracted position as shown in Fig. 5, adaptor pin 511 is within housing 301, but in the engaged position the adaptor pin extends into cradle 302.

Figure 6 shows a cross section of the adaptor body shown in Figure 4, through D-D. Handle 303 is located on housing 301. Shaft 605 extends downward from handle 303 and connects handle 303 to pinion 601; pinion 601 is more clearly seen in Figure 7, and is attached to shaft 605 by screw 604. Rotation of handle 303 causes rotation of pinion 601. Handle 303 has, on its lower side, handle projection 608, which is shown as being located in indent 609 in housing 301. Indent 609, and a similar indent that is not shown, serve to position and retain handle 303 in predetermined locations.

In a preferred embodiment, indent 609 has an adjustable screw therein (not shown), such screw being tapered or having a shoulder thereon. Projection 608 contacts the adjustable screw, on said taper or shoulder. Adjustment of the position of the screw adjusts the location of the taper or shoulder, and hence radially adjusts the position at which handle 303 is positioned and retained. This permits precise adjustment of the positioning of the fill port adaptor.

Figure 7 shows the rack and pinion, generally indicated by 600. Rack and pinion 600 has pinion 601 with pinion cogs 602. Pinion 601 rotates about pinion shaft 603, which extends down from handle 303, forming part thereof, as discussed above. Pinion 601 is located within pinion housing 606 which is part of housing 301. Pinion cogs 602 intermesh with ratchet slots 607 of ratchet 401. Ratchet 401 forms part of adaptor channel housing 507 illustrated in Figure 5.

Figure 8 illustrates the flow controller body, generally indicated by 700. Flow controller body 700 has pressure gauge 701, rupture disc housing 709, outlet fitting 706, and flow restrictor 704. Outlet fitting 706 is adapted to receive a flexible hose. The body is adapted to be threaded onto a high pressure cylinder by threaded port 705, flow restrictor 704 being located within threaded port 705. Flow controller body 700 has an integral cradle housing 702 which is shaped and dimensioned to fit precisely in the cradle 302 (see Figure 3). A flow control (ON/OFF) knob 703 with mechanical alignment/interlock bar 708 is attached to flow controller body 700 at the end opposed to the threaded port 705. Fill port adaptor inlet 707 is located in integral cradle housing 702.

Figure 9 shows an end view of flow controller body 700. Flow controller body 700 has flow restrictor 704 in the end thereof. Pressure gauge 701 and outlet port 706 are shown at an angle.

Figure 10 shows a cross section of flow controller body 700 through line A-A of Figure 9. Adaptor inlet 707 has inlet valve 800. Inlet valve 800 has inlet valve stem

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801 located within inlet valve chamber 802, but it will be noted that as illustrated inlet valve stem 801 does not extend fully to the end of inlet valve chamber 802. Inlet valve stem 801 has inlet valve spring 803 which biases valve end 804 towards valve seat 805 thereby biasing the valve toward a closed position.

In operation, flow controller body 700 is attached to a cylinder, not shown, through threaded cylinder port 705. Flow controller body 700 would normally be located on a cylinder, and remain thereon although it can be removed if desired. The cylinder with flow controller body 700 thereon is placed into fill port adaptor body 300 which forms part of the oxygen concentrator. Cradle housing 702 is adapted to fit within cradle 302 of fill port adaptor body 300. Alignment/interlock bar 708 on flow controller body 700 fits into housing slot 309 on adaptor housing 305. Flow controller knob 703 must be in the OFF position in order to insert alignment/interlock bar 708 into housing slot 309. This locates the rupture disk opposite housing window 308, but also locates inlet valve 800 opposite fill port adaptor 306. In order to insert flow controller body 700 into cradle 302, it is necessary to move locking clip 304 away from fill port adaptor 300, but after flow controller body 700 has been inserted into cradle 302, locking clip 304 biases back and locks flow controller body 700 in position.

Handle 303 is then tilted, rotated and locked in position, with handle projection 608 of handle 303 engaging in indent 609 in housing 301, at which time adaptor 306 moves inwards into cradle 302. In doing so, fill port adaptor 306 is inserted into adaptor inlet 707, with adaptor pin 511 contacting valve end 804. This moves valve end 804 away from valve seat 805, thereby opening the valve. However the amount of movement of valve end 804 is limited, thereby also causing check valve 509 to open. This forms a channel for the flow of oxygen-enriched air from the oxygen concentrator through fill port adaptor body 300, flow controller body 700, and out of cylinder port 704 into the cylinder. The cylinder cannot be removed without moving handle 303 such that fill port adaptor 306 becomes retracted. This disconnects the fill port adaptor so that the oxygen concentrator is not connected to the cylinder, and closes both the cylinder and the oxygen concentrator check valves 804 and 509, to prevent the flow or leakage of gas therefrom. In particular, the check valve in the fill port adaptor, 509, prevents gas from oxygen plenum 220 from escaping to atmosphere through check valves 247-250 in the pressure intensifier when the pressure intensifier is not in operation. A single movement of handle 303 opens or closes the channels for flow of high pressure air to the cylinder.

It will be appreciated that the flow controller body permits the use of cylinders of various sizes to be filled using the concentrator described herein.

It is to be understood that the oxygen concentrator described herein may be operated in a mode in which oxygen-enriched air is only supplied to a patient. Alternatively, the oxygen concentrator may be operated in a mode in which oxygen-enriched air is only supplied for the re-charging or filling of a cylinder. However, the oxygen concentrator also may be operated in a dual mode, supplying oxygen-enriched air to a patient and simultaneously supplying oxygen-enriched air for re-charging or filling of a cylinder.

Figure 11A shows a compressor system, generally indicated by 820. Compressor system 820 has compressor 821 mounted on base 822. Base 822 also has an integral sound suppressor 823 for suppressing noise from both air drawn into the compressor and air exhausted from the concentrator. The integral sound suppressor assists in reducing the size and complexity of the compressor system and permits the suppressors to be mounted in the base, thus reducing the manufacturing steps required in the fabrication of the oxygen concentrator. Sound suppressor 823 is more clearly shown in cross-section, through B-B, in Figure 11B.

Figure 11B illustrates air compressor sound suppressor, generally indicated by 900. Sound suppressor 900 has compressor base 901 into which two outer silencer tubes 902 and 903 have been moulded, utilizing the natural contour of the air compressor. End caps 904 and 905 along with inner silencer tubes 906 and 907 are attached to each end of the compressor base silencer tubes 902 and 903. Compressor port 910 is adapted to be connected to an air compressor.

Operation of the sound suppressor can be described as follows:

As air is drawn into an air compressor, valve noise and air noise is generated. In more general terms, noise is generated when compressed air is exhausted to atmosphere in any pneumatic device.

In air compressor sound suppressor 900, compressor port 910 is connected to an air compressor and air is drawn into silencer tube chamber 908, which is moulded into the compressor base 901, via inlet port 911 in the end cap 904. The air travels through inner silencer tube 906 and into the inlet silencer chamber 908. Noise coming from the air compressor is muffled, because as sound travels from the air compressor and into compressor port 910, the noise is absorbed and deflected through outlet silencer chamber 909 by the outer silencer tube 902 and the inner silencer tube 906 before exiting through outlet 911. By varying the diameter and length of outer silencer tube 902 and inner silencer tub 906, sound compressor 900 can be tuned to minimize the unwanted noise from the compressor.

The concentrator exhaust silencer operates in a similar manner as the inlet silencer except exhaust air noise is minimized. Air enters the silencer tube 903 through exhaust inlet 913 in end cap 905. Noise coming from the exhaust air is muffled, because as air travels through inlet exhaust inlet 913, the exhaust air noise is absorbed and deflected by the inner silencer tube 907 and outer silencer tube 903 before exiting through outlet 912. By varying the diameter and length of the outer si-

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lencer tube 903 and inner silencer tube 907, sound suppressor 900 can be tuned to minimize the unwanted exhaust air noise.

It is understood that the air compressor may be mechanically or an electrically driven compressor, or any other mechanism that compresses air for introduction into the oxygen enrichment portion of the apparatus.

The apparatus described herein may be used to fill cylinders of a variety of different sizes and configurations by providing suitable adaptors to the oxygen fill port adaptor, including use of adaptors to fill stationary cylinder which would not otherwise fit into the fill port. For example, a flow controller body may be adapted to fit in the fill port adaptor 300 and to be connected via a high pressure hose to a flow controller body 700 on a cylinder which is not, itself, contained with the fill port adaptor. The substitute flow controller body may be used to otherwise mimic the functions of a flow controller body when installed in the fill port adaptor to permit gas from the oxygen concentrator to be used to replenish a large (for example, stationary) cylinder which would not otherwise fit within the fill port adaptor body 300. Lastly, it is be noted that outlet port 706 may be used to connect via tubing (not shown) the cylinder to which the flow controller body is attached to the patient so that a patient may breathe oxygen enriched air contained in the cylinder by adjusting the flow rate of oxygen enriched air by means of the flow control knob 703. Pressure gauge 701 may be used by the patient to monitor the gas remaining in the cylinder.

Claims

1. An apparatus for providing oxygen-enriched air comprising, in combination:

   a low pressure oxygen enriched air separation system for enriching the oxygen content of inlet air, said air separation system adapted to provide oxygen-enriched air to a first outlet at a first pressure, said air separation system adapted to provide oxygen-enriched air to a second outlet at approximately said first pressure;
   a pressure intensifier connected to said second outlet of the air separation system to pressurize said oxygen-enriched air and to provide said oxygen-enriched air to an outlet of the pressure intensifier at a second pressure; and
   wherein said air separation system is capable of simultaneously providing oxygen-enriched air to said first outlet and said second outlet such that a flow of oxygen-enriched air can be supplied to said first outlet while said pressure intensifier is pressurizing said oxygen-enriched air to said second pressure.

2. The apparatus of Claim 1 further comprising a compressor, said compressor being adapted to provide compressed air to said air separation system.

3. The apparatus of Claim 1 or Claim 2 further comprising a compressor, said compressor being adapted to provide compressed air to said pressure intensifier.

4. The apparatus of any one of Claims 1-3 in which the first pressure is provided to a flow meter and is suitable for patient respiration and said second pressure is suitable for filling high pressure cylinders or storage plenums.

5. The apparatus of any one of Claims 1-4 in which the first pressure is up to about 10 psi and the second pressure is up to about 3000 psi.

6. The apparatus of Claim 2 in which the air separation system and the pressure intensifier are interconnected and are adapted to cycle cooperatively.

7. The apparatus of any one of Claims 1-6 wherein the outlet to the pressure intensifier is adapted to accept an ambulatory pressure vessel using a securing mechanism.

8. The apparatus of any one of Claims 1-7 further comprising an oxygen concentration monitoring system to prevent cycling of the pressure intensifier if the oxygen concentration of the oxygen-enriched air falls below a predetermined value.

9. The apparatus of any one of Claims 1-8 in which the flow rate of the oxygen-enriched air to the first outlet may be adjusted independent of the pressure intensifier.

10. The apparatus of any one of Claims 1-9 which further includes a rupture disc in the pressure intensifier to prevent the pressure exceeding a predetermined value.

11. The apparatus of Claim 2 having a sound suppression system to suppress inlet noise to said compressor and exhaust noise from said air separation system.

12. The apparatus of Claim 11 in which the sound suppression system is located in a base of said compressor, said sound suppression system comprising inlet and exhaust air silencer tubes integrally incorporated into said base, said tubes being tuned to minimize noise associated with intake of air into the compressor and exhaustion of air from the concentrator.

13. The apparatus of Claim 12 in which said tubes have

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a variable length and a variable diameter, said tubes being tuned to suppress said noise by varying the diameter and length of said tubes.

14. The apparatus of any one of Claims 1-13, wherein said low pressure oxygen-enriched air separation system is an oxygen generator.

15. The apparatus of Claim 14, wherein said oxygen generator is a pressure swing adsorption system.

16. The apparatus of any one of Claims 1-13, wherein said air separation system is one of a distiller, an air separator and a membrane separator.

17. The apparatus of any one of Claims 1-13, wherein said pressure intensifier includes:

a first stage cylinder, a second stage cylinder and a drive air cylinder located therebetween.

18. A method for providing oxygen-enriched air at a first pressure and at a second pressure, said second pressure being greater than the first pressure, said method comprising:

feeding air to an air separation system;
providing oxygen-enriched air from said air separation system to a first outlet at said first pressure and controlling the flow of oxygen-enriched air at said first outlet;
providing oxygen-enriched air from said air separation system to a pressure intensifier at approximately said first pressure, increasing the pressure of said oxygen-enriched air to said second pressure using said pressure intensifier; and
wherein said air separation system is capable of simultaneously providing oxygen-enriched air to said first outlet and said second outlet such that a flow of oxygen-enriched air can be supplied to said first outlet while said pressure intensifier is pressurizing said oxygen-enriched air to said second pressure.

19. The method of Claim 18 in which said air separation system and said pressure intensifier are interconnected such that cycling of the air separation system and said pressure intensifier are coordinated.

20. The method of Claim 18 or Claim 19 in which the oxygen-enriched air has an oxygen content of at least 90% by volume.

21. The method of any one of Claims 18-20, wherein said low pressure oxygen-enriched air separation system is an oxygen generator.

22. The method of Claim 21, wherein said oxygen generator is a pressure swing adsorption system.

23. Apparatus for providing oxygen-enriched air comprising, in combination:

an air compressor, a low pressure oxygen-enriched air separation system and a pressure intensifier;
said air compressor being adapted to provide compressed air to said air separation system;
said air separation system being adapted to provide oxygen-enriched air to a first outlet at a first pressure, said first outlet having a controller to control the flow of oxygen-enriched air at a first outlet;
said air separation system further providing oxygen-enriched air to the pressure intensifier at said first pressure, said pressure intensifier being adapted to provide oxygen-enriched air at said second pressure;
wherein said air separation system is capable of simultaneously providing oxygen-enriched air to said first outlet and said second outlet such that a flow of oxygen-enriched air can be supplied to said first inlet while said pressure intensifier is pressurizing said oxygen-enriched air to said second pressure.

24. The apparatus of Claim 23 in which said air separation system and said pressure intensifier being interconnected such that cycling of the air separation system and said pressure intensifier are coordinated.

25. The apparatus of Claim 23 or Claim 24 in which said compressor is adapted to provide compressed air to said pressure intensifier.

26. The apparatus of any one of Claims 23-25 in which the first pressure is provided to a flow meter and is suitable for patient respiration and said second pressure is suitable for filling high pressure cylinders or storage plenums.

27. The apparatus of any one of Claims 23-26 in which the first pressure is up to about 10 psi and the second pressure is up to about 3000 psi.

28. The apparatus of any one of Claims 23-27 adapted to accept an ambulatory pressure vessel to said second outlet using a securing mechanism.

29. The apparatus of any one of Claims 23-28 in which there is an oxygen concentration monitoring system to prevent cycling of the pressure intensifier if the oxygen concentration of the oxygen-enriched air falls below a predetermined value.

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30. The apparatus of any one of Claims 23-29 in which the flow rate of the oxygen-enriched air to the first outlet may be adjusted independent of the pressure intensifier.

31. The apparatus of any one of Claim 23-30 which further includes a rupture disc in the pressure intensifier to prevent the pressure exceeding a predetermined value.

32. The apparatus of any one of Claims 23-31 having a sound suppression system to suppress inlet noise to said air compressor and exhaust noise from said concentrator.

33. The apparatus of Claim 32 in which the sound suppression system located in a base of said compressor, said sound suppression system comprising inlet and exhaust air silencer tubes integrally incorporated into said base, said tubes being tuned to minimize noise associated with intake of air into the compressor and exhaustion of air from the air separation system.

34. The apparatus of Claim 33 in which said tubes have a variable length and a variable diameter, said tubes being tuned to suppress said noise by varying the diameter and length of said tubes.

35. The apparatus of Claim 28 further comprising an ON/OFF flow controller adapted to prevent flow of oxygen-enriched air through said second outlet when said second outlet is disconnected from said ambulatory pressure vessel.

36. The apparatus of any one of Claims 23-35, wherein said low pressure oxygen-enriched air separation system is an oxygen generator.

37. The apparatus of Claim 36, wherein said oxygen generator is a pressure swing adsorption system.

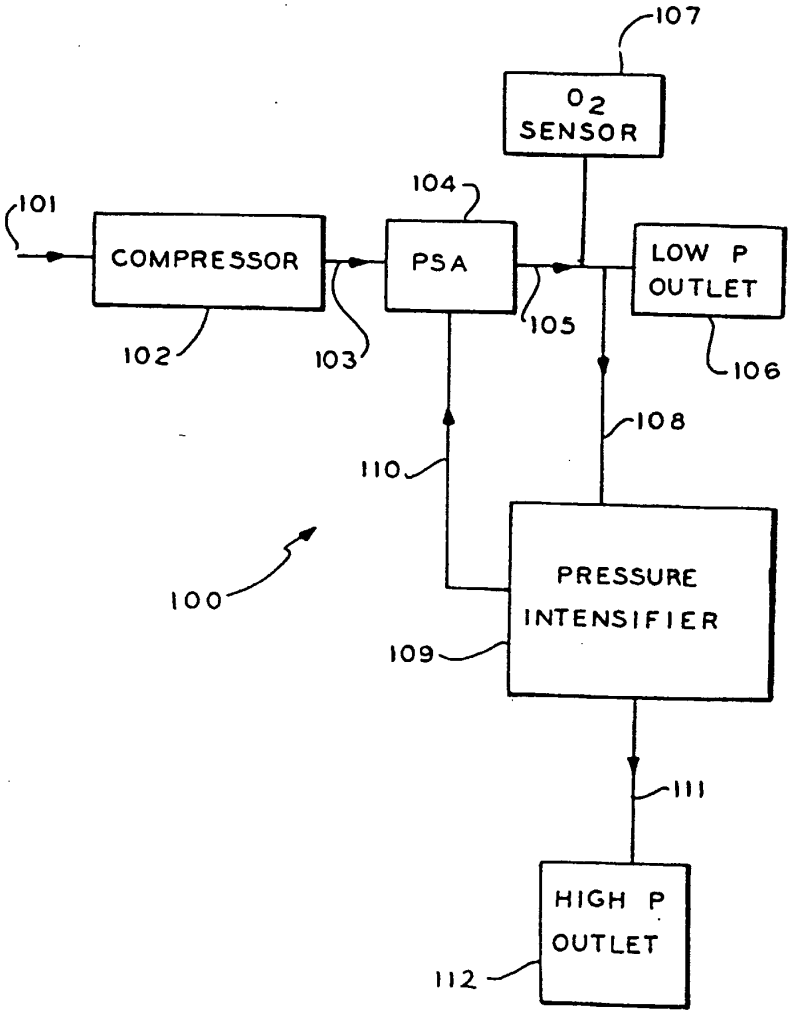
38. The apparatus of any one of Claims 23-35, wherein said air separation system is one of a distiller, an air separator and a membrane system.

39. The apparatus of any one of Claims 23-35, wherein said pressure intensifier includes:

a first stage cylinder, a second stage cylinder and a drive air cylinder located therebetween.

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FIG. 1



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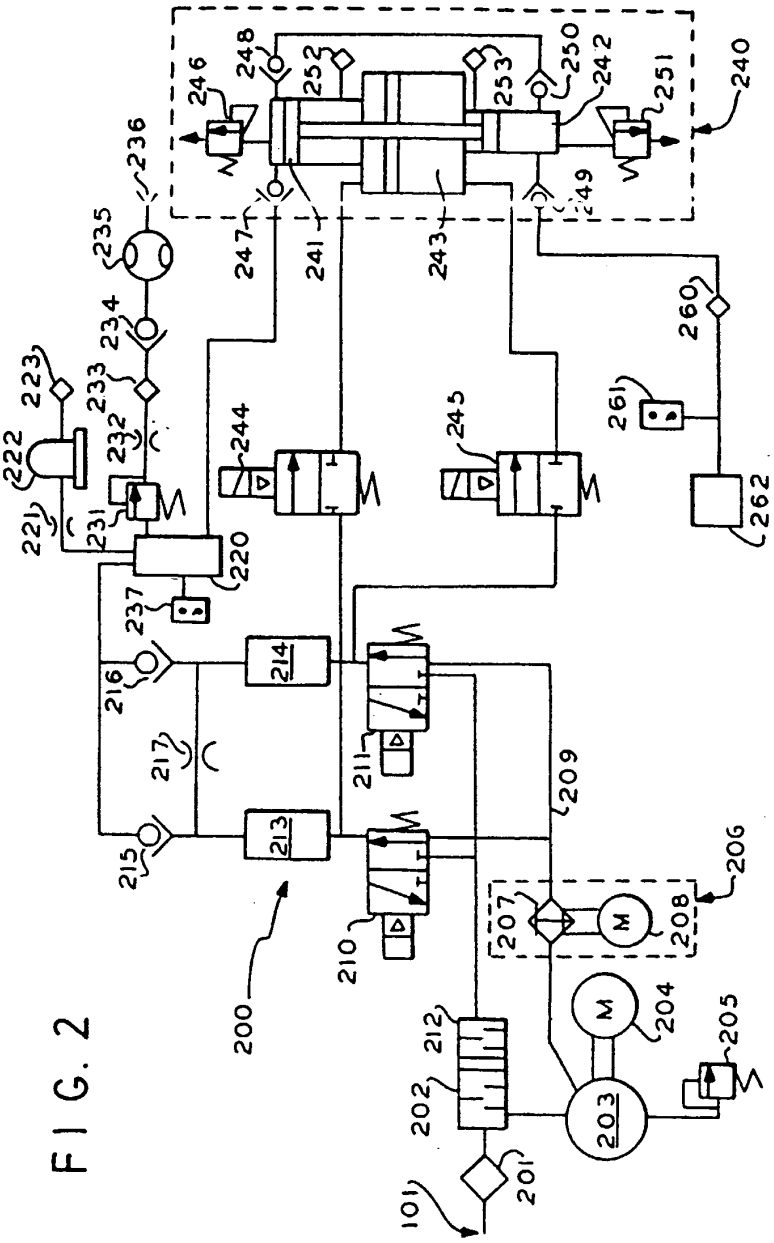
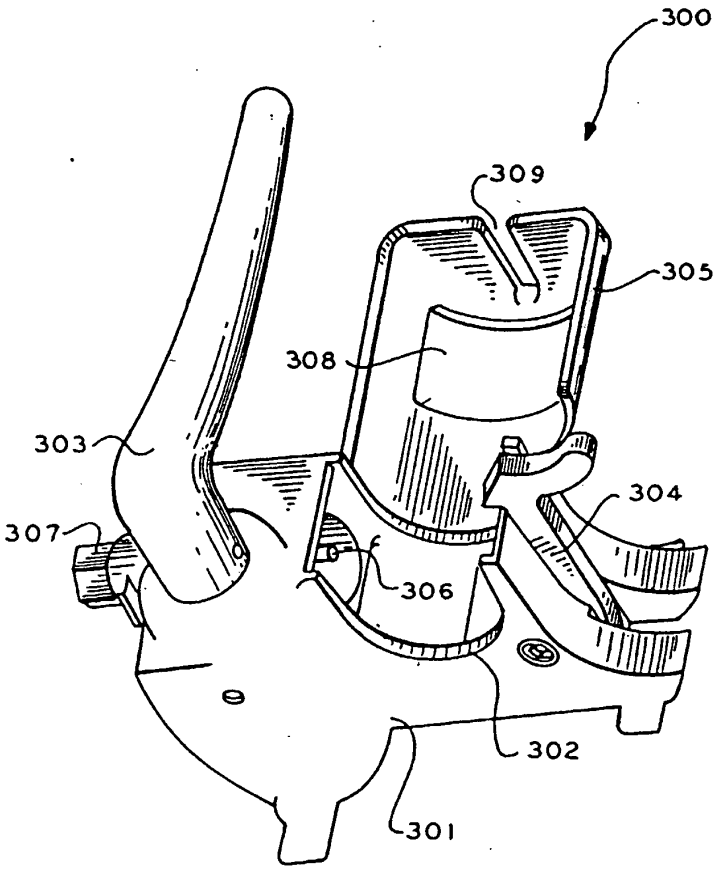


FIG. 2

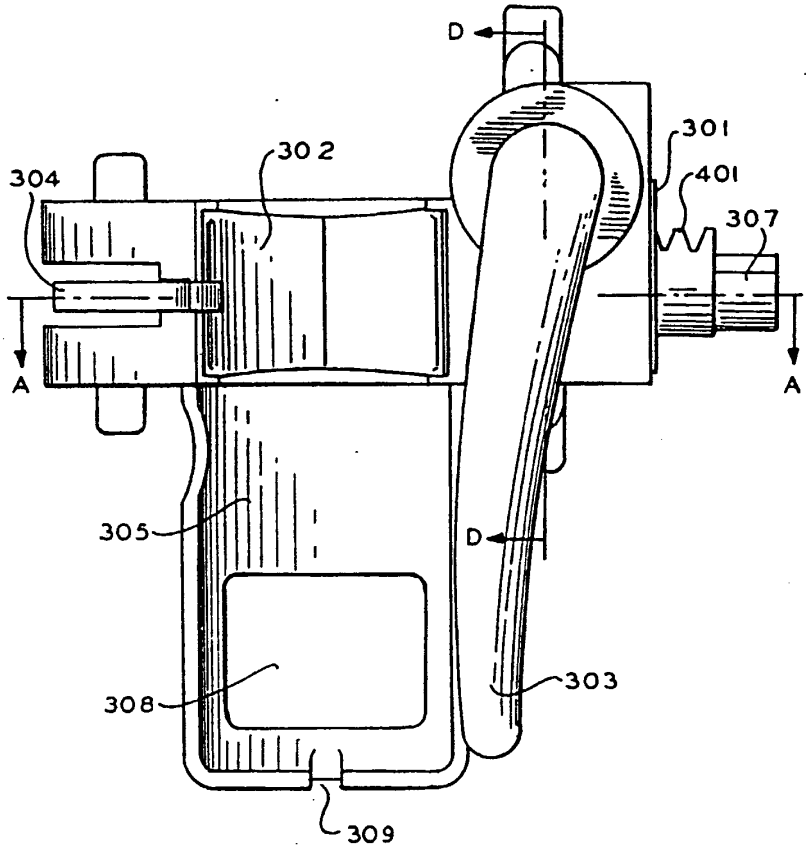
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FIG. 3



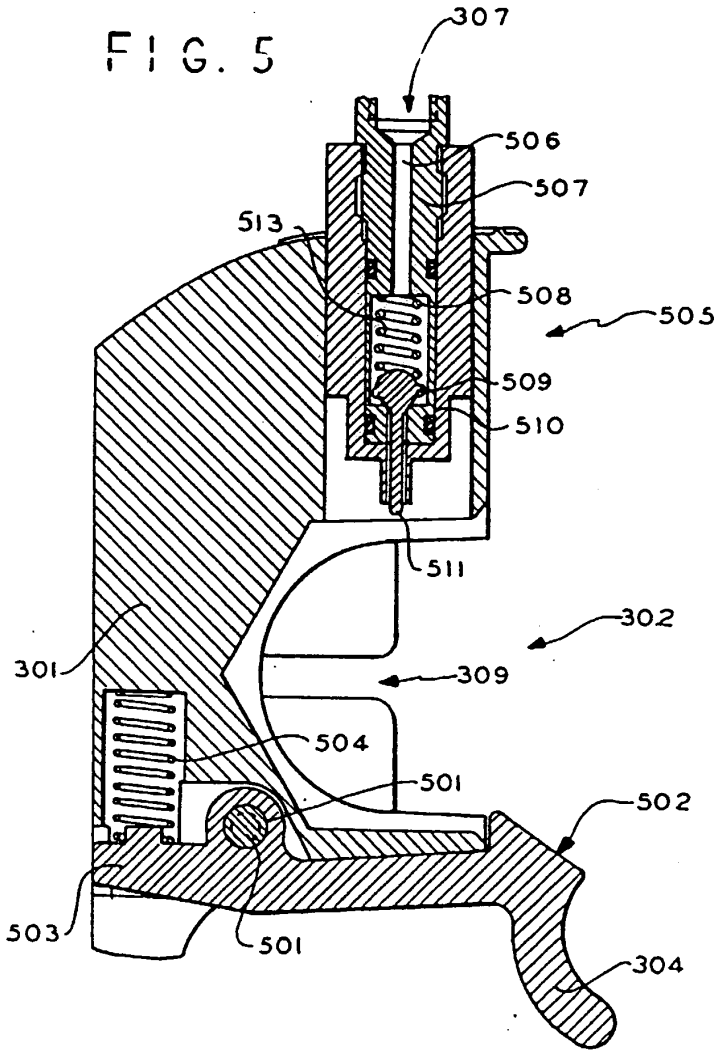
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FIG. 4



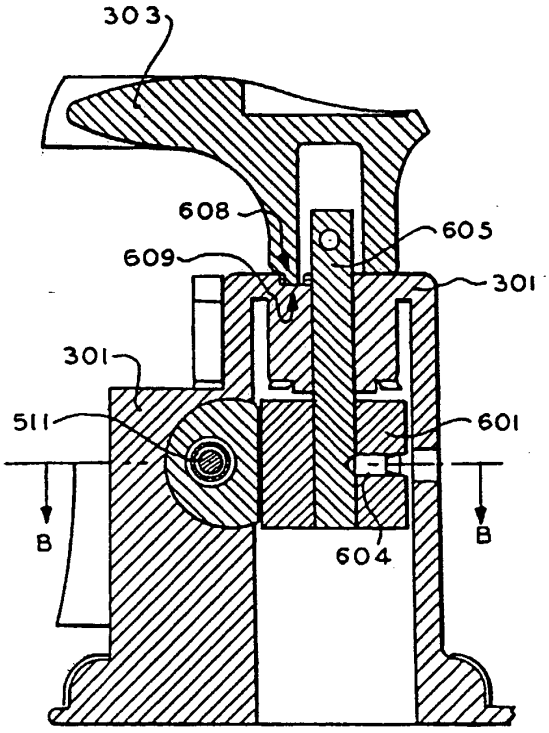
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FIG. 5



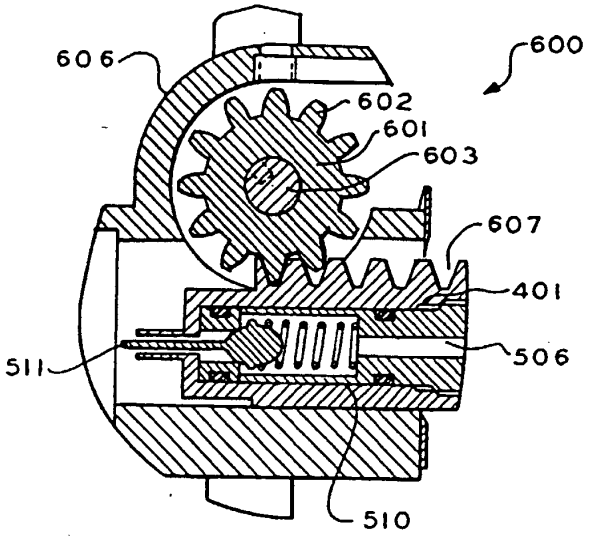
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FIG. 6



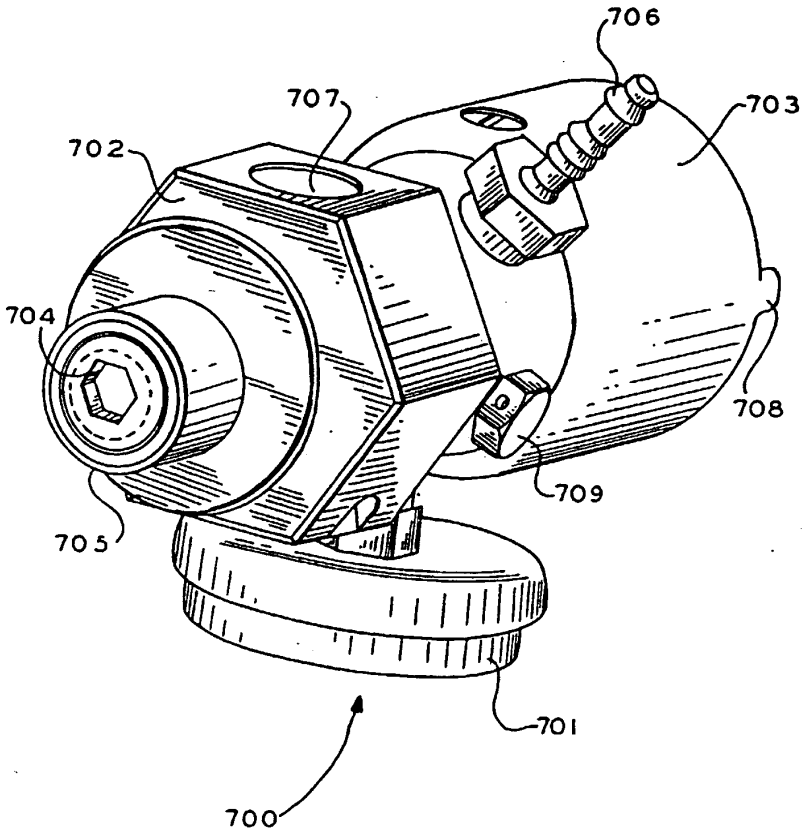
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FIG. 7



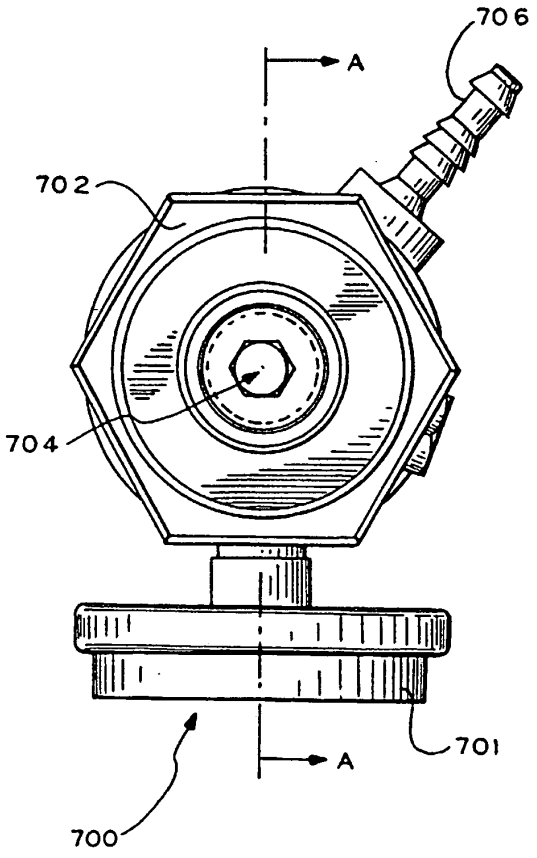
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FIG. 8



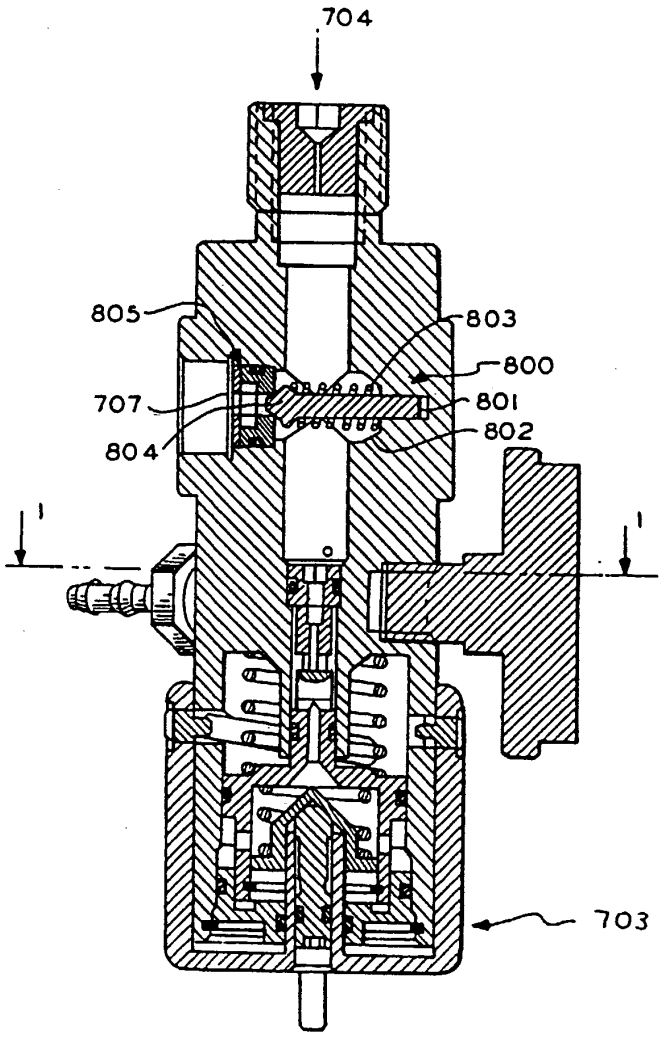
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FIG. 9



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FIG. 10



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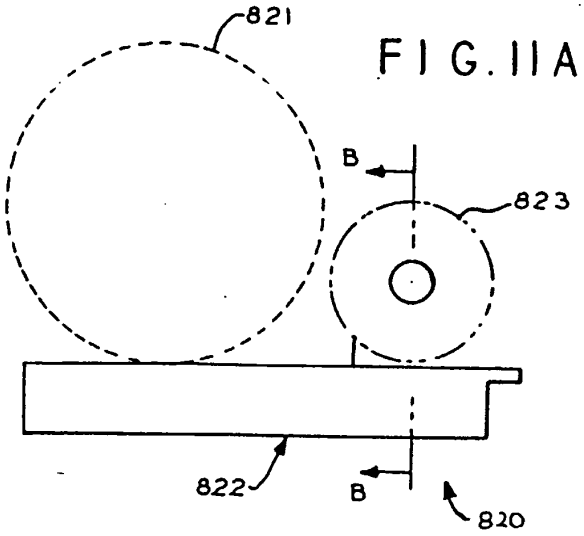
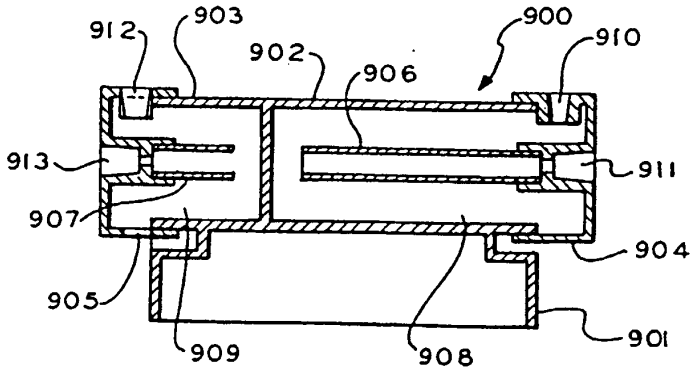


FIG. 11A

FIG. 11B



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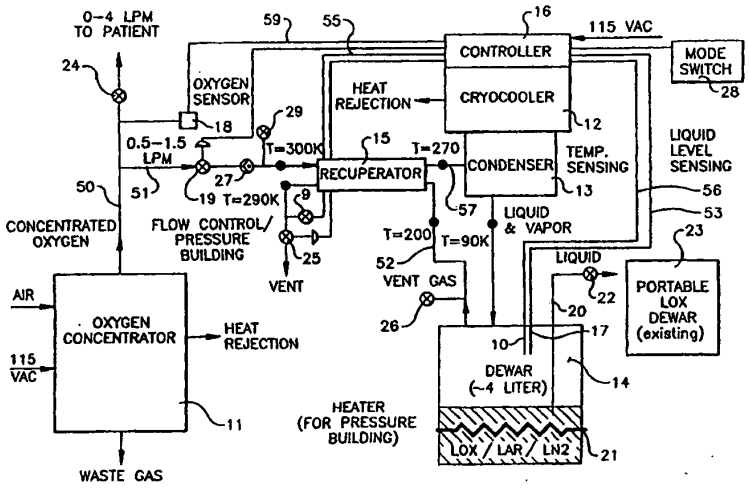
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(57) Abstract

In one preferred embodiment, the present invention splits off some of the excess capacity gas flow from a gas concentrator (11) which is then stored (14) via liquefaction. The stored gas can then be used as a portable supply. A portion of the oxygen gas flow generated by the oxygen concentrator is channeled to a condenser (13) which receives and liquefies the oxygen gas using cryocooler (12). A storage dewar (14) is used for storing the oxygen liquefied by the condenser. Liquid is then selectively transferred to a smaller portable dewar (23). A controller can be used for monitoring the parameters of liquefaction, including oxygen concentration, the amount of liquid oxygen in the dewar, and for controlling the parameters of liquid oxygen generation and transfer.

