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(54) **HIGH EFFICIENCY LIQUID OXYGEN STORAGE AND DELIVERY SYSTEM**

FLÜSSIGSAUERSTOFFBEHÄLTER UND ZULEITUNGSSYSTEM MIT HOHER LEISTUNGSFÄHIGKEIT

SYSTEME EXTREMEMENT EFFICACE SERVANT A CONTENIR ET A ADMINISTRER DE L'OXYGENE LIQUIDE

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(56) References cited:
WO-A-98/58219 **US-A- 4 211 086**
US-A- 5 417 073

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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention.

[0001] The present invention relates generally to a liquid oxygen storage and delivery system.

2. Description of the Background Art.

[0002] Therapeutic oxygen is the delivery of relatively pure oxygen to a patient in order to ease pulmonary/respiratory problems. When a patient suffers from breathing problems, inhalation of oxygen may ensure that the patient is getting an adequate level of oxygen into his or her bloodstream.

[0003] Therapeutic oxygen may be warranted in cases where a patient suffers from a loss of lung capacity for some reason. Some medical conditions that may make oxygen necessary are chronic obstructive pulmonary disease (COPD) including asthma, emphysema, etc., as well as cystic fibrosis, lung cancer, lung injuries, and cardiovascular diseases, for example.

[0004] Related art practice has been to provide portable oxygen in two ways. In a first approach, compressed oxygen gas is provided in a pressure bottle, and the gas is output through a pressure regulator through a hose to the nostrils of the patient. The bottle is often wheeled so that the patient may be mobile. This is a fairly simple and portable arrangement.

[0005] The drawback of compressed, gaseous oxygen is that a full charge of a bottle that is portable does not last a desirable amount of time.

[0006] In order to get around this limitation, in a second approach a related art liquid oxygen (LOX) apparatus has been used wherein LOX is stored in a container and the gaseous oxygen formed from the LOX is inhaled by the patient.

[0007] The related art LOX apparatus enjoys a longer usable charge than the compressed gas apparatus for any given size and weight, but has its own drawbacks.

[0008] US Patent No. US 4,211,086 discusses a cryogenic breathing system where vaporization of the liquid oxygen is minimized by the use of an outer casing and inner container forming an evacuable space there between that includes insulating means to inhibit heat transfer between the inner container and ambient atmosphere.

[0009] Related art LOX systems typically include a stationary storage container located in a patient's home and a portable unit that the patient uses outside the home. The stationary storage container must be periodically refilled with LOX by a distributor.

[0010] A significant percentage of the cost of having a LOX system is in the cost of frequent recharging trips by the LOX distributor. A distributor may have to make weekly recharge trips to a patient's home, or even more frequently, to recharge the patient's LOX system. There thus is a need in the art to cut deliveries or cut costs in other ways.

[0011] The main drawback of the related art is that considerable waste occurs. One source of waste is that prior art devices provide continuous flow. Also, in the related art, the portable unit may be filled with LOX and used for normal activities and movement. When the patient is done using the related art portable unit, remaining LOX left within the related art portable unit is vented, wasting any remaining oxygen. Because the LOX continues to convert to gaseous oxygen when not being withdrawn, venting is provided for in both the stationary and portable related art units. When the pressure in the related art stationary unit increases beyond a certain point (such as when the related art portable unit is being used), the related art stationary unit must be vented.

[0012] There remains a need in the art, therefore, for an improved LOX storage and delivery system, with less gas consumption and requiring fewer deliveries of LOX to the patients home.

SUMMARY OF THE INVENTION

[0013] In accordance with the invention there is provided a portable, high-efficiency liquid oxygen (LOX) storage/delivery apparatus comprising a portable LOX container, a portable-unit LOX transfer connector connected to said portable container and capable of receiving and transferring LOX to said portable container, a portable-unit oxygen gas transfer connector for transferring oxygen gas from the portable LOX container to an oxygen gas delivery device for delivery, and an inter-unit oxygen gas transfer connector capable of receiving and transferring oxygen gas to said portable container. A high-efficiency liquid oxygen (LOX) storage/delivery system is also provided according to another aspect of the invention. The high-efficiency liquid oxygen (LOX) storage/delivery system includes a primary reservoir LOX storage/delivery apparatus comprising a primary reservoir LOX container and a portable LOX/delivery apparatus including a portable LOX container, as defined above. The primary reservoir LOX apparatus includes a main LOX transfer connector connected to the primary reservoir LOX container for inputting LOX into the primary reservoir LOX container and for outputting LOX from the primary reservoir LOX container to the portable LOX container, and a main-unit oxygen gas transfer connector for transferring oxygen gas from the primary reservoir LOX container. A primary reservoir indicator device may be connected to the primary reservoir LOX container for indicating the LOX contents of the primary reservoir LOX container. A main-unit primary relief valve may be connected to the primary reservoir LOX container for venting oxygen gas out of the primary reservoir LOX container when pressure of oxygen gas in the primary reservoir LOX container reaches a predetermined level for the primary reservoir container. The portable LOX apparatus includes a portable-unit LOX transfer connector connected to the portable LOX container and connectable to the main LOX transfer connector for transferring LOX to the portable container from the primary reservoir container, a portable-unit oxygen gas transfer connector for transferring oxygen gas from the portable LOX container to an oxygen gas delivery device for delivering oxygen gas to a patient, an inter-unit oxygen gas transfer connector for connecting the portable apparatus to the main-unit oxygen gas transfer connector for transferring oxygen gas from the primary reservoir container to the portable apparatus, and may also comprise a portable-unit primary relief valve connected to the portable LOX container for venting oxygen gas out of the portable LOX container when pressure in the portable LOX container reaches a predetermined level for the portable container. When the inter-unit oxygen gas transfer connector of the portable container is connected to the main-unit oxygen transfer connector of the primary reservoir container, oxygen gas can be transferred from the portable container to the oxygen gas delivery device while oxygen gas is transferred to the portable container from the primary reservoir LOX container.

[0014] A method for utilizing a high-efficiency liquid oxygen (LOX) storage/delivery system is provided according to a second aspect of the invention. One method comprises connecting the inter-unit oxygen gas transfer connector of a portable container to the main-unit oxygen transfer connector of a primary reservoir container, and withdrawing oxygen gas from the portable container through the portable-unit oxygen gas transfer connector while oxygen gas is transferred to the portable apparatus from the primary reservoir container through the main-unit oxygen transfer connector. The oxygen gas may be subsequently transferred to a patient.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015]

FIG. 1 schematically shows one embodiment of a high efficiency LOX system of the present invention, and illustrates how the primary reservoir and portable LOX storage/deliver apparatus may be interconnected;

FIG. 2 schematically shows detail of one embodiment of the primary reservoir LOX storage/delivery apparatus;

FIG. 3 schematically shows detail of one embodiment of the portable LOX storage/delivery apparatus.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0016] FIG. 1 shows one embodiment of a high efficiency LOX system 100 of the present invention. The LOX system 100 includes a primary reservoir LOX storage/delivery apparatus (primary reservoir apparatus) 120 and a portable LOX storage/delivery apparatus (portable apparatus) 160. An umbilical conduit 110 may extend between an inter-unit oxygen gas transfer connector 190 of the portable apparatus 160 and a main-unit oxygen gas transfer connector 213 of the primary reservoir apparatus 120, and may be used to transfer gaseous oxygen therebetween. An oxygen delivery device 90, such as a mask or nasal tubes or cannulas may be attached to either apparatus in order to deliver gaseous oxygen to a patient. Alternatively, the inter-unit oxygen gas transfer connector 190 may be directly connected to the main-unit oxygen gas transfer connector 213.