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DESCRIPTION

METHODS AND APPARATUS TO GENERATE LIQUID AMBULATORY OXYGEN FROM AN OXYGEN CONCENTRATOR

Background of the Invention

The field of this invention relates to using an oxygen concentrator to create a portable supply of supplementary oxygen for ambulatory respiratory patients so that they can lead normal and productive lives -- as the typical primary oxygen sources are too bulky to carry or require excessive power to operate.

There is a burgeoning need for home and ambulatory oxygen. Supplemental oxygen is necessary for patients suffering from lung disorders; for example, pulmonary fibrosis, sarcoidosis, or occupational lung disease. For such patients, oxygen therapy is an increasingly beneficial, life-giving development. While not a cure for lung disease, supplemental oxygen increases blood oxygenation, which reverses hypoxemia. This therapy prevents long-term effects of oxygen deficiency on organ systems -- in particular, the heart, brain and kidneys. Oxygen treatment is also prescribed for Chronic Obstructive Pulmonary Disease (COPD), which afflicts about 25 million people in the U.S., and for other ailments that weaken the respiratory system, such as heart disease and AIDS. Supplemental oxygen therapy is also prescribed for asthma and emphysema.

The normal prescription for COPD patients requires supplemental oxygen flow via nasal cannula or mask twenty four hours per day. The average patient prescription is

two liters per minute of high concentration oxygen to increase the oxygen level of the total air inspired by the patient from the normal 21% to about 40%. While the average oxygen flow requirement is two liters per minute, the average oxygen concentrator has a capacity of four to six liters of oxygen per minute. This extra capacity is occasionally necessary for certain patients who have developed more severe problems but they are not generally able to leave the home (as ambulatory patients) and do not require a portable oxygen supply.

There are currently three modalities for supplemental medical oxygen: high pressure gas cylinders, cryogenic liquid in vacuum insulated containers or thermos bottles commonly called "dewars," and oxygen concentrators. Some patients require in-home oxygen only while others require in-home as well as ambulatory oxygen depending on their prescription. All three modalities are used for in-home use, although oxygen concentrators are preferred because they do not require dewar refilling or exchange of empty cylinders with full ones.

Only small high pressure gas bottles and small liquid dewars are portable enough to be used for ambulatory needs (outside the home). Either modality may be used for both in-home and ambulatory use or may be combined with an oxygen concentrator which would provide in-home use.

As we describe below, the above-described current methods and apparatus have proven cumbersome and unwieldy and there has been a long-felt need for improved means to supply the demand for portable/ambulatory oxygen.

For people who need to have oxygen but who need to operate away from an oxygen-generating or oxygen-storage source such as a stationary oxygen system (or even a portable system which cannot be easily carried), the two most prescribed options generally available to patients are: (a) to carry with them small cylinders typically in a wheeled stroller; and (b) to carry portable containers typically on a shoulder sling. Both these gaseous oxygen and liquid oxygen options have substantial drawbacks. But from a medical view, both have the ability to increase the productive life of a patient.

The major drawback of the gaseous oxygen option is that the small cylinders of gaseous oxygen can only provide gas for a short duration. Oxygen conserving devices that limit the flow of oxygen to the time of inhalation may be used. However, the conserving devices add to the cost of the service and providers have been reluctant to add it because there often is no health insurance reimbursement. Indeed, the insurance reimbursement for medical oxygen treatment appears to be shrinking.

Another drawback of the gaseous oxygen option is the source of or refill requirement for oxygen once the oxygen has been depleted from the cylinder. These small gas cylinders must be picked up and refilled by the home care provider at a specialized facility. This requires regular visits to a patient□s home by a provider and a substantial investment in small cylinders for the provider because so many are left at the patient□s home and refilling facility. Although it is technically possible to refill these cylinders in the patient□s home using a commercial

oxygen concentrator that extracts oxygen from the air, this task would typically require an on-site oxygen compressor to boost the output pressure of the concentrator to a high level in order to fill the cylinders. Additionally, attempting to compress the oxygen in pressurized canisters in the home is dangerous, especially for untrained people. This approach or course presents several safety concerns for in-home use. For example, in order to put enough of this gas in a portable container, it must typically be compressed to high pressure (~2000 psi). Compressing oxygen from 5 psi (the typical output of an oxygen concentrator) to 2000 psi will produce a large amount of heat. (Enough to raise the temperature 165□ C per stage based on three adiabatic compression stages with intercooling.) This heat, combined with the oxygen which becomes more reactive at higher pressures, sets up a potential combustion hazard in the compressor in the patient's home. Thus, utilizing and storing a high pressure gas system in the patient's home is dangerous and not a practical solution.

The convenience and safety issues are not the only drawbacks of this compressed oxygen approach. Another drawback is that the compressors or pressure boosters needed are costly because they require special care and materials needed for high pressure oxygen compatibility. For example, a Rix Industries, Benicia, CA, 1/3 hp unit costs about $10,000 while a Haskel International, Burbank, CA, air-powered booster costs about $2200 in addition to requiring a compressed air supply to drive it. Litton Industries and others also make oxygen pressure boosters.

Turning now to the liquid oxygen storage option, its main drawback is that it requires a base reservoir -- a stationary reservoir base unit about the size of a standard beer keg -- which has to be refilled about once a week. The liquid oxygen can then be obtained from a base unit and transferred to portable dewars which can be used by ambulatory patients. Also, with the liquid oxygen option, there is substantial waste, as a certain amount of oxygen is lost during the transfer to the portable containers and from evaporation. It is estimated that 20% of the entire contents of the base cylinder will be lost in the course of two weeks because of losses in transfer and normal evaporation. These units will typically boil dry over a period of 30 to 60 days even if no oxygen is withdrawn.

There are other complications. Typically, supplemental oxygen is supplied to the patient by a home care provider, in exchange for which it receives a fixed monetary payment from insurance companies or Medicare regardless of the modality. Oxygen concentrators for use in the home are preferred and are the least expensive option for the home care provider. For outside the home use however, only small high pressure gas bottles and small liquid dewars are portable enough to be used for ambulatory needs. One of these two modalities may be used for both in-home and ambulatory use or may be combined with an oxygen concentrator which would provide in-home use. In either case, the home care provider must make costly weekly or biweekly trips to the patient's home to replenish the oxygen. One of the objects of this invention is to eliminate these costly "milk runs."

Portable oxygen concentrators are commercially available for providing patients with gaseous oxygen. These devices are "portable" solely in the sense that they can be carried to another point of use such as in an automobile or in an airplane. At present, there are no home oxygen concentrators commercially available that can provide liquid oxygen. One type of medical oxygen concentrator takes in air and passes it through a molecular sieve bed, operating on a pressure swing adsorption cycle, which strips most of the nitrogen out, producing a stream of ~90% oxygen, for example, as shown in U.S. Patent Nos. 4,826,510 and 4,971,609 (which are incorporated herein by reference). While, as set out in the Information Disclosure Statement, complex oxygen liquefaction systems have been disclosed for use by the military in jet aircraft, and while large-scale commercial plants have been disclosed, this technology has not yet found its way into the home to help individual patients and to benefit the general public. A truly portable oxygen concentrator has not yet been perfected and this event is unlikely, at least in the near future, because the power requirements are too large to be provided by a lightweight battery pack.

Since liquid oxygen requires periodic delivery and home oxygen concentrators are not commercially available that would create liquid oxygen, there has existed a long-felt need for a device or method having the capability to concentrate oxygen from the air, liquefy it, and transfer it into portable dewars in a home environment, and for a home oxygen concentrator unit which allows excess flow capacity from the concentrator to be stored by either compression or liquefaction for later use.

Summary of Invention

The present invention presents a much safer and less expensive way of providing portable oxygen for patients who do not want to be tied to a stationary machine or restricted by present oxygen technology. In one preferred embodiment, the present invention splits off some of the excess capacity gas flow from a PSA (pressure swing adsorption) or membrane gas concentrator which has a relatively stable base load. This small portion of the excess flow capacity, about one liter per minute (□1LPM) is stored via liquefaction. The stored gas can then be used as a portable supply away from the location of the gas concentrator. The daily six hour range capacity for a two liter per minute patient can be accumulated by liquefying a one liter per minute gas flow for less than 24 hours. Therefore, the entire daily requirement for mobility can be produced every day if needed.

A summary of one of the many representative embodiments of the present invention is disclosed including a home liquid oxygen ambulatory system for supplying a portable supply of oxygen, where a portion of the gaseous oxygen output obtained from an oxygen concentrator is condensed into liquid oxygen, comprising: (a) an oxygen concentrator which separates oxygen gas from the ambient air; (b) an outlet flow line to transfer flow of oxygen gas from said oxygen concentrator for patient use; (c) a valve placed in the outlet flow line for splitting off a portion of the oxygen gas flow generated by the oxygen generator; (d) a generally vertically oriented, gravity assisted, condenser for receiving and liquefying the split off portion of the

oxygen gas flow; (e) a cryocooler associated with said condenser; (f) a first storage dewar in fluid communication with said condenser for storing the oxygen liquefied by the condenser, the first storage dewar having an outlet selectively engageable to and in fluid communication with at least one second smaller dewar and a fluid path for supplying liquid oxygen from the first dewar to the second dewar; (g) a heater for heating said first storage dewar; (h) a controller for monitoring (i) oxygen concentration of the oxygen gas flowing from said concentrator, and (j) the amount of liquid oxygen in said first dewar, and for controlling the parameters of liquid oxygen generation and transfer from said first storage dewar.

Another representative embodiment is the feature where the flow rate into the condenser is chosen to exceed the capacity of the condenser. In particular, only 20 to 90% of the incoming flow into the condenser is condensed to minimize the liquefaction of argon, nitrogen and trace gases, and to purge the system.

Additionally, the controller may control condenser parameters so that the condenser temperature varies in the range from approximately 69.2 to 109.7K, the condenser pressure varies from approximately 5 to 65 psia, and the concentrations of gas into the condenser varies with the oxygen range being 80 to 100%, the nitrogen range being 0 to 20%, and the argon range being 0 to 7%.

A unique condenser design is also disclosed where the condenser is in thermal contact with a cryocooler for use in liquefying oxygen and comprises: (a) an inlet conduit

for receiving oxygen; (b) an outer member; (c) an inner member; (d) a passage defined by said outer and inner members; (e) said inner member having radial slots to passages; (f) means for circulating said oxygen in said condenser.

Also disclosed is a representative method for controlling a home ambulatory liquid oxygen system comprised of an oxygen concentrator, a controller having a microprocessor, a condenser, a cryocooler and a storage dewar, where all or only a portion of the oxygen flow is utilized for liquefaction, comprising: (a) providing the microprocessor with a database and control functions; (b) sensing the parameters relating to the concentration and supply of gaseous oxygen, the level of liquid oxygen in the dewar, and the pressure of the condenser; (c) providing the microprocessor with these sensed parameters and having the microprocessor calculate optimal conditions; (d) controlling servomechanisms to regulate the system so that optimal conditions are realized as a function of said calculations.

The feature is also described wherein the liquid dewar will be periodically boiled dry to eliminate any small amounts of water and hydrocarbons that may pass through the gas concentrator.

The above-summarized apparatus and methods, more specifically set out in the claims, fill long-felt needs without posing any new safety issues to the patient in that, for example, there are no potentially dangerous canisters of high pressure compressed oxygen. The end result is that patients can ultimately use equipment with

which they are familiar. For example, patients on liquid oxygen currently perform liquid transfers from large (30-50 liquid liter) dewars to small (0.5-1.2 liquid liter -- corresponding to six hours of support) portable dewars. The present invention will provide a means of supplying ambulatory oxygen for a lower life cycle cost than the conventional method. Unlike industrial or military use liquefiers, which can take up whole rooms, the claimed oxygen liquefier (not including the oxygen concentrator) weighs less than 60 pounds and takes up less than six cubic feet of volume. There are currently about 700,000 patients in the United States using ambulatory oxygen with an average yearly cost of about $1,960 per patient. The estimated annual cost of oxygen per patient with the present invention is about $540.

Brief Description of the Drawings

Figure 1 is a block diagram of the invention in the medical oxygen preferred embodiment where gaseous oxygen is split off and liquefied for storage in a stationary dewar or container.

Figure 2 shows another preferred embodiment of the invention for ambulatory supplemental oxygen using a portable LOX dewar.

Figure 3 shows a typical temperature-composition diagram for oxygen-argon mixtures at typical dewar pressures.

Figure 4 shows a typical temperature-composition diagram for nitrogen-oxygen mixtures at typical dewar pressures.

Figure 5 shows typical oxygen concentration test data for gas streams into the condenser and out of the dewar during liquefaction, and out of the dewar as the

liquid is re-vaporized. (Oxygen source is a PSA oxygen concentrator.)

Figure 6 shows the controller block diagram for operation of the system.

Figures 7A through 7D are flow charts showing the controller logic.

Figure 8 shows the controller input levels and output states for the start-up mode of the preferred embodiment.

Figure 9 shows the controller input levels and output states for the condense mode of the preferred embodiment.

Figure 10 shows the controller input levels and output states for the transfer mode of the preferred embodiment.

Figure 11 shows the controller input levels and output state for the boil dry mode of the preferred embodiment.

Figure 12 illustrates basic components of a pulse tube refrigerator.

Figure 13 illustrates another embodiment of a cryocooler which may be used in the subject invention.

Figure 14 is a side cross-sectional view of the preferred embodiment of the condenser.

Figure 15 is an end cross-sectional view of the preferred embodiment of the condenser corresponding to Figure 14.

Figure 16 shows a side cross-sectional view of another preferred embodiment of the condenser.

Figure 17 shows an end cross-sectional view of another preferred embodiment of the condenser corresponding to Figure 16.

Figure 18 is an isometric view of the embodiment of the condenser shown in Figures 16 and 17.

Detailed Description of the Preferred Embodiment

A flow chart of the preferred embodiment of the invention is set out in Figure 1. Its main components include an oxygen concentrator 11, a cryocooler 12, a condenser 13, and a storage/collection dewar or vacuum insulated container 14. In the preferred embodiment, the oxygen concentrator 11 operates on a pressure swing adsorption cycle and essentially strips all or most of the nitrogen from air along with other minor components such as H_2O, CO_2, CO, NO_x, etc. The result is a stream of dry gas with high oxygen concentration (~92%) flowing in fluid outlet 50. A portion of the gas from this output in fluid outlet 50 is routed to a condenser 13 in association with a cryocooler (or cryogenic refrigerator) 12 through flow lines 51 and 57. The cryocooler provides cooling of the condenser heat exchanger 13 to liquefaction temperatures, causing the oxygen in contact therewith to go from the gaseous to the liquid phase. The condenser 13 typically must be insulated from ambient heating and may in practice even be located inside the dewar 14. In order to lessen the load on the cryocooler 12, a recuperator 15 may be used to pre-cool the incoming stream utilizing the vent flow through line 52 out of the dewar as a cooling medium. In practice, this recuperator 15 may also be located within the dewar 14 to reduce ambient heating.

Controller 16 may be equipped with a microprocessor, adequate memory, software and ancillary equipment comprising a computer which can be used to monitor and control the operation of the system. The controller 16 may be provided with signals from liquid level sensor 17, oxygen sensor 18, pressure transducer 9, and temperature sensor 10 via lines 53, 59, 55 and 56, respectively.

These signals are sensed and processed by the computer, with the controller operating valve 19, valve 25, heater 21, and cryocooler 12, in accordance with predetermined programs.

The controller also provides output indicators for the patient. The liquid level in the dewar is continuously displayed and the patient is alerted when the oxygen concentration is low and when the system is ready for them to transfer liquid to a portable dewar. A modem or wireless link may be included to enable remote monitoring of the key parameters of the system by the home care provider as well as information which is useful for repair, maintenance, billing, and statistical studies of patients for the medical oxygenation market. Key system parameters of interest include the number of liquid transfers performed, the oxygen concentration history, number of run hours on the cryocooler, and time of the last boil-dry as well as number of boil dries performed. The controller may include a computer and/or a microprocessor located either integrally with the liquefaction system claimed herein or remotely therefrom but in communication therewith using either a modem and telephone lines or with a wireless interface. The computer and/or microprocessor may include memory having a database, or may be remotely connected to a memory or database using a network. An Optimal Liquefaction Schedule for optimal operation of the liquefaction system is set out in Figures 7-10 and may be stored in said controller using the memory and database. The controller can sense optimum parameters of the system and optimally control, including by activating servomechanisms, liquefaction and transfer of liquid oxygen.

Dewar 14 is equipped with a dip tube 20 and heater 21. Heater 21 is used to build pressure in the dewar in order to expel liquid out the dip tube 20 when so desired. A quick disconnect valve 22 or other flow control means is located on the end of the dip tube. This allows connection of a portable LOX dewar 23, which can then be carried by the patient requiring a mobile/ambulatory supply of oxygen.

In another embodiment of this system shown in Figure 2, the dewar 14 could be eliminated and replaced with a portable dewar 23 which is modified slightly from those existing today. The new portable dewar would interface with the condenser 13, recuperator 15, and controller 16. This embodiment requires a slightly different control scheme from that given for the preferred embodiment as the transfer and boil-dry modes are eliminated. Any small amount of accumulated water and hydrocarbons are eliminated from the portable dewar 23 after each use by allowing it to warm to room temperature before reuse.

In operation, in the preferred embodiment of Figure 1, where a pressure swing adsorption (□PSA□) system is used, air is drawn into the oxygen concentrator 11, where it is compressed by an oilless compressor, cooled, and passed through molecular sieve beds operating on the pressure swing adsorption cycle, as shown in U.S. Patents 5,366,541; 5,112,367; 5,268,021 and Re. 35,009, which are incorporated herein by reference. This PSA system produces a 5-6 liters per minute (LPM) gas stream with high oxygen concentration at 3-7 pounds per square inch gauge (psig). The composition of this gas stream varies

but is typically 90-95% oxygen, 5-6% argon, 0-4% nitrogen, <15 parts per million (ppm) water vapor, and <1 ppm hydrocarbons. Exhaust from the PSA cycle (80-84% nitrogen, 15-19% oxygen, 0.6-0.8% argon, and trace amounts of water vapor, carbon dioxide and hydrocarbons) is vented into the atmosphere as waste gas. In the preferred embodiment, the high concentration oxygen stream in fluid outlet 50 is split with 0-4 lpm going through control valve 24, for patient consumption, and 0.5-1.5 lpm through line 51 and control valve 19 for liquefaction. Oxygen sensor 18, monitors the oxygen concentration produced by oxygen concentrator 11. If the oxygen concentration falls below 88%, controller 16 will close valve 19 and turn off the cryocooler 12.

Even though 88% oxygen is adequate as supplemental oxygen therapy, if this was liquefied, as will be described below, the initial revaporized stream may have a reduced oxygen content because of the close boiling points of the components of the mixture. The temperature of the split gas stream entering the recuperator 15 is about room temperature. It is cooled to about 270K (or colder) by the vent gas from the dewar flowing through the other side of the recuperator via line 52. The recuperator 15 reduces the load on the cryocooler by using the cold vent gas to pre-cool the oxygen-rich gas stream flowing into the condenser 13. From the recuperator 15 the high oxygen concentration stream flows through a line 57 to the condenser 13, which is cooled to ~90K by the cryocooler 12.

The condenser 13 provides cold surfaces to further cool and condense the flow. It is important to note that

the gas passing through the condenser 13 is a mixture of oxygen, argon, and nitrogen. The normal boiling points of these components are: 90.18K, 87.28K, and 77.36K respectively. Because of the close boiling points of the components of this mixture, there was initial skepticism because of the concern that all the nitrogen and argon would condense along with the oxygen. If this concern was realized, when this liquid mixture was revaporized, the lower boiling point components; i.e., nitrogen and argon, would boil off first, resulting in flow with high concentrations of nitrogen, argon and a much lower oxygen concentration than that which was supplied to the condenser -- which would make the process of oxygen treatment ineffective or a failure.

This concern is explained in Figures 3 and 4 which are temperature composition diagrams for binary mixtures of oxygen-argon and oxygen-nitrogen. In these diagrams taken from K.D. Timmerhaus and T.M. Flynn, *Cryogenic Process Engineering,* Plenum Press, 1989, pp. 296-297, the upper curve at a given pressure defines the dew point and the lower curve defines the bubble point. Looking at Figure 4 for a pressure of 0. 10 1 MPa, if there is a gas mixture with 10 mole percent nitrogen (point 1), condensation will start when the gas has cooled to the dew point curve (point 2g) which is at a temperature of about 89.5K in this case. Because oxygen has a higher boiling point than nitrogen, the initial liquid formed (point 2f) will have only 7.4 mole percent nitrogen. If the temperature is lowered to point 3, the liquid will have the composition of point 3f while the remaining vapor will

have the composition of point 3g. As the temperature is lowered further to point 4f or below, all of the mixture liquefies and the composition is 10 mole percent nitrogen, the same as at point 1. If this liquid is heated, the nitrogen which has a lower boiling point will vaporize first. Thus, the composition of the first vapor formed will be that of point 4g or about 50 mole percent. As the remaining liquid boils, the mole percent of nitrogen in the vapor drops back to 10 mole percent when point 2g is reached. It is believed that the composition swings with a ternary mixture of oxygen, argon and nitrogen will be even more pronounced than those shown in Figures 3 and 4 for binary mixtures. Fortunately, this concern was avoided when the system was set so that only 20 to 90% of the incoming flow to the condenser was actually condensed and when the condenser was controlled in accordance with the parameters as explained herein. This is believed to work because the excess flow operates to purge the vapor with higher impurity concentration from the system and avoid the aforementioned problem. Instead, the results realized were that a high concentration stream of oxygen could be liquefied and stored as set out in the portable ambulatory device claimed herein.

Figure 5 shows typical oxygen concentration test data for condensing and re-vaporizing part of the product outlet stream from the oxygen concentrator 11 in the preferred embodiment. For the first 120 minutes after the system was turned on, the system was cooling down without any net liquid accumulation in the dewar 14. From this point up to about 500 minutes, condensation continued with liquid accumulation. During this time phase, the inlet stream to the condenser 13 had an oxygen concentration of

95%, while the vent flow through line 52 had an oxygen concentration of only 92-93%. After 500 minutes the inlet stream and condenser cooling were stopped. The oxygen concentration of the re-vaporized liquid increased as the liquid boiled off due to the lower boiling point components (argon and nitrogen) boiling off first. This change in oxygen concentration presents no problem for medical ambulatory use because the oxygen concentration remains above 85%.

Because of the aforementioned mixture problem, it is important and even critical not to let the amount of argon and nitrogen in the liquid become too high or when it is revaporized, the oxygen concentration will initially be much lower than that conventionally used in supplemental oxygen therapy (>85%). This can be accomplished by selecting the proper condenser temperature, which is a function of pressure, and by not condensing all of the incoming flow. If only part of the incoming flow (20-90%) is liquefied, the remainder of the flow will purge the vapor with higher impurity concentration from the system. A condenser temperature of about 90K (for □17 psia) minimizes the amount of argon and nitrogen liquefied without overly diminishing the yield of oxygen. Hence there will be both liquid and vapor leaving the condenser. The liquid will fall into the dewar 14 and collect. The vapor which has not condensed is vented to the atmosphere through line 52 and the recuperator 15.

The amount of incoming flow liquefied is controlled by setting the mass flow rate relative to the cooling capacity of the cryocooler. The parameters of the condenser and/or cryocooler can be stored in the memory of

the controller and/or computer and the controller regulating the incoming flow depending on the parameters stored and/or sensed. Having a mass flow rate which exceeds the cooling capacity of the cryocooler/condenser combination, prevents the incoming flow from being completely liquefied. The mass flow rate is controlled by the amount of flow restriction between inlet valve 19 and flow control valve 25. This includes the flow losses of the valves themselves as well as those in the recuperator, condenser, and all of the interconnecting plumbing.

The pressure in the dewar 14 is maintained slightly above ambient pressure while the cryocooler is operating by valve 25. It is desirable to keep the pressure in the condenser as high as possible because this increases the condensation temperature (as shown in figures 3 and 4) which eases the requirements on the cryocooler. Once again this can be controlled by the controller and/or the computer, microprocessor and memory system.

This pressure regulating function of the solenoid on-off valve 25 is accomplished by the pressure transducer 9 and controller 16. Alternately, a back pressure regulating valve (such as a Tescom BB-3 series) or a suitable servomechanism may be used in lieu of the actively controlled solenoid. Liquid keeps accumulating in the dewar 14 until the liquid level sensor 17 signals the controller that the dewar is full or until the oxygen sensor 18 signals that the oxygen concentration of fluid exiting the oxygen concentrator 11 is too low.

In the best mode, operating parameters for optimal operation of the system for the condenser should be that

the condenser surface temperature should be in the range from 69.2-109.7K and pressure should be in the range from 5-65 psia. The gas concentrations into the condenser for medical use should have oxygen in the range of 80-100%, nitrogen from 0-20%, and argon from 0-7%.

In order to transfer liquid from the dewar 14; e.g. to fill a portable LOX dewar 23, the pressure in the dewar 14 must be increased so that liquid can be forced up the dip tube 20. As shown in Figure 1, heater 21 is used for this purpose. Heater 21 may be immersed in the liquid oxygen or attached to the outer surface of the inner vessel. The controller 16 ensures that the cryocooler 12 is turned off and valve 25 is closed before the heater 21 is energized. The heater 21 remains turned on until the pressure, measured by pressure transducer 9, reaches about 22 psig.

In order to eliminate accumulation of solid water and hydrocarbons which may be supplied in trace amounts from the oxygen concentrator, the dewar 14 will be warmed to room temperature periodically (preferably after about 30 fillings of a portable dewar, or every two months). This procedure is accomplished most economically when the inventory of liquid in the storage dewar is low; e.g. shortly after liquid transfer and a portable dewar has been filled. In this □boil-dry□ mode, valve 19 will be closed, the cryocooler 12 is turned-off, valve 25 is open, and heater 21 is energized. The heater will boil-off the remaining liquid in the dewar and with it any trace amounts of water and hydrocarbons which are condensed and solidified in the liquid oxygen or on the cold surfaces. The heater 21 will remain turned on until the dewar

temperature, measured by temperature sensor 10, has warmed to about 300K. Any remaining water vapor will be flushed out by gaseous oxygen during the subsequent cool-down.

At initial start-up or after a periodic boil-dry phase, the dewar, condenser, recuperator, and all associated hardware are at room temperature and must be cooled down. This is accomplished in the □start-up□ mode, where valve 19 (see Figure 1) is open, the heater is off, the cryocooler is on, and valve 25 is modulated to control the pressure/flow rate. It is desired to keep the pressure and hence the density of the gas as high as possible while maintaining the flow rate.

The higher density gas will have better heat transfer with the dewar walls and associated hardware. It is noted that higher flow rates will enhance the convection heat transfer but may exceed the cooling capacity. Based on the cooling characteristics of the cryocooler between room temperature and 90K, the flow rate can be changed to minimize the cool-down time.

The dewar 14 is equipped with at least one relief valve 26 as a safety feature. Another relief valve 29 is provided and in communication with the inlet gas stream 51, before flowing into the recuperator 15. This serves as a back-up for relief valve 26 as well as providing a means to eliminate accumulated water from the recuperator 15 during periods when the cryocooler 12 is off, if valve 25 is closed. A check valve 27 is also provided to prevent backflow into the oxygen concentrator in the event of a malfunction.

Figure 6 provides a block diagram of the controller 16 control system with sensor input value ranges and output states. It also shows interfaces to an indicator and a modem or wireless interface. The mode switch 28 may be used by the patient to request the system to prepare for a liquid transfer to a portable dewar. The indicator then provides a visual signal that the system is building pressure in the dewar. Once the pressure has reached the desired value, a visual and/or audio signal is given to alert the patient that the system is ready to transfer liquid. The controller may also be programmed to perform an unattended liquid transfer. The modem, telephone line or wireless interface connections are optional hardware that may be added to the controller to enable remote monitoring of the system by the home care provider (e.g., to assist with maintenance and repair) or insurance companies or health providers/administrators (e.g., to assess if patients are using enough ambulatory oxygen to justify payments, etc.).

Figures 7A-D show a logic flow chart for the controller for the normal operation modes. This can also be referred to as the □input/output control schedule.□ The mode switch 28 can also be used by a repair or factory technician to put the controller in a calibration mode which serves as a method to check and reset the program. As shown in Figure 6, the indicator provides liquid level readout, transfer request status, and low oxygen concentration information to the patient. All of the sensors are continuously scanned to provide the controller with the latest information. Figures 8 through 11 provide detailed output states as a function

of input levels for the normal operating modes (start-up, condense, transfer, and boil-dry), which can be referred to as the □Optimal Liquefaction Operational Schedule.□

For example, Figure 8 relates to the start-up mode; i.e., when the system is first turned on or after the boil-dry cycle. As shown in Figures 6 through 8 and as depicted in Figure 1, at start-up mode, the liquid sensor 17 shows zero liquid volume in the dewar and, when the oxygen sensor 18 shows an oxygen concentration greater than 88%, valve 19 is open, heater 21 is off, cryocooler 12 is on, and the indicator or the controller indicates a cool-down state. Valve 25 is modulated to control pressure.

Once the system attains a cool enough temperature, steady state or normal operational condense mode is used. As shown in Figure 9, the input to the controller 16 is such that when the oxygen sensor indicates oxygen concentration being greater than 88% and when the other criteria in the left-hand column of Figure 9 are achieved, the output states set out in the right portion of the chart are attained. For example, when the level of the dewar is sensed as being full, the liquid level sensor indicates a level of approximately 100%, causing closure of valves 19 and 25, keeping the heater off, turning the cryocooler off, and having the indicator signal that the dewar is full.

The transfer mode in Figure 10 is the stage where one can fill the portable thermos bottles or dewars 23 from the main storage dewar 14. The top portion of

Figure 10, for example, shows controller readouts where, if the liquid sensor indicates a liquid level of less than 20%, then the conclusion is computed that there is not enough liquid to transfer into the portable dewar from the main dewar as shown. When the operator wants to increase the pressure in the storage dewar to force the liquid oxygen into the portable dewar, the heater is activated, and when the pressure sensor indicates that the pressure exceeds 22 psig, as shown on the last line in the left-hand column of Figure 10, the heater 21 is then turned off and the controller readout or indicator shows that the transfer of liquid oxygen can be made to the portable dewar. Finally, Figure 11 indicates the boil-dry mode, with valve 25 open to allow the vapor to escape, and the various parameters relating thereto.

Figure 12 shows a schematic of a pulse tube refrigerator, the preferred embodiment of the cryocooler 12 in Figure 1. Because the cooling load on the condenser is small (7-15W), the pulse tube refrigerator is preferred for use in the subject ambulatory oxygen system because of its good efficiency with only one moving part, the pressure oscillator. Pulse tube refrigerators are shown in US Patent Nos. 5,488,830; 5,412,952 and 5,295,355 the disclosure of which are hereby incorporated by reference. Figure 11 depicts a pulse tube refrigerator of the double inlet type. Other types of pulse tube refrigerators (PTR) could also be used such as the basic PTR or the inertance tube PTR (Zhu et al., 9th International Cryocooler Conference, NH, June 1996).

The double inlet pulse tube refrigerator as shown in Figure 12 is comprised of a pressure oscillator 30, primary heat rejector 31, regenerator 32, heat acceptor 33, pulse tube 34, orifice rejector 35, bypass orifice 36, primary orifice 37, and reservoir volume 38. The preferred refrigerant gas in the PTR closed and pressurized circuit is helium but various other gases such as neon or hydrogen could also be used. In operation, the PTR essentially pumps heat accepted at low temperature in the heat acceptor 33 to the orifice heat rejector 35 where it is rejected at near ambient temperature. Although Figure 12 depicts a □U-tube□ configuration of the PTR, in-line and coaxial configurations are other possible options. Depicted therein is a piston type pressure oscillator, but other types are possible such as those utilizing diaphragms or bellows.

Figure 13 shows a schematic of another embodiment of the cryocooler. This is a vapor compression cycle cryocooler using a mixed gas refrigerant such as shown in US Patent No. 5,579,654; a 1969 German Patent by Fuderer & Andrija; British Patent No. 1,336,892. Other types of cryocoolers will work as long as they meet the important criteria of small size, convenience and low cost. In Figure 13, the refrigerant is compressed by the compressor to high pressure. Then it is cooled by the aftercooler with heat Qh being rejected to the environment. Oil is separated in the oil separator. Oil flows back to the compressor inlet through a flow restriction. The refrigerant gas flows to a heat exchanger where it is cooled by the returning cold stream. Some components of the mixture may condense in

this process. The liquid/gas refrigerant mixture flows through a throttle valve where its pressure is reduced and its temperature drops. This cold refrigerant enters the evaporator where the heat load Qc is absorbed and some liquid is boiled into vapor. This vapor flows up the cold side of the heat exchanger absorbing heat from the incoming stream. Then it flows back to the compressor. Heat Qc is accepted at cold temperature Tc. This is where the condenser would interface with the cryocooler.

It is noted that with this type of cryocooler, it may be possible to remove some of the heat from the oxygen stream at a temperature warmer than Tc.

One possible geometry of the generally vertically oriented, gravity assisted condenser 13 in Figure 1 is shown in Figures 14 and 15. The incoming gas from the oxygen concentrator flows from conduit 57 to chamber 58 and then is distributed through an annular passage 59 between the outer tube 41 and inner rod 42. The inner rod 42 is made of a high thermal conductivity material such as OFHC (Oxygen Free High Conductivity) copper, to minimize the temperature gradient between the surface on which the oxygen condenses (13) and the cryocooler 12. The cold end of the cryocooler is shown by cross-hatched member 61. Due to surface tension, the axial slots or grooves 43 will draw in liquid as it condenses. This will enhance heat transfer from the incoming gas by preventing a liquid film from forming over the entire condenser surface. Condensed liquid will drip off the bottom of the rod 42 while non-condensed gases flow out the end of the annulus 60. It is possible to liquefy

all of the incoming flow to the condenser provided the cryocooler has sufficient cooling capacity and temperature capability. However, in order to minimize the amount of nitrogen and argon condensed, the preferred embodiment only condenses between 20-90% of the incoming flow. The incoming flow rate can be determined by the appropriate sizing of flow restrictions downstream of and by controlling valve 19. As mentioned previously, the mass flow rate is chosen to exceed the cooling capacity of the condenser/cryocooler so that only part of the incoming flow is liquefied. Also, the pressure in the condenser is maintained as high as possible while maintaining the desired flow rate. The higher pressure increases the condensation temperature which in turn reduces the requirements on the cryocooler.

Figures 16 and 17 show another embodiment of the condenser that allows easier integration with the mixed gas refrigerant cryocooler. This configuration also allows access to the liquid in the dewar through the center of the condenser. The cold end of the cryocooler 45 is in thermal contact with an outer tube 46 and an inner tube 47, both of which are made of a high thermal conductivity material such as OFHC copper and which utilize flanges 62 and 64 to interface with the cryocooler. The inner tube has axial slots or grooves 48 cut into its outer surface (see, Figure 17) to increase the surface area and to wick condensed liquid, preventing a liquid film from forming over its entire surface. Gas enters the condenser through port 63. The liquid and vapor flow down through an annular passage

49. An isometric view of this embodiment is shown in Figure 18.

Thus, an improved home/ambulatory liquid oxygen system is disclosed. While the embodiments and applications of this invention have been shown and described, and while the best mode contemplated at the present time by the inventors has been described, it should be apparent to those skilled in the art that many more modifications are possible, including with regard to scaled-up industrial applications, without departing from the inventive concepts therein. Both product and process claims have been included and in the process claims it is understood that the sequence of some of the claims can vary and still be within the scope of this invention. The invention therefore can be expanded, and is not to be restricted except as defined in the appended claims and reasonable equivalence departing therefrom.

CLAIMS

1. A home liquid oxygen ambulatory system for supplying a portable supply of oxygen, where a portion of the gaseous oxygen output obtained from an oxygen concentrator is condensed into liquid oxygen, comprising.

(a) an oxygen concentrator which separates oxygen gas from the ambient air;
(b) an outlet flow line to transfer flow of oxygen gas from said oxygen concentrator for patient use;
(c) a valve placed in the outlet flow line for splitting off a portion of the oxygen gas flow generated by the oxygen generator;
(d) a condenser for receiving and liquefying the split off portion of the oxygen gas flow;
(e) a cryocooler associated with said condenser;
(f) a first storage dewar in fluid communication with said condenser for storing the oxygen liquefied by the condenser, the first storage dewar having an outlet selectively engageable to and in fluid communication with at least one second smaller dewar and a fluid path for supplying liquid oxygen from the first dewar to the second dewar;
(g) a heater for heating said first storage dewar;

(h) a controller for monitoring (i) oxygen concentration of the oxygen gas flowing from said concentrator, and (ii) the amount of liquid oxygen in said first dewar, and for controlling the parameters of liquid oxygen generation and transfer from said first storage dewar.

2. The liquid oxygen system of claim 1 wherein the oxygen concentrator is a pressure swing adsorption (□PSA□) type oxygen concentrator.

3. The liquid oxygen system of claim 1 wherein the flow rate into the condenser is chosen to exceed the capacity of the condenser.

4. The liquid oxygen system of claim 1 wherein only 20 to 90% of the split off portion flowing into the condenser is condensed to minimize the liquefaction of argon, nitrogen and trace gases.

5. The liquid oxygen system of claim 1 wherein the controller controls condenser parameters so that the condenser temperature varies in the range from approximately 69.2 to 109.7K, the condenser pressure varies from approximately 5 to 65 psia, and the concentrations of gas into the condenser varies approximately as follows:

oxygen: 80 to 100%
nitrogen: 0 to 20%
argon: 0 to 7%

6. The liquid oxygen system of claim 1 wherein vent gas from the first storage dewar is recovered and used to pre-cool the gas into the condenser.

7. The liquid oxygen system of claim 1 wherein the condenser is in thermal contact with the cryocooler and comprises:

(a) an inlet conduit for receiving the split off portion of oxygen;
(b) an outer member;
(c) an inner member having a chamber in communication with said inlet conduit;
(d) a passage defined by said outer and inner members;
(e) said inner member having axial slots; and
(f) means for circulating said oxygen in said passage defined by said inner and outer members;

8. The liquid oxygen system of claim 1 wherein a generally vertically oriented, gravity assisted condenser for use in liquefaction of oxygen from its gaseous to its liquid phase comprises:

(a) an inlet for receiving a stream of gaseous oxygen;
(b) an outer member;
(c) an inner member;
(d) a passage defined by said inner and outer members, the inlet being in communication with said passage;

(e) the inner member having axial slots to enhance heat transfer and to avoid liquid film build-up; and

(f) at least one of said members being in thermal contact with said cryocooler.

9. The liquid oxygen system of claim 1, further comprising a recuperator interfaced between the oxygen concentrator and the condenser.

10. The liquid oxygen system of claim 1, wherein the controller senses pressure in said first dewar and controls said heater in response thereto.

11. The liquid oxygen system of claim 1 wherein the first storage dewar will be periodically boiled dry to eliminate any trace gases that may pass through the gas concentrator.

12. The liquid oxygen system of claim 1, wherein the condenser comprises a generally vertically oriented, gravity assisted, circular housing with an inner center grooved core defining an annulus and with axial slits to wick away the condensed liquid.

13. The liquid oxygen system of claim 1 wherein the controller is located remotely from the oxygen source.

14. The liquid oxygen system of claim 1 wherein the controller monitors the oxygen concentration and amount of liquid oxygen and controls the parameters of

liquid oxygen generation and transfer remotely using a modem.

15. The liquid oxygen system of claim 1 wherein the controller monitors the oxygen concentration and amount of liquid oxygen and controls the parameters of liquid oxygen generation and transfer remotely using a wireless interface.

16. A control system for a home ambulatory liquid oxygen system having an oxygen concentrator, condenser, cryocooler, a heater and a storage dewar, the control system comprising:

(a) an oxygen concentration sensor which senses the concentration of oxygen gas generated by the oxygen concentrator and generates a first signal in response thereto;

(b) a liquid level sensor which senses the liquid level in the dewar and generates a second signal in response thereto;

(c) a temperature sensor which senses the temperature in the dewar and generates a third signal in response thereto;

(d) a microprocessor for receiving the first, second and third signals for computing the flow concentration of gaseous oxygen out of the concentrator and into the condenser, the level of liquid oxygen in the dewar, the temperature in the dewar and for controlling the transfer of liquid oxygen from said storage dewar.

17. The control system in claim 16 wherein the microprocessor is located remotely from the home ambulatory system and connected to the sensors and controllers using a modem.

18. The control system in claim 16 wherein the microprocessor is located remotely from the home ambulatory system and connected to the sensors and controllers using a wireless interface.

19. The control system in claim 16 wherein the actual flow rate into the condenser is chosen to exceed the designed flow capacity of the condenser allowing the excess flow to purge the system.

20. The liquid oxygen system of claim 16 wherein only 20 to 90% of the incoming flow into the condenser is condensed to minimize the liquefaction of argon, nitrogen and trace gases.

21. The apparatus of claim 16 wherein the controller controls condenser parameters so that the condenser temperature varies in the range from approximately 69.2 to 109.7K, the condenser pressure varies from approximately 5 to 65 psia, and the concentrations of gas into the condenser varies approximately as follows:

oxygen: 80 to 100%
nitrogen: 0 to 20%
argon: 0 to 7%

22. An ambulatory liquid oxygen system where liquid oxygen is formed from gaseous oxygen obtained from an oxygen concentrator comprising:

(a) an oxygen concentrator which separates oxygen gas from the air line;

(b) a first output line from said oxygen concentrator for delivering oxygen gas from said concentrator;

(c) a first valve placed in said first output line to control the output flow of oxygen;

(d) a condenser in cooperation with a cryocooler for providing cooling for said condenser;

(e) a second output line in communication between the first valve and the condenser for delivering the oxygen gas from the concentrator output to the condenser for cooling to form liquid oxygen;

(f) a storage dewar for storing liquid oxygen liquefied by the condenser;

(g) a third output line in communication between said condenser and storage dewar for delivering liquid oxygen from the condenser to the storage dewar;

(h) a heater for heating liquid oxygen in said dewar;

(i) an oxygen sensor to measure the oxygen concentration of flow from said concentrator;

(j) a liquid level sensor in said dewar;

(k) a temperature sensor in said dewar;

(l) a pressure sensor in communication with said dewar; and

(m) a controller for receiving output from the oxygen sensor, liquid level sensor, temperature sensor and pressure sensor, and for controlling the flow of input gaseous oxygen to the condenser and for controlling liquefaction and transfer from the storage dewar in accordance with the sensed conditions.

23. The system of claim 22 wherein the oxygen concentrator is of the Pressure Swing Adsorption (□PSA□) type.

24. The system of claim 22 wherein the condenser parameters are maintained as follows:

temperature from approximately 69.2 to 109.7K;
pressure from approximately 5 to 65 psia;
gas concentrations into condenser:
oxygen from approximately 80 to 100%,
nitrogen from approximately 0 to 20%, and
argon from approximately 0 to 7%

25. The system of claim 22 further comprising a recuperator between the oxygen concentrator and condenser for pre-cooling the flow of gas into the condenser.

26. The liquid oxygen system of claim 22 wherein the flow rate into the condenser is chosen to exceed the designated capacity of the condenser.

27. The liquid oxygen system of claim 22 wherein only 20 to 90% of the incoming flow to the condenser is condensed to minimize the liquefaction argon, nitrogen and trace gases.

28. The liquid oxygen system of claim 22 wherein the generally vertically oriented, gravity assisted condenser is in contact with the cryocooler and comprises:

(a) an inlet for receiving gaseous oxygen;
(b) an outer tubular member;
(c) an inner member;
(d) a passage defined by said outer and inner members;
(e) said inner member having axial slots cut into its outer surface;
(f) means for circulating said oxygen in said passage; and
(g) an outlet for releasing liquid oxygen,

wherein when said oxygen gas enters said condenser at said inlet and passes through said passage, condensation takes place causing a transition from gas to liquid phase.

29. The liquid oxygen system of claim 22 where the generally vertically oriented, gravity assisted, condenser comprises:

(a) an inlet for receiving a stream of oxygen;
(b) an outer member;

(c) an inner member;

(d) passage defined by said inner and outer members;

(e) the inner member having axial slots to enhance heat transfer and to avoid liquid film build-up; and

(f) an outlet for the oxygen which is liquefied.

30. The liquid oxygen system in claim 22 wherein the controller is located remotely from the oxygen generator.

31. The liquid oxygen system in claim 22 wherein the controller monitors the oxygen concentration and amount of liquid oxygen and controls the parameters of liquid oxygen generation and transfer remotely using a modem.

32. The liquid oxygen system in claim 22 wherein the controller monitors the oxygen concentration and amount of liquid oxygen and controls the parameters of liquid oxygen generation and transfer remotely using a wireless interface.

33. A method for controlling an ambulatory oxygen generator and oxygen liquefier having an oxygen concentrator, a condenser, a storage dewar and a controller comprising the following steps:

(a) generating a gaseous supply of oxygen using the oxygen concentrator for supplying oxygen to a patient;
(b) splitting off a portion of the gaseous supply to be liquefied;
(c) cooling said split-off supply of oxygen using the condenser to transform the oxygen from gaseous phase to liquid phase;
(d) storing the liquid oxygen in the storage dewar;
(e) sensing a concentration of oxygen being supplied by the oxygen concentrator, the level of liquid oxygen in said dewar and the temperature and pressure in said dewar; and
(f) the controller calculating conditions and controlling the operation of the above system to allow for liquefaction and operative transfer of liquid oxygen to a portable dewar.

34. A method for controlling a home ambulatory liquid oxygen system comprised of an oxygen generator, a controller having a microprocessor, a condenser, a cryocooler and a storage dewar, where all or only a portion of the oxygen flow is utilized for liquefaction, comprising:

(a) providing the microprocessor with a database and control functions;
(b) sensing the parameters relating to the concentration and supply of gaseous

oxygen, the level of liquid oxygen in the dewar, and the pressure of the condenser;

(c) providing the microprocessor with these sensed parameters and having the microprocessor calculate optimal conditions;

(d) controlling servomechanisms to regulate the system so that optimal conditions are realized as a function of said calculations.

35. An ambulatory home oxygen concentrator liquefaction system comprising:

(a) an oxygen concentrator which can isolate oxygen gas from the air;

(b) a first output means from the concentrator to channel the oxygen which is isolated;

(c) a second means to split off all or a portion of the gaseous oxygen from the output means of said concentrator for liquefaction;

(d) a condenser which can cause gaseous oxygen to change phase into liquid oxygen;

(e) means to channel the oxygen stream from said output means to a condenser;

(f) means to liquefy said oxygen stream in said condenser using a cryocooler; and

(g) means to collect the condensed liquid oxygen using a first dewar, wherein said first dewar includes a heater which can

be used to effectuate the transfer of liquid oxygen from the first dewar to a second dewar for storing a quantity of liquid oxygen from which smaller quantities can be transferred for moveable oxygen treatment.

36. The apparatus of claim 35 wherein the oxygen concentrator is a pressure swing adsorption (□PSA□) type oxygen concentrator.

37. The liquid oxygen system of claim 35 wherein the flow rate into the condenser is chosen to exceed the capacity of the condenser.

38. The liquid oxygen system of claim 35 wherein only 20 to 90% of the incoming flow to the condenser is condensed to minimize the liquefaction argon, nitrogen and trace gases.

39. The apparatus of claim 35 wherein the controller controls condenser parameters or ranges so that the condenser temperature varies in the range from approximately 69.2 to 109.7K and the condenser pressure varies from approximately 5 to 65 psia, and the concentrations of gas into the condenser varies approximately as follows:

Oxygen: 80 to 100%
Nitrogen: 0 to 20%
Argon: 0 to 7%

40. The apparatus of claim 35 wherein vent gas from the storage dewar is recovered and used to pre-cool the gas into the condenser.

41. The apparatus of claim 35, further comprising a recuperator interfaced between the oxygen concentrator and the condenser.

42. The apparatus of claim 35, further comprising a controller which senses pressure in the first dewar and controls said heater in response thereto.

43. The system set forth in claim 35 wherein the liquid dewar will be periodically boiled dry to eliminate any trace gases that may pass through the gas concentrator.

44. The apparatus of claim 35, wherein the generally vertically oriented, gravity assisted condenser comprises a circular housing with an inner center grooved core defining an annulus and with axial slits to wick away the condensed liquid.

45. The liquid oxygen system in claim 42 wherein the controller is located remotely from the oxygen generator.

46. The liquid oxygen system in claim 42 wherein the controller monitors the oxygen concentration and amount of liquid oxygen and controls the parameters of liquid oxygen generation and transfer remotely using a modem.

47. The liquid oxygen system in claim 42 wherein the controller monitors the oxygen concentration and amount of liquid oxygen and controls the parameters of liquid oxygen generation and transfer remotely using a wireless interface.

48. A controller for a home ambulatory liquid oxygen system having a computer, an oxygen concentrator, condenser, and storage dewar comprising:

(a) means for sensing the oxygen pressure of flow out of the concentrator;

(b) means for sensing the oxygen concentration of flow out of the concentrator;

(c) means for sensing the liquid level in the dewar;

(d) means for sensing flow parameters at the condenser;

(e) means for sensing the temperature at the dewar;

(f) means for controlling input of gaseous oxygen to the condenser;

(g) means for initiating and controlling the output of liquid oxygen from the storage dewar;

(h) a programmable control means coupled to each means for sensing, said programmable control means to be used for storing at least one required input/output control schedule, for processing the inputted signals and for actuating one or more control means.

49. A system for liquefying oxygen utilizing an oxygen concentrator, condenser, cryocooler and storage dewar comprising:

(a) a first flow control means for channeling off gaseous fluid flow from an oxygen concentrator;

(b) a second flow control means for advancing said gaseous fluid to a condenser;

(c) means for cooling said condenser to change the phase of said oxygen flow from gas to liquid;

(d) a conduit for transferring the liquid oxygen from the condenser to a storage dewar;

(e) a third flow control means for advancing the flow of liquid oxygen out of the storage dewar;

(f) a controller for sensing the oxygen concentration of flow into the condenser, for sensing the liquid level in the storage dewar, and for controlling said first, second, and third flow control means;

(g) programmable control means in said controller coupled to each of said flow control means, for storing flow delivery and liquefaction parameters for use by the controller in optimizing liquefaction of oxygen.

50. The liquid oxygen system of claim 49 wherein the flow rate into the condenser is controlled to exceed the capacity of the condenser.

51. The liquid oxygen system of claim 49 wherein only 20 to 90% of the incoming flow to the condenser is condensed to minimize the liquefaction argon, nitrogen and trace gases.

52. The liquid oxygen system of claim 49 wherein contact with a cryocooler for use in liquefying oxygen comprises:

(a) an inlet for receiving gaseous oxygen;
(b) an outer tubular member;
(c) a generally vertically oriented inner member;
(d) a passage defined by said outer and inner members;
(e) said generally vertically oriented inner member having axial slots cut into its outer surface;
(f) means for circulating said oxygen in said passage; and
(g) an outlet for releasing liquid oxygen;

wherein when said oxygen gas enters said condenser at said inlet and passes through said passage, condensation takes place causing a transition from gas to liquid phase.

53. The liquid oxygen system of claim 49 where the generally vertically oriented, gravity assisted condenser for use in liquefaction of oxygen from its

gaseous to its liquid phase and for use with a cryocooler comprises:

(a) an inlet for receiving a stream of oxygen;
(b) an outer member;
(c) an inner member;
(d) passage defined by said inner and outer members;
(e) the inner member having axial slots to enhance heat transfer and to avoid liquid film build-up
(f) an outlet for the oxygen which is liquefied.

54. A generally vertically oriented, gravity assisted condenser in thermal contact with a cryocooler for use in liquefying oxygen comprising:

(a) an inlet for receiving gaseous oxygen;
(b) an outer tubular member;
(c) an inner member;
(d) a passage defined by said outer and inner members;
(e) said inner member having axial slots cut into its outer surface;
(f) means for circulating said oxygen in said passage; and
(g) an outlet for said liquid oxygen;

wherein when said oxygen gas enters said condenser at said inlet and passes through said passage, condensation takes place causing a transition from gas to liquid phase.

55. A generally vertically oriented, gravity assisted condenser for use in liquefaction of oxygen from its gaseous to its liquid phase and for use with a cryocooler comprising:

(a) an inlet for receiving a stream of oxygen;
(b) an outer member;
(c) an inner member;
(d) passage defined by said inner and outer members;
(e) the inner member having axial slots to enhance heat transfer and to avoid liquid film build-up; and
(f) an outlet for the liquid oxygen to exit the condenser.

56. A home liquefaction system including an oxygen concentrator, controller with a programmable control means, condenser, cryocooler and storage dewar comprising:

(a) an oxygen concentrator which separates oxygen gas from the air;
(b) a first flow line from said oxygen concentrator for delivering oxygen gas from said concentrator;
(c) a first valve placed in said first flow line to control the output flow of oxygen;

(d) a condenser in cooperation with a cryocooler for providing cooling for said condenser;

(e) a second flow line in communication between the first valve and the condenser for delivering the oxygen gas from the concentrator output to the condenser for cooling to form liquid oxygen;

(f) a storage dewar for storing liquid oxygen liquefied by the condenser;

(g) a third flow line in communication between said condenser and storage dewar for delivering liquid oxygen from the condenser to the storage dewar;

(h) a heater for heating liquid oxygen in said dewar;

(i) an oxygen sensor to measure the oxygen concentration of flow from said concentrator;

(j) a liquid level sensor in said dewar;

(k) a temperature sensor in said dewar;

(l) a pressure sensor for sensing pressure in said dewar;

(m) a second valve for regulating flow of liquid oxygen from said dewar;

(n) a controller for receiving output from the oxygen sensor, liquid level sensor, temperature sensor and pressure sensor, and having means for storing at least one parameter from the Optimum Liquefaction Schedule, for controlling the flow of input gaseous oxygen to the condenser, and for optimizing liquefaction and

transfer from the storage dewar in accordance with the sensed conditions.

57. The apparatus of claim 56 wherein said programmable control means including means for storing information relating to optimum condenser parameters and for displaying an indicium of the modes of operation prior to activating any of said flow control means.

58. A system as in claim 56 wherein said programmable control means includes means for scheduling intermittent actuation of one or more of said valves so as to permit the system to be operated in accordance with the Optimum Liquefaction Schedule;

59. A system as in claim 56 including means for adjusting actuation of selected flows and conditions so as to optimize condenser parameters in response to said programmable control means and Optimum Liquefaction Schedule.

60. A system as in claim 56 including means for visually displaying controller parameters.

61. A system in claim 56 including means for transferring said liquid oxygen from said storage dewar to the delivery port at a controllable rate and including means to actuate said means in accordance with a predetermined Optimum Liquefaction Schedule;

62. An oxygen liquefaction system utilizing a concentrator to increase the oxygen concentration of an oxygen enriched product gas comprising:

(a) a first output line for transporting said product gas from said concentrator;

(b) a first valve for selectively withdrawing all or a portion of said product gas from said conduit to be liquefied;

(c) flow rate sensor independent of said first valve for sensing the rate of withdrawal of the product gas from said conduit to be liquefied and for communicating the sensed rate of withdrawal of said product gas to a modem;

(d) an oxygen sensor for sensing the oxygen concentration in said oxygen enriched product gas selectively withdrawn for liquefaction and for communicating the sensed oxygen concentration in said product gas to a first modem;

(e) a condenser for receiving the product gas withdrawn from said first flow control means;

(f) a second output line from said first flow control means oxygen concentrator for delivering oxygen gas from said concentrator for a first use;

(g) a second flow rate sensor in said second output line;

(h) a second oxygen sensor in said second output line;

(i) a cryocooler for providing cooling for said condenser;

(j) a storage dewar for storing liquid oxygen liquefied by the condenser;

(k) a third output line in communication between said condenser and storage dewar for delivering liquid oxygen from the condenser to the storage dewar;

(l) a heater for heating liquid oxygen in said dewar;

(m) a liquid level sensor for sensing the level in said dewar;

(n) a temperature sensor for sensing the temperature in said dewar;

(o) a pressure sensor for sensing the pressure in said dewar;

(p) a second modem for receiving quantitative signals communicated from said flow rate sensing means and said oxygen sensing means and for transmitting said signals to a remote controller; and

(q) a remote controller in telephonic communication with said first and second modems for receiving transmitted signals from said modems and having means for displaying the liquefaction parameters in the liquefaction process.

63. The oxygen liquefaction system of claim 62 wherein the concentrator increases the oxygen concentration of an oxygen enriched product gas recovered therefrom using a plurality of molecular sieve beds for receiving atmospheric air for selectively adsorbing nitrogen therefrom, an electric motor driven compressor including means for providing line voltage

for operating said compressor, and a valve cooperating with said compressor for alternately charging said sieve beds with atmospheric air and timing means for switching said valve to alternately charge said sieve beds according to a timing cycle.

64. The oxygen liquefaction system of claim 62 wherein said flow rate sensors comprise a pressure transducer for measuring product gas pressure therein.

65. The system of claim 64 including a microprocessor cooperating with said pressure transducers and having means for determining the rate of flow of product gas into the condenser in response to pressure sensings therein.

66. The system of claim 65 wherein said test apparatus includes visual display means for displaying the product gas flow rate and the oxygen concentration into the condenser and the pressure and temperature in the storage dewar.

67. The system of claim 62 wherein said remote control apparatus includes means for selectively signaling said modem to transmit said signals from said liquefaction apparatus.

68. The system of claim 62 including a microprocessor having means for receiving the sensed rate of product gas withdrawal and oxygen concentration in said product gas from said oxygen sensor, the pressure, temperature, and liquid level in the storage dewar, and having memory means provided with minimum

selected parameters at different conditions, means for comparing the sensed parameters with the minimum selected parameters, and means for signaling said modem to transmit said signals to said controller when said sensed parameters fall below said minimum selected parameters.

69. The oxygen concentrator of claim 68 wherein said first modem is connected to said microprocessor and said second remote modem is connected to said controller at a remote location, and wherein said modems are in telephonic communication.

70. The concentrator of claim 69 wherein said microprocessor includes means for signaling said first modem to transmit said signals to said controller when said sensed oxygen concentration or liquefaction falls below said minimum selected parameters.

71. The apparatus of claim 70 wherein said microprocessor cooperates with said first means and said second means and wherein said controller includes selective digital display means for displaying liquefaction parameters.

72. The system in claim 70 wherein the entry system not including the oxygen concentrator weighs no more than about 60 pounds and takes up less than about six cubic feet of volume.

73. An ambulatory liquid oxygen system where liquid oxygen is formed from gaseous oxygen obtained from an oxygen concentrator comprising:

(a) an oxygen concentrator which separates oxygen gas from the air;

(b) a first output means from said oxygen concentrator for delivering oxygen gas from said concentrator;

(c) a first valve placed in said first output means to control the output flow of oxygen;

(d) a condenser in cooperation with a cryocooler for providing cooling for said condenser;

(e) a second output line in communication between the first valve and the condenser for delivering the oxygen gas from the concentrator output to the condenser for cooling to form liquid oxygen;

(f) a storage dewar for storing liquid oxygen liquefied by the condenser;

(g) a third output line in communication between said condenser and storage dewar for delivering liquid oxygen from the condenser to the storage dewar;

(h) a heater for heating liquid oxygen in said dewar;

(i) an oxygen sensor to measure the oxygen concentration of flow from said concentrator;

(j) a liquid level sensor in said dewar;

(k) a temperature sensor in said dewar;

(l) a pressure sensor in communication with said dewar;

(m) a controller for receiving output from the oxygen sensor, liquid level sensor, temperature sensor and pressure sensor, and for controlling the flow of input gaseous oxygen to the condenser and for optimizing liquefaction and transfer from the storage dewar in accordance with the sensed conditions.

74. An ambulatory home oxygen concentrator liquefaction system comprising:

(a) an oxygen concentrator which can isolate oxygen gas from the air;

(b) a first output means from the concentrator to channel the oxygen which is isolated;

(c) a second means to split off all or a portion of the gaseous oxygen from the output means of said concentrator for liquefaction;

(d) a condenser which can cause gaseous oxygen to change phase into liquid oxygen;

(e) means to channel the oxygen stream from said output means to a condenser;

(f) means to liquefy said oxygen stream in said condenser using a cryocooler;

(g) means to collect the condensed liquid oxygen using a dewar;

(h) wherein said dewar includes a heater which can be used to effectuate the transfer of liquid oxygen from the dewar

for storing a quantity of liquid oxygen from which smaller quantities can be transferred for moveable oxygen treatment.

75. A system for liquefying oxygen utilizing an oxygen concentrator, condenser, cryocooler and storage dewar comprising:

(a) a first flow control means for channeling off gaseous fluid flow from an oxygen concentrator;
(b) a second flow control means for advancing said gaseous fluid to a condenser;
(c) means for cooling said condenser to change the phase of said oxygen flow from gas to liquid;
(d) a conduit for transferring the liquid oxygen from the condenser to a storage dewar;
(e) a third flow control means for advancing the flow of liquid oxygen out of the storage dewar;
(f) a controller for sensing the oxygen concentration of flow into the condenser, for sensing the liquid level in the storage dewar, and for controlling said first, second, and third flow control means;
(g) programmable control means in said controller coupled to each of said flow control means, for storing flow delivery and liquefaction parameters for use by

the controller in optimizing liquefaction of oxygen.

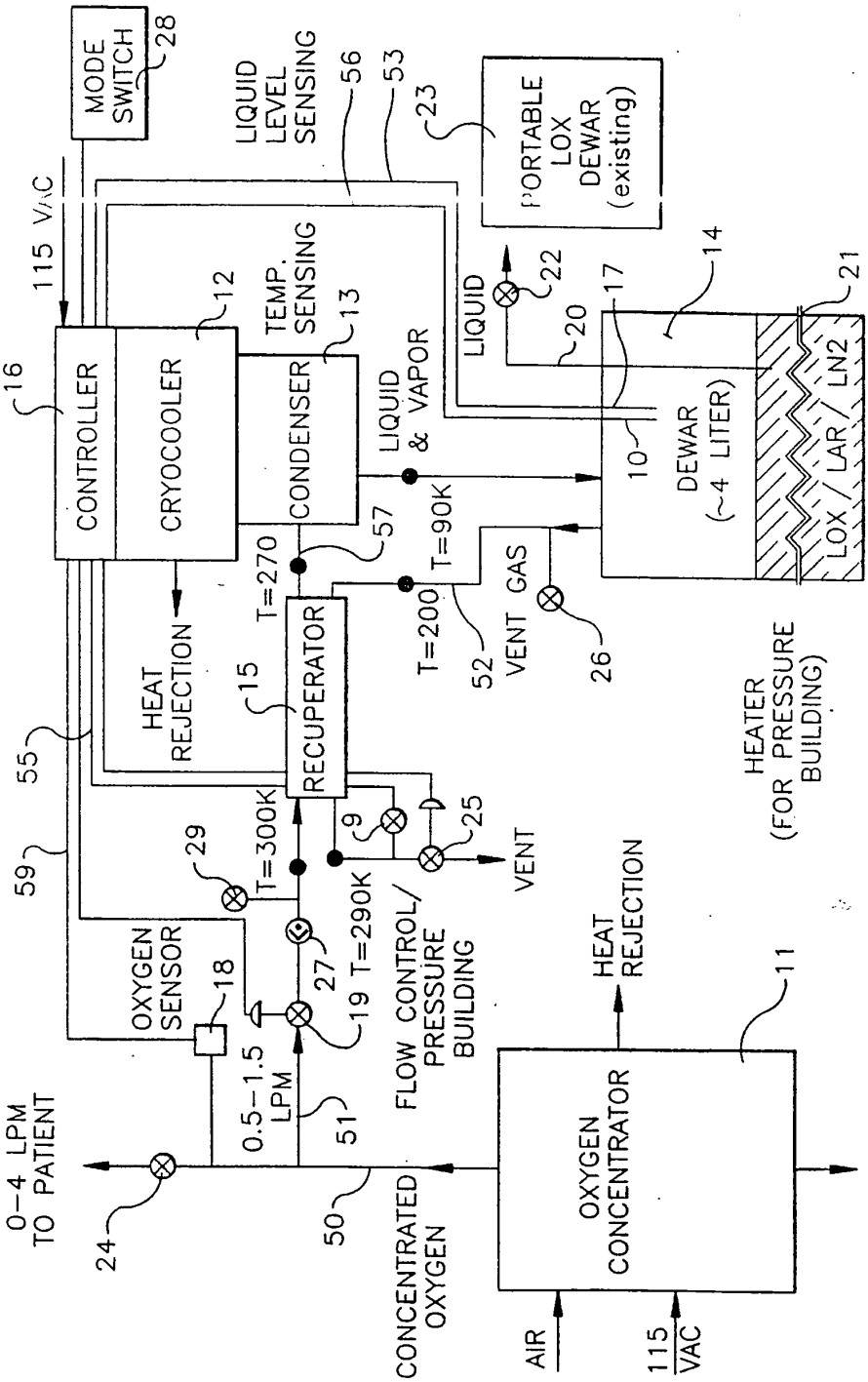

MODE SWITCH
28
LIQUID LEVEL SENSING
56
53
23
PORTABLE LOX DEWAR (existing)
115 VAC
TEMP. SENSING
13
12
22
LIQUID
20
17
14
21
16
CONTROLLER
CRYOCOOLER
CONDENSER
LIQUID & VAPOR
10
DEWAR (~4 LITER)
LOX / LAR / LN2
57
T=270
T=90K
T=200
52
VENT GAS
26
HEAT REJECTION
15
RECUPERATOR
55
59
29
T=300K
9
25
VENT
HEATER (FOR PRESSURE BUILDING)
OXYGEN SENSOR
18
27
19 T=290K
FLOW CONTROL/ PRESSURE BUILDING
HEAT REJECTION
11
0.5–1.5 LPM
51
0–4 LPM TO PATIENT
24
50
CONCENTRATED OXYGEN
OXYGEN CONCENTRATOR
WASTE GAS
AIR
115 VAC