[0017] Because LOX transforms from a liquid to a gas as heat is added related art LOX systems have typically relied on venting of excess gaseous pressure to maintain acceptable internal pressure levels. The result is a higher cost for the health care provider. Pressure control of the portable apparatus 160 and the primary reservoir apparatus 120 is of great importance, as keeping pressures down yields a safe, light weight, economical system through the reduction or elimination of venting. The present invention achieves such economy by balancing use of the primary reservoir apparatus 120 and portable apparatus 160 so that internal pressures do not build up to a point where either apparatus must be excessively vented. The LOX system 100 therefore allows usage cycles that make possible efficient LOX use without excessive venting.

[0018] The primary reservoir apparatus 120 can be of any usable size for storage and delivery of LOX over a desired time period. Suitable units in accordance with the present invention can hold from 20-60 or more liters of LOX. In accordance with one embodiment a primary reservoir container holding about 36 liters (about 39 kg (85 pounds)) of LOX is provided. In a second embodiment, a primary reservoir container holding about 43 liters (about 50 kg (110 pounds)) of LOX is provided.

[0019] The primary reservoir apparatus 120 includes the main LOX storage and container. The LOX may be transferred from the primary reservoir apparatus 120 to the portable apparatus 160 as needed to charge the portable apparatus 160 for mobile use. The primary reservoir apparatus 120 is intended to hold a sufficiently large charge so that the primary reservoir apparatus 120 can recharge the portable apparatus 160 on a substantially daily basis for a substantially long period of time, e.g., up to about one month or more. This can reduce recharge costs by up to seventy-five percent or more over the related art.

[0020] The portable apparatus 160 preferably is about 1.6 kg (3.5 pounds) fully charged with LOX and about 1.1 kg (2.5 pounds) empty, is much smaller and lighter than the primary reservoir apparatus 120, and may provide gaseous oxygen to the patient while being carried by the patient.

[0021] In use, the primary reservoir apparatus 120 is charged with LOX. The patient may use gaseous oxygen from the primary reservoir apparatus 120 directly via the main-unit oxygen gas transfer connector 213, or may transfer LOX to the portable apparatus 160 wherein the patient may withdraw gaseous oxygen from the portable apparatus 160. The portable apparatus 160 allows the patient mobility outside the home, while the umbilical conduit 110, which may be up to 15-30 m (50-100 feet) in length or longer, allows the patient to connect the portable apparatus to the main reservoir container to conserve LOX.

[0022] The inter-unit oxygen gas transfer connector 190 may be connected to the main-unit oxygen gas transfer connector 213 of the primary reservoir apparatus 120 to allow oxygen gas withdrawal alternatively from either the portable apparatus 160 or the primary reservoir apparatus 120, or simultaneously from both.

[0023] FIG. 2 shows detail of one embodiment of the primary reservoir apparatus 120. The primary reservoir apparatus 120 includes a primary reservoir container assembly 205, a main LOX transfer connector 209, a main-unit oxygen gas transfer connector 213, and a main-unit primary relief valve 257. In the embodiment shown, a primary indicator device 274 also is included.

[0024] The primary reservoir container assemble 205 include an outer container 223, an inner primary reservoir LOX container 226 spaced apart from the outer container 223, insulation 229 located between the outer container 223 and the inner container 226, a molecular sieve 231, and a vacuum plug 235. The space between the outer container 223 and the inner container 226 is preferably evacuated to at least a partial vacuum in order to minimize heat transfer to the LOX inside the inner container 226.

[0025] The primary reservoir LOX container assembly 205 also includes an outlet port 238, through which passes a neck conduit 242. The neck conduit 242 extends a short distance into the inner container 226, and is employed for gaseous oxygen withdrawal from the primary reservoir LOX container 226. Inside the neck conduit 242 is a fill conduit 244, preferably concentric with the neck conduit 242. The fill conduit 244 may be used to fill the primary reservoir LOX container 226 with LOX Inside the fill conduit 244 is a liquid withdrawal conduit 247, preferably concentric with the fill conduit 244. The liquid withdrawal conduit 247 may be used to withdraw LOX from the primary reservoir LOX container 226.

[0026] Above the outlet port 238 of the primary reservoir LOX container 205 the neck conduit 242 splits into two independent conduits. A main-unit vent valve conduit 250 leads to a main-unit vent valve 251 which is openable for filling inner container 226 with LOX through the main LOX transfer connector 209. When filling inner container 226 with LOX, main unit vent valve 251 is opened until liquid exits valve 251, indicating that container 226 is filled with LOX.

[0027] Relief/economizer conduit 255 leads to a main-unit primary relief valve 257 and an economizer valve 261. The main-unit primary relief valve 257 is provided for relieving excess internal gas pressure from the primary reservoir LOX container 226 if the internal gas pressure exceeds a predetermined limit, e.g., 380,000 Pa (55 psi). Conduit 255 also leads to a main-unit secondary relief valve 258, which can be set at the same or a higher level (e.g., 10-20% higher) than the main-unit primary relief valve, and is a back-up thereto in case of failure thereof.

[0028] Conduit 255 further leads to an economizer valve 261, the purpose of which will be explained below.

[0029] Above the neck conduit 242 extends the fill conduit 244, which extends upward to the main-unit LOX transfer connector 209. Between the top of the neck conduit 242 and the main-unit LOX transfer connector 209 is a tee 263, where the liquid withdrawal conduit 247 exits the fill conduit 244. After exiting the fill conduit 244, the liquid withdrawal conduit 247 encounters a second tee 264 that joins the liquid withdrawal conduit 247 with an economizer conduit 266 in advance of a warming coil 269. The economizer conduit 266 connects the economizer valve 261 with warming coil 269. Gaseous oxygen passes through economizer valve 261 when the economizer valve is open. In order to conserve LOX, the economizer valve 261 can be set at any suitable level below the primary and secondary relief valve settings, so that gaseous oxygen will pass through the economizer valve 261 into the warming coil 269 before such gaseous oxygen is vented through the main-unit primary relief valve 257 or the main-unit secondary relief valve 258. One suitable setting for the economizer valve 261 is 152,000 Pa (22 psi). The liquid withdrawal conduit 247 supplies LOX to the warming coil 269, while the economizer conduit 266 supplies gaseous oxygen withdrawn by way of the relief/economizer conduit 255. In the warming coil 269 the withdrawn LOX and gaseous oxygen is warmed by exposure to room temperature, speeding the liquid-to-gas transformation. It should be noted that the inside diameter of the warming coil 269 may be greater than the inside diameter of the liquid withdrawal conduit 247, allowing the LOX to expand as it warms up and transforms from a liquid phase to a gaseous phase. However, the inside diameter of the liquid withdrawal conduit 247 preferably is sized so that when the economizer valve 261 is open, gas flow through line 266 is favored to warming coil 269 over liquid withdrawal through conduit 247. In the embodiment shown, the warming coil 269 is connected to a pressure regulator 271 which can maintain a desired operating pressure at a main-unit oxygen gas transfer connector 213.

[0030] In the embodiment shown, the primary reservoir LOX container 205 includes a primary indicator device 274 that indicates a LOX level in the primary reservoir LOX container 226. The primary indicator device 274 is connected to a bottom portion of the primary reservoir LOX container 226 via a high pressure sensing conduit 279. The primary indicator device 274 may be interconnected to a pressure gauge 217. The pressure gauge 217 gives a visual readout of an internal gas pressure for the primary reservoir LOX container 226, and may be, for example, a mechanical pressure gauge. The pressure gauge 217 is connected to conduit 255 via a low pressure sensing conduit 277.