Fig. 1

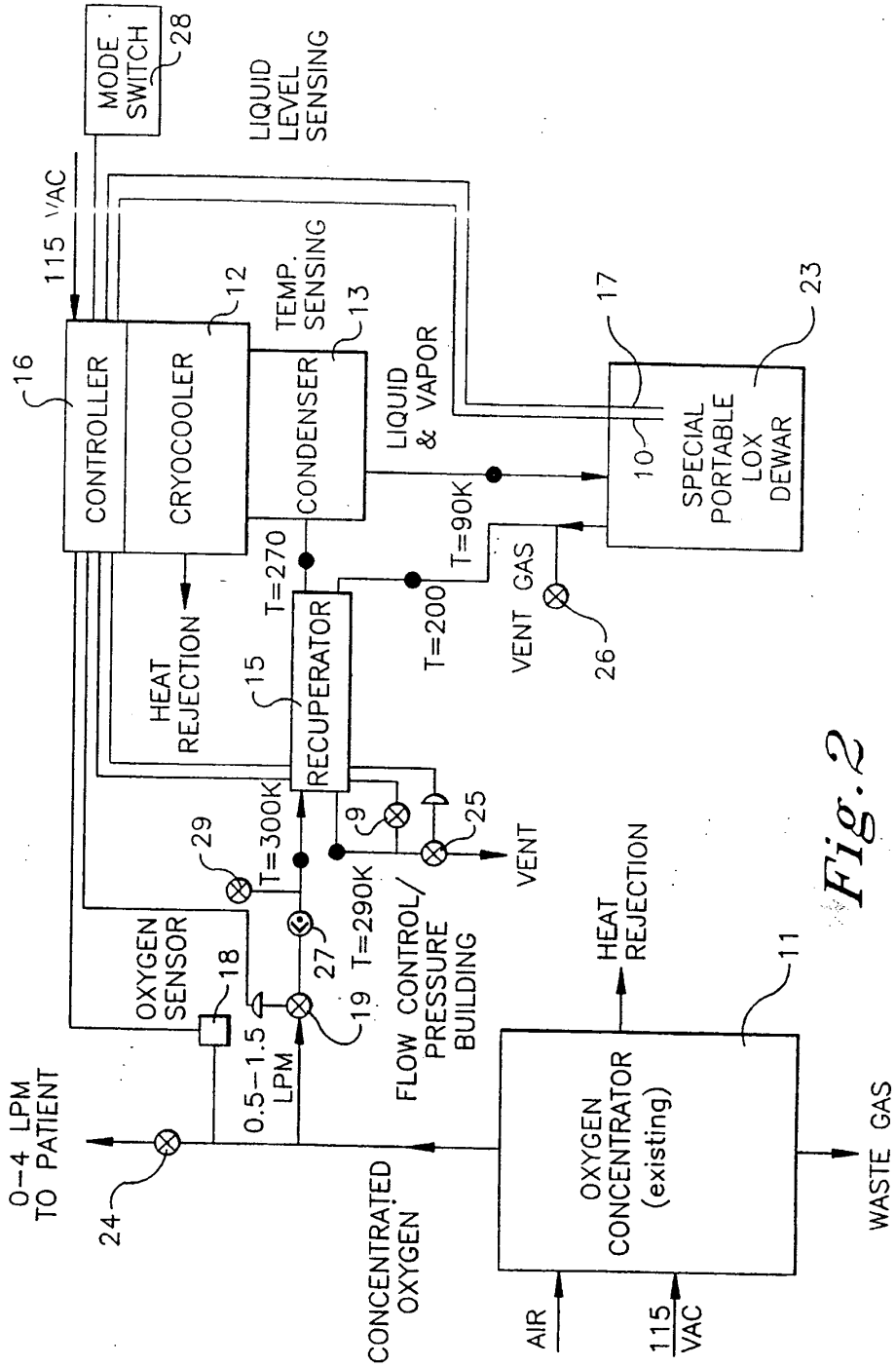
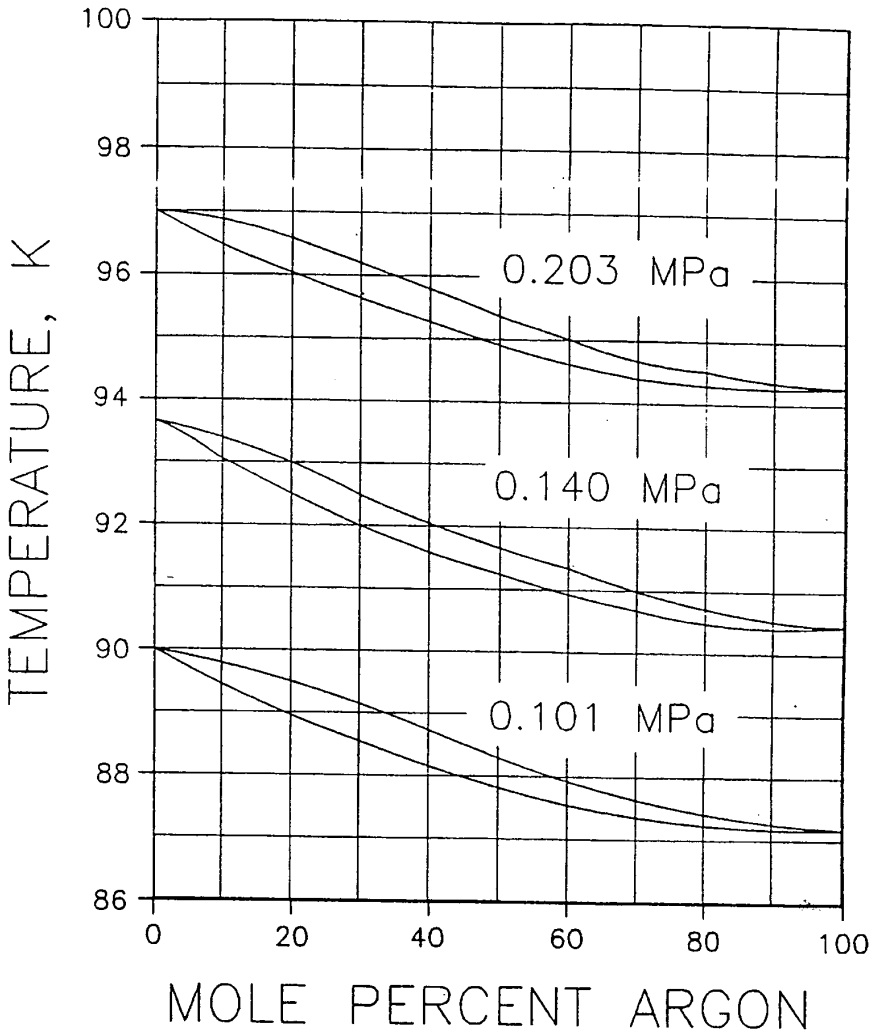

MODE SWITCH
28
LIQUID LEVEL SENSING
115 VAC
16
CONTROLLER
CRYOCOOLER
12
TEMP. SENSING
13
CONDENSER
LIQUID & VAPOR
17
23
SPECIAL PORTABLE LOX DEWAR
10
T=90K
T=270
T=200
VENT GAS
26
HEAT REJECTION
15
RECUPERATOR
9
25
VENT
29
T=300K
OXYGEN SENSOR
18
27
T=290K
19
FLOW CONTROL/ PRESSURE BUILDING
HEAT REJECTION
11
0.5-1.5 LPM
0-4 LPM TO PATIENT
24
CONCENTRATED OXYGEN
OXYGEN CONCENTRATOR (existing)
WASTE GAS
AIR
115 VAC

Fig. 2



TEMPERATURE – COMPOSITION DIAGRAM
FOR OXYGEN – ARGON MIXTURES

Fig. 3

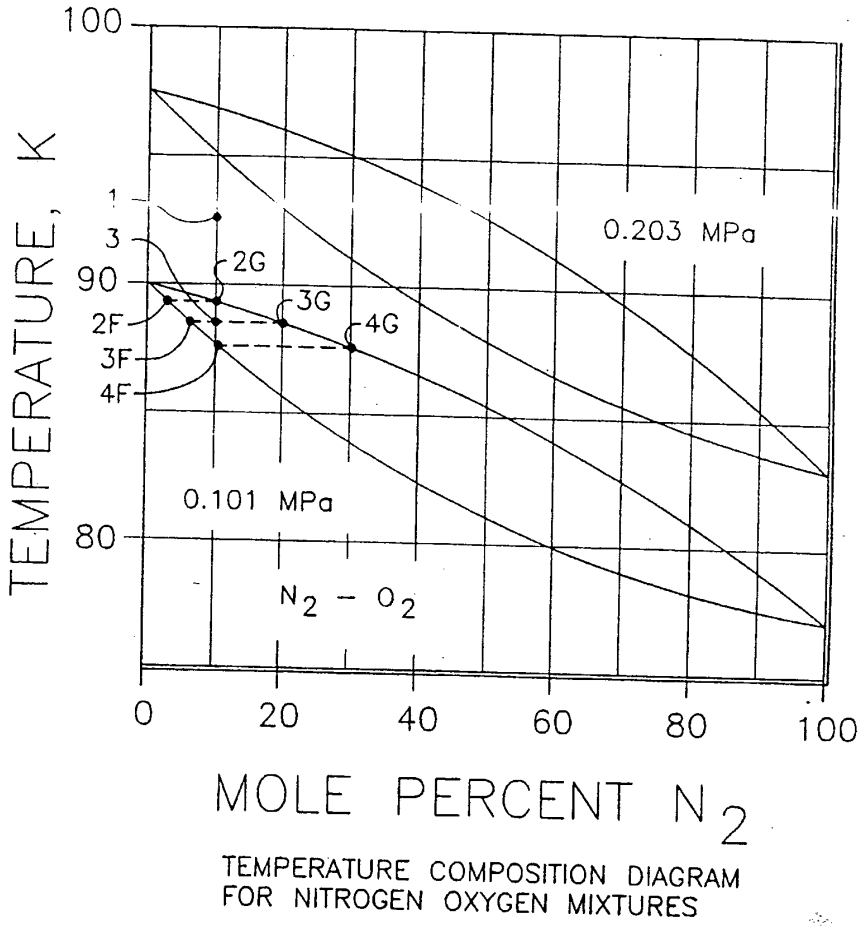
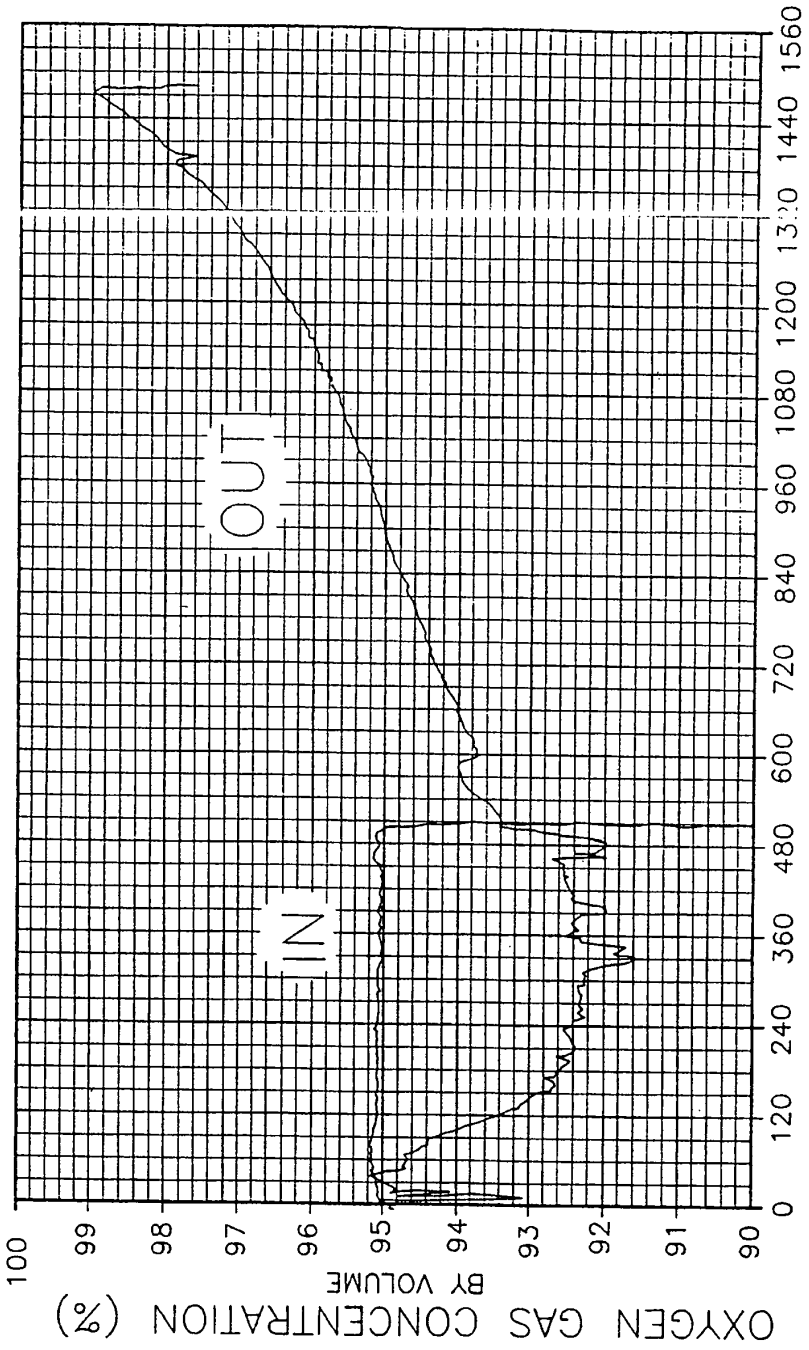
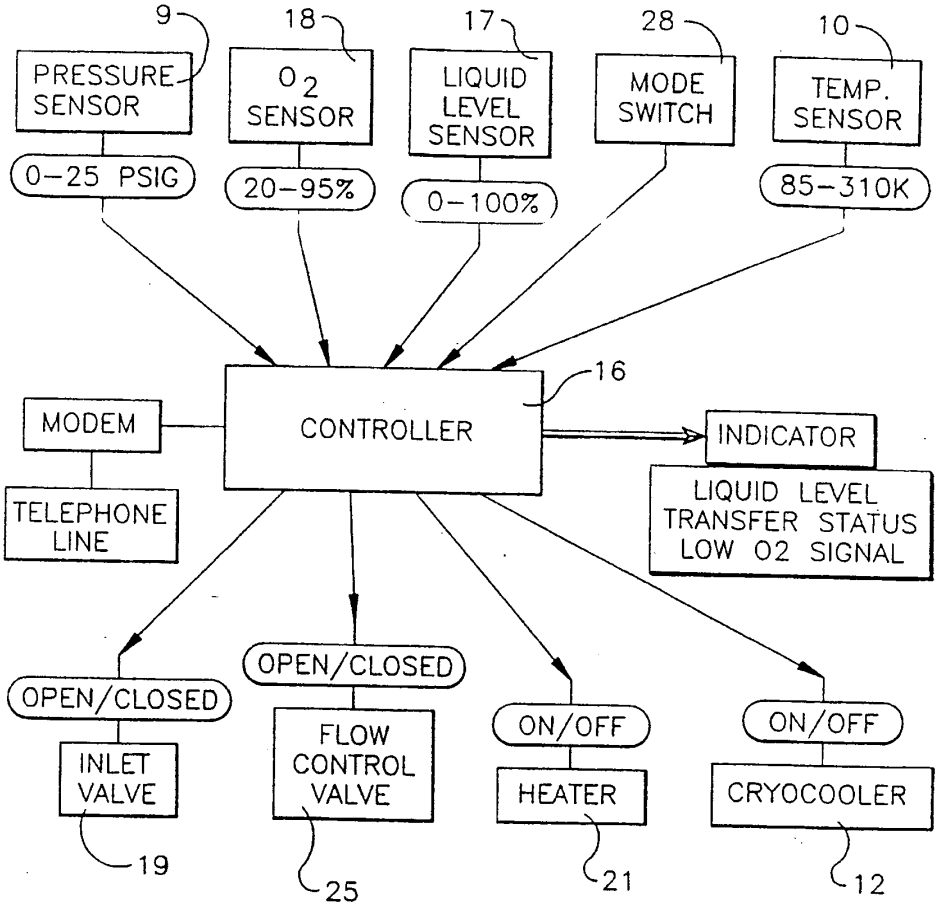

100
90
80
TEMPERATURE, K
1
3
2F
3F
4F
2G
3G
4G
0.203 MPa
0.101 MPa
$N_2 - O_2$
0
20
40
60
80
100
MOLE PERCENT N_2
TEMPERATURE COMPOSITION DIAGRAM
FOR NITROGEN OXYGEN MIXTURES

Fig. 4



OXYGEN CONCENTRATION TEST DATA

Fig. 5



CONTROL BLOCK DIAGRAM

Fig. 6

Fig. 7A

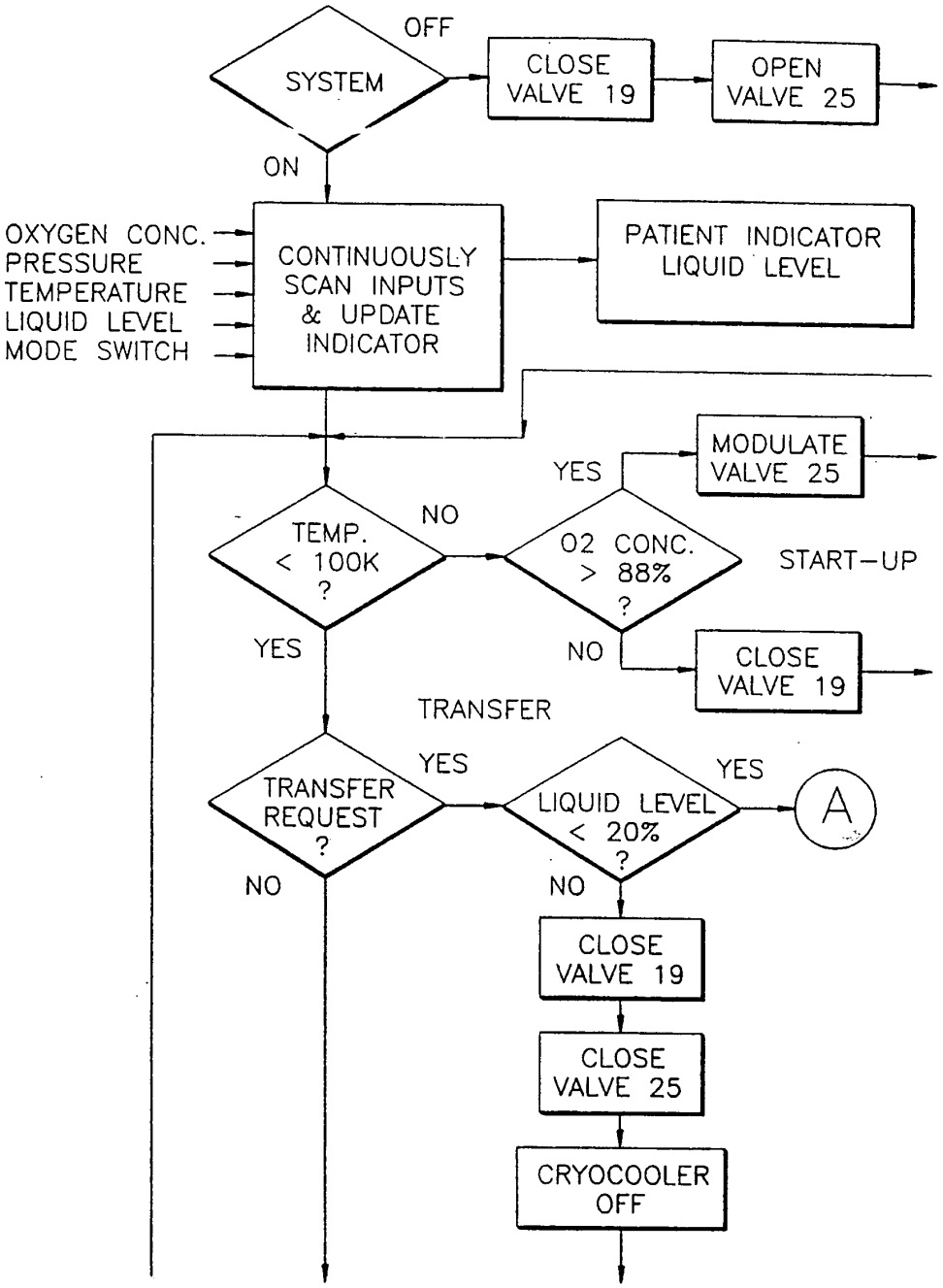
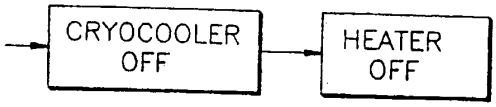
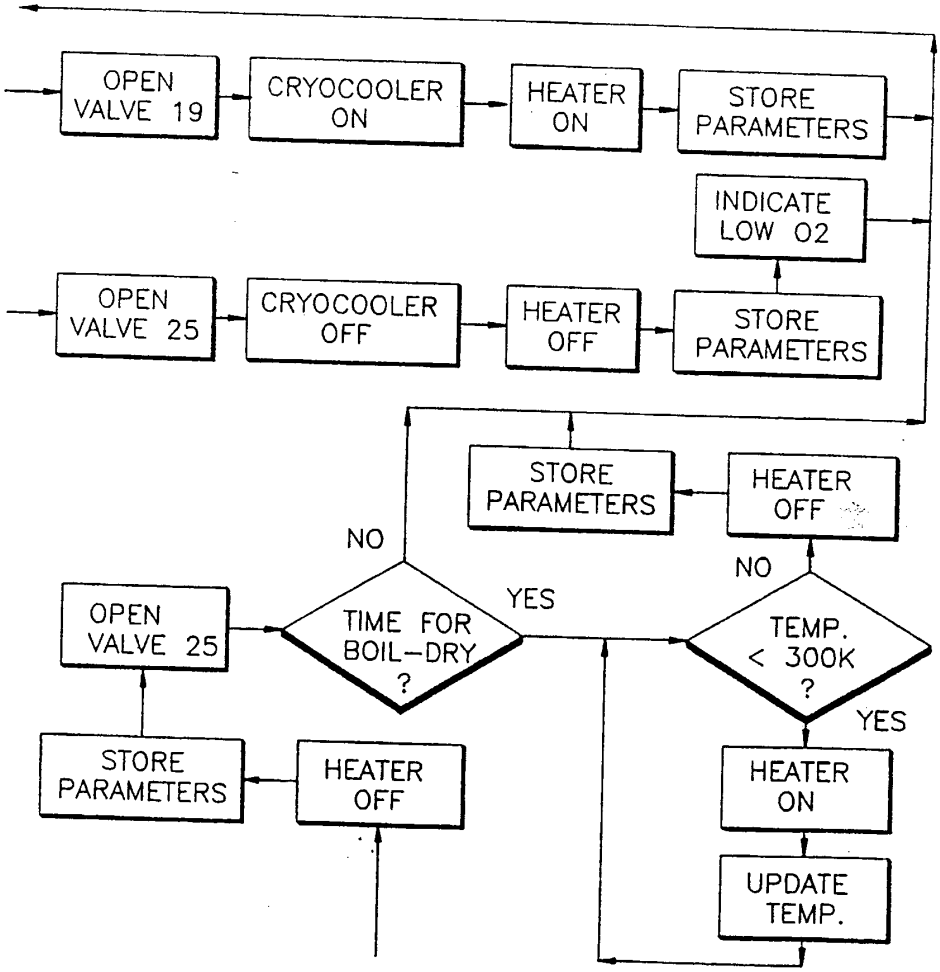

SYSTEM
OFF
CLOSE VALVE 19
OPEN VALVE 25
ON
OXYGEN CONC.
PRESSURE
TEMPERATURE
LIQUID LEVEL
MODE SWITCH
CONTINUOUSLY SCAN INPUTS & UPDATE INDICATOR
PATIENT INDICATOR LIQUID LEVEL
MODULATE VALVE 25
YES
TEMP. < 100K ?
NO
O2 CONC. > 88% ?
START-UP
YES
NO
CLOSE VALVE 19
TRANSFER
TRANSFER REQUEST ?
YES
LIQUID LEVEL < 20% ?
YES
A
NO
NO
CLOSE VALVE 19
CLOSE VALVE 25
CRYOCOOLER OFF

Fig. 7 B


CRYOCOOLER OFF
HEATER OFF


OPEN VALVE 19
CRYOCOOLER ON
HEATER ON
STORE PARAMETERS
INDICATE LOW O2
OPEN VALVE 25
CRYOCOOLER OFF
HEATER OFF
STORE PARAMETERS
STORE PARAMETERS
HEATER OFF
NO
NO
OPEN VALVE 25
TIME FOR BOIL-DRY ?
YES
TEMP. < 300K ?
YES
STORE PARAMETERS
HEATER OFF
HEATER ON
UPDATE TEMP.

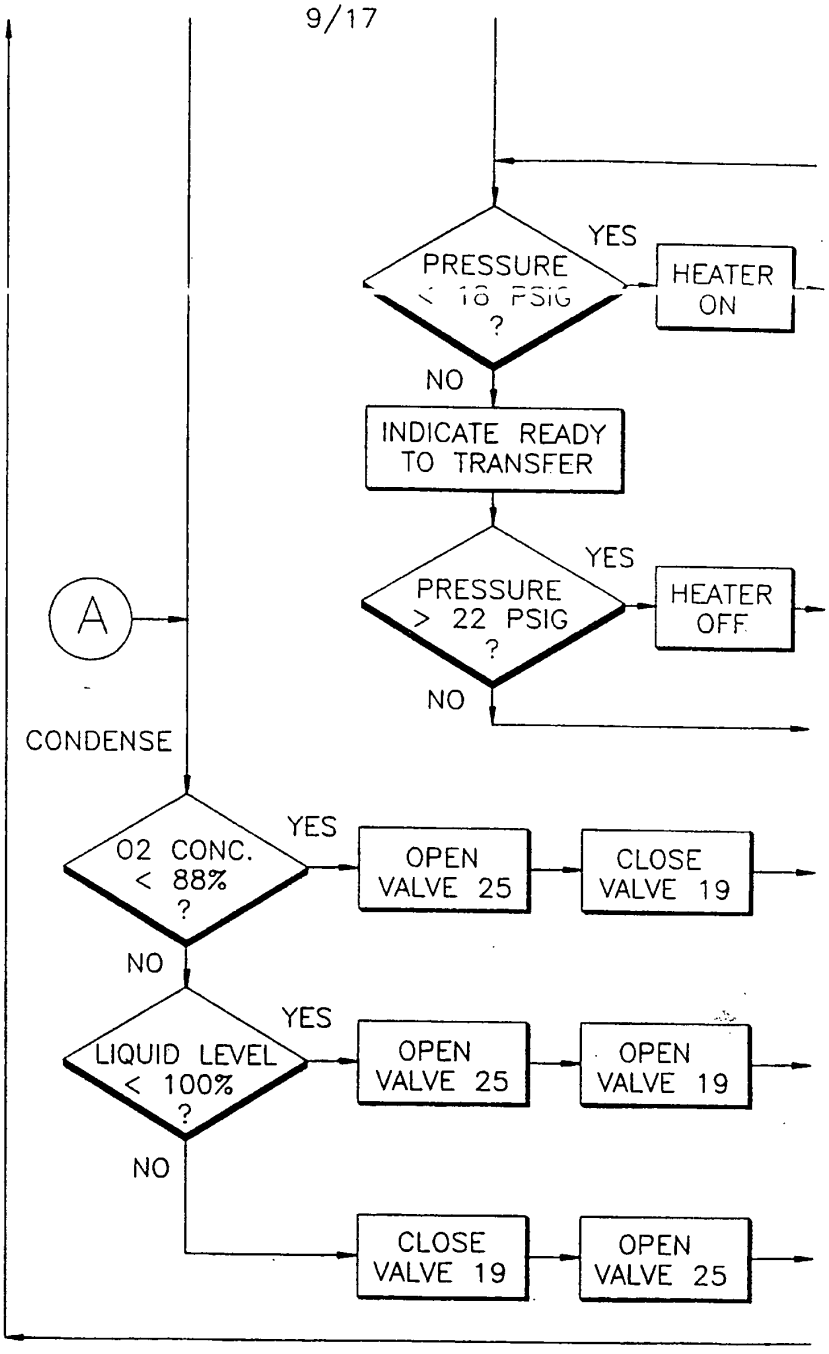

PRESSURE < 18 PSIG ?
YES
HEATER ON
NO
INDICATE READY TO TRANSFER
PRESSURE > 22 PSIG ?
YES
HEATER OFF
NO
A
CONDENSE
O2 CONC. < 88% ?
YES
OPEN VALVE 25
CLOSE VALVE 19
NO
LIQUID LEVEL < 100% ?
YES
OPEN VALVE 25
OPEN VALVE 19
NO
CLOSE VALVE 19
OPEN VALVE 25

Fig. 7C

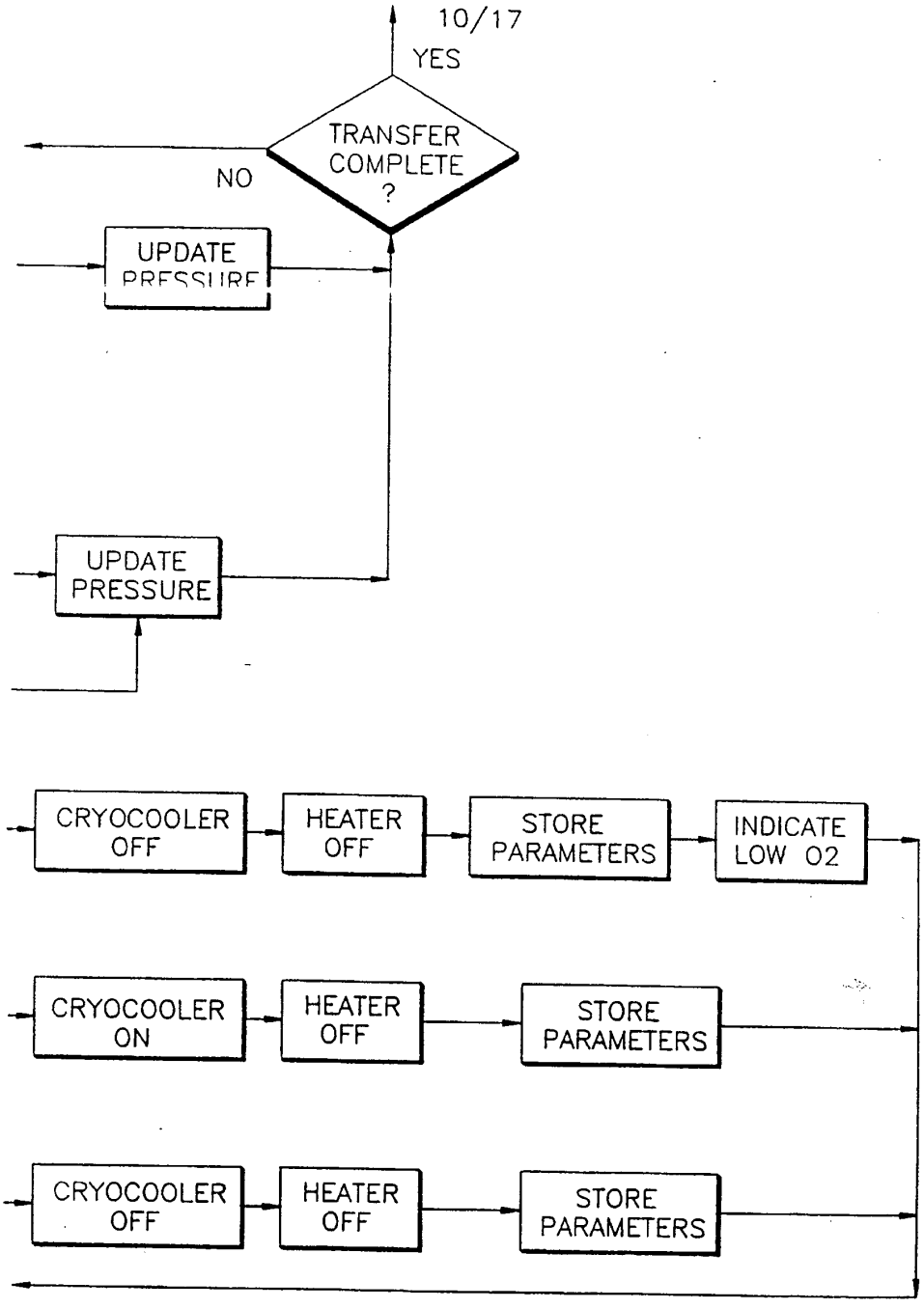

10/17
YES
TRANSFER COMPLETE ?
NO
UPDATE PRESSURE
UPDATE PRESSURE
CRYOCOOLER OFF
HEATER OFF
STORE PARAMETERS
INDICATE LOW O2
CRYOCOOLER ON
HEATER OFF
STORE PARAMETERS
CRYOCOOLER OFF
HEATER OFF
STORE PARAMETERS

Fig. 7D

Fig. 8

START–UP MODE

INPUT LEVELS & OUTPUT STATES

INPUT	LEVEL	OUTPUT	STATE
OXYGEN SENSOR	>88%	VALVE 19	OPEN
LIQUID LEVEL SENSOR	0%	VALVE 25	OPEN/CLOSED *
		HEATER	OFF
		CRYOCOOLER	ON
		INDICATOR	COOLDOWN

* MODULATED TO CONTROL PRESSURE

Fig. 9

CONDENSE MODE

INPUT LEVELS & OUTPUT STATES

INPUT	LEVEL	OUTPUT	STATE
OXYGEN SENSOR	>88%	VALVE 19	OPEN
LIQUID LEVEL SENSOR	<100%	VALVE 25	OPEN
		HEATER	OFF
		CRYOCOOLER	ON
		INDICATOR	CONDENSE
OXYGEN SENSOR	≤88%	VALVE 19	CLOSED
LIQUID LEVEL SENSOR	<100%	VALVE 25	OPEN
		HEATER	OFF
		CRYOCOOLER	OFF
		INDICATOR	O_2 LOW
OXYGEN SENSOR	>88%	VALVE 19	CLOSED
LIQUID LEVEL SENSOR	≥100%	VALVE 25	OPEN
		HEATER	OFF
		CRYOCOOLER	OFF
		INDICATOR	FULL

Fig. 10

TRANSFER MODE

INPUT LEVELS & OUTPUT STATES

INPUT	LEVEL	OUTPUT	STATE
OXYGEN SENSOR	20–95%	VALVE 19	CLOSED
LIQUID LEVEL SENSOR	<20%	VALVE 25	OPEN
		HEATER	OFF
		CRYOCOOLER	OFF
		INDICATOR	LIQ. LOW
OXYGEN SENSOR	20–95%	VALVE 19	CLOSED
LIQUID LEVEL SENSOR	≥20%	VALVE 25	CLOSED
PRESSURE SENSOR	<18 PSIG	HEATER	ON
		CRYOCOOLER	OFF
		INDICATOR	WAIT
OXYGEN SENSOR	20–95%	VALVE 19	CLOSED
LIQUID LEVEL SENSOR	≥20%	VALVE 25	CLOSED
PRESSURE SENSOR	>18 PSIG	HEATER	ON
		CRYOCOOLER	OFF
		INDICATOR	TRANSFER
OXYGEN SENSOR	20–95%	VALVE 19	CLOSED
LIQUID LEVEL SENSOR	≥20%	VALVE 25	CLOSED
PRESSURE SENSOR	>22 PSIG	HEATER	OFF
		CRYOCOOLER	OFF
		INDICATOR	TRANSFER

Fig. 11

BOIL–DRY MODE

INPUT LEVELS & OUTPUT STATES

INPUT	LEVEL	OUTPUT	STATE
OXYGEN SENSOR	20–95%	VALVE 19	CLOSED
LIQUID LEVEL SENSOR	<100%	VALVE 25	OPEN
TEMPERATURE SENSOR	<300K	HEATER	ON
		CRYOCOOLER	OFF
		INDICATOR	BOIL–DRY
OXYGEN SENSOR	20–95%	VALVE 19	CLOSED
LIQUID LEVEL SENSOR	0–100%	VALVE 25	OPEN
TEMPERATURE SENSOR	≥300K	HEATER	OFF
		CRYOCOOLER	OFF
		INDICATOR	WARM

DOUBLE INLET PULSE TUBE REFRIGERATOR

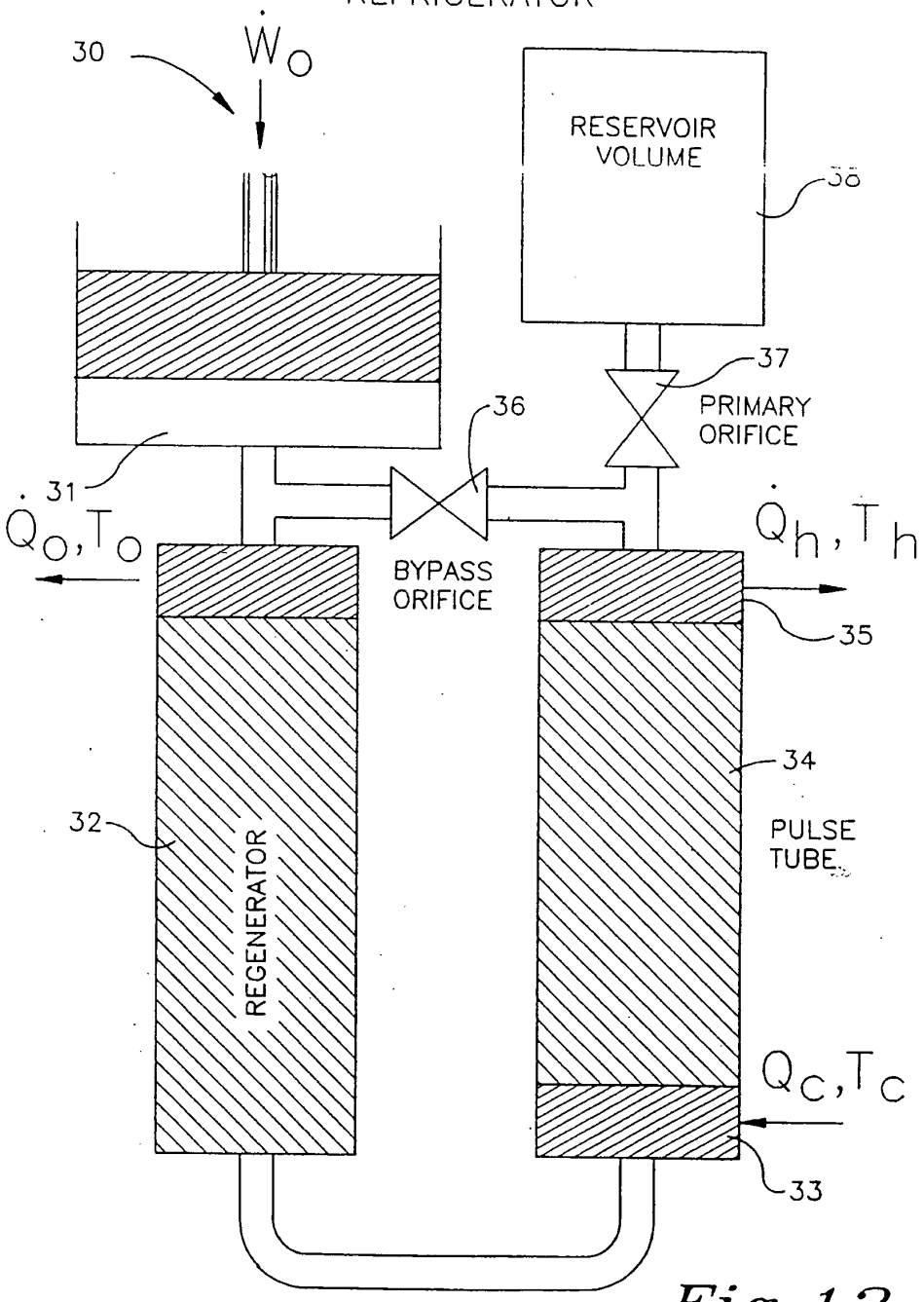


Fig. 12

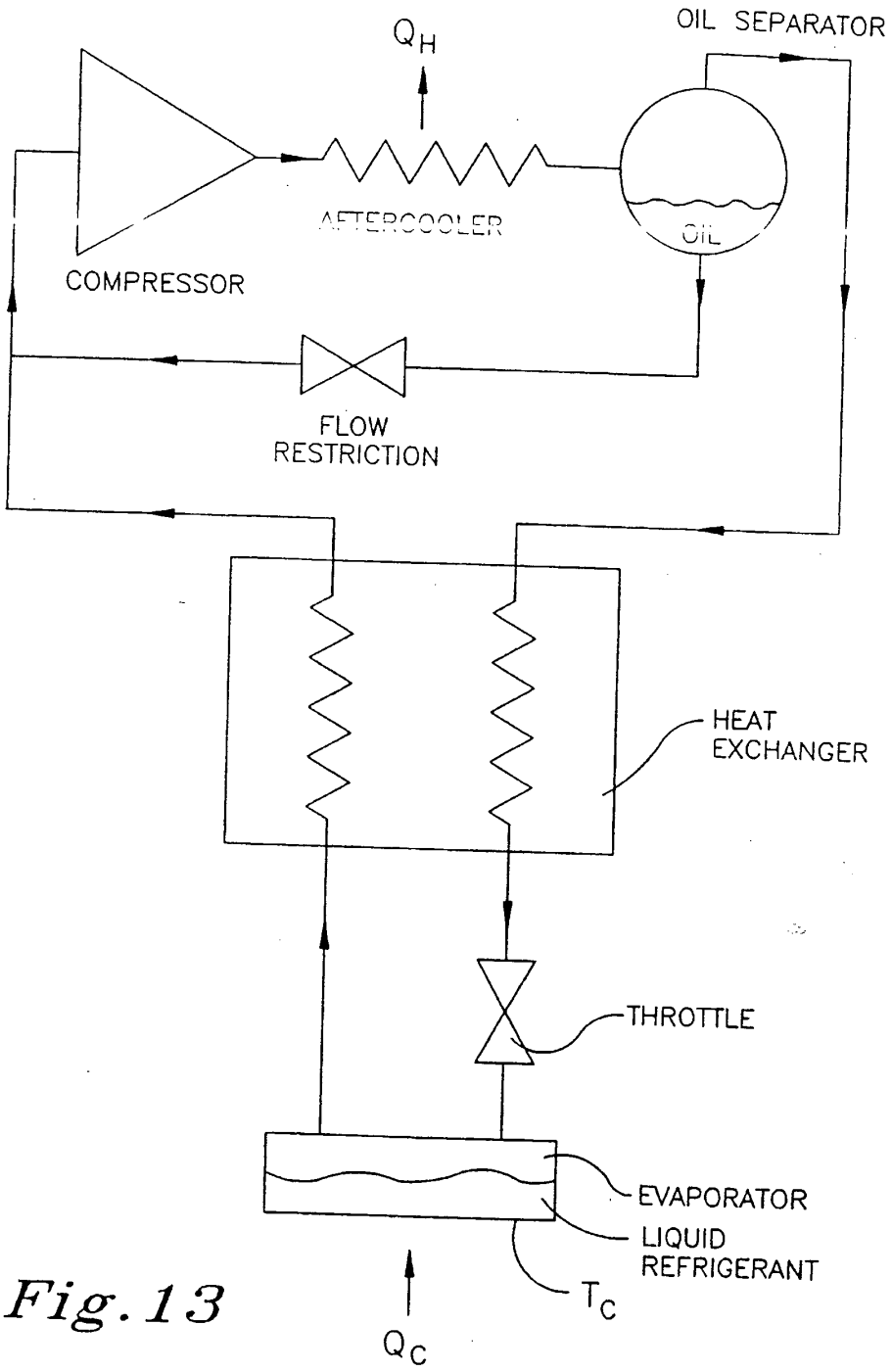
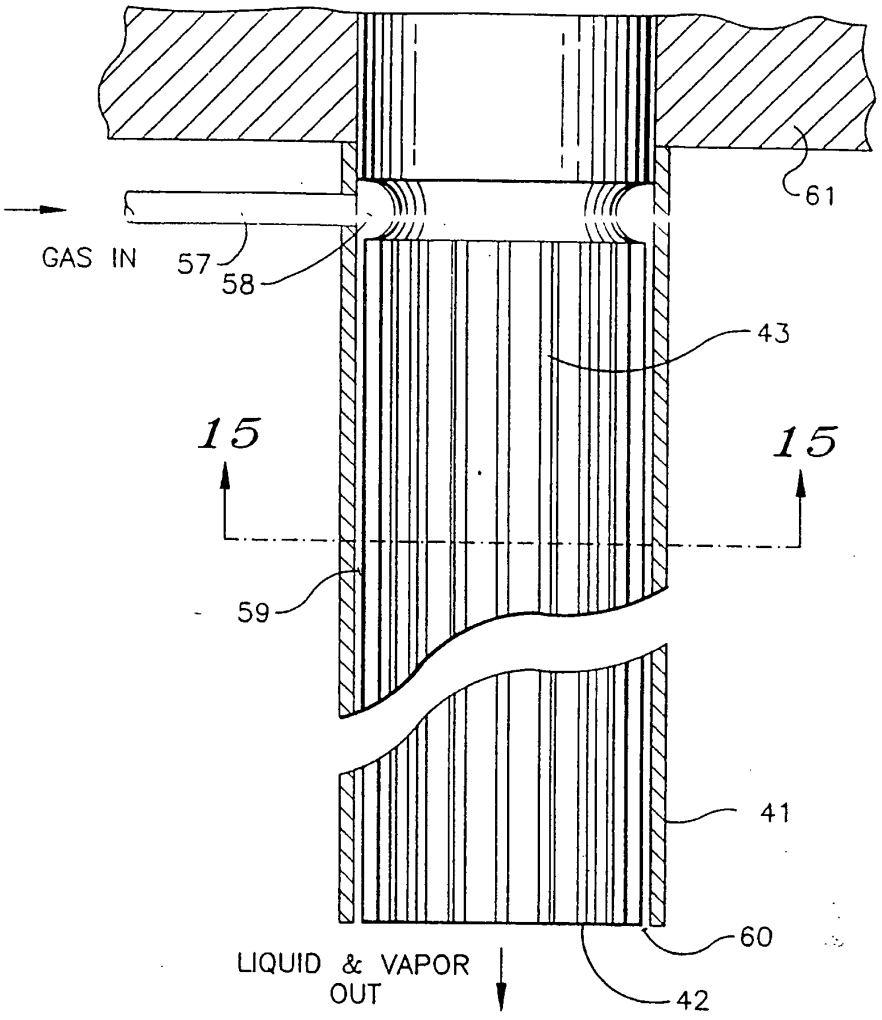

Q_H
OIL SEPARATOR
AFTERCOOLER
OIL
COMPRESSOR
FLOW
RESTRICTION
HEAT
EXCHANGER
THROTTLE
EVAPORATOR
LIQUID
REFRIGERANT
T_C
Q_C

Fig. 13

Fig. 14



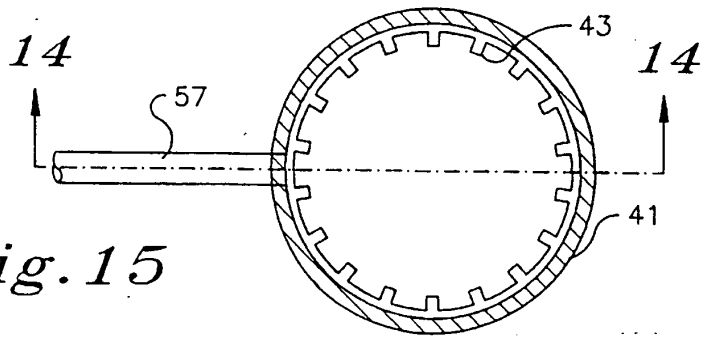


Fig. 15

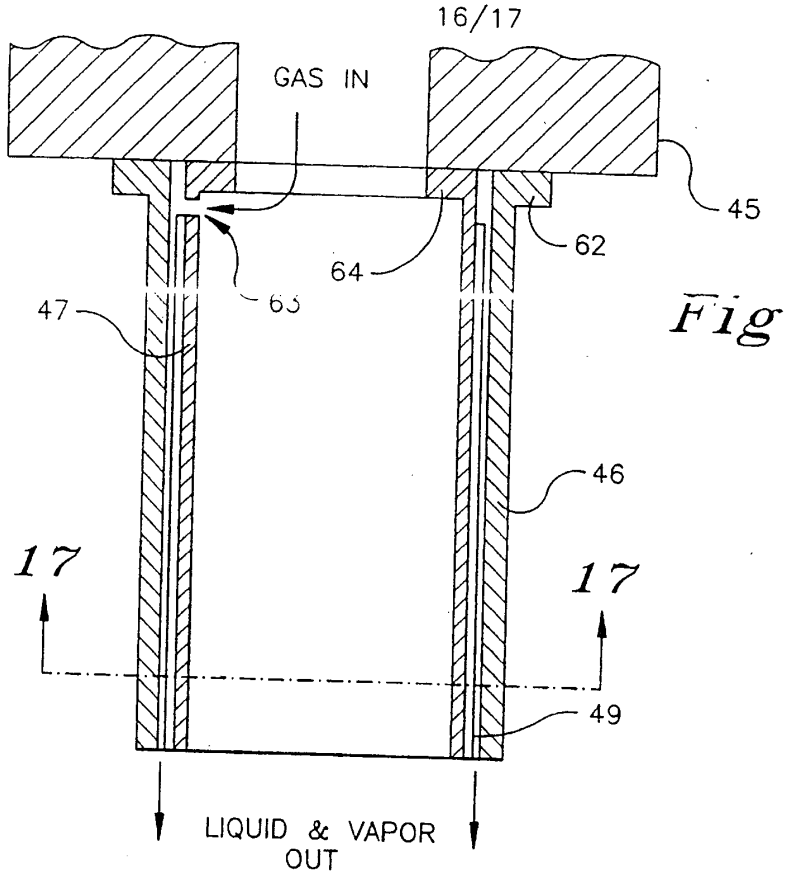

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LIQUID & VAPOR
OUT

Fig. 16

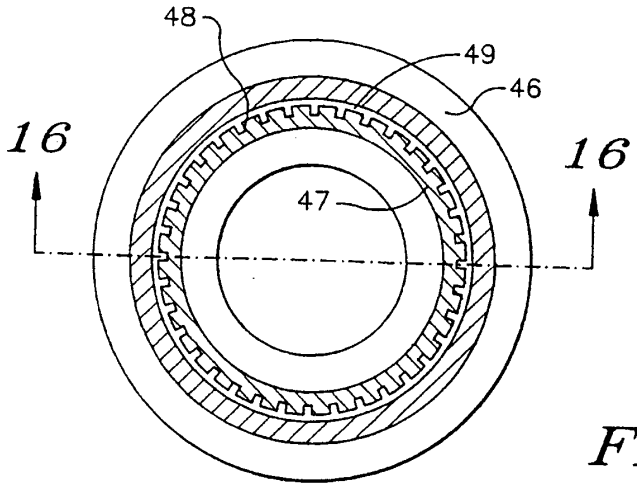

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Fig. 17

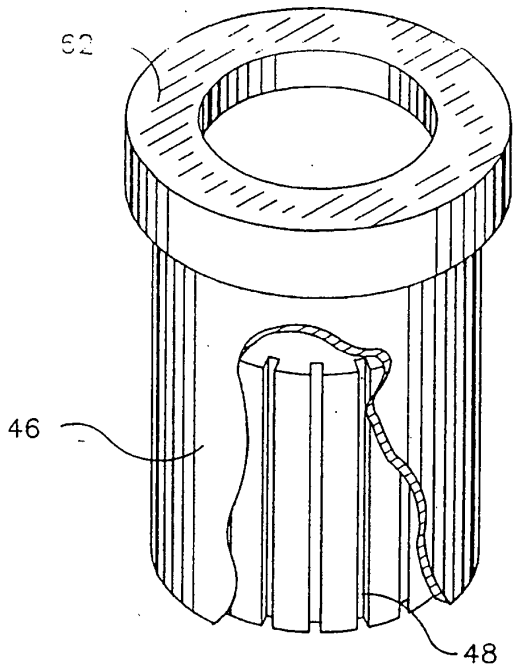


Fig. 18

INTERNATIONAL SEARCH REPORT

Inter nal Application No
PCT/US 98/11154

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 F25J3/06 B01D8/00 B01D5/00 F28D7/10 F25J3/00

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
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Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 870 960 A (HRADEK RICHARD W) 3 October 1989 ---	1-48, 56-61, 73,74
A	US 4 627 860 A (ROWLAND ROBERT O) 9 December 1986 ---	1-48, 56-61, 73,74
A	GB 1 416 163 A (BOC INTERNATIONAL LTD) 3 December 1975 ---	49-53, 62-72,75
A	US 5 584 194 A (GARDNER THOMAS W) 17 December 1996 ---	49-53, 62-72,75
A	US 5 163 297 A (YANI MASAYOSHI ET AL) 17 November 1992 --- -/--	54,55

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

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

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
17 September 1998	25/09/1998

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Meertens, J

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INTERNATIONAL SEARCH REPORT

Intern. al Application No
PCT/US 98/11154

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 211 086 A (HULSTYN JAN ET AL) 8 July 1980 ---	
A	US 4 971 609 A (PAWLOS ROBERT A) 20 November 1990 cited in the application ---	
A	US 4 826 510 A (MCCOMBS NORMAN R) 2 May 1989 cited in the application -----	

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INTERNATIONAL SEARCH REPORT

Information on patent family members

Intern al Application No
PCT/US 98/11154

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		JP 1183402 A	21-07-1989

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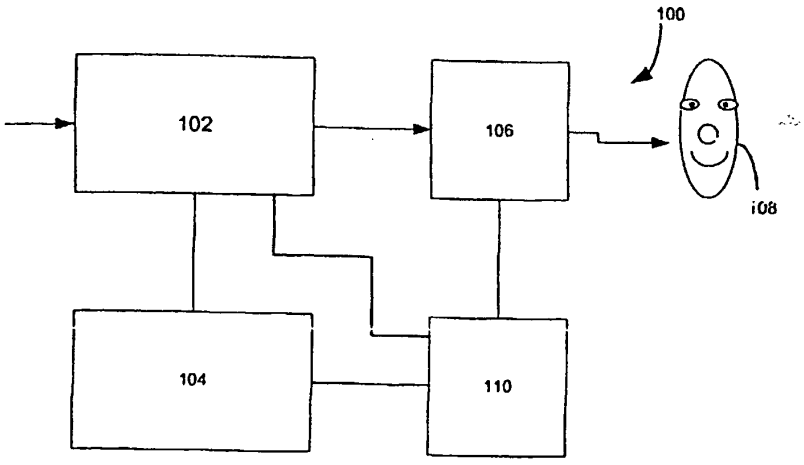
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(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*
— *with amended claims and statement*

[Continued on next page]

(54) Title: PORTABLE OXYGEN CONCENTRATION SYSTEM



(57) Abstract: A portable oxygen concentrator system (100) adapted to be readily transported by a user includes a rechargeable energy source (104) and a concentrator (114) powered by the energy source (104). The concentrator (114) converts ambient air into concentrated oxygen gas for the user and includes a plurality of adsorption beds (300) and a rotary valve assembly (310). The rotary valve assembly (310) is relatively rotatable with respect to the plurality of adsorption beds (300) to provide valving action for selectively transferring fluids through the plurality of absorption beds (300) for converting ambient air into concentrated oxygen gas for the user. The ratio of adiabatic power to oxygen flow for the concentrator (114) is in the range of 6.2 W/LPM to 23.0 W/LPM.

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

DESCRIPTION

PORTABLE OXYGEN CONCENTRATION SYSTEM

Background of the Invention

[0001] The field of this invention relates, in general, to oxygen concentrators and, in particular, to portable oxygen concentration systems for ambulatory respiratory patients that allow them to lead normal and productive lives.

[0002] There is a burgeoning need for home and ambulatory oxygen. Supplemental oxygen is necessary for patients suffering from lung disorders; for example, pulmonary fibrosis, sarcoidosis, or occupational lung disease. For such patients, oxygen therapy is an increasingly beneficial, life-giving development. While not a cure for lung disease, supplemental oxygen increases blood oxygenation, which reverses hypoxemia. This therapy prevents long-term effects of oxygen deficiency on organ systems -- in particular, the heart, brain and kidneys.

[0003] Oxygen treatment is also prescribed for Chronic Obstructive Pulmonary Disease (COPD), which afflicts about six-hundred million people in the U.S., and for other ailments that weaken the respiratory system, such as heart disease and AIDS. Supplemental oxygen therapy is also prescribed for asthma and emphysema.

[0004] The normal prescription for COPD patients requires supplemental oxygen flow via nasal cannula or mask twenty four hours per day. The average patient prescription is two liters per minute of high concentration oxygen to increase the oxygen level of the total air inspired by the patient from the normal 21% to about 40%. While the average oxygen flow requirement is two liters per minute, the average oxygen concentrator has a capacity of four to six liters of oxygen per minute. This extra capacity is occasionally necessary for certain patients who have developed more severe problems, are not generally able to leave the home (as ambulatory patients) and do not require a portable oxygen supply.

[0005] There are currently three modalities for supplemental medical oxygen: high pressure gas cylinders, cryogenic liquid in vacuum insulated containers or thermos bottles commonly called "dewars," and oxygen concentrators. Some patients require in-home oxygen only while others require in-home as well as ambulatory oxygen depending on their prescription. All three modalities are used for in-home use, although oxygen concentrators are preferred because they do not require dewar refilling or exchange

of empty cylinders with full ones. Home oxygen concentrators, however, do have their drawbacks. They consume relatively large amounts of electricity (350-400 Watts), are relatively large (about the size of a night stand), are relatively heavy (weight about 50 lbs.), emit quite a bit of heat, and are relatively noisy.

[0006] Only small high pressure gas bottles and small liquid dewars are truly portable enough to be used for ambulatory needs (outside the home). Either modality may be used for both in-home and ambulatory use or may be combined with an oxygen concentrator which would provide in-home use.

[0007] As described below, the current oxygen-supplying methods and devices have proven cumbersome and unwieldy and there has been a long-felt need for an improved portable device for supplying oxygen to the user.

[0008] For people who need to have oxygen and operate away from an oxygen-generating or oxygen-storage source such as a stationary oxygen system (or even a portable system which cannot be readily transported), the two most prescribed options generally available to patients are: (a) to carry with them small cylinders typically in a wheeled stroller; and (b) to carry portable containers typically on a shoulder sling. Both these gaseous oxygen and liquid oxygen options have substantial drawbacks, but from a medical view, both have the ability to increase the productive life of a patient.

[0009] The major drawback of the gaseous oxygen option is that the small cylinders of gaseous oxygen can only provide gas for a short duration. Another drawback is that a patient's high-pressure gaseous oxygen cylinders are not allowed in some locations such as airplanes because of safety considerations. A further drawback of the gaseous oxygen option is the refill requirement for oxygen once the oxygen has been depleted from the cylinder. These small gas cylinders must be picked up and refilled by the home care provider at a specialized facility. This requires regular visits to a patient's home by a provider and a substantial investment in small cylinders by the provider because so many are left at the patient's home and refilling facility. Although it is technically possible to refill these cylinders in the patient's home using a commercial oxygen concentrator that extracts oxygen from the air, this task would typically require an on-site oxygen compressor to boost the output pressure of the concentrator to a high level in order to fill the cylinders. Some disadvantages of common on-site oxygen compressors are that they are expensive, loud and emit a lot of heat. Additionally, attempting to

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compress the oxygen in pressurized canisters in the home is potentially dangerous, especially for untrained people.

[0010] This approach of course presents several safety concerns for in-home use. For example, in order to put enough of this gas in a portable container, it must typically be compressed to high pressure (~2000 psi) Compressing oxygen from 5 psi (the typical output of an oxygen concentrator) to 2000 psi will produce a large amount of heat. (Enough to raise the temperature 165 degrees C per stage based on three adiabatic compression stages with intercooling.) This heat, combined with the oxygen which becomes more reactive at higher pressures, sets up a potential combustion hazard in the compressor in the patient's home. Thus, operation of a high-pressure gas system in the patient's home is dangerous and not a practical solution.

[0011] The convenience and safety issues are not the only drawbacks of this compressed oxygen approach. Another drawback is that the compressors or pressure boosters needed are costly because they require special care and materials needed for high pressure oxygen compatibility.

[0012] Turning now to the liquid oxygen storage option, its main drawback is that it requires a base reservoir -- a stationary reservoir base unit within the patient's home about the size of a standard beer keg -- which may be refilled about once a week from an outside source. Liquid oxygen can then be transferred from the patient's base unit to a portable dewar, which can be used by the ambulatory patient. Also, with the liquid oxygen option, there is substantial waste, as a certain amount of oxygen is lost during the transfer to the portable containers and from evaporation. It is estimated that 20% of the entire contents of the base cylinder will be lost in the course of two weeks because of losses in transfer and normal evaporation. These units will typically boil dry over a period of 30 to 60 days even if no oxygen is withdrawn.

[0013] Home refilling systems that produce liquid oxygen and have the capability of refilling portable liquid oxygen dewars have been proposed. However, these devices require the user to perform the task of refilling bottles and add tens of dollars per month to the user's electric bill, which is not reimbursable.

[0014] There are other complications with these portable high-pressure cylinders and liquid dewars. Typically, supplemental oxygen is supplied to the patient by a home care provider, in exchange for which the provider receives a fixed monetary payment from

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insurance companies or Medicare regardless of the modality. Oxygen concentrators are preferred by the provider as the least expensive option for supplying the patient's at-home needs. For outside the home use, however, only small high-pressure gas bottles and small liquid dewars are portable enough to be used for ambulatory needs. Either one of these two modalities may be used for both in-home and ambulatory use or may be combined with an oxygen concentrator, which would provide in-home use. In either case, the home care provider must make costly weekly or biweekly trips to the patient's home to replenish the oxygen. One of the objects of this invention is to eliminate these costly milk runs."

[0015] So-called "portable" oxygen concentrators are commercially available for providing patients with gaseous oxygen by converting ambient air into concentrated gaseous oxygen. However, these devices are only "portable" in the sense that they are capable of being transported to another point of use via an automobile or an airplane. One of these devices is packaged in a suitcase and is billed as a transportable machine rather than a truly portable oxygen concentrator. The device weighs about 37 lbs. without battery and requires 135 Watts of power at a 2 LPM (liters per minute) oxygen flow rate. Operation from an automobile battery is possible when in route in a car, but operation from a separate battery is impractical. Another device is a 3 LPM concentrator mounted on its own cart. It weighs 22 lbs. without battery and also requires about 135 Watts of power. A further device weighs about 28 lbs. without battery and has a similar flow rate and power requirements to the above devices. Even without a battery, these devices are too heavy for the average ambulatory respiratory patient. With the weight of a battery, these prior art devices are not "portable" in the true sense of the word because they can not be readily transported from one point to another. Because these devices have relatively large power consumption requirements, they also require a sizable battery.

[0016] Further, in addition to the weight and power consumption problems with the above oxygen concentrators, none of these prior art concentrators are particularly quiet. They produce noise levels similar to those produced by a home concentrator. In fact, one of these devices specifie's noise production at 60 dBA (decibels), about twice the noise of a home concentrator. Consequently, none of these so-called "portable" oxygen concentrators are suitable for use in environments where low noise is especially important, e.g., restaurants, libraries, churches and theatres.

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[0017] Thus, a long-felt need exists for a truly "portable" oxygen concentration system that eliminates the need for high-pressure gas cylinders and liquid dewars, the constant refilling/replacing requirements associated with high-pressure gas cylinders and liquid dewars, and the need for a separate home oxygen concentration system for ambulatory respiratory patients. A truly "portable" oxygen concentration system would be light enough so that, even with a battery, an average ambulatory respiratory patient could carry the device. Inherently the device would have to be designed to have relatively low power consumption requirements so that a light-weight battery pack or other energy source could be used. Further, the device should be small enough so that it can be conveniently carried by the user, emit a relatively low amount of noise and should only emit a small amount of heat.

Summary of Invention

[0018] An aspect of the present invention involves a portable oxygen concentrator system adapted to be readily transported by a user. The portable oxygen concentrator system includes a rechargeable energy source and a concentrator powered by the energy source. The concentrator converts ambient air into concentrated oxygen gas for the user and includes a plurality of adsorption beds and a rotary valve assembly. The rotary valve assembly is relatively rotatable with respect to the plurality of adsorption beds to provide valving action for selectively transferring fluids through the plurality of adsorption beds for converting ambient air into concentrated oxygen gas for the user. The ratio of adiabatic power to oxygen flow for the concentrator is in the range of 6.2 W/LPM to 23.0 W/LPM.

[0019] Another aspect of the invention involves a rotary valve assembly for a pressure swing adsorption system having a plurality of adsorption beds. The rotary valve assembly includes a valve port plate and a rotary valve shoe having respective engaged surfaces and are relatively rotatable about a common center of rotation to provide valving action for selectively transferring fluids therethrough. The valve port plate includes at least two ports interconnected with at least two adsorption beds. The rotary valve shoe includes a second valve surface opposite the engaged surface with at least one equalization passage to register with the at least two ports of the port plate to equalize pressure between the at least two adsorption beds.

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[0020] Other and further objects, features, aspects, and advantages of the present inventions will become better understood with the following detailed description of the accompanying drawings.

Brief Description of the Drawings

[0021] Figure 1 is a block diagram of a portable oxygen concentration system constructed in accordance with an embodiment of the invention;

[0022] Figure 2 is a block diagram of a portable oxygen concentration system constructed in accordance with another embodiment of the invention, and illustrates, in particular, an embodiment of an air separation device;

[0023] Figure 3A is a perspective, cut-away view of an embodiment of a concentrator that may be used with the portable oxygen concentration system.

[0024] Figure 3B is a perspective, exploded view of the concentrator illustrated in Figure 3A.

[0025] Figure 4 is a top perspective view of an embodiment of a top manifold and multiple adsorption beds that may be used with the concentrator illustrated in Figures 3A and 3B.

[0026] Figures 5A and 5B are a bottom plan view and a top plan view respectively of an embodiment of a rotary valve shoe that may be used with the concentrator illustrated in Figures 3A and 3B.

[0027] Figure 6A is a top plan view of an embodiment of a valve port plate that may be used with the concentrator illustrated in Figures 3A and 3B.

[0028] Figure 6B is a flow chart of an exemplary process cycle for the concentraotor illustrated in Figures 3A and 3B.

[0029] Figures 7A and 7B are a top plan view and a bottom plan view respectively of an embodiment of a media retention cap that may be used with the concentrator illustrated in Figures 3A and 3B.

[0030] Figures 8A and 8B are a top perspective, exploded view and a bottom perspective, exploded view respectively of an embodiment of a rotary valve assembly including a centering pin that may be used with the concentrator illustrated in Figures 3A and 3B.

[0031] Figures 9A and 9B are a bottom perspective, exploded view and a top perspective, exploded view respectively of an embodiment of a rotary valve assembly

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including a centering ring that may be used with the concentrator illustrated in Figures 3A and 3B.

[0032] Figure 10A is a bottom perspective view of an embodiment of a rotary valve shoe, a motor drive, and a pair of elastic chain links that may be used with the concentrator illustrated in Figures 3A and 3B.

[0033] Figures 10B and 10C are a top perspective, exploded view and a bottom perspective, exploded view respectively of the rotary valve shoe, motor drive, and pair of elastic chain links illustrated in Figure 10A.

[0034] Figure 11 is a table of experimental data for a portable oxygen concentration system including the concentrator illustrated in Figures 3A and 3B.

[0035] Figure 12 is a schematic illustration of a further embodiment of the portable oxygen concentration system and an embodiment of a cradle for use with the portable oxygen concentration system;

[0036] Figure 13 is a block diagram of the one or more sensors that may be used with an embodiment of the portable oxygen concentration system;

[0037] Figure 14 is a block diagram of the one or more components that may be controlled by the control unit of the portable oxygen concentration system;

[0038] Figure 15 is a block diagram of a portable oxygen concentration system constructed in accordance with additional embodiment of the invention; and

[0039] Figure 16 is a schematic illustration of another embodiment of a portable oxygen concentration system including a high-pressure reservoir.

Detailed Description of the Preferred Embodiment

I. Portable Oxygen Concentration System

[0040] With reference to Figure 1, a portable oxygen concentration system, indicated generally by the reference numeral 100, constructed in accordance with an embodiment of the invention will now be described. The oxygen concentration system 100 includes an air separation device such as an oxygen gas generator 102 that separates concentrated oxygen gas from ambient air, an energy source such as rechargeable battery, battery pack, or fuel cell 104 that powers at least a portion of the oxygen gas generator 102, one or more output sensors 106 used to sense one or more conditions of the user 108, environment, etc. to determine the oxygen output needed by the user or required from the system 100, and a control unit 110 linked to the output sensor 106, the air separation

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device 102, and the energy source 104 to control the operation of the air separation device 102 in response to the one or more conditions sensed by the one or more output sensors 106.

[0041] In an alternative embodiment, the system 100 may not include the one or more output sensors 106 coupled to the control unit 110. In this embodiment, conditions of the system 100 such as flow rate, oxygen concentration level, etc. may be constant for the system or may be manually controllable. For example, the system 100 may include a user interface 111 (Figure 14) that allows the user, provider, doctor, etc. to enter information, e.g., prescription oxygen level, flow rate, etc. to control the oxygen output of the system 100.

[0042] Each element of the system 100 will now be described in more detail.

A. Air Separation Device

[0043] With reference to Figure 2, the air separation device is preferably an oxygen generator 102 generally including a pump such as a compressor 112 and an oxygen concentrator 114 (OC), which may be integrated.

[0044] The oxygen generator 102 may also include one or more of the elements described below and shown within the segmented boundary line in Figure 2. Ambient air may be drawn through an inlet muffler 116 by the compressor 112. The compressor 112 may be driven by one or more DC motors 118 (M) that run off of DC electrical current supplied by the rechargeable battery 104 (RB). The motor 118 also preferably drives the cooling fan part of the heat exchanger 120. A variable-speed controller (VSC) or compressor motor speed controller 119, which is described in more detail below, may be integral with or separate from the control unit 110 (CU) and is preferably coupled to the motor 118 for conserving electricity consumption. The compressor 112 delivers the air under pressure to the concentrator 114.

[0045] In a preferred embodiment, at a maximum speed air is delivered to the concentrator 114 at 7.3 psig nominal and may range from 5.3 to 12.1 psig. At maximum speed, the flow rate of feed is a minimum of 23.8 SLPM at inlet conditions of 14.696 psi absolute, 70 degrees F, 50% relative humidity.

[0046] A heat exchanger 120 may be located between the compressor 112 and the concentrator 114 to cool or heat the air to a desired temperature before entering the concentrator 114, a filter (not shown) may be located between the compressor 112 and the

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concentrator 114 to remove any impurities from the supply air, and a pressure transducer 122 may be located between the compressor 112 and the, concentrator 114 to get a pressure reading of the air flow entering the concentrator 114.

[0047] The concentrator 114 separates oxygen gas from air for eventual delivery to the user 108 in a well-known manner. One or more of the following components may be located in a supply line 121 between the concentrator 114 and the user 108: a pressure sensor 123, a temperature sensor 125, a pump 127, a low-pressure reservoir 129, a supply valve 160, a flow and purity sensor 131, and a conservation device 190. As used herein, supply line 121 refers to the tubing, connectors, etc. used to connect the components in the line. The pump 127 may be driven by the motor 118. The oxygen (gas may be stored in the low-pressure reservoir 129 and delivered therefrom via the supply line 121 to the user 108. The supply valve 160 may be used to control the delivery of oxygen gas from the low-pressure reservoir 129 to the user 108 at atmospheric pressure.

[0048] Exhaust gas may also be dispelled from the concentrator 114. In a preferred embodiment of the invention, a vacuum generator 124 (V), which may also be driven by the motor 118 and integrated with the compressor 112, draws exhaust gas from the concentrator 114 to improve the recovery and productivity of the concentrator 114. The exhaust gas may exit the system 100 through an exhaust muffler 126. A pressure transducer 128 may be located between the concentrator 114 and the vacuum generator 124 to get a pressure reading of the exhaust flow from the concentrator 114. At maximum rated speed and a flow rate of 20.8 SLPM, the pressure at the vacuum side is preferably -5.9 psig nominal and may range from -8.8 to -4.4 psig.

1. Compressor/Variable Speed Controller

[0049] Example of compressor technologies that may be used for the compressor 112 include, but not by way of limitation, rotary vane, linear piston with wrist pin, linear piston without wrist pin, nutating disc, scroll, rolling piston, diaphragm pumps, and acoustic. Preferably the compressor 112 and vacuum generator 124 are integrated with the motor 118 and are oil-less, preventing the possibility of oil or grease from entering the air flow path.

[0050] The compressor 112 preferably includes, at a minimum, a 3:1 speed ratio, with a low speed of at least 1,000 rpm and a 15,000 hour operating life when run at full speed. Operating temperature surrounding the compressor/motor system is preferably

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32 to 122 degrees F. Storage temperature is preferably -4 to 140 degree F. Relative humidity is preferably 5 to 95% RH noncondensing. Voltage for the compressor 112 is preferably 12 V DC or 24V DC and the electrical power requirements are preferably less than 100 W at full speed and rated flow/nominal pressure and less than 40 W at 1/3 speed and 1/3 flow at rated pressure. A shaft mounted fan or blower may be incorporated with the compressor 112 for compressor cooling and possible complete system cooling. Preferably, the maximum sound pressure level of the compressor 112 may be 46 dBA at a maximum rated speed and flow/pressure and 36 dBA at 1/3 rated speed. Preferably the compressor 112 weighs less than 3.5 pounds.