[0031] In use, LOX may be added to or withdrawn from the primary reservoir LOX container 226 through the main-unit LOX transfer connector 209 and the fill conduit 244. The main-unit oxygen gas transfer connector 213 may be used to withdraw gaseous oxygen for use. The gaseous oxygen is provided to the main-unit oxygen gas transfer connector 213 from the economizer valve 261 and/or by conversion of LOX to gas through the liquid withdrawal conduit 247, both through the warming coil 269.

[0032] FIG. 3 shows detail of one embodiment of the portable apparatus 160. The portable apparatus 160 includes a portable LOX container 302, a portable-unit LOX transfer connector 304, a portable-unit oxygen gas transfer connector 384, an inter-unit oxygen gas transfer connector 190, and a portable-unit primary relief valve 315.

[0033] The portable container assembly 302 includes an outer container 318, an inner portable LOX container 319 spaced apart from the outer container 318, a fill conduit 322, a liquid withdrawal conduit 326, a vacuum plug 328, and a multi-lumen annular conduit 331. The space between the outer container 318 and the inner container 319 is preferably evacuated to at least a partial vacuum in order to minimize heat transfer to the LOX inside the inner container 319.

[0034] LOX may be introduced into the portable LOX container 319 through the portable-unit LOX transfer connector 304 and the fill conduit 322. The portable-unit LOX transfer connector 304 may be connected to the main-unit LOX transfer connector 209 of the primary reservoir apparatus 120; whereby the portable apparatus 160 may be filled with LOX from the primary reservoir apparatus 120.

[0035] LOX may be withdrawn via the liquid withdrawal conduit 326, and gaseous oxygen may be withdrawn via the neck conduit 331.

[0036] A manifold 336 is connected to the neck conduit 331, and splits the neck conduit 331 into a gaseous oxygen withdrawal conduit 339 and a vent conduit 341. The vent conduit 341 may include a vent valve 344. The vent valve 344 may be opened during filling of the portable LOX container 302. When LOX emerges from the vent conduit 341, it is a visual indication that the portable LOX container 319 is full.

[0037] In the embodiment shown, the liquid with drawal conduit 326 passes through the manifold 336 and is connected to a liquid withdrawal warming coil 349 in which the LOX can transform to the gaseous phase. The liquid withdrawal warming coil 349 warms the LOX by exposure to room temperature, speeding the liquid-to-gas transformation. It should be noted that the inside diameter of the liquid withdrawal warming coil 349 may be greater than the inside diameter of the liquid withdrawal conduit 326, allowing the LOX to expand as it warms up and transforms from a liquid phase to a gaseous phase.

[0038] The gaseous oxygen withdrawal conduit 339 connects with a gas withdrawal warming coil 352. The gas withdrawal warming coil 352 warms the gaseous oxygen before delivery to an oxygen user.

[0039] Connected to the gas withdrawal warming coil 352 is a portable-unit primary relief valve 315. The portable-unit primary relief valve 315 is capable of opening and relieving a gaseous oxygen pressure in the portable LOX container 319 if the internal gas pressure exceeds a predetermined level, e.g., 185,000 Pa (27 psi).

[0040] An economizer valve 356 connects the gas withdrawal warming coil 352 with conduit 380 containing gaseous oxygen from liquid withdrawal warming coil 349. The portable-unit economizer valve 356 can be set at any suitable level below the portable-unit primary relief valve 315, such as 152,000 Pa (22 psi), and allows gaseous oxygen from coil 352 to pass into line 380 when the pressure of the gaseous oxygen in the portable LOX container 319 exceeds the predetermined threshold level, e.g., 152,000 Pa (22 psi). In preferred embodiment, the inside diameter of the liquid withdrawal conduit 326 is sized so that when the portable-unit economizer valve 356 is open, gas flow through line 339 is favored over liquid flow through conduit 326. This permits gaseous oxygen from the gaseous head-space in portable container 319 to pass to the patient without the need to waste through the portable-unit primary relief valve 315. The portable-unit economizer valve 356 thus balancers gaseous and liquid oxygen withdrawal from the portable LOX container 319, and outputs a resulting gaseous oxygen to a conduit 309. A portable-unit secondary relief valve 382 is provided as a back-up unit to the portable-unit primary relief valve 315, and can be set at the same or a higher level than the portable-unit primary relief valve, and is a back-up thereto in case of failure thereof.

[0041] Although the function of the economizer valves of the present invention has been described above with reference to preferred embodiments, other configurations, utilizing operating systems of any suitable pressure, will fall within the scope of the present invention. For example, with systems operating at 138,000 Pa (20 psig), an economizer valve may be set at any suitable setting such as between 135,000 Pa and 152,000 (19.5 psig and 22 psig). Alternatively, for systems having operating pressures at about 345,000 Pa (50 psig), economizer valves having settings, for example, between 330,00 and 380,000 Pa (48 psig and 55 psig) can be utilized. Corresponding primary relief setting for a 138,000 Pa (20 psig) system can, for example, be between 145,000 and 165,000 Pa (21 psig and 24 psig). Corresponding primary relief settings for a 345,000 Pa (50 psig) system can, for example, be between about 345,000 and 400,000 Pa (50 psig and 58 psig). However, these configurations are merely exemplary, and other configurations can be utilized in accordance with the present invention.

[0042] The gaseous oxygen from the conduit 309 may be delivered to a demand flow control device 360, which also may receive gaseous oxygen from the primary reservoir apparatus 120 via the inter-unit oxygen gas transfer connector 190. A check valve 363 may be included between the conduit 309 and the inter-unit oxygen gas transfer connector 190 to prevent backflow of gaseous oxygen from the portable apparatus 160 to the primary reservoir apparatus 120.

[0043] The demand flow control device 360 is for adjustment of gas flow through a portable-unit oxygen gas transfer connector 384a to an oxygen delivery device 90 for delivery of gaseous oxygen to a patient.

[0044] Gaseous oxygen is provided to the patient through the portable-unit oxygen gas transfer connector 384a, either from the portable unit, or from the main reservoir unit through connector 190.

[0045] In preferred embodiments, the demand flow control device 360 can be connected to a gas conserving device 390. A known conserving device is disclosed in U.S. Patent No. 5,360,000.

[0046] In the embodiment shown, a gas transfer connector system 384a and 384b is utilized, so that when the patient exhales, flow to the oxygen delivery device 90 is stopped, and gas accumulates in the conserving device 390. When the patient inhales, a puff (bolus) of oxygen gas is delivered to the patient from conserving device 390, thereby further preventing waste of gaseous oxygen, followed by an even flow of gaseous oxygen, which then is stopped again when the patient exhales.

[0047] Use of a conserving device 390 with the portable apparatus of the present invention connected to the primary reservoir apparatus 120 through connector 190 results in tremendous savings and LOX conservation.

[0048] A method of utilizing the high-efficiency LOX storage/delivery system 100 of the present invention is disclosed. The method uses an umbilical conduit 110 to economize oxygen use by a patient and balance use of the primary reservoir apparatus 120 and portable apparatus 160 so that excess oxygen venting is avoided.