[0051] It is desirable for the compressor 112 to run at a variety of speeds; provide the required vacuum/pressure levels and flow rates, emit little noise and vibration, emit little heat, be small, not be heavy, and consume little power.

[0052] The variable-speed controller 119 is important for reducing the power consumption requirements of the compressor 112 on the rechargeable battery 104 or other energy source. With a variable-speed controller, the speed of the compressor 112 may be varied with the activity level of the user, metabolic condition of the user, environmental condition, or other condition indicative of the oxygen needs of the user as determined through the one or more output sensors 106.

[0053] For example, the variable-speed controller may decrease the speed of the motor 118 when it is determined that the oxygen requirements of the user 108 are relatively low, e.g., when the user is sitting, sleeping, at lower elevations, etc., and increased when it is determined that the oxygen requirements of the user 108 are relatively high or higher, e.g., when the user stands, when the user is active, when the user is at higher elevations, etc. This helps to conserve the life of the battery 104, reduce the weight and size of the battery 104, and reduce the compressor wear rate, improving its reliability.

[0054] One of the inventors of the present invention was a co-inventor on a variable-speed controller in the past that regulated the compressor speed to operate the compressor only at the speed and power needed to deliver oxygen at the user's prescribed flow rate.

[0055] The variable-speed controller 119 allows the compressor 112 to operate at a low average rate, typically the average rate or speed will be between full speed and 1/6

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full speed of the compressor 112, resulting in an increase in battery life, decrease in battery size and weight, and decrease in compressor noise and emitted heat.

2. Concentrator

[0056] In a preferred embodiment, the concentrator 114 is an Advanced Technology Fractionator (ATF) that may be used for medical and industrial applications. The ATF may implement a pressure swing adsorption (PSA) process, a vacuum pressure swing adsorption (VPSA) process, a rapid PSA process, a very rapid PSA process or other process. If a PSA process is implemented, the concentrator preferably includes a rotary valve assembly to control air flow through multiple sieve beds. In an alternative, less preferred embodiment, the concentrator may include a non-rotating valve mechanism to control air flow through multiple sieve beds. The sieve beds may be tapered so that they have larger diameter where gaseous flow enters the beds and a smaller diameter where gaseous flow exits the beds. Tapering the sieve beds in this manner requires less sieve material and less flow to obtain the same output.

[0057] Although an ATF concentrator 114 is used in a preferred embodiment, it will be readily apparent to those skilled in the art that other types of concentrators or air-separation devices may be used such as, but not by way of limitation, membrane separation types and electrochemical cells (hot or cold). If other types of concentrators or air-separation devices are used, it will be readily apparent to those skilled in the art that some aspects described herein may change accordingly. For example, if the air-separation device is a membrane separation type, pumps other than a compressor may be used to move air through the system.

[0058] The ATF preferably used is significantly smaller that ATFs designed in the past. The inventors of the present invention recognized that reducing the size of the ATF concentrator 114 not only made the system 100 smaller and more portable, it also improved the recovery percentage, i.e., the percentage of oxygen gas in air that is recovered or produced by the concentrator 114 and the productivity (liters per minute/lb. of sieve material) of the concentrator 114. Reducing the size of the ATF decreases the cycle time for the device. As a result, productivity is increased.

[0059] Further, the inventors also determined that finer sieve materials increased recovery rates and productivity. The time constant to adsorb unwanted gases is smaller for finer particles because the fluid path is shorter for the gases than for larger particles. Thus,

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fine sieve materials having small time constants are preferred. The sieve material may be a LithiumX Zeolite that allows for a high exchange of Lithium ions. The bead size may, for example, be 0.2-0.6 mm. In an alternative embodiment, the Zeolite may be in the form of a rigid structure such as an extruded monolith or in the form of rolled up paper. In this embodiment, the Zeolite structure would allow for rapid pressure cycling of the material without introducing significant pressure drop between the feed and product streams.

[0060] The size of the concentrator 114 may vary with the flow rate desired. For example, the concentrator 114 may come in a 1.5 Liter per minute (LPM) size, a 2 LPM size, a 2.5 LPM size, a 3 LPM size, etc.

[0061] The oxygen gas generator 102 may also include an oxygen source in addition to the concentrator 114 such as, but not by way of limitation, a high-pressure oxygen reservoir, as described in more detail below.

[0062] An ATF valve controller 133 may be integral with or separate from the control unit 110 and is coupled with valve electronics in the concentrator 114 for controlling the valve(s) of the concentrator 114.

[0063] The concentrator may have one or more of the following energy saving modes: a sleep mode, a conserving mode, and an active mode. Selection of these modes may be done manually by the user 108 or automatically such as through the described one or more sensors 106 and control unit 110.

[0064] With reference to Figures 3A and 3B, an embodiment of a concentrator 114 that may be used in the oxygen generator 102 will now be described in more detail. Although the concentrator 114 will be described as separating oxygen from air, it should be noted that the concentrator 114 may be used for other applications such as, but not by way of limitation, air separations for the production of nitrogen, hydrogen purification, water removal from air, and argon concentration from air. As used herein, the term "fluids" includes both gases and liquids.

[0065] The concentrator 114 described below includes numerous improvements over previous concentrators that result in increased recovery of the desired component and increased system productivity. Improved recovery is important since it is a measure of the efficiency of the concentrator. As a concentrator's recovery increases, the amount of feed gas required to produce a given amount of product decreases. Thus, a concentrator with higher recovery may require a smaller feed compressor (e.g., for oxygen concentration

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from air) or may be able to more effectively utilize feed gas to recover valuable species (e.g., for hydrogen purification from a reformate stream). Improved productivity is important since an increase in productivity relates directly to the size of the concentrator. Productivity is measured in units of product flow per mass or volume of the concentrator. Thus, a concentrator with higher productivity will be smaller and weigh less than a concentrator that is less productive, resulting in a more attractive product for many applications. Therefore, concentrator improvements in recovery, productivity, or both are advantageous. The specific improvements that lead to improved recovery and productivity are detailed below.

[0066] The concentrator 114 includes five adsorption beds 300, each containing a bed of adsorbent material which is selective for a particular molecular species of fluid or contaminant, a rotary valve assembly 310 for selectively transferring fluids through the adsorption beds 300, an integrated tube-assembly and mainifold "manifold" 320, a product tank cover 330, and a valve assembly enclosure 340.

[0067] The adsorption beds 300 are preferably straight, elongated, molded, plastic vessels surrounded by the product tank cover 330, which is made of metal, preferably aluminum. The molded, plastic adsorption beds 300 surrounded by the metal cover 330 make for a low-cost design without the detrimental effects of water influx that occur with prior-art plastic housings or covers. Plastic adsorption beds have the inherent problem of the plastic being permeable to water. This allows water to penetrate into the adsorbent material, decreasing the performance of the adsorbent material. Surrounding the plastic adsorption beds 300 with the aluminum cover 330, which also may serve as a product accumulation tank, maintains the low cost of the design and does not sacrifice performance.

[0068] Each adsorption bed 300 includes a product end 350 and a feed end 360. With reference additionally to Figure 4, the product ends 350 of the beds 300 communicate with incoming product passages 370 of the manifold 320 through product lines 380 for communication with the rotary valve assembly 310. The feed ends 360 of the beds 300 communicate with outgoing feed passages 390 of the manifold 320 for communication with the rotary valve assembly 310.

[0069] The manifold 320 may also include outgoing product passages 400 that communicate the rotary valve assembly 310 with the interior of the product tank 330, an

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incoming feed passage 410 that communicates the rotary valve assembly 310 with a feed pressure line 420, and a vacuum chamber 430 that communicates the rotary valve assembly 310 with a vacuum pressure line 440. A product delivery line 450, which may be the same as the supply line 121 described above with respect to Figure 2, communicates with the interior of the product tank 330. The vacuum pressure line 440 may communicate directly or indirectly with the vacuum generator 124 for drawing exhaust gas from the concentrator 114.

[0070] In use, air flows from the compressor 112 to the feed pressure line 420, through the incoming feed passage 410 of the manifold 320. From there, air flows to the rotary valve assembly 310 where it is distributed back through outgoing feed passages 390 of the manifold 320. From there, the feed air flows to the feed ends 360 of the adsorption beds 300. The adsorption beds 300 include adsorbent media that is appropriate for the species that will be adsorbed. For oxygen concentration, it is desirable to have a packed particulate adsorbent material that preferentially adsorbs nitrogen relative to oxygen in the feed air so that oxygen is produced as the non-adsorbed product gas. An adsorbent such as a highly Lithium exchanged X-type Zeolite may be used. A layered adsorbent bed that contains two or more distinct adsorbent materials may also be used. As an example, for oxygen concentration, a layer of activated alumina or silica gel used for water adsorption may be placed near the feed end 360 of the adsorbent beds 300 with a lithium exchanged X-type zeolite used as the majority of the bed toward the product end 350 to adsorb nitrogen. The combination of materials, used correctly, may be more effective than a single type of adsorbent. In an alternative embodiment, the adsorbent may be a structured material and may incorporate both the water adsorbing and nitrogen adsorbing materials.

[0071] The resulting product oxygen gas flows towards the products ends 350 of the adsorption beds 300, through the product lines 380, through incoming product passages 370 of the manifold 320, and to the rotary valve assembly 310, where it is distributed back through the manifold 320 via the outgoing product passage 400 and into the product tank 330. From the product tank 330, oxygen gas is supplied to the user 108 through the product delivery line 450 and the supply line 121.

[0072] With reference to Figures 3B, 5A, 5B, 6A, 8A, and 8B, an embodiment of the rotary valve assembly 310 will now be described. The rotary valve assembly 310 includes a rotary valve shoe or disk 500 and a valve port plate or disk 510. The rotary

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valve shoe 500 and valve port plate 510 are both preferably circular in construction and made from a durable material such as ceramic, which can be ground to a highly polished flat finish to enable the faces of the valve shoe 500 and port plate 510 to form a fluid-tight seal when pressed together.

[0073] With reference specifically to FIG. 5A, the rotary valve shoe 500 has a flat, bottom engagement surface 520 and a smooth cylindrical sidewall 530. The valve shoe 500 has several symmetrical arcuate passages or channels cut into the engagement surface 520, all of which have as their center the geometric center of the circular engagement surface 520. The passages or channels include opposite high-pressure feed channels 540, equalization channels 550, opposite low-pressure exhaust passages 560, circular low-pressure exhaust groove 570 which communicates with exhaust passages 560, opposite product delivery channels 580, opposite purge channels 590, a high-presure central feed passage 600, a first annular vent groove 610, and a second annular vent groove 620.

[0074] With reference additionally to Figure 5B, a parallel, top, second valve surface 630 of the rotary valve shoe 500 will now be described. The purge channels 590 of the engagement surface 520 communicate with each other through vertical, cylindrical purge passages 640 and a rainbow-shaped purge groove 650 on the top surface 630. The equalization channels 550 of the engagement surface 520 extend vertically through the valve shoe 500. Pairs of equalization channels 550 communicate through equalization grooves 660 on the top surface 630. The equalization grooves 660 are generally U-shaped and extend around receiving holes 670. Equalization routing via the grooves 660 on the second valve surface 630, in a plane out of and parallel to a plane defined by the engagement surface 520, helps to maintain the relatively small size of the rotary valve shoe 500 while at the same time enabling more complex fluid routing through the valve shoe 500. The equalization grooves allow the secondary valve surface to be used to equalize pressures between adsorption beds 300.

[0075] With reference to Figures 3B, 8A, and 8B, a first valve shoe cover 680 is disposed over the second valve surface 630 to isolate the various grooves and passages on the second valve surface 630. Both the first valve shoe cover 680 and the second valve shoe cover 690 include aligned central holes 691, 692, respectively, for communicating the central feed passage 600 with a high-pressure feed fluid chamber formed around the

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periphery of a cylindrical base 693 of the second valve shoe cover 690. The first valve shoe cover 680 also includes a plurality of holes 694 near its periphery for the purpose of maintaining a balance of pressure during operation on either side of the first valve shoe cover 680 between the cylindrical base 693 and the second valve surface 630. Routing the high-pressure feed fluid into the high-pressure feed fluid chamber on the top or backside of the valve shoe 500 causes pressure balancing on the valve shoe 500 that counteracts the pressure force urging the valve shoe 500 away from the port plate 510. A spring or other type of passive sealing mechanism (not shown) may be used to hold the rotary valve shoe 500 against the port plate 510 when the concentrator 114 is not operating.

[0076] With reference to Figure 5A, to additionally counteract the pressure force that works to unseat the rotary valve shoe 500 from the port plate 510, the exhaust goove 570 is sized such that, when the concentrator 114 is operated at nominal feed and purge (vacuum) pressures, the sealing force due to the vacuum in the exhaust groove 570 subtantially balances this unseating pressure force. This enables the use of relatively small passive sealing mechanisms, reducing the torque and power required to turn the rotary valve shoe 500 and also reduces the weight and size of the concentrator 114.

[0077] With reference to Figure 6A, the valve port plate 510 will now be described in greater detail. The valve port plate 510 has a flat engagement surface 700 that engages the flat engagement surfce 520 of the rotary valve shoe 500 and a smooth cylindrical sidewall 710. With reference additionally to Figure 3B, an underside of the valve port plate 510 is disposed on a manifold gasket 720. The valve port plate 510 includes multiple sets of generally symmetric concentrically disposed ports or openings aligned with openings in the manifold gasket 720 to communicate the ports in the plate 510 with the passages in the manifold 320. The ports extend vertically through the valve port plate 510 in a direction generally perpendicular to the engagement surface 700. In an alternative embodiment, the ports extend vertically through the valve port plate 510 in an angular direction toward the engagement surface 700. Preferably, all of the ports of each concentric set have the same configuration. Each concentric set of ports will now be described in turn.

[0078] A first set of eight circular vacuum ports 730 concentrically disposed at a first radius from the geometric center of the valve port plate 510 communicate with the vacuum chamber 430 of the manifold 320 and the exhaust gas grooves 570 of the valve

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shoe 500. In the prefered embodiment, eight ports are used as they allow sufficient gas flow through the valve without significant pressure drop. In an alternative embodiment, a number of ports different from eight could be used.

[0079] A second set of five round outgoing feed ports 740 concentrically disposed at a second radius from the geometric center of the valve port plate 510 communicate with outgoing feed passages 390 of the manifold 320, the feed channels 540 of the valve shoe 500, and the vacuum ports 730 via the exhaust passages 560 of the valve shoe 500.

[0080] A third set of five generally elliptical incoming product ports 750 concentrically disposed at a third radius from the geometric center of the valve port plate 510 communicate with the incoming product passages 370 of the manifold 320, the equalization channels 550 of the valve shoe 500, the purge channels 590 of the valve shoe 500, and the product delivery channels 580.

[0081] A fourth set of five circular outgoing product ports 760 concentrically disposed at a fourth radius from the geometric center of the valve port plate 510 communicate with the outgoing product passages 400 of the manifold 320 and the incoming product ports 750 via the product delivery channels 580.

[0082] A fifth set of three circular port plate alignment holes 731 concentrically disposed at a fifth radius from the geometric center of the valve port plate 510 align with alignment pins 321 (Figures 3B, 4) on the manifold 320. The alignment holes 731 ensure the port plate 510 will sit in proper alignment with the manifold 320. In an alternative embodiment, two or more alignment holes located at one or more radiuses from the geometric center of the valve port plate 510 may be aligned with an equal number of alignment pins located at set positions on the manifold 320.

[0083] A round central incoming feed port 770 disposed at the geometric center of the valve port plate 510 and the center of rotation of the valve assembly 310 communicates with the incoming feed passage 410 of the manifold 320 and the central feed pasage 600 of the rotary valve shoe 500.

[0084] In the rotary valve assembly 310 described above, a maximum of 1 PSI pressure drop occurs through any port of the valve asembly 310 when the system is producing 3 LPM of oxygen product. At lesser flows, the pressure drop is negligible.

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[0085] With reference additionally to Figure 6B, a single pressure swing adsorption cycle of the concentrator 114 will now be described. During use, the rotary valve shoe 500 rotates with respect to the valve port plate 510 so that the cycle described below is sequentially and continuously established for each adsorption bed 300. The speed of rotation of the rotary valve shoe 500 with respect to the valve port plate 510 may be varied alone, or in combination with a variable-speed compressor, in order to provide the optimal cycle timing and supply of ambient air for a given production of product. To help the reader gain a better understanding of the invention, the following is a description of what occurs in a single adsorption bed 300 and the rotary valve assembly 310 during a single cycle. It should be noted, with each revolution of the rotary valve shoe 500, the adsorption beds 300 undergo two complete cycles. For each cycle, the steps include: 1) pre-pressurization 774, 2) adsorption 776, 3) first equalization down 778, 4) second equalization down 780, 5) co-current blowdown 782, 6) low-pressure venting 784, 7) counter-current purge and low-pressure venting 786, 8) first equalization up 788, and 9) second equalization up 790. Each of these steps will be described in turn below for an adsorption bed 300.

[0086] In the pre-pressurization step 774, air flows from the compressor 112 to the feed pressure line 420, through the incoming feed passage 410 of the manifold 320. From there, air flows through the central incoming feed port 770 of the port plate 510, through the central feed passage 600 and out the feed channels 540 of the valve shoe 500, through the outgoing feed ports 740, and through outgoing feed passages 390 of the manifold 320. From there, the feed air flows to the feed ends 360 of the adsorption beds 300. With reference to Figure 5A, because the feed channel 540 is advanced with respect to the product delivery channel 580 (i.e., initially the feed channel 540 is in communication with outgoing feed port 740 and the product delivery channel 580 is blocked, not in communication with the incoming product port 750), the feed end 360 of the adsorption bed 300 is pressurized with feed gas, i.e., pressurized, prior to the commencement of product delivery. In alternative embodiments, the product end 350 may be pre-pressurized with product gas, or the product end 350 may be pre-pressurized with product gas and the feed end 360 may be pre-pressurized with feed gas.

[0087] In the adsorption step 776, because the product delivery channel 580 is in communication with the incoming product port 750, adsorption of Nitrogen occurs in the

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bed 300 and the resulting product oxygen gas flows towards the product ends 350 of the adsorption beds 300, through the product lines 380, and through incoming product passages 370 of the manifold 320. From there, oxygen gas flows through the incoming product port, into and out of the product delivery channel 580, through outgoing product port 760, through the outgoing product passage 400, and into the product tank 330. From the product tank 330, oxygen gas is supplied to the user 108 through the product delivery line 450 and the supply line 121.

[0088] In the first equalization-down step 778, the product end 350 of the bed 300, which is at a high pressure, is equalized with the product end of another bed, which is at a low pressure, to bring the product end 350 of the bed 300 to a lower, intermediate pressure. The product ends 350 communicate through the product lines 380, the incoming product passages 370, the incoming product ports 750, the equalization channels 550, and the equalization groove 660. As indicated above, equalization routing via the grooves 660 on the second valve surface 630, in a plane out of and parallel to a plane defined by the engagement surface 520, helps to maintain the relatively small size of the rotary valve shoe 500, in order to keep the torque required to turn the valve shoe 500 as low as possible, while at the same time enabling more complex fluid routing through the valve shoe 500. In this step 778 and the equalization steps 780, 788, 790 to be discussed below, the adsorption beds 300 may be equalized at either the feed end 360, the product end 350, or a combination of the feed end 360 and the product end 350.

[0089] In the second equalization-down step 780, the product end 350 of the bed 300, which is at an intermediate pressure, is equalized with the product end of another bed, which is at a lower pressure, to bring the product end 350 of the bed 300 further down to an even lower pressure than in step 778. Similiar to the first equalization-down step 778, the product ends 350 communicate through the product lines 380, the incoming product passages 370, the incoming product ports 750, the equalization channels 550, and the equalization groove 660.

[0090] In the co-current blowdown ("CCB") step 782, oxygen enriched gas produced from the product end 350 of the adsorption bed 300 is used to purge a second adsorption bed 300. Gas flows from the product side of the adsorption bed 300, through product line 380, incoming product passage 370, and incoming product port 750. The gas further flows through purge channel 590, purge passage 640, through the purge groove

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650, out the purge passage 640 on the opposite side of the valve shoe 500, through the purge channel 590, through the incoming product port 750, through the incoming product pasasge 370, through the product line 380, and into the product end 350 of adsorption bed 300 to serve as a purge stream. In an alternative embodiment, in this step 782 and the following step 784, co-current blowdown may be replaced with counter-current blowdown.

[0091] In the low-pressure venting ("LPV") step 784, the adsorption bed 300 is vented to low pressure through the feed end 360 of the adsorption bed 300. The vacuum in the exhaust groove 570 of the rotary valve shoe 500 communicates with the exhaust passage 560 and the feed end 360 of the adsorption bed 300 (via the outgoing feed port 740 and outgoing feed passage 390) to draw the regeneration exhaust gas out of the adsorption bed 300. The low pressure venting step 784 occurs without introduction of oxygen enriched gas because the exhaust passage 560 is in communication with the outgoing feed port 740 and the purge channel 590 is not in communication with the incoming product port 750.

[0092] In the counter-current purge and low-pressure venting ("LPV") step 786, oxygen enriched gas is introduced into the product end 350 of the adsorption bed 300 in the manner described above in step 782 concurrently with the feed end 360 of the adsorption bed 300 being vented to low pressure as was described in the above step 784. Counter-current purge is introduced into the product end 350 of the adsorbent bed 300 through fluid communication with the product end 350 of a second adsorption bed 300. Oxygen enriched gas flows from the product end 350 of the second adsorption bed 300 through the product line 380, incoming product passage 370, incoming product port 750, through purge channel 590, purge passage 640, through the purge groove 650, out the purge passage 640 on the opposite side of the valve shoe 500, through the purge channel 590, through the incoming product port 750, through the incoming product passage 370, through the product line 380, and into the product end 350 of adsorption bed 300. Because the exhaust passage 560 is also in communication with the outgoing feed port 740 during this step 786, oxygen enriched gas flows from the product end 350 to the feed end 360, regenerating the adsorption bed 300. The vacuum in the exhaust groove 570 of the rotary valve shoe 500 communicates with the exhaust passage 560 and the feed end 360 of the adsorption bed 300 (via the outgoing feed port 740 and outgoing feed passage 390) to

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draw the regeneration exhaust gas out of the adsorption bed 300. From the exhaust passage 560, the exhaust gas flows through the vacuum ports 730, into the vacuum chamber 430, and out the vacuum presure line 440. In an alternative embodiment, the vacuum may be replaced with a low-pressure vent that is near atmospheric pressure or another pressure that is low relative to the feed pressure. In another embodiment, product gas from the product tank 330 is used to purge the product end 350 of the adsorbent bed 300.

[0093] In the first equalization-up step 788, the product end 350 of the bed 300, which is at a very low pressure, is equalized with the product end of another bed, which is at a high pressure, to bring the adsorption bed 300 to a higher, intermediate pressure. The product ends 350 communicate through the product lines 380, the incoming product passages 370, the incoming product ports 750, the equalization channels 550, and the equalization groove 660.

[0094] In the second equalization-up step 790, the product end 350 of the bed 300, which is at an intermediate pressure, is equalized with the product end of another bed, which is at a higher pressure, to bring the product end 350 of the bed 300 further up to an even higher pressure than in step 788. Similiar to the first equalization-down step 778, the product ends 350 communicate through the product lines 380, the incoming product passages 370, the incoming product ports 750, the equalization channels 550, and the equalization groove 660.

[0095] It should be noted, in a preferred embodiment, the combined duration of feed steps 774, 776 may be substantially the same as the combined duration of purge steps 782, 784, 786, which may be substantially three times the duration of each equalization step 778, 780, 788, 790. In an alternative embodiment, the relative duration of the feed steps 774, 776, the purge steps 782, 784, 786, and the each equalization step 778, 780, 788, 790 may vary.

[0096] After the second equalization-up step 790, a new cycle begins in the adsorption bed 300 starting with the pre-pressurization step 774.

[0097] The five-bed concentrator 114 and cycle described above has a number of advantages over other-numbered concentrators and cycles used in the past, some of which are described below. The multiple equalization steps 788, 790 at the product ends 350 and the pre-pressurization step 774 contribute to the pre-pressurization of the

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adsorption beds 300 prior to product delivery. As a result, the beds 300 reach their ultimate pressure (substantially equal to the feed pressure) quickly and thereby allow for maximum utilization of the adsorbent media. Additionally, pre-pressurizing the adsorbent beds 300 allows product to be delivered at substantially the same pressure as the feed, thereby retaining the energy of compression in the stream, which makes the product stream more valuable for use in downstream processes. In an alternative embodiment, pre-pressurizing the beds 300 with product before exposing the feed end 360 of the bed 300 to the feed stream eliminates any pressure drop experienced due to the fluid interaction or fluid communication between two or more adsorbent beds 300 on the feed end 360. Additionally, compared to systems with greater numbers of beds, the use of a 5-bed system, reduces the duration and number of beds that are in fluid communication with the feed chanels 540 at the same time, thereby reducing the propensity for fluid flow between adsorption beds. Since fluid flow between adsorption beds is associated with a reversal of the flow direction in the higher pressure bed (resulting in decreased performance), reduction in this effect is advantageous.

[0098] A further advantage of a 5-bed system over many systems is that it includes a small number of adsorption beds 300, allowing the concentrator to be relative small, compact, and light-weight, while delivering sufficient flow and purity and maintaining high oxygen recovery. Other PSA systems, typically those with a small number of adsorption beds, result in deadheading the compressor (resulting in high power use) during a portion of the cycle. Deadheading the compressor eliminates detrimental flow between the feed side 360 of the two or more adsorption beds 300 (as discussed above) but increases system power. The 5-bed system eliminates compressor deadheading and minimizes performance-limiting feed side 360 flow between adsorbent beds 300.

[0099] Use of the multiple pressure equalization steps 778, 780, 788, 790 reduces the amount of energy of compression required to operate the concentrator 114. Equalizing the beds 300 conserves high-pressure gas by moving it to another bed 300 rather than venting it to the atmosphere or to a vacuum pump. Because there is a cost associated with pressurizing a gas, conserving the gas provides a savings and improves recovery. Also, because a bed 300 may contain gas enriched with product, usually at the product end 350 of the bed 300, allowing this gas to move into another bed 300, rather than venting it, conserves product and improves recovery. The number of equalizations

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are preferably between one and four. It should be noted, each equalization represents two equalization steps, an equalization-down step and an equalization-up step. Thus, two equalizations means two down equalizations and two up equalizations, or four total equalizations. The same is true for other-number equalizations. In a preferred embodiment, one to four equalizations (two to eight equalization steps) are used in each cycle. In a more preferred embodiment, one to three equalizations (two to six equalization steps) are used in each cycle. In a most preferred embodiment, two equalizations (four equalization steps) are used in each cycle.

[00100] In alternative embodiments, the concentrator 114 may have other numbers of adsorption beds 300 based on the concentration of the feed stream, the specific gases to be separated, the pressure swing adsorption cycle, and the operating conditions. For example, but not by way of limitation, there also are advantages to four-bed concentrators and six-bed concentrators. When operating a cycle similar to that described above with a four-bed concentrator, the problem of fluid communication between the feed chanels 540 and more than one adsorption bed (at one instant) is completely eliminated. When the feed-end fluid communication is eliminated, the feed steps 774, 776 occur in a more desirable fashion resulting in improved recovery of the desired product.
The advantages of a six-bed system, compared to a five-bed system, are realized when the pressure-swing cycle described above is modified so that there are three equalization up stages and three equalization down stages instead of two equalization up stages and two equalization down stages. A third equalization is advantageous when the feed gas is available at high pressure. The third equalization conserves compressor energy because it allows the equalized beds to obtain substantially 75% of the feed pressure compared to substantially 67% of the feed pressure when two equalization stages are used. In any PSA cycle, whenever an equalization up occurs, there is a corresponding equalization down. The requirement of matching equalization stages inparts some restrictions on the relative timing of the cycle steps. If, for example, the duration of the feed step is substantially the same as the duration of each equalization step, then a six-bed cycle would provide the required matching of equalization stages.

[0100] A number of additional inventive aspects related to the concentrator 114 that increase recovery of a desired component and system productivity will now be described. With reference to Figures 3A, 3B, 7A, and 7B, an embodiment of a media

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retention cap 800 that reduces dead volume in the adsorption beds 300 will now be described. Each media retention cap 800 is located at the product end 350 of the adsorption bed 300 and supports the adsorbent material above the media retention cap 800. A spring 810 located within and below the media retention cap 800 urges the media retention cap 800 upwards to hold the packed bed of adsorbent material firmly in place. The media retention cap 800 has a cylindrical base 820 with first and second annular flanges 830, 840. The second annular flange 840 terminates at its top in a circular rim 850. A top surface 860 of the media retention cap 800 includes a plurality of ribs 870 radiating in a generally sunburst pattern from a central port 880. Adjacent the central port 880, gaps 890 create diffusion zones for purge fluid coming out of the central port 880. The gaps 890 and the radiating ribs 870 cause the purge fluid to be distributed outward from the central port 880, causing a more uniform, improved regeneration of the adsorbent material during a purging step. The radiating ribs 870 also help to channel product gas towards the central port 880 during a product delivery step. In an alternative embodiment, the media retention cap 800 may have a generally non-cylindrical surface to retain media in a generally non-cylindrical adsorbtion bed 300. In a further alternative embodiment, the central port 880 may be located away from the geometric center of the either cylindrical or non-cylindrical media retention cap 800.

[0101] With reference to Figure 7B, on the underside of the media retention cap 800, the cydrical base 820 forms an interior chamber in which the spring 810 is disposed. A central port nipple 900 extends from a bottom surface 910 of the media retention cap 800. An end of the product line 380 connects to the central port nipple 900 for communicating the product end 350 of the adsorption bed 300 with the incoming product passage 370 of the manifold 320.

[0102] In the past, media retention caps may be held in place with a spring that fits inside and above the cap so that the spring is in the fluid flow path between the bottom of the adsorbent material and any exit port, at the product end 350 of the bed 300. The volume in which the spring is housed represents dead volume in the system. As used herein, "dead volume" is system volume that is compressed and purged, but does not contain adsorbent media. The process of filling this volume with compressed feed and then venting that volume represents wasted feed. The improved media retention cap 800 does not add dead volume to the system because the spring 810 is housed outside of the

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fluid flow path. Elimination of any extra volume within the system results directly in more effective utilization of the feed, and, thus, higher recovery of the desired product.

[0103] With reference to Figures 8A and 8B, an embodiment of a centering mechanism for maintaining the rotary valve shoe 500 laterally fixed and centered with respect to the valve port plate 510 will now be described. The centering mechanism may include a centering pin 920 having a hollow cylindrical shape and made of a rigid material. When the engagement surface 520 of the rotary valve shoe 500 is engaged with the engagement surface 700 of the valve port plate 510, the centering pin 920 is partially disposed in the central feed pasage 600 of the rotary valve shoe 500 and the central incoming feed port 770 of the valve port plate 510. In use, the rotary valve shoe 500 rotates around the centering pin 920 and the hollow interior of the centering pin 920 allows high-pressure feed fluid to flow therethrough. The pin 920 maintains the rotating valve shoe in a fixed position relative to the valve port plate 510. In the past, the rotary valve shoe was roughly centered with respect to the valve port plate by the motor that drives the rotary valve shoe. If the rotary valve shoe 500 and the valve port plate 510 are off center with respect to each other, the concentrator 114 will not cycle as intended, inhibiting the productivity, recovery, and efficiency of the concentrator. The precision offered by the centering pin 920 is important when the valve assembly 310 is controlling complex cycles or maintaining very small pressure drops.

[0104] With reference to Figures 9A and 9B, a rotary valve assembly constructed in accordance with another embodiment of the invention includes an alternative centering mechanism to maintain the rotating valve shoe 500 in a fixed position relative to the valve port plate 510. A circular centering ring 930 fits snugly over the smooth cylindrical sidewall 530 of the rotary valve shoe 500 and the smooth cylindrical sidewall 710 of the stationary valve port plate 510. The circular ring 930 centers the rotary valve shoe 500 relative to the valve port plate 510 by holding the rotary shoe 500 in a fixed position relative to the port plate 510 while at the same time allowing the rotary valve shoe 500 to rotate.

[0105] With reference to Figures 10A-10C, an embodiment of an elastic link for coupling the motor 118 to the valve shoe 500 will now be described. A drive mechanism 940 includes a drive shaft 950, a drive wheel 960, and three (two shown) elastic chain links 970. The drive shaft 950 may be connected to the motor 118 for rotating the drive

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wheel 960. With reference to Figure 10C, a lower side 980 of the drive wheel 960 may include downwardly protruding cylindrical support posts 990. Similarly, with reference to Figure 10B, an upper side 1000 of the second valve shoe cover 690 may include upwardly protruding cylindrical support posts 1010. The elastic chain links 970 are preferably made of semi-rigid, elastic material (such as silicon rubber) and have a generally wrench-shaped configuration. Each elastic chain link 970 includes cylindrical receiving members 1020 with central cylindrical bores 1030. The cylindrical receiving members 1020 are joined by a narrow connecting member 1040. The drive wheel 960 is coupled to the second valve shoe cover 690 through the elastic chain links 970. One receiving member 1020 of each elastic chain link receives the support post 990 of the drive wheel 960 and the other receiving member 1020 receives the support post 1010 of the second valve shoe cover 690. In the past, rigid connections were made between the motor and the rotating valve shoe. These rigid connections caused the rotating valve shoe to be affected by vibration or other non-rotational movement of the motor. The elastic chain links 970 absorb the vibration and non-rotational movement of the motor, preventing this detrimental energy from being imparted to the rotating valve shoe 500.

[0106] Figure 11 is a table of experimental data from a concentrator similar to the concentrator 114 shown and described above with respect to Figures 3-10. As shown by this table, the recovery of oxygen from air with the concentrator 114 is 45-71% at about 90% purity. The ratio of adiabatic power (Watts) to oxygen flow (Liters Per Minute) is in the range of 6.2 W/LPM to 23.0 W/LPM. As defined in Marks' Standard Handbook for Mechanical Engineers, Ninth Edition, by Eugene A. Avallone and Theodore Baumeister, the equation for adiabatic power, tanken from the equation from adiabatic work, is as follows:

$$Power = \frac{W}{t} = P_1 V_1 \left(\frac{k}{1-k} \right) \left[\left(\frac{P_2}{P_1} \right)^{\frac{k-1}{k}} - 1 \right] C$$

Power = Adiabatic Power (Watts)

W = Adiabatic Work (Joule)

t = time (Second)

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P_1 = Atmospheric Pressure (psia)

P_2 = Compressor / Vacuum pressure (psia)

k = Ratio of Specific Heats = constant = 1.4 (for air)

V_1 = Volumetric flow rate at atmospheric pressure (SLPM)

C = Conversion Factor, added by authors for clarity = 0.114871 Watts / psi / LPM

B. Energy Source

[0107] With reference additionally to Figure 12, in order to properly function as a lightweight, portable system 100, the system 100 must be energized by a suitable rechargeable energy source. The energy source preferably includes a rechargeable battery 104 of the lithium-ion type. It will be readily apparent to those skilled in the art that'. the system 100 may be powered by a portable energy source other than a lithium-ion battery. For example, a rechargeable or renewable fuel cell may be used. Although the system is generally described as being powered by a rechargeable battery 104, the system 100 may be powered by multiple batteries. Thus, as used herein, the word "battery" includes one or more batteries. Further, the rechargeable battery 104 may be comprised of one or more internal and/or external batteries. The battery 104 or a battery module including the battery 104 is preferably removable from the system 100. The system 100 may use a standard internal battery, a low-cost battery, an extended-operation internal battery, and an external secondary battery in a clip-on module.

[0108] The system 100 may have a built-in adapter including battery charging circuitry 130 and one or more plugs 132 configured to allow the system 100 to be powered from a DC power source (e.g., car cigarette lighter adapter) and/or an AC power source (e.g., home or office 110 VAC wall socket) while the battery 104 is simultaneously being charged from the DC or AC power source. The adapter or charger could also be separate accessories. For example, the adapter may be a separate cigarette lighter adapter used to power the system 100 and/or charge the battery 104 in an automobile. A separate AC adapter may be used to convert the AC from an outlet to DC for use by the system 100 and/or charging the battery 104. Another example of an adapter may be an adapter used with wheel chair batteries or other carts.

[0109] Alternatively, or in addition, a battery-charging cradle 134 adapted to receive and support the system 100 may have an adapter including battery charging

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circuitry 130 and a plug 132 that also allow the system 100 to be powered while the battery 104 is simultaneously being charged from a DC and/or AC power source.

[0110] The system 100 and cradle 134 preferably include corresponding mating sections 138, 140 that allow the system 100 to be easily dropped into and onto the cradle 134 for docking the system 100 with the cradle 134. The mating sections 138, 140 may include corresponding electrical contacts 142, 144 for electrically connecting the system 100 to the cradle 134.

[0111] The cradle 134 may be used to recharge and/or power the system 100 in the home, office, automobile, etc. The cradle 134 may be considered part of the system 100 or as a separate accessory for the system 100. The cradle 134 may include one or more additional charging receptacles 146 coupled to the charging circuitry 130 for charging spare battery packs 104. With a charging receptacle 146 and one or more additional battery packs 104, the user can always have a supply of additional fresh, charged batteries 104.

[0112] In alternative embodiments, the cradle 134 may come in one or more different sizes to accommodate one or more different types of systems 100.

[0113] The cradle 134 and/or system 100 may also include a humidifying mechanism 148 for adding moisture to the air flow in the system 100 through appropriate connections 149. In an alternative embodiment of the invention, the humidifying mechanism 148 may be separate from the system 100 and the cradle 134. If separate from the system 100 and cradle 134, the cradle 134 and/or system 100 may include appropriate communication ports for communicating with the separate humidifying mechanism 148. The cradle 134 may also include a receptacle adapted to receive a separate humidifying mechanism 148 for use with the system 100 when the system 100 is docked at the cradle 134.

[0114] The cradle 134 and/or system 100 may also include a telemetry mechanism or modem 151 such as a telephone modem, high-speed cable modem, RF wireless modem or the like for communicating the control unit 110 of the system 100 with one or more remote computers. To this end, the cradle 135 may include a line 153 with a cable adapter or telephone jack plug 155, or a RF antenna 157. In an alternative embodiment of the invention, the telemetry mechanism or modem 151 may be separate from the cradle 134 and to this end, the cradle 134 or system 100 may include one or more

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appropriate communication ports, e.g., a PC port, for directly communicating the telemetry mechanism or modem 151 with the cradle 134 or system 100. For example, the cradle 134 may be adapted to communicate with a computer (at the location of the cradle) that includes the telemetry mechanism or modem 151. The computer may include appropriate software for communicating information described below using the telemetry mechanism or modem 151 with the one or more remote computers.

[0115] The telemetry mechanism or modem 151 may be used to communicate physiological information of the user such as, but not by way of limitation, heart rate, oxygen saturation, respiratory rate, blood pressure, EKG, body temperature, inspiratory/expiratory time ratio (I to E ratio) with one or more remote computers. The telemetry mechanism or modem 151 may be used to communicate other types of information such as, but not by way of limitation, oxygen usage, maintenance schedules on the system 100, and battery usage with one or more remote computers.

[0116] A user ideally uses the system 100 in its cradle 134 at home, at the office, in the automobile, etc. A user may decide to have more than one cradle, e.g., one at home, one at the office, one in the automobile, or multiple cradles at home, one in each room of choice. For example, if the user has multiple cradles 134 at home, when the user goes from room to room, e.g., from the family room to the bedroom, the user simply lifts the system 100 out of its cradle 134 in one room, and walks to the other room under battery operation. Dropping the system 100 in a different cradle 134 in th destination room restores the electrical connection between the system 100 and the AC power source. Since the system's batteries 104 are constantly charging or charged when located in the cradle 134, excursions outside the home, office, etc. are as simple as going from room to room in the user's home.

[0117] Because the system 100 is small and light (2-15 pounds), the system 100 may simply be lifted from the cradle 134 and readily carried, e.g., with a shoulder strap, by an average user to the destination. If the user is unable to carry the system 100, the system 100 may be readily transported to the destination using a cart or other transporting apparatus. For an extended time away from home, office, etc., the user may bring one or more cradles 134 for use at the destination. Alternatively, in the embodiment of the system 100 including the built-in adapter, power may be drawn from power sources such as a car cigarette lighter adapter and/or an AC power outlet available at the destination.

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Further, spare battery Packs 104 may be used for extended periods away from standard power sources.

[0118] If the battery pack 104 includes multiple batteries, the system 100 may include a battery sequencing mechanism to conserve battery life as is well known in the cellphone and laptop computer arts.

C. Output Sensor

[0119] With reference to Figures 1, 2 and 13, one or more output sensors 106 are used to sense one or more conditions of the user 108, environment, etc. to determine the oxygen flow rate needs of the user and, hence, the oxygen flow rate output requirements for the system 100. A control unit 110 is linked to the one or more output sensors 106 and the oxygen gas generator 102 to control the oxygen generator 102 in response to the condition(s) sensed by the one or more output sensors 106. These output sensors include a pressure sensor 150, a position sensor 152, an acceleration sensor 154, as well as a physiological condition or metabolic sensor 156 and an altitude sensor 158.

[0120] The first three sensors 150, 152, 154 (and, in certain circumstances, the physiological condition sensor 156) are activity sensors because these sensors provide a signal representing activity of the user 108. In the delivery of oxygen with a portable oxygen concentration system, it is important to deliver an amount of oxygen gas proportional to the activity level of the user 108 without delivering too much oxygen. Too much oxygen may be harmful for the user 108 and reduces the life of the battery 104. The control unit 110 regulates the oxygen gas generator 102 to control the flow rate of oxygen gas to the user 108 based on the oneor more signals representative of the activity level of the user produced by the one or more sensors 106. For example, if the output sensor(s) 106 indicates that the user 108 has gone from an inactive state to an active state, the control unit 110 may cause the oxygen gas generator 102 to increase the flow rate of oxygen gas to the user 108 and/or may provide a burst of oxygen gas to the user 108 from a high-pressure oxygen reservoir to be described. If the output sensor(s) 106 indicates that the user 108 has gone from an active state to an inactive state, the control unit 110 may cause the oxygen gas generator 102 to reduce the flow rate of oxygen gas to the user.

[0121] In an embodiment of the invention, the amount of oxygen gas supplied is controlled by controlling the speed of the compressor motor 118 via the variable-speed controller 119.

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[0122] Alternatively, or in addition to the variable-speed controller, the supply of oxygen gas may be controlled by the supply valve 160 located in the supply line 121 between the oxygen gas (generator 102 and the user 108. For example, the supply valve 160 may be movable between at least a first position and a second position, the second position allowing a greater flow of concentrated gaseous oxygen through than the first position. The control unit 110 may cause the supply valve 160 to move from the first position to the second position when one or more of the activity level sensors 152, 154, 156 senses an active level of activity of the user 108. For example, the control unit 110 may include a timer, and when an active level is sensed for a time period exceeding a predetermined timed period, the control unit 110 causes the valve 160 to move from the first position to the second position.

[0123] Examples of pressure sensors 150 include, without limitation, a foot switch that indicates when a user is in a standing position compared to a sedentary position, and a seat switch that indicates when a user is in a seated position compared to a standing position.

[0124] A pendulum switch is an example of a position sensor 152. For example, a pendulum switch may include a thigh switch positioned pendulously to indicate one mode when the user is standing, i.e., the switch hangs vertically, and another mode when the user seated, i.e., the thigh switch raised to a more horizontal position. A mercury switch may be used as a position sensor.

[0125] An acceleration sensor 158 such as an accelerometer is another example of an activity sensor that provides a signal representing activity of the user.

[0126] The physiological condition or metabolic sensor 156 may also function as an activity sensor. The physiological condition sensor 156 may be used to monitor one or more physiological conditions of the user for controlling the oxygen gas generator 102 or for other purposes. Examples of physiological conditions that may be monitored with the sensor 156 include, but without limitation, blood oxygen level, heart rate, respiration rate, blood pressure, EKG, body temperature, and I to E ratio. An oximeter is an example of a sensor that is preferably used in the system 100. The oximeter measures the blood oxygen level of the user, upon which oxygen production may be at least partially based.

[0127] An altitude sensor 158 is an example of an environmental or ambient condition sensor that may sense an environmental or ambient condition upon which

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control of the supply of oxygen gas to the user may be at least partially based. The altitude sensor 158 may be used alone or in conjunction with any or all of the above sensors, the control unit 110 and the oxygen gas generator 102 to control the supply of oxygen gas to the user in accordance with the sensed altitude or elevation. For example, at higher sensed elevations, where air is less concentrated, the control unit may increase the flow rate of oxygen gas to the user 108 and at lower sensed elevations, where air is more concentrated, the control unit may decrease the flow rate of oxygen gas to the user 108 or maintain it at a control level.

[0128] It will be readily apparent to those skilled in the art that one or more additional or different sensors may be used to sense a condition upon which control of the supply of oxygen gas to the user may be at least partially based. Further, any or all of the embodiments described above for regulating the amount of oxygen gas supplied to the user 108, i.e., variable-speed controller 119, supply valve 160, (or alternative embodiments) may be used with the one or more sensors and the control unit 110 to control of the supply of oxygen gas to the user 108.

D. Control Unit

[0129] With reference to Figure 14, the control unit 110 may take any well-known form in the art and includes a central microprocessor or CPU 160 in communication with the components of the system described herein via one or more interfaces, controllers, or other electrical circuit elements for controlling and managing the system. The system 100 may include a user interface (Figure 14) as part of the control unit 110 or coupled to the control unit 110 for allowing the user, provider, doctor, etc. to enter information, e.g., prescription oxygen level, flow rate, activity level, etc., to control the system 100.

[0130] The main elements of an embodiment of the system 100 have been described above. The following sections describe a number of additional features, one or more of which may be incorporated into the embodiments of the invention described above as one or more separate embodiments of the invention.

II. Conserving Device

[0131] With reference to Figure 15, a conserving device or demand device 190 may be incorporated into the system 100 to more efficiently utilize the oxygen produced by the oxygen gas generator 102. During normal respiration, a user 108 inhales for about

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one-third of the time of the inhale/exhale cycle and exhales the other two-thirds of the time. Any oxygen flow provided to the user 108 during exhalation is of no use to the user 108 and, consequently, the additional battery power used to effectively provide this extra oxygen flow is wasted. A conserving device 190 may include a sensor that senses the i nhale/exhale cycle by sensing pressure changes in the cannula 111 or another part of the system 100, and supply oxygen only during the inhale portion or a fraction of the inhale portion of the breathing cycle. For example, because the last bit of air inhaled is of no particular use because it is trapped between the nose and the top of the lungs, the conserving device 190 may be configured to stop oxygen flow prior to the end of inhalation, improving the efficiency of the system 100. Improved efficiency translates into a reduction in the 20size, weight, cost and power requirements of the system 100.

[0132] The conserving device 190 may be a stand-alone device in the output line of the system 100, similar to a regulator for scuba diving, or may be coupled to the control unit 110 for controlling the oxygen generator 102 to supply oxygen only during inhalation by the user 108.

[0133] The conserving device 190 may include one or more of the sensors described above. For example, the conserving device may include a sensor for monitoring the respiration rate of the user.

[0134] The system 100 may also include a special cannula retraction device for retracting the cannula ill when not in use. Further, the cannula 111 may come in different lengths and sizes.

III. High-pressure reservoir

[0135] With reference to Figure 16, a high-pressure reservoir 164 may be located in a secondary line 166 for delivering an additional supply of oxygen gas to the user 108 when the oxygen gas generator 102 can not meet the oxygen gas demands of the user 108. Any of the components described below in the secondary line 166 may be coupled to the control unit 110 or a high-pressure reservoir controller 167 (Figure 14) for control thereby. Exemplary situations where this additional oxygen gas need may occur are when a user suddenly goes from an inactive state to an active state, e.g., when getting out of a chair, when the system 100 is turned on, or when the system 100 goes from a conserving mode or sleep mode to an active mode. As used herein, secondary line 166 refers to the tubing, connectors, etc. used to connect the components in the line. A valve

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168 may be controlled by the control unit 110 to allow gaseous oxygen to flow into the secondary line 166. The valve 168 may be configured to allow simultaneous flow to both the supply line 121 and the secondary line 166, flow to only the supply line 121, or flow to only the secondary line 166.

[0136] A pump or compressor 168, which is preferably powered by the motor 118, delivers the oxygen gas at a relatively high pressure, e.g., at least approximately 100 psi, to the high-pressure reservoir 164.

[0137] An oxygen-producing electrochemical cell 171 may be used in conjunction with or instead of the elements described in the secondary line 166 to supply additional oxygen gas to the user 108. For example the electrochemical cell 171 may be used to deliver oxygen gas at a relatively high pressure to the highpressure reservoir 164.

[0138] A pressure sensor 172 is in communication with the high-pressure reservoir 164 and the control unit 110 so that when the pressure in the high-pressure reservoir 164 reaches a certain limit, the control unit 110 causes the valve 168 to direct oxygen to the secondary line 166.

[0139] A regulator 174 may be used to control flow and reduce pressure of the oxygen gas to the user 108.

[0140] A valve 176 may also be controlled by the control unit110 to allow gaseous oxygen from the high-pressure reservoir 164 to flow into the supply line 121 when the user 108 requires an amount of oxygen gas that cannot be met by the oxygen gas generator 102. The valve 176 may be configured to allow simultaneous flow from the oxygen gas generator 102 and the high-pressure reservoir 164, from only the oxygen gas generator 102, or from only the high-pressure reservoir 164.

[0141] The one or more sensors 106 are interrelated with the control unit 110 and the oxygen gas generator 102 so as to supply an amount of oxygen gas equivalent to the oxygen gas needs of the user 108 based at least in part upon one or more conditions sensed by the one or more sensors 106. When the oxygen gas generator 102 cannot meet the oxygen gas demands of the user 108, the control unit 110, based at least in part upon sensing one or more conditions indicative of the oxygen needs of the user, may cause the high-pressure reservoir 164 (via the valve 176) to supply the additional oxygen gas needed.

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[0142] In the scenario where the oxygen gas generator 102 is capable of supplying the full oxygen gas needs of the user 108, but is simply turned off or is in a conserving or sleep mode, the period of time that the high-pressure reservoir 164 supplies the oxygen gas, i.e., the period of time that the valve 176 connects the high-pressure reservoir 164 with the supply line 121, is at least as long as the time required for the oxygen gas generator 102 to go from an off or inactive condition to an on or active condition. In another scenario, the control unit 110 may cause oxygen gas to be supplied to the user from the high-pressure reservoir 164 when the demand for gaseous oxygen by the user exceeds the maximum oxygen gas output of the oxygen gas generator 102. Although the high-pressure reservoir 164 is shown and described as being filled by the oxygen gas generator 102, in an alternative embodiment, the high-pressure reservoir 164 may be filled by a source outside or external to the system.

IV. Global Positioning System

[0143] With reference back to Figure 12, in an alternative embodiment of the invention, the system 100 may include a global positioning system (GPS) receiver 200 for determining the location of the system 100. The location of the receiver 200 and, hence, the user 108 can be transmitted to a remote computer via the telemetry mechanism or modem 151. This may be desirable for locating the user 108 in the event the user has a health problem, e.g., heart attack, hits a panic button on the system, an alarm is actuated on the system, or for some other reason.

V. Additional Options and Accessories

[0144] In addition to the cradle 134, the portable oxygen concentration system 100 may include additional options and accessories. A number of different types of bags and carrying cases such as, but not by way of limitation, a shoulder bag, a backpack, a fanny pack, a front pack, and a split pack in different colors and patterns may be used to transport the system 100 or other system accessories. A cover may be used to shield the system from inclement weather or other environmental damage. The system 100 may also be transported with a rolling trolley/cart, a suit case, or a travel case. The travel case may be designed to carry the system 100 and include enough room to carry the cannulae 111, extra batteries, an adapter, etc. Examples of hooks, straps, holders for holding the system 100 include, but not by way of limitation, hooks for seatbelts in cars, hooks/straps for walkers, hooks/straps, for wheel chairs, hooks/straps for hospital beds, hooks for other

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medical devices such as ventilators, hooks/straps for a golf bag or golf cart, hooks/straps for a bicycle, and a hanging hook. The system 100 may also include one or more alarm options. An alarm of the system 100 may be actuated if, for example, a sensed physiological condition of the user 108 falls outside a pre-defined range. Further, the alarm may include a panic alarm that may be manually actuated by the user 108. The alarm may actuate a buzzer or other sounding device on the system 100 and/or cause a communication to be sent via the telemetry mechanism or modem 151 to another entity, e.g., a doctor, a 911 dispatcher, a caregiver, a family member, etc.

[0145] Although this invention has been described in terms of certain preferred embodiments, other embodiments apparent to those of ordinary skill in the art are also within the scope of this invention. Accordingly, the scope of this invention is intended to be defined only by the claims that follow.

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We claim:

1. A portable oxygen concentrator system adapted to be readily transported by a user, comprising:

a rechargeable energy source;

a concentrator powered by said energy source and adapted to convert ambient air into concentrated oxygen gas for said user, the concentrator including a plurality of adsorption beds and a rotary valve assembly, the rotary valve assembly relatively rotatable with respect to the plurality of adsorption beds to provide valving action for selectively transferring fluids through the plurality of adsorption beds for converting ambient air into concentrated oxygen gas for said user,

wherein the ratio of adiabatic power to oxygen flow for the concentrator is in the range of 6.2 W/LPM to 23.0 W/LPM.

2. The portable oxygen concentrator system of claim 1, wherein the concentrator includes exactly five adsorption beds.

3. The portable oxygen concentrator system of claims 1 or 2, wherein the rotary valve assembly includes a valve port plate and a rotary valve shoe having respective engaged surfaces and relatively rotatable about a common center of rotation to provide valving action for selectively transferring fluids therethrough, and a centering mechanism other than a motor to center the rotary valve shoe relative to the valve port plate.

4. The portable oxygen concentrator system of claim 3, wherein the valve port plate and the rotary valve shoe include respective central holes, and the centering mechanism includes a centering pin disposed in the central holes of the valve port plate and rotary valve shoe to center the rotary valve shoe relative to the valve port plate.

5. The portable oxygen concentrator system of claim 3, wherein the valve port plate and rotary valve shoe include cylindrical sidewalls, and the centering mechanism includes a centering ring disposed around the sidewalls of the valve port plate and the rotary valve shoe to center the rotary valve shoe relative to the valve port plate.

6. The portable oxygen concentrator system of any of claims 1-5, wherein the adsorption beds carry adsorbent material, and include a first end, a second end, an adsorbent media disposed in the adsorption beds between the first end and the second end, a media retention cap disposed between the adsorbent media and the second end, a spring

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to urge the media retention cap against the adsorbent material to hold the adsorbent media in place, and the spring not located in a flow path of the adsorption beds.

7. The portable oxygen concentrator system of claim 6, wherein the media retention cap includes a surface that contacts the adsorbent media, the surface including a central hole and a plurality of ribs radiating from the central hole.

8. The portable oxygen concentrator system of claim 6, wherein the media retention cap includes a bottom base with an interior, and the spring is disposed in the interior of the bottom base.

9. The portable oxygen concentrator system of any of claims 1-8, wherein the rotary valve assembly includes a valve port plate and a rotary valve shoe having respective engaged surfaces and relatively rotatable about a common center of rotation to provide valving action for selectively transferring fluids therethrough, and the portable oxygen concentrator system further includes a motor to rotate the rotary valve shoe, and one or more elastic links to couple the motor to the rotary valve shoe.

10. The portable oxygen concentrator system of claim 9, wherein the motor includes a drive shaft and a drive wheel with one or more protruding support members, the rotary valve shoe includes one or more protruding support members, and the elastic link connects the one or more protruding support members of the drive wheel with the one or more protruding support members of the rotary valve shoe.

11. The portable oxygen concentrator system of any of claims 1-10, wherein the concentrator includes plastic adsorption beds and a metal cover surrounding the plastic adsorption beds.

12. The portable oxygen concentrator system of claim 11, wherein the adsorption beds are, elongated, molded, plastic vessels.

13. The portable oxygen concentrator system of claim 12, wherein the metal cover is made of aluminum and surrounds the adsorption beds to form a product tank.

14. The portable oxygen concentrator system of any of claims 1-13, wherein the rotary valve assembly includes a valve port plate and a rotary valve shoe having respective engaged surfaces and relatively rotatable about a common center of rotation to provide valving action to put the adsorption beds in a pressure swing adsorption cycle, and the pressure swing adsorption cyle includes a number of equalization steps in each adsorption bed ranging from two to eight.

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15. The portable oxygen concentrator system of claim 14, wherein the pressure swing adsorption cyle includes a number of equalization steps in each adsorption bed ranging from two to six.

16. The portable oxygen concentrator system of claim 14, wherein the pressure swing adsorption cyle includes four equalization steps in each adsorption bed.

17. The portable oxygen concentrator system of claim 14, wherein the equalization steps include a first equalization down step, a second equalization down step, a first equalization up step, and a second equalization up step.

18. The portable oxygen concentrator system of claim 14, wherein adsorption beds include a feed end and a product end, and equalization occurs between product ends of adsorption beds.

19. The portable oxygen concentrator system of any of claims 1-18, further including a variable-speed compressor to supply ambient air to the concentrator.

20. The portable oxygen concentrator system of any of claims 1-19, wherein recovery of oxygen from air from the concentrator is 45-71% at about 90% purity.

21. The portable oxygen concentrator system of any of claims 1-20, wherein the rotary valve assembly includes a valve port plate and a rotary valve shoe having respective engaged surfaces and relatively rotatable about a common center of rotation to provide valving action for selectively transferring fluids therethrough, said valve port plate having at least two ports interconnected with at least two adsorption beds, and said rotary valve shoe having a second valve surface opposite said engaged surface with at least one equalization passage to register with said at least two ports of the port plate to equalize pressure in said at least two adsorption beds.

22. The portable oxygen concentrator system of any of claims 1-21, wherein a pressure drop through the rotary valve assembly is no more than 1 PSI when the concentrator is producing 3 LPM of oxygen gas.

23. The portable oxygen concentrator system of any of claims 1-22, wherein the rotary valve assembly includes a valve port plate and a rotary valve shoe having respective engaged surfaces and relatively rotatable about a common center of rotation to provide valving action for selectively transferring fluids therethrough, the rotation speed of the rotary valve shoe with respect to the valve port plate is varied in order to provide desired cycle timing for a given production of product.

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24. The portable oxygen concentrator system of claim 23, further including a variable-speed compressor to supply compressed ambient air to the concentrator, and the rotation speed of the rotary valve shoe with respect to the valve port plate is varied in combination with variation in the speed of the variable-speed compressor in order to provide desired cycle timing and desired supply rate of ambient air to the concentrator for a given production of product.

25. The portable oxygen concentrator system of any of claims 1-24, wherein the rotary valve assembly includes a valve port plate and a rotary valve shoe having respective engaged surfaces and relatively rotatable about a common center of rotation to provide valving action for selectively transferring fluids therethrough, and the rotary valve shoe includes a vacuum sealing mechanism that counteracts a pressure force working to unseat the rotary valve shoe from the valve port plate.

26. A rotary valve assembly for a pressure swing adsorption system having a plurality of adsorption beds, comprising:

a valve port plate and a rotary valve shoe having respective engaged surfaces and relatively rotatable about a common center of rotation to provide valving action for selectively transferring fluids therethrough, said valve port plate having at least two ports interconnected with at least two adsorption beds, and said rotary valve shoe having a second valve surface opposite said engaged surface with at least one equalization passage to register with said at least two ports of the port plate to equalize pressure in said at least two adsorption beds.

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AMENDED CLAIMS

[received by the International Bureau on 07 October 2003 (07.10.2003); original claim 26 cancelled; new claims 27-35 added; remaining claims unchanged (2 pages)]

24. The portable oxygen concentrator system of claim 23, further including a variable-speed compressor to supply compressed ambient air to the concentrator, and the rotation speed of the rotary valve shoe with respect to the valve port plate is varied in combination with variation in the speed of the variable-speed compressor in order to provide desired cycle timing and desired supply rate of ambient air to the concentrator for a given production of product.

25. The portable oxygen concentrator system of any of claims 1-24, wherein the rotary valve assembly includes a valve port plate and a rotary valve shoe having respective engaged surfaces and relatively rotatable about a common center of rotation to provide valving action for selectively transferring fluids therethrough, and the rotary valve shoe includes a vacuum sealing mechanism that counteracts a pressure force working to unseat the rotary valve shoe from the valve port plate.

27. A portable oxygen concentrator system adapted to be readily transported by a user, comprising:

an internal rechargeable energy source;

an air separation device powered by said energy source and adapted to convert ambient air into concentrated oxygen gas for said user, the air separation device including a plurality of adsorber columns and a rotating valve, the rotating valve relatively rotatable with respect to the plurality of adsorber columns to provide valving action for selectively transferring fluids through the plurality of adsorber columns for converting ambient air into concentrated oxygen gas for said user,

wherein the portable oxygen concentrator system weighs 2-15 pounds and the adsorber columns each including a layered adsorbent bed having two or more distinct adsorbent material layers.

28. The portable oxygen concentrator system of claim 27, wherein the adsorber columns each include a feed end and a product end, and the two or more distinct adsorbent material layers include at least a water adsorption layer and a nitrogen adsorption layer, the water adsorption layer located closer to the feed end than the nitrogen adsorption layer.

29. The portable oxygen concentrator system of claim 28, wherein the water adsorption layer is an activated alumina.

30. The portable oxygen concentrator system of claim 28, wherein the water adsorption layer is a silica gel.

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31. The portable oxygen concentrator system of any of claims 28-30, wherein the nitrogen adsorption layer is a lithium exchanged X-type zeolite.

32. A portable oxygen concentrator system adapted to be readily transported by a user, comprising:

an internal rechargeable energy source;

an air separation device powered by said energy source and adapted to convert ambient air into concentrated oxygen gas for said user, the air separation device including a plurality of adsorber columns each including a feed end and a product end and at least one valve operable with respect to the plurality of adsorber columns to provide valving action for selectively transferring fluids through the plurality of adsorber columns for converting ambient air into concentrated oxygen gas for said user,

wherein the portable oxygen concentrator system weighs 2-15 pounds and the adsorber columns each including a layered adsorbent bed having two or more distinct adsorbent material layers, the two or more distinct adsorbent material layers including at least a water adsorption layer and a nitrogen adsorption layer, the water adsorption layer located closer to the feed end than the nitrogen adsorption layer.

33. The portable oxygen concentrator system of claim 32, wherein the water adsorption layer is an activated alumina.

34. The portable oxygen concentrator system of claim 32, wherein the water adsorption layer is a silica gel.

35. The portable oxygen concentrator system of any of claims 32-34, wherein the nitrogen adsorption layer is a lithium exchanged X-type zeolite.

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Statement Under PCT Article 19(1)

New claims have been added to further refine and clarify the claimed invention. Prior pending claims 1-25 have not been amended. Claim 26 has been cancelled.

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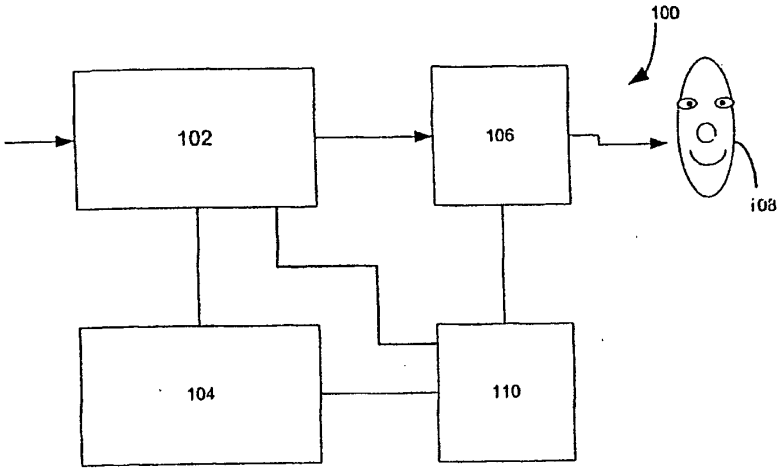