[0049] The main-unit oxygen gas transfer connector 213 is connected to the inter-unit oxygen gas transfer connector 190, e.g., by umbilical conduit 110. The connection allows gaseous oxygen to flow from the primary reservoir apparatus 120 to the portable apparatus 160. The gaseous oxygen from either the primary reservoir LOX storage delivery apparatus 120 or the portable apparatus 160 may be provided to the patient, depending on which has the higher gas pressure.

[0050] The umbilical conduit 110 may be a flexible conduit (such as a hose, for example) to give the portable apparatus 160 mobility while yet being connected to the primary reservoir apparatus 120. In this hookup, the oxygen deliver device 90 is connected to the demand flow control device 3 60 in order to provide gaseous oxygen to the patient.

[0051] The method may utilize a filling/using cycle of the portable apparatus 160. The method of filling/using of the present invention avoids or reduces unnecessary venting of either the portable apparatus 160 or the primary reservoir apparatus 120.

[0052] Gaseous oxygen is withdrawn from the primary reservoir 120 for a withdrawal time period, which preferably is at least 5 hours per day, more preferably about 10 hours per day or more. The withdrawal of gaseous oxygen from the primary reservoir apparatus 120 may be through oxygen deliver device 90 either connected directly to connector 213, or connected to connector 384 of the portable apparatus with connector 190 of the portable apparatus connected to the main reservoir apparatus. This gaseous withdrawal time period hook-up to the primary reservoir apparatus 120 permits withdrawal of gaseous oxygen from the primary reservoir LOX container without internal pressure in the primary reservoir LOX container reaching excess levels requiring venting. This conserving measure, in conjunction with economizer valve 261 (and economizer valve 356 if the portable unit is hooked-up), enables oxygen withdrawal without wasteful venting.

[0053] After the above-discussed withdrawal time period, the portable apparatus 160 may be filled with LOX from the primary reservoir apparatus 120 and disconnected, for example, if the patient wishes to go outside the home.

[0054] In preferred embodiments, the portable LOX container holds about 0.45 kg (1 pound) of LOX, which, when utilized with the portable LOX/delivery apparatus of the present invention, can last approximately 10 hours at a typical patient use/withdrawal rate of about 2 liters per minute.

[0055] During withdrawal of gaseous oxygen from the primary reservoir LOX apparatus, oxygen gas pressure in the primary reservoir LOX apparatus is reduced to a level at which the economizer valve is set (e.g., 152,000 Pa (22 psi)) such that after the portable container is filled with LOX and disconnected from the primary reservoir LOX apparatus, pressure may increase within the primary reservoir container for a gas pressurizing period within a range of 5-15 hours per day, e.g., about 10 hours per day, to a pressure of, for example, about 345,000Pa (50 psi) without LOX or oxygen gas being withdrawn from the primary reservoir container and without oxygen gas being vented from the primary reservoir container during the gas pressurizing period.

[0056] When the patient returns home prior to complete withdrawal of oxygen gas from the portable LOX container, the inter-unit oxygen gas transfer connector of the portable LOX container is connected to the main-unit oxygen transfer connector of the primary reservoir LOX container, and oxygen gas may be withdrawn from the portable LOX container or the primary reservoir LOX container while oxygen gas may be transferred to the portable LOX apparatus from the primary reservoir LOX container through the main-unit oxygen transfer connector, depending on the pressure differential between the containers.

[0057] In accordance with one embodiment, during the withdrawal period, the inter-unit oxygen gas transfer connector of me portable LOX container is connected to the main-unit oxygen transfer connector of the primary reservoir LOX container, and oxygen gas is transferred from the portable container to the oxygen gas delivery device alternately or concurrently with oxygen gas being transferred to the oxygen gas delivery device through the portable LOX apparatus from the primary reservoir LOX container, thereby lowering gas pressure in the primary reservoir LOX container.

[0058] The present invention can provide significant savings as compared to related art systems. For example, at a patient use rate of 2 liters per minute, related art systems utilize about 4.5 kg (10 pounds) LOX per day. The present invention can provide the same 2 liters per minute utilizing about 0.9 kg (2 pounds) LOX per day, a savings of up to about 3.6 kg (8 pounds) LOX per day.

[0059] While the invention has been described in detail above, and shown in the drawings, the invention is not intended to be limited to the specific embodiments as described and shown.

Claims

1. A portable, high-efficiency liquid oxygen (LOX) storage/delivery apparatus (160), comprising:

- a portable LOX container (302);
- a portable-unit LOX transfer connector (304) connected to said portable container and capable of receiving and transferring LOX to said portable container;
- a portable-unit oxygen gas transfer connector (384) for transferring oxygen gas from the portable LOX container to an oxygen gas delivery device (90) for delivery; and
- an inter-unit oxygen gas transfer connector (190) capable of receiving and transferring oxygen gas to said portable container.

2. The apparatus as claimed in claim 1 further comprising a portable-unit primary relief valve (315) connected to the portable LOX container for venting oxygen gas out of the portable LOX container when pressure in the portable LOX container reaches a predetermined level for said portable LOX container.

3. The apparatus as claimed in claim 1 or claim 2 which further comprises an economizer valve (356) for minimizing venting by balancing gaseous and liquid oxygen withdrawal from said portable LOX container (302).

4. The apparatus of claim 2, wherein said economizer valve (356) opens to allow oxygen gas from a gaseous head-space in said portable LOX container (302) to pass through when the pressure of said oxygen gas in said portable LOX container exceeds a predetermined threshold level and otherwise is closed and allows oxygen gas from evaporated LOX to pass through.

5. The apparatus of claim 3 or claim 4, further comprising a relief valve (315).

6. The apparatus of any one of the preceding claims, further comprising a conserving device (390).

7. The apparatus of claim 6 wherein when a patient using the device exhales, flow to the oxygen delivery device (90) is stopped and gas accumulates in the conserving device (390).

8. The apparatus of claim 7 wherein when the patient inhales, a puff of oxygen gas is delivered to the patient from the conserving device (390).

9. The apparatus of claim 8 wherein the conserving device (390) delivers an even flow of oxygen gas to said delivery device after said puff and until the patient exhales again.

10. The apparatus of any one of the preceding claims wherein said apparatus can last at least approximately 10 hours at a gas withdrawal rate of about 2 liters per minute.

11. The apparatus of any one of the preceding claims further comprising a check valve (363) to prevent backflow of gaseous oxygen through said inter-unit oxygen gas transfer connector (190).

12. The apparatus of any one of the preceding claims further comprising a liquid withdrawal conduit (326) and a neck conduit (331), the neck conduit comprising a gaseous oxygen withdrawal conduit (339) and a vent conduit (341), the liquid withdrawal conduit and the neck conduit being in communication with the interior of said container.

13. The apparatus of claim 12 further comprising a vent valve (344) as part of the vent conduit.

14. The apparatus of claim 13 wherein said vent valve (344) may be opened during filling of said portable LOX container (302).

15. The apparatus of any one of claims 12 to 14 when dependent upon any one of claims 3 to 5, wherein an inner diameter of said liquid withdrawal conduit is sized so that when said economizer valve is open, gaseous flow from the head-space of said portable LOX container is preferred over flow through said liquid withdrawal conduit.

16. The apparatus of any one of the preceding claims further comprising at least one of a liquid withdrawal warming coil (349) and a gaseous withdrawal warming coil (352).

17. The apparatus of claim 16 which comprises both a liquid withdrawal warming coil (349) and a gaseous withdrawal warming coil (352).

18. The apparatus of claim 16 or claim 17 wherein an inner diameter of said liquid withdrawal warming coil (349) is greater than the inner diameter of said liquid withdrawal conduit (326).

19. The apparatus of any one of the preceding claims further comprising a demand flow control device (360) for adjustment of gas flow through said portable-unit oxygen gas transfer connector (384).

20. The apparatus of any one of the preceding claims wherein said portable LOX container comprises a multi-lumen annular conduit.

21. The apparatus of any one of the preceding claims, wherein said portable LOX container contains about 0.45 kg of LOX when fully charged with LOX.

22. The apparatus of any one of the preceding claims, wherein said apparatus can deliver a gas withdrawal rate of about 2 liters per minute with a LOX use rate up to about 0.0378 kilograms per hour.

23. The apparatus of any one of claims 6 to 9 wherein said conserving device delivers puffs of oxygen gas.

24. A high-efficiency liquid oxygen (LOX) storage/delivery system (100) comprising

- the portable, high-efficiency LOX storage/delivery apparatus (160) of any one of claims 1 to 23; and
- a primary reservoir storage/delivery apparatus (205) which is a stationary source of oxygen and comprises a primary reservoir LOX container (226) connected to the portable LOX container (302) via the portable-unit LOX transfer connector (304), and connected to the portable LOX container via the inter-unit oxygen gas transfer connector (190);

wherein when the inter-unit oxygen gas transfer connector of the portable container is connected to the stationary source of oxygen in said primary reservoir container, oxygen gas can be transferred to the oxygen gas delivery device (90) for delivery to the patient from the stationary source of gas in the primary LOX container through the inter-unit gas transfer connector.

25. The system (100) as claimed in claim 24 wherein the inter-unit oxygen gas transfer connector (190) is configured such that, when the inter-unit oxygen gas transfer connector of the portable container (302) is connected to said stationary source of oxygen in said primary reservoir container (226), oxygen gas can be transferred to the oxygen gas delivery device (90) for delivery to the patient from the portable LOX container (302) and gaseous oxygen is permitted to be transferred to the oxygen gas delivery device from the stationary source of gas in the primary reservoir LOX container.

26. The system as claimed in claim 24 or 25 wherein the primary reservoir LOX apparatus further comprises a main LOX transfer connector (209) connected to the primary reservoir LOX container for inputting LOX into said primary reservoir LOX container and connectable to the portable-unit LOX transfer connector (304) for outputting LOX from said primary reservoir LOX container to said portable LOX container (302);
a main-unit oxygen gas transfer connector (213) for transferring oxygen gas from said primary reservoir LOX container, the main-unit oxygen gas transfer connector being connectable to said inter-unit gas transfer connector (190) for said transfer of said oxygen gas from said stationary source of oxygen to said portable apparatus (160) wherein said gaseous oxygen is permitted to be transferred to the oxygen gas delivery device (90) from said stationary source of oxygen.

27. The system (100) as claimed in any one of claims 24 to 26 when dependent upon claim 2, further comprising a main-unit primary relief valve (257) connected to the primary reservoir LOX container (226) for venting oxygen gas out of said primary reservoir LOX container when pressure of oxygen gas in said primary reservoir LOX container reaches a predetermined leve.

28. The system (100) of claim 26 further comprising a primary indicator device (274) connected to the primary reservoir LOX container (226) for indicating the LOX contents of the primary reservoir LOX container.

29. The system (100) of claim 26 wherein said oxygen gas is withdrawn from the primary reservoir container (226) for a withdrawal period of at least about 5 hours per day, then said portable LOX apparatus (160) is filled with LOX from said primary reservoir apparatus (120), whereby oxygen gas pressure in said primary reservoir LOX apparatus is reduced to a level such that pressure may increase within said primary reservoir container for a gas pressurizing period of about 5 to 15 hours per day without LOX or oxygen gas being withdrawn from said primary reservoir container and without oxygen gas being vented from said primary reservoir container during said gas pressurizing period.

30. The system (100) of claim 29 wherein said inter-unit oxygen gas transfer connector (190) of said portable LOX apparatus (160) is connected to said main-unit oxygen transfer connector (213) of said primary reservoir container (226) so that oxygen gas can be transferred from the portable container (302) to the oxygen gas delivery device (90) while oxygen gas is transferred to the portable apparatus from the primary reservoir container through the first oxygen transfer connector (190) during said withdrawal period.

31. The system (100) of claim 28, wherein said system is adapted for functioning within an operating cycle in which said withdrawal period is at least about 10 hours per day.

32. The system (100) of claim 26, wherein said oxygen gas delivery device (90) is connectable to said main-unit oxygen gas transfer connector (213) for transferring oxygen gas from said primary reservoir LOX container (226) for delivery to said patient.

33. The system (100) of claim 32, wherein a flexible gas conduit (110) is connectable between the main-unit oxygen gas transfer connector (213) to said oxygen gas delivery device (90).

34. The system (100) of claim 26, wherein a flexible gas conduit (110) is capable of connecting the main-unit oxygen gas transfer connector (213) to the inter-unit oxygen gas transfer connector (190) for transferring oxygen gas from said primary reservoir container (226) to said portable apparatus (160).

35. The system (100) of claim 26, further including a gas conserving device (390) so that when said patient exhales, oxygen gas accumulates in said conserving device, and when said patient inhales, oxygen gas is delivered to said patient from said conserving device.

36. The system (100) of claim 10, wherein said primary reservoir LOX apparatus (205) further includes a pressure indicator device (274, 217) for indicating an internal gaseous oxygen pressure within said primary reservoir LOX container (226).

37. A method for utilizing a high-efficiency liquid oxygen (LOX) storage/delivery system (100) as claimed in any one of claims 24 to 36, said method comprising connecting said inter-unit oxygen gas transfer connector (190) of said portable container (302) to said main-unit oxygen transfer connector (213) of said primary reservoir container (226), and withdrawing oxygen gas from said portable container through said portable-unit oxygen gas transfer connector (384) while oxygen gas is transferred to the portable container from the primary reservoir container through the main-unit oxygen transfer connector.

38. The method of claim 37, further comprising the steps of withdrawing oxygen gas from the primary reservoir container (226) for a withdrawal period of at least about 5 hours per day, then filling said portable LOX apparatus (160) with LOX from said primary reservoir LOX apparatus (120) through said portable-unit LOX transfer connector (304) connected to said main-unit LOX transfer connector (209), disconnecting said portable LOX apparatus from said primary reservoir LOX apparatus (120), and withdrawing oxygen gas from said portable LOX apparatus, whereby during said withdrawal period, oxygen gas pressure in said primary reservoir LOX apparatus is reduced to a level such that thereafter, pressure may increase within said primary reservoir container for a gas pressurizing period of about 5 to 15 hours per day without LOX or oxygen gas being withdrawn from said primary reservoir container and without oxygen gas being vented from said primary reservoir container during said gas pressurizing period.

39. The method of claim 37, wherein prior to complete withdrawal of oxygen gas from said portable LOX container (302) while said portable LOX container is partially filled with LOX, the inter-unit oxygen gas transfer connector (190) of said portable LOX container is connected to said main-unit oxygen transfer connector (213) of said primary reservoir LOX container, and oxygen gas is withdrawn from the portable LOX container while oxygen gas is transferred to the portable LOX apparatus from the primary reservoir LOX container (226) through the main-unit oxygen transfer connector.

40. The method of claim 39, wherein during said withdrawal period, said inter-unit oxygen gas transfer connector (190) of said portable LOX container (302) is connected to said main-unit oxygen transfer connector (213) of said primary reservoir LOX container (226) and oxygen gas is transferred from the portable container to the oxygen gas delivery device (90) while oxygen gas is transferred to the portable LOX apparatus (160) from the primary reservoir LOX container through the main-unit oxygen transfer connector.

41. The method of claim 40, wherein during said withdrawal period, the inter-unit oxygen gas transfer connector (190) is connected to the main-unit oxygen gas transfer connector (213) by a flexible gas conduit

(110).

42. The method of claim 37, wherein during said withdrawal period, the main-unit oxygen gas transfer connector (190) is connected to said oxygen gas delivery device (90) by a flexible gas conduit (110).

43. The method of claim 37, further including a gas conserving device (390), so that when said patient exhales, oxygen gas accumulates in said conserving device, and when said patient inhales, oxygen gas is delivered to said patient from said conserving device.

Patentansprüche

1. Tragbare, hocheffiziente Aufbewahrungs-/Abgabevorrichtung (160) für flüssigen Sauerstoff (LOX), die umfasst:

- einen tragbaren LOX-Behälter (302);
- einen LOX-Übertragungsverbinder (304) an der tragbaren Einheit, der mit dem tragbaren Behälter verbunden ist und LOX empfangen und an den tragbaren Behälter übertragen kann;
- einen Sauerstoffgas-Übertragungsverbinder (384) an der tragbaren Einheit, um Sauerstoffgas von dem tragbaren LOX-Behälter an eine Sauerstoffgas-Abgabevorrichtung (90) für die Abgabe zu übertragen; und
- einen Sauerstoffgas-Übertragungsverbinder (190) zwischen den Einheiten, der Sauerstoffgas empfangen und an den tragbaren Behälter übertragen kann.

2. Vorrichtung nach Anspruch 1, die ferner ein Hauptentlastungsventil (315) an der tragbaren Einheit umfasst, das mit dem tragbaren LOX-Behälter verbunden ist, um Sauerstoffgas aus dem tragbaren LOX-Behälter abzulassen, wenn der Druck in dem tragbaren LOX-Behälter einen für den tragbaren LOX-Behälter vorgegebenen Pegel erreicht.

3. Vorrichtung nach Anspruch 1 oder Anspruch 2, die ferner ein Sparventil (356) umfasst, um das Ablassen von Gas zu minimieren, indem die Entnahme von gasförmigem und flüssigem Sauerstoff aus dem tragbaren LOX-Behälter (302) ausgeglichen wird.

4. Vorrichtung nach Anspruch 2, wobei das Sparventil (356) öffnet, um den Durchgang von Sauerstoffgas aus dem gasförmigen Kopfraum im tragbaren LOX-Behälter (302) zuzulassen, wenn der Druck des Sauerstoffgases in dem tragbaren LOX-Behälter einen vorgegebenen Schwellenpegel übersteigt, und sonst geschlossen ist, um den Durchgang von Sauerstoffgas aus verdampftem LOX zuzulassen.

5. Vorrichtung nach Anspruch 3 oder Anspruch 4, die ferner ein Entlastungsventil (315) umfasst.

6. Vorrichtung nach einem der vorhergehenden Ansprüche, die ferner eine Aufbewahrungsvorrichtung (390) umfasst.

7. Vorrichtung nach Anspruch 6, wobei dann, wenn ein Patient, der die Vorrichtung verwendet, ausatmet, die Strömung zu der Sauerstoffabgabevorrichtung (90) angehalten wird und Gas in der Aufbewahrungsvorrichtung (390) angesammelt wird.

8. Vorrichtung nach Anspruch 7, wobei dann, wenn der Patient einatmet, ein Sauerstoffgasstoß von der Aufbewahrungsvorrichtung (390) an den Patienten abgegeben wird.

9. Vorrichtung nach Anspruch 8, wobei die Aufbewahrungsvorrichtung (390) nach dem Stoß und bis zum erneuten Ausatmen des Patienten eine gleichmäßige Strömung von Sauerstoffgas an die Abgabevorrichtung abgibt.

10. Vorrichtung nach einem der vorhergehenden Ansprüche, wobei die Vorrichtung wenigstens etwa 10 Stunden mit einer Gasentnahmerate von etwa 2 Litern pro Minute arbeiten kann.

11. Vorrichtung nach einem der vorhergehenden Ansprüche, die ferner ein Rückschlagventil (363) umfasst, um eine Rückströmung von gasförmigem Sauerstoff durch den Sauerstoffgas-Übertragungsverbinder (190) zwischen den Einheiten zu verhindern.

12. Vorrichtung nach einem der vorhergehenden Ansprüche, die ferner eine Flüssigkeitsentnahmeleitung (326) und eine Einschnürungsleitung (331) umfasst, wobei die Einschnürungsleitung eine Entnahmeleitung (339) für gasförmigen Sauerstoff und eine Ablassleitung (341) umfasst, wobei die Flüssigkeitsentnahmeleitung und die Einschnürungsleitung mit dem Innenraum des Behälters kommunizieren.

13. Vorrichtung nach Anspruch 12, die ferner ein Ablassventil (344) als Teil der Ablassleitung umfasst.

14. Vorrichtung nach Anspruch 13, wobei das Ablassventil (344) während des Befüllens des tragbaren LOX-Behälters (302) geöffnet werden kann.

15. Vorrichtung nach einem der Ansprüche 12 bis 14, wenn abhängig von einem der Ansprüche 3 bis 5, wobei ein Innendurchmesser der Flüssigkeitsentnahmeleitung so bemessen ist, dass dann, wenn das Sparventil geöffnet ist, eine gasförmige Strömung aus dem Kopfraum des tragbaren LOX-Behälters gegenüber einer Strömung durch die Flüssigkeitsentnahmeleitung bevorzugt wird.

16. Vorrichtung nach einem der vorhergehenden Ansprüche, die ferner eine Flüssigkeitsentnahme-Erwärmungsspule (349) und/oder eine Gasentnahme-Erwärmungsspule (352) umfasst.

17. Vorrichtung nach Anspruch 16, die sowohl eine Flüssigkeitsentnahme-Erwärmungsspule (349) als auch eine Gasentnahme-Erwärmungsspule (352) umfasst.

18. Vorrichtung nach Anspruch 16 oder Anspruch 17, wobei ein Innendurchmesser der Flüssigkeitsentnahme-Erwärmungsspule (349) größer ist als der Innendurchmesser der Flüssigkeitsentnahmeleitung (326).

19. Vorrichtung nach einem der vorhergehenden Ansprüche, die ferner eine Steuervorrichtung (360) für angeforderte Strömung umfasst, um eine Gasströmung durch den Sauerstoffgas-Übertragungsverbinder (384) an der tragbaren Einheit einzustellen.

20. Vorrichtung nach einem der vorhergehenden Ansprüche, wobei der tragbare LOX-Behälter eine Mehrfachhohlraum-Ringleitung umfasst.

21. Vorrichtung nach einem der vorhergehenden Ansprüche, wobei der tragbare LOX-Behälter etwa 0,45 kg LOX enthält, wenn er vollständig mit LOX gefüllt ist.

22. Vorrichtung nach einem der vorhergehenden Ansprüche, wobei die Vorrichtung mit einer Gasentnahmerate von etwa 2 Litern pro Minute bei einer LOX-Nutzungsrate von bis zu etwa 0,0378 Kilogramm pro Stunde abgeben kann.

23. Vorrichtung nach einem der Ansprüche 6 bis 9, wobei die Aufbewahrungsvorrichtung Stöße von Sauerstoffgas abgibt.

24. Hocheffizientes Aufbewahrungs-/Abgabesystem (100) für flüssigen Sauerstoff (LOX), das umfasst:

- die tragbare hocheffiziente LOX-Aufbewahrungs-/Abgabevorrichtung (160) nach einem der Ansprüche 1 bis 23; und
- eine Hauptspeicher-Aufbewahrungs-/Abgabevorrichtung (205), die eine stationäre Sauerstoffquelle ist und einen Hauptspeicher-LOX-Behälter (226) umfasst, der mit dem tragbaren LOX-Behälter (302) über den LOX-Übertragungsverbinder (304) an der tragbaren Einheit verbunden ist und mit dem tragbaren LOX-Behälter über den Sauerstoffgas-Übertragungsverbinder (190) zwischen den Einheiten verbunden ist;

wobei dann, wenn der Sauerstoffgas-Übertragungsverbinder zwischen den Einheiten des tragbaren Behälters mit der stationären Sauerstoffquelle in dem Hauptspeicherbehälter verbunden ist, Sauerstoffgas an die Sauerstoffgas-Abgabevorrichtung (90) für die Abgabe an den Patienten von der stationären Gasquelle in dem Hauptspeicher-LOX-Behälter durch den Gasübertragungsverbinder zwischen den Einheiten übertragen werden kann.

25. System (100) nach Anspruch 24, wobei der Sauerstoffgas-Übertragungsverbinder (190) zwischen den Einheiten in der Weise konfiguriert ist, dass dann, wenn der Sauerstoffgas-Übertragungsverbinder zwischen den Einheiten des tragbaren Behälters (302) mit der stationären Sauerstoffquelle in dem Hauptspeicherbehälter (226) verbunden ist, Sauerstoffgas von dem tragbaren LOX-Behälter (302) an die Sauerstoffgas-Abgabevorrichtung (90) für die Abgabe an den Patienten übertragen werden kann und die Übertragung von gasförmigem Sauerstoff an die Sauerstoffgas-Abgabevorrichtung von der stationären Gasquelle im Hauptspeicher-LOX-Behälter zugelassen wird.

26. System nach Anspruch 24 oder 25, wobei die Hauptspeicher-LOX-Vorrichtung ferner einen Haupt-LOX-Übertragungsverbinder (209) umfasst, der mit dem Hauptspeicher-LOX-Behälter verbunden ist, um LOX in den Hauptspeicher-LOX-Behälter einzugeben, und mit dem LOX-Übertragungsverbinder (304) an der tragbaren Einheit verbunden werden kann, um LOX aus dem Hauptspeicher-LOX-Behälter zu dem tragbaren LOX-Behälter (302) auszugeben;
einen Sauerstoffgas-Übertragungsverbinder (213) an der Haupteinheit, um Sauerstoffgas von dem Hauptspeicher-LOX-Behälter zu übertragen,
wobei der Sauerstoffgas-Übertragungsverbinder an der Haupteinheit mit dem Sauerstoffgas-Übertragungsverbinder (190) zwischen den Einheiten verbunden werden kann, um Sauerstoffgas von der stationären Sauerstoffquelle an die tragbare Vorrichtung (160) zu übertragen, wobei zugelassen wird, dass der gasförmige Sauerstoff von der stationären Sauerstoffquelle an die Sauerstoffgas-Abgabevorrichtung (90) übertragen wird.

27. System (100) nach einem der Ansprüche 24 bis 26, wenn abhängig von Anspruch 2, das ferner ein Hauptentlastungsventil (257) an der Haupteinheit umfasst, das mit dem Hauptspeicher-LOX-Behälter (226) verbunden ist, um Sauerstoffgas aus dem Hauptspeicher-LOX-Behälter abzulassen, wenn der Druck von Sauerstoffgas in dem Hauptspeicher-LOX-Behälter einen vorgegebenen Pegel erreicht.

28. System (100) nach Anspruch 26, das ferner eine Hauptanzeigervorrichtung (274) umfasst, die mit dem Hauptspeicher-LOX-Behälter (226) verbunden ist, um die LOX-Inhalte des Hauptspeicher-LOX-Behälters anzuzeigen.

29. System (100) nach Anspruch 26, wobei das Sauerstoffgas aus dem Hauptspeicherbehälter (226) während einer Entnahmeperiode von wenigstens etwa 5 Stunden pro Tag entnommen wird, woraufhin die tragbare LOX-Vorrichtung (160) mit LOX von der Hauptspeichervorrichtung (120) befüllt wird, wobei der Sauerstoffgasdruck in der Hauptspeicher-LOX-Vorrichtung auf einen Pegel gesenkt wird, derart, dass der Druck in dem Hauptspeicherbehälter während einer Gasdruckbeaufschlagungsperiode von etwa 5 bis 15 Stunden pro Tag ansteigen kann, ohne dass LOX oder Sauerstoffgas aus dem Hauptspeicherbehälter entnommen wird und ohne dass während der Gasdruckbeaufschlagungsperiode Sauerstoffgas aus dem Hauptspeicherbehälter abgelassen wird.

30. System (100) nach Anspruch 29, wobei der Sauerstoffgas-Übertragungsverbinder (190) zwischen den Einheiten der tragbaren LOX-Vorrichtung (160) mit dem Sauerstoffgas-Übertragungsverbinder (213) an der Haupteinheit des Hauptspeichers (226) verbunden ist, so dass Sauerstoffgas von dem tragbaren Behälter (302) an die Sauerstoffgas-Abgabevorrichtung (90) übertragen werden kann, während Sauerstoffgas von dem Hauptspeicherbehälter durch den ersten Sauerstoffübertragungsverbinder (190) während der Entnahmeperiode an die tragbare Vorrichtung übertragen wird.

31. System (100) nach Anspruch 28, wobei das System dazu ausgelegt ist, in einem Arbeitszyklus zu arbeiten, in dem die Entnahmeperiode wenigstens etwa 10 Stunden pro Tag beträgt.

32. System (100) nach Anspruch 26, wobei die Sauerstoffgas-Abgabevorrichtung (90) mit dem Sauerstoffgas-Übertragungsverbinder (213) an der Haupteinheit verbunden werden kann, um Sauerstoffgas von dem Hauptspeicher-LOX-Behälter (226) für die Abgabe an den Patienten zu übertragen.

33. System (100) nach Anspruch 32, wobei eine flexible Gasleitung (110) einerseits mit dem Sauerstoffgas-Übertragungsverbinder (213) an der Haupteinheit und andererseits mit der Sauerstoffgas-Abgabevorrichtung (90) verbunden werden kann.

34. System (100) nach Anspruch 26, wobei eine flexible Gasleitung (110) den Sauerstoffgas-Übertragungsverbinder (213) an der Haupteinheit mit dem Sauerstoffgas-Übertragungsverbinder (190) zwischen den Einheiten verbinden kann, um Sauerstoffgas von dem Hauptspeicherbehälter (226) an die tragbare Vorrichtung (160) zu übertragen.

35. System (100) nach Anspruch 26, das ferner eine Gasaufbewahrungsvorrichtung (390) umfasst, damit dann, wenn der Patient ausatmet, Sauerstoffgas in der Aufbewahrungsvorrichtung angesammelt wird, und dann, wenn der Patient einatmet, Sauerstoffgas aus der Aufbewahrungsvorrichtung an den Patienten abgegeben wird.

36. System (100) nach Anspruch 10, wobei die Hauptspeicher-LOX-Vorrichtung (205) ferner eine Druckanzeigervorrichtung (274, 217) umfasst, um einen Innendruck von gasförmigem Sauerstoff in dem Hauptspeicher-LOX-Behälter (226) anzuzeigen.

37. Verfahren für die Verwendung eines hocheffizienten Aufbewahrungs/Abgabesystems (100) für flüssigen Sauerstoff (LOX) nach einem der Ansprüche 24 bis 36, wobei das Verfahren umfasst: Verbinden des Sauerstoffgas-Übertragungsverbinder (190) zwischen den Einheiten des tragbaren Behälters (302) mit dem Sauerstoffgas-Übertragungsverbinder (213) an der Haupteinheit des Hauptspeichers (226) und Entnehmen von Sauerstoffgas aus dem tragbaren Behälter durch den Sauerstoffgas-Übertragungsverbinder (384) an der tragbaren Einheit, während Sauerstoff von dem Hauptspeicherbehälter durch den Sauerstoffgas-Übertragungsverbinder an der Haupteinheit an den tragbaren Behälter übertragen wird.

38. Verfahren nach Anspruch 37, das ferner die folgenden Schritte umfasst: Entnehmen von Sauerstoffgas aus dem Hauptspeicherbehälter (226) während einer Entnahmeperiode von wenigstens etwa 5 Stunden pro Tag, daraufhin Befüllen der tragbaren LOX-Vorrichtung (160) mit LOX aus der Hauptspeicher-LOX-Vorrichtung (120) durch den LOX-Übertragungsverbinder (304) an der tragbaren Einheit, der mit dem LOX-Übertragungsverbinder (209) an der Haupteinheit verbunden ist, Trennen der tragbaren LOX-Vorrichtung von der Hauptspeicher-LOX-Vorrichtung (120) und Entnehmen von Sauerstoffgas aus der tragbaren LOX-Vorrichtung, wobei während der Entnahmeperiode der Sauerstoffgasdruck in der Hauptspeicher-LOX-Vorrichtung auf einen Pegel gesenkt wird, derart, dass danach der Druck in dem Hauptspeicherbehälter während einer Gasdruckbeaufschlagungsperiode von etwa 5 bis 15 Stunden pro Tag erhöht werden kann, ohne dass LOX oder Sauerstoffgas aus dem Hauptspeicherbehälter entnommen wird und ohne dass während der Gasdruckbeaufschlagungsperiode Sauerstoffgas aus dem Hauptspeicherbehälter abgelassen wird.

39. Verfahren nach Anspruch 37, wobei vor dem Beenden des Entnehmens von Sauerstoffgas aus dem tragbaren LOX-Behälter (302), wenn der tragbare LOX-Behälter teilweise mit LOX gefüllt ist, der Sauerstoffgas-Übertragungsverbinder (190) zwischen den Einheiten des tragbaren LOX-Behälters mit dem Sauerstoffgas-Übertragungsverbinder (213) an der Haupteinheit des Hauptspeicher-LOX-Behälters verbunden ist und Sauerstoffgas aus dem tragbaren LOX-Behälter entnommen wird, während Sauerstoffgas von dem Hauptspeicher-LOX-Behälter (226) durch den Sauerstoffgas-Übertragungsverbinder an der Haupteinheit an die tragbare LOX-Vorrichtung übertragen wird.

40. Verfahren nach Anspruch 39, wobei während der Entnahmeperiode der Sauerstoffgas-Übertragungsverbinder (190) zwischen den Einheiten des tragbaren LOX-Behälters (302) mit dem Sauerstoffgas-Übertragungsverbinder (213) an der Haupteinheit des Hauptspeicher-LOX-Behälters (226) verbunden ist und Sauerstoffgas von dem tragbaren Behälter an die Sauerstoffgas-Abgabevorrichtung (190) übertragen wird, während Sauerstoffgas von dem Hauptspeicher-LOX-Behälter durch den Sauerstoffgas-Übertragungsverbinder an der Haupteinheit an die tragbare LOX-Vorrichtung (160) übertragen wird.

41. Verfahren nach Anspruch 40, wobei während der Entnahmeperiode der Sauerstoffgas-Übertragungsverbinder (190) zwischen den Einheiten durch eine flexible Gasleitung (110) mit dem Sauerstoffgas-Übertragungsverbinder (213) an der Haupteinheit verbunden ist.

42. Verfahren nach Anspruch 37, wobei während der Entnahmeperiode der Sauerstoffgas-Übertragungsverbinder (190) an der Haupteinheit durch eine flexible Gasleitung mit der Sauerstoffgas-Abgabevorrichtung (90) verbunden ist.

43. Verfahren nach Anspruch 37, das ferner eine Gasaufbewahrungsvorrichtung (390) umfasst, so dass dann, wenn der Patient ausatmet, Sauerstoffgas in der Aufbewahrungsvorrichtung angesammelt wird, und dann, wenn der Patient einatmet, Sauerstoffgas von der Aufbewahrungsvorrichtung an den Patienten abgegeben wird.

Revendications

1. Appareil portatif (160) de grande efficacité, destiné au stockage et à l'administration d'oxygène liquide (LOX), comprenant :

un réservoir portatif de LOX (302)
un raccord de transfert de LOX d'unité portative (304) relié audit réservoir portatif et pouvant recevoir et transférer de l'oxygène liquide audit réservoir portatif ;
un raccord de transfert d'oxygène gazeux d'unité portative (384) pour transférer de l'oxygène gazeux depuis le réservoir portatif de LOX vers un dispositif d'administration d'oxygène gazeux (90) pour être administré au patient ; et
un raccord de transfert d'oxygène gazeux entre unités (190) pouvant recevoir et transférer de l'oxygène gazeux vers ledit réservoir portatif.

2. Appareil selon la revendication 1, comprenant en outre une soupape de sûreté primaire d'unité portative (315) raccordée au réservoir portatif de LOX pour évacuer de l'oxygène gazeux du réservoir portatif de LOX lorsque la pression dans le réservoir portatif de LOX atteint un niveau prédéterminé pour ledit réservoir portatif de LOX.

3. Appareil selon la revendication 1 ou la revendication 2, qui comprend en outre une soupape économique (356) pour minimiser l'évacuation en équilibrant le retrait d'oxygène gazeux et d'oxygène liquide hors dudit réservoir portatif de LOX (302).

4. Appareil selon la revendication 2, dans lequel ladite soupape économique (356) s'ouvre pour permettre à l'oxygène gazeux venant d'un espace libre gazeux situé dans ledit réservoir portatif de LOX (302) de passer au travers lorsque la pression dudit oxygène gazeux dans ledit réservoir portatif de LOX dépasse un niveau de seuil prédéterminé et se ferme autrement et permet à l'oxygène gazeux provenant de l'oxygène liquide évaporé de passer.

5. Appareil selon la revendication 3 ou la revendication 4, comprenant en outre une soupape de sûreté (315).

6. Appareil selon l'une quelconque des précédentes revendications, comprenant en outre un dispositif de conservation (390).

7. Appareil selon la revendication 6, dans lequel, quand un patient qui utilise le dispositif exhale, l'écoulement vers le dispositif d'administration d'oxygène (90) est arrêté et le gaz s'accumule dans le dispositif de conservation (390).

8. Appareil selon la revendication 7, dans lequel, lorsque le patient inhale, une bouffée d'oxygène gazeux est administrée au patient à partir du dispositif