Figure 1

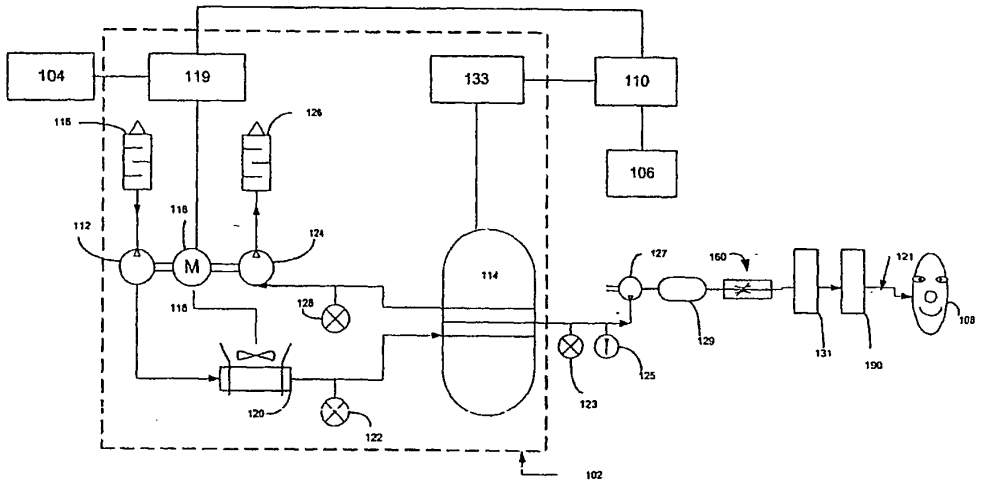


Figure 2

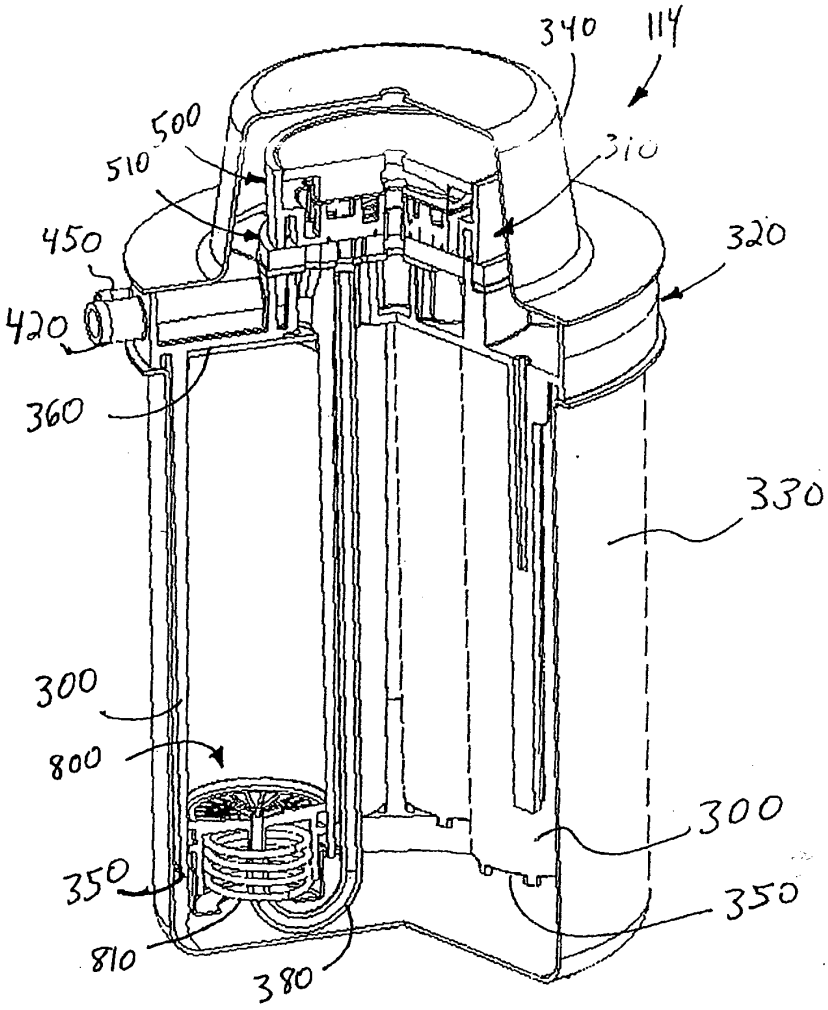

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Figure 3A

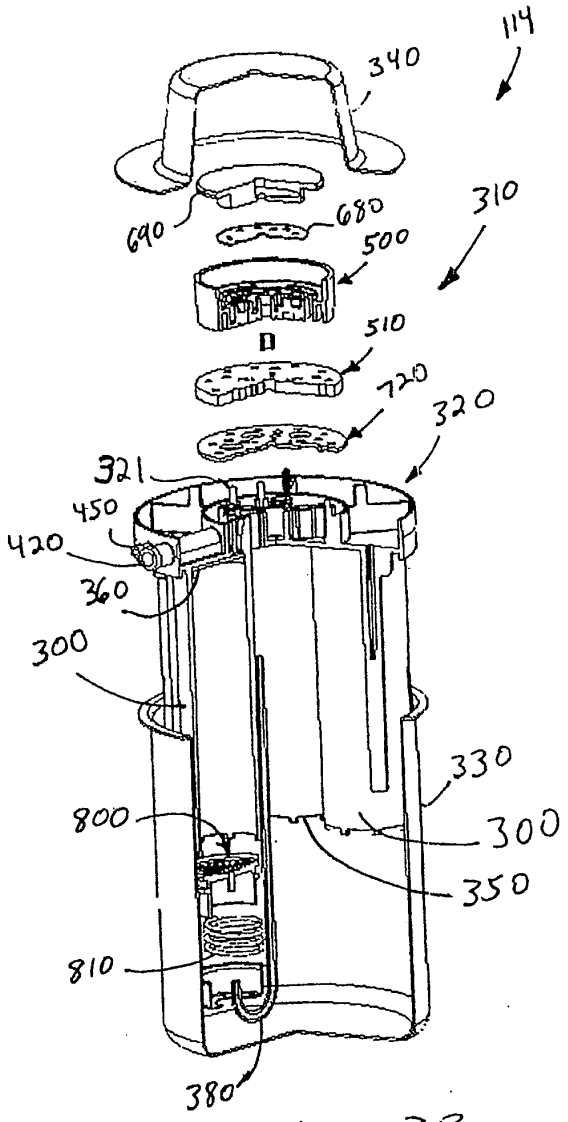

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Figure 3B

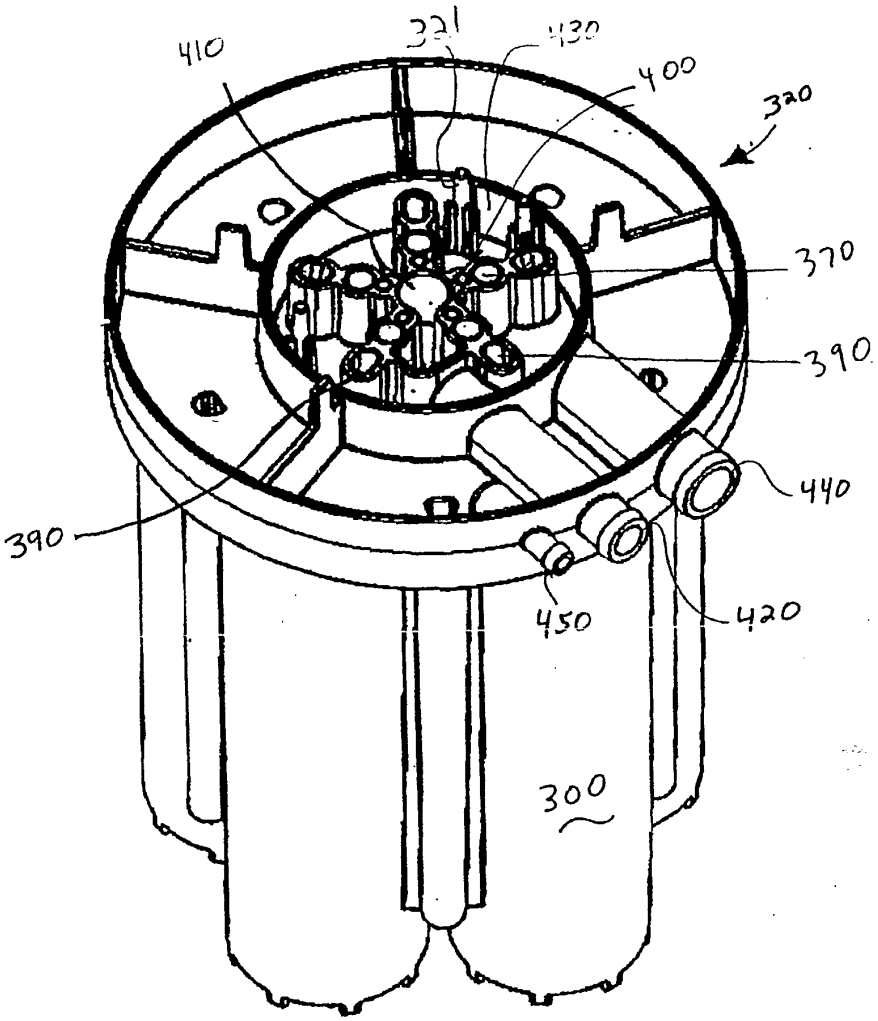


Figure 4

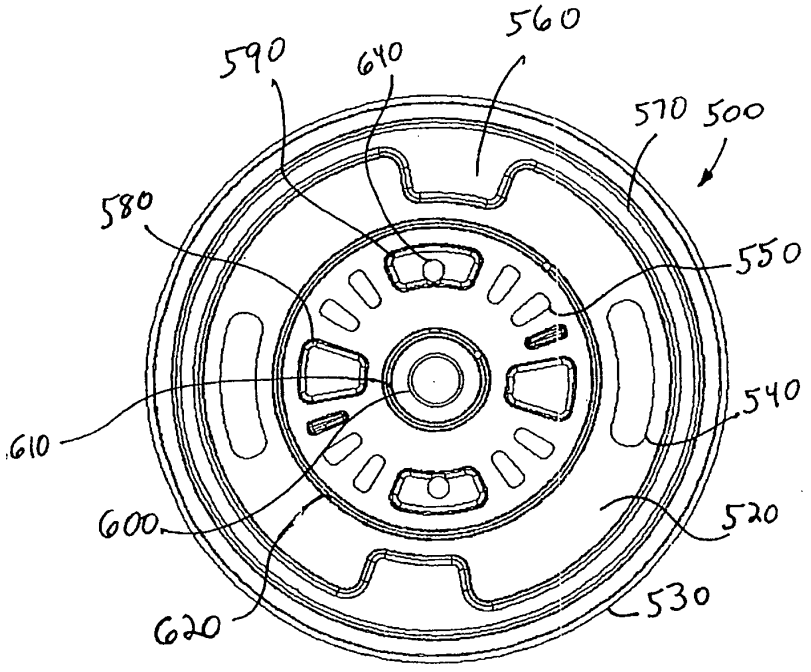


Figure 5A

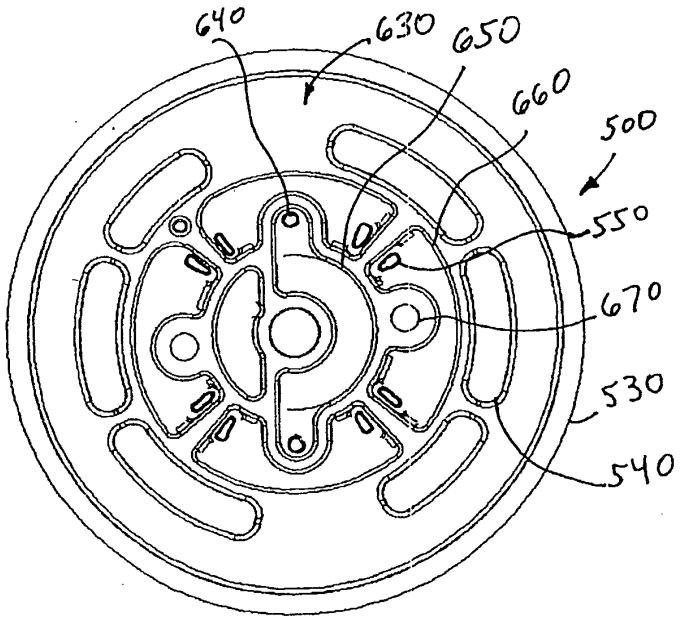


Figure 5B

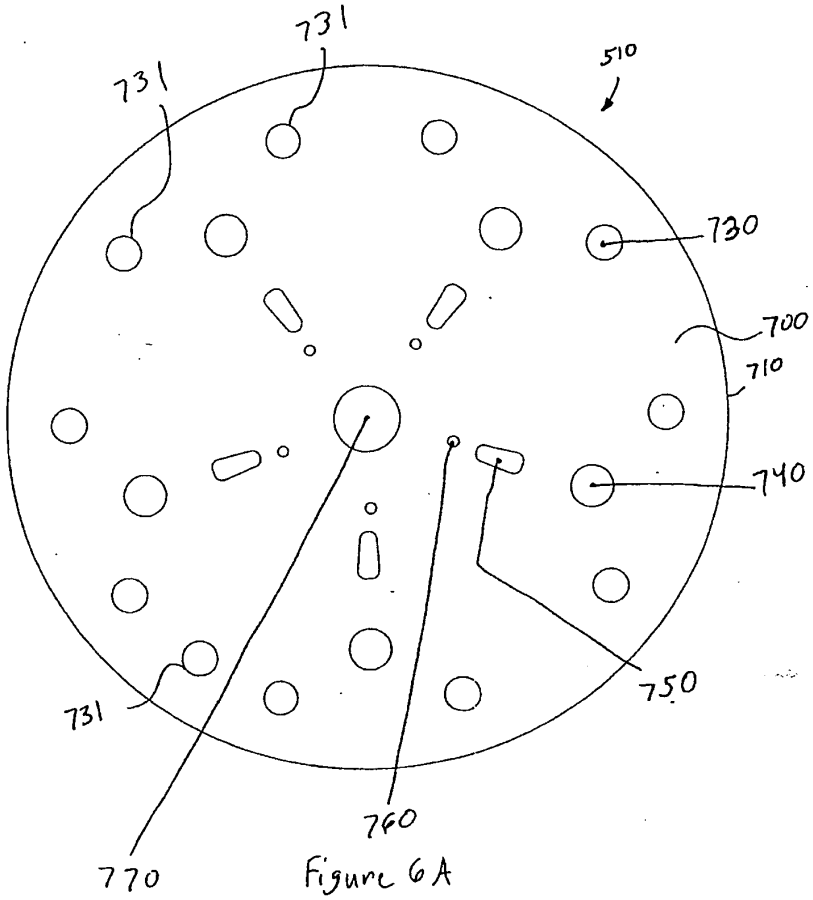


Figure 6A

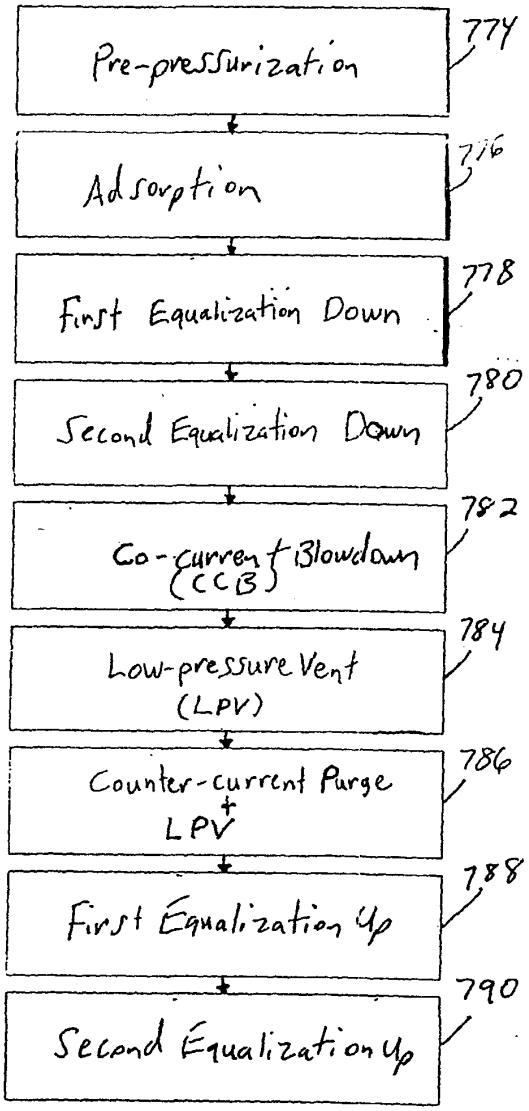

Pre-pressurization
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Adsorption
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First Equalization Down
778
Second Equalization Down
780
Co-current Blowdown (CCB)
782
Low-pressure Vent (LPV)
784
Counter-current Purge + LPV
786
First Equalization Up
788
Second Equalization Up
790

Figure 6B

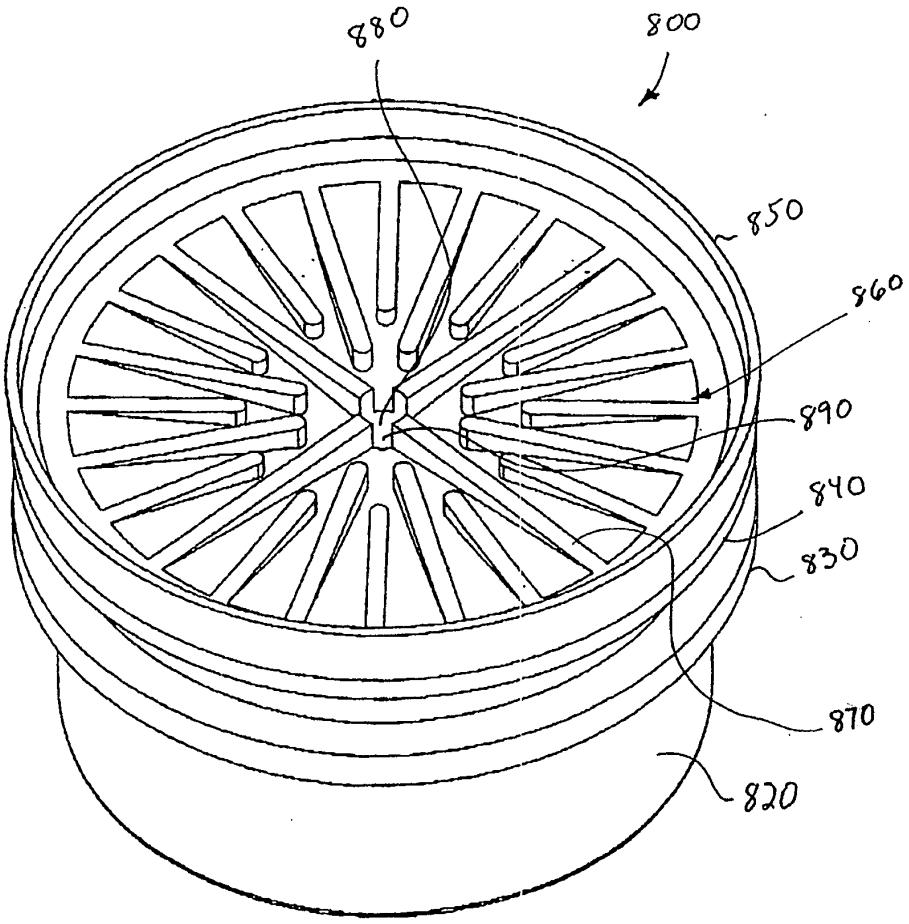


Figure 7A

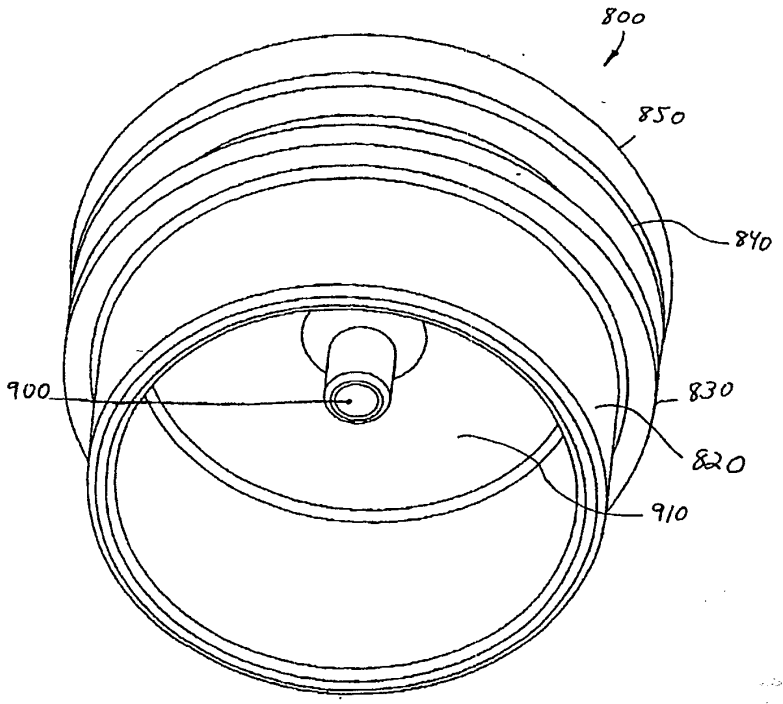


Figure 7B

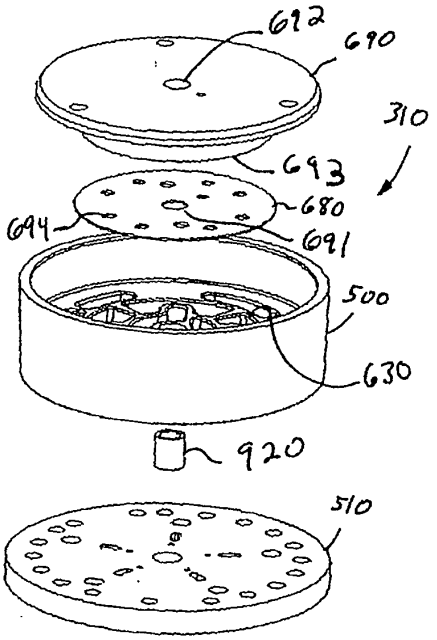


Figure 8A

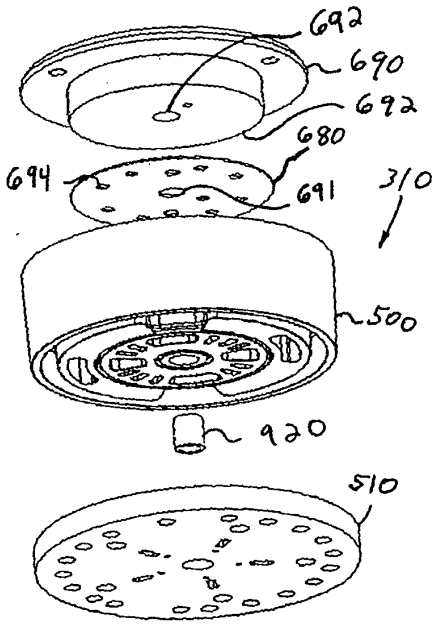


Figure 8B

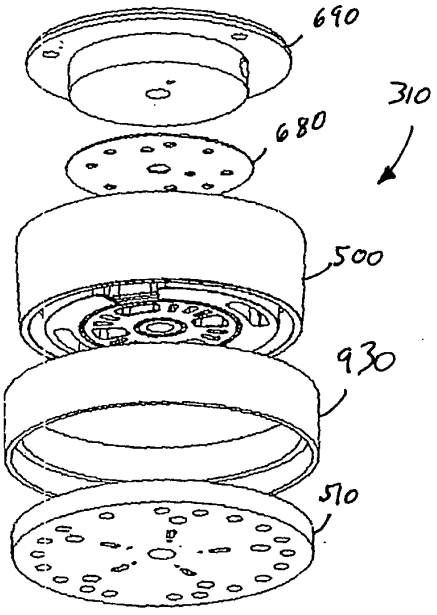


Figure 9A

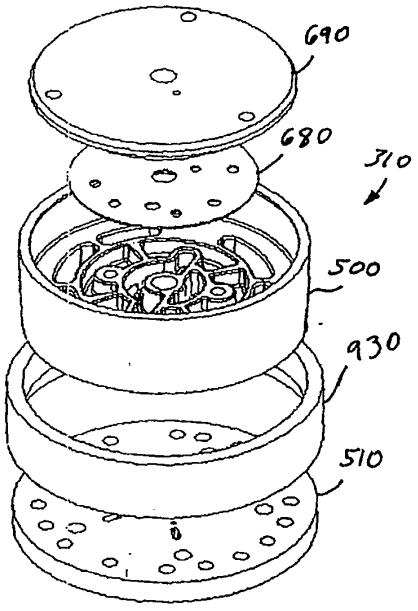


Figure 9B

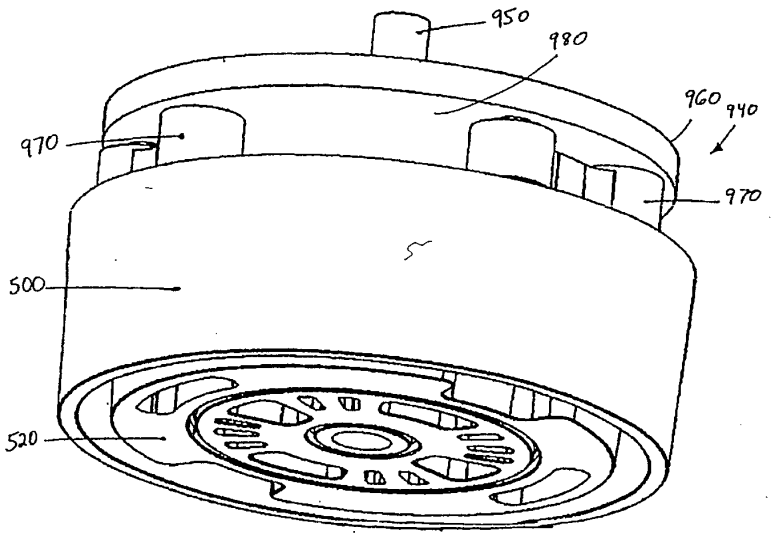


Figure 10A

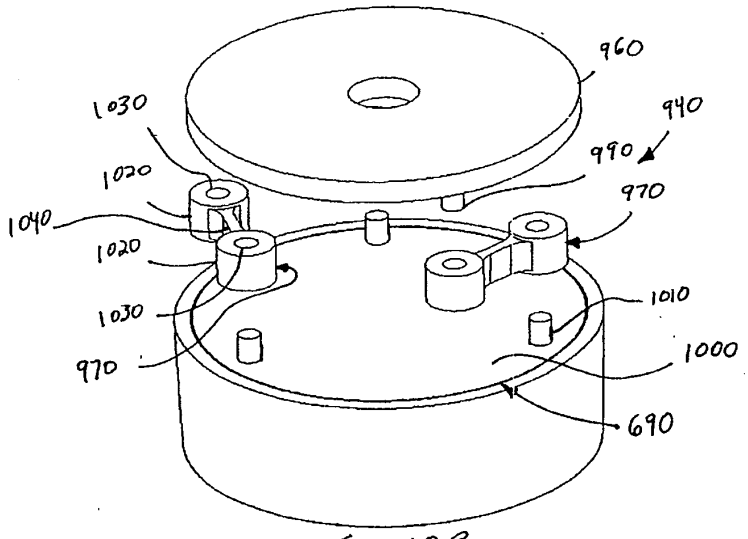


Figure 10B

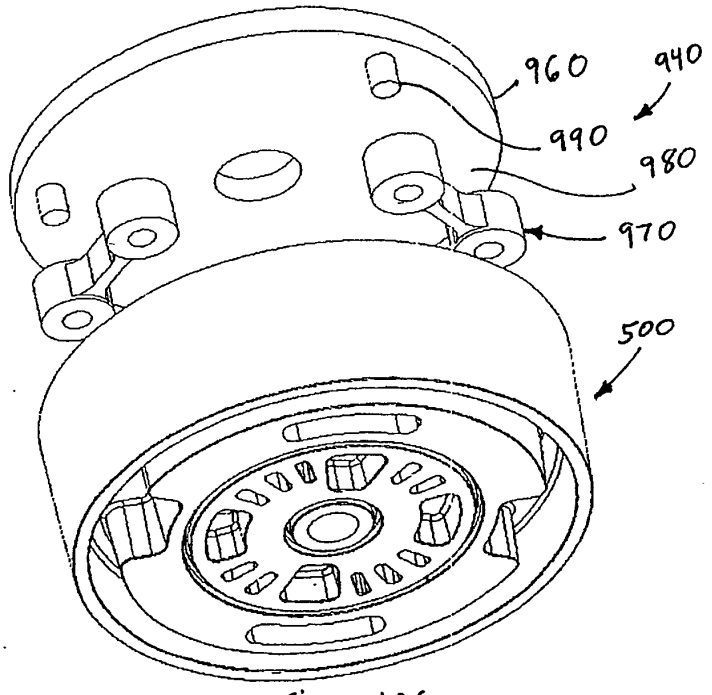


Figure 10C

Product Flow Rate (slpm)	Recovery (%)	Product Purity (%)	Feed Pressure (psig)	Vacuum Pressure (psig)	Flow Rate (slpm)		Adiabatic Work (W)*		
					Comp.	Vacuum	Comp	Vacuum	Total
3.0	55.1	91.7	7.7	-7.0	23.8	20.8	17.9	20.6	38.5
3.0	53.6	90.4	7.2	-7.0	24.1	21.1	17.1	21.2	38.3
3.0	53.6	90.9	7.2	-7.0	24.2	21.2	17.2	21.2	38.4
1.0	54.6	91.6	9.0	-7.0	8.0	7.0	6.9	7.0	13.9
2.0	57.2	92.0	10.6	-7.0	15.3	13.3	15.2	13.3	28.4
3.0	54.9	92.3	9.6	-7.5	24.0	21.0	21.8	22.9	44.7
2.8	51.7	93.6	10.1	-7.4	24.1	21.3	22.9	22.8	45.8
2.5	46.3	94.5	10.3	-7.5	24.3	21.8	23.5	23.8	47.2
3.2	56.3	90.7	9.9	-7.5	24.6	21.4	23.0	23.3	46.3
3.4	58.4	88.0	9.9	-7.0	24.4	21.0	22.8	20.9	43.7
2.0	46.9	94.7	12.1	-7.1	19.3	17.3	21.3	17.5	38.8
2.2	51.3	94.3	11.9	-7.2	19.3	17.1	21.0	17.6	38.6
2.4	55.6	93.6	11.7	-7.3	19.3	16.9	20.8	17.7	38.5
2.5	57.9	92.7	11.1	-7.3	19.1	16.6	19.7	17.4	37.1
2.8	61.8	89.0	11.3	-7.2	19.2	16.4	20.0	16.9	37.0
1.5	58.1	94.3	10.8	-7.2	11.2	9.8	11.3	10.1	21.4
1.5	59.9	94.0	10.8	-7.2	11.2	9.7	11.3	10.0	21.3
1.6	67.3	90.1	10.4	-7.3	11.2	9.4	10.9	9.9	20.8
1.0	64.0	94.1	9.0	-7.2	7.0	6.0	6.1	6.2	12.3
1.2	70.4	86.3	8.5	-7.4	7.0	5.8	5.8	6.2	12.0
1.1	68.1	90.3	8.7	-7.3	7.0	5.9	5.8	6.2	12.0
2.5	45.5	94.4	9.5	-6.1	24.7	22.2	22.3	18.8	41.1
2.8	50.5	93.7	9.7	-6.2	24.8	22.0	22.8	18.9	41.7
3.0	54.1	92.5	10.1	-6.3	24.4	21.4	23.2	18.6	41.8
3.2	56.3	90.7	9.9	-6.4	24.6	21.4	22.9	18.8	41.7
3.5	59.2	87.4	9.7	-6.4	24.6	21.1	22.7	18.8	41.5
1.0	46.0	90.9	5.8	-5.3	9.4	8.4	5.5	5.9	11.5
2.0	47.8	90.5	6.7	-5.4	18.0	16.0	12.0	11.6	23.6
3.0	48.2	90.7	10.1	-5.6	26.9	23.9	25.6	17.9	43.5
1.0	52.3	92.3	5.7	-6.1	8.4	7.4	4.9	6.1	11.0
1.0	51.3	91.1	5.3	-6.0	8.5	7.5	4.6	6.2	10.8
2.0	51.6	92.4	7.3	-5.9	17.1	15.1	12.2	12.2	24.4
2.0	52.4	91.5	7.1	-5.9	16.6	14.6	11.7	11.8	23.5
3.0	48.6	89.9	8.5	-5.8	26.4	23.4	21.8	18.3	40.1
3.0	48.9	90.7	8.8	-5.8	26.5	23.5	22.6	18.4	40.9

Figure 11

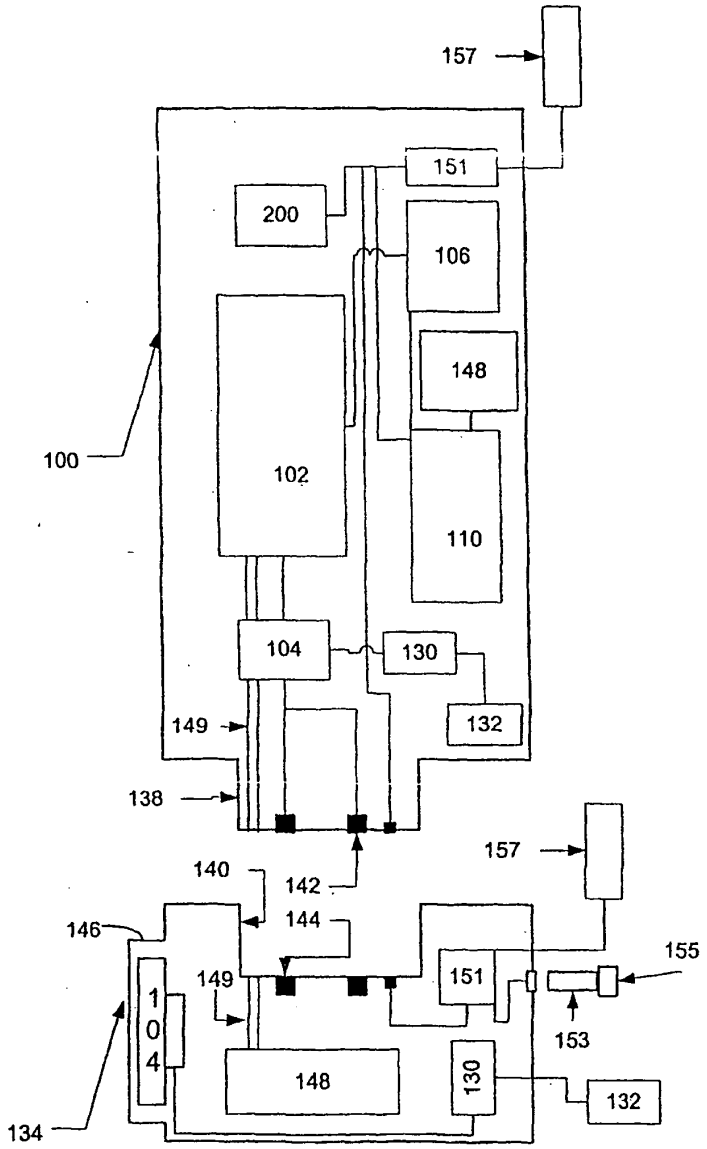

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Figure 12

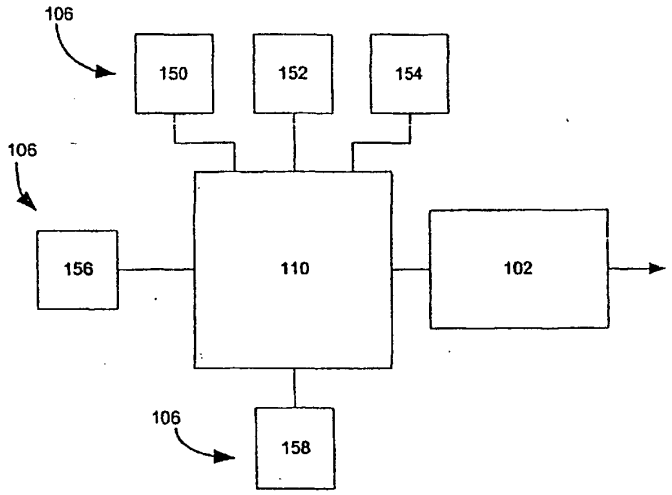


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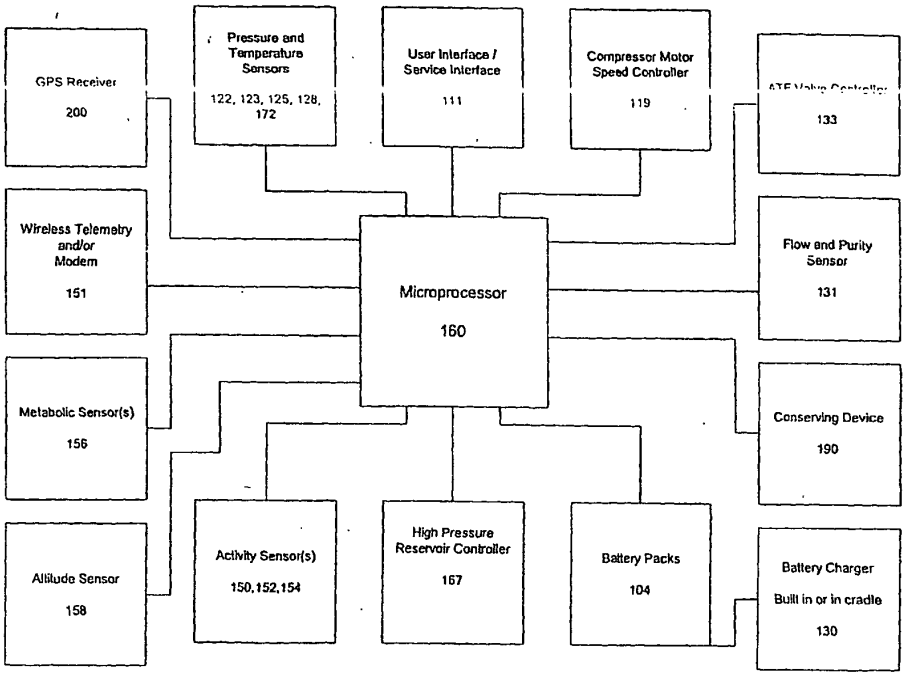


Figure 14

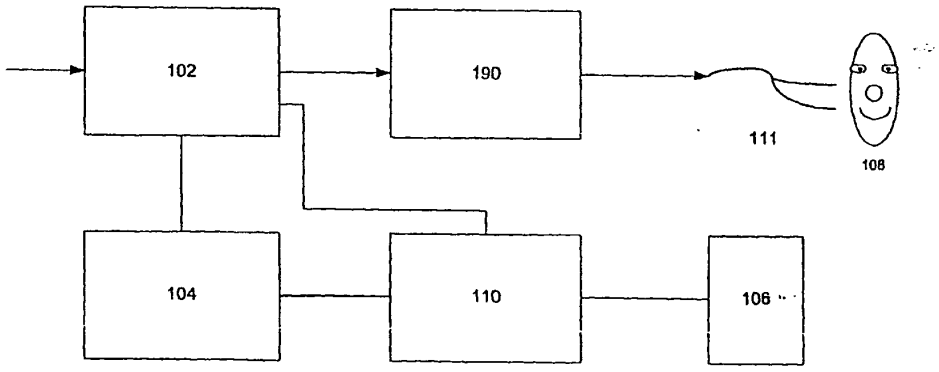


Figure 15

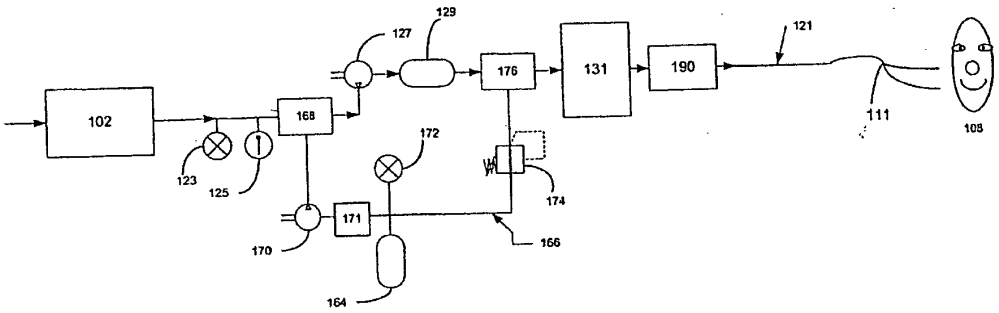

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Figure 16

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US03/13496

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : A62B 7/10, 9/00, 19/00, 23/02; A61M 16/00; F24J 3/00; G05B 1/00
US CL : 128/201.25, 204.17, 205.11, 205.18

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : 128/201.25, 204.17, 205.11, 205.18

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5, 268, 021 A (HILL et al) 7 December 1993, see entire document	26
X	US 5, 366, 541 (HILL et al) 22 November 1994, see entire document	26
X	US 5,827, 358 (KULISH et al) 27 October 1998, see entire document	26
A	US 5, 882, 380 A (SIRCAR) 16 march 1999, see entire document	1-26
A	US 6, 056, 804 A (KEEFER et al) 02 May 2000, see entire document	1-26
A	US 4, 576, 616 A (MOTTRAM et al) 18 March 1986, see entire document	1-26

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

* Special categories of cited documents:

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

"E" earlier application or patent published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search
15 September 2003 (15.09.2003)

Date of mailing of the international search report
02 OCT 2003

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Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
Facsimile No. (703)305-3230

Authorized officer
Weilun Lo
Telephone No. 308-0858

Form PCT/ISA/210 (second sheet) (July 1998)

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PATENT APPLICATION FEE DETERMINATION RECORD
Effective December 8, 2004

11054615

CLAIMS AS FILED - PART I

	(Column 1)	(Column 2)
TOTAL CLAIMS	16	
FOR	NUMBER FILED	NUMBER EXTRA
TOTAL CHARGEABLE CLAIMS	16 minus 20=	* —
INDEPENDENT CLAIMS	2 minus 3 =	* —
MULTIPLE DEPENDENT CLAIM PRESENT		☐

* If the difference in column 1 is less than zero, enter "0" in column 2

SMALL ENTITY TYPE ☐		OR	OTHER THAN SMALL ENTITY	
RATE	FEE		RATE	FEE
BASIC FEE	150	OR	BASIC FEE	
X$ 25=		OR	X$50=	
X100=		OR	X200=	
+180=		OR	+360=	
TOTAL	150	OR	TOTAL	

CLAIMS AS AMENDED - PART II

AMENDMENT A

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA
Total	*	Minus	**	=
Independent	*	Minus	***	=
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM				☐

SMALL ENTITY		OR	OTHER THAN SMALL ENTITY	
RATE	ADDITIONAL FEE		RATE	ADDITIONAL FEE
X$ 25=		OR	X$50=	
X100=		OR	X200=	
+180=		OR	+360=	
TOTAL ADDIT. FEE		OR	TOTAL ADDIT. FEE	

AMENDMENT B

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA
Total	*	Minus	**	=
Independent	*	Minus	***	=
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM				☐

RATE	ADDITIONAL FEE		RATE	ADDITIONAL FEE
X$ 25=		OR	X$50=	
X100=		OR	X200=	
+180=		OR	+360=	
TOTAL ADDIT. FEE		OR	TOTAL ADDIT. FEE	

AMENDMENT C

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA
Total	*	Minus	**	=
Independent	*	Minus	***	=
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM				☐

RATE	ADDITIONAL FEE		RATE	ADDITIONAL FEE
X$ 25=		OR	X$50=	
X100=		OR	X200=	
+180=		OR	+360=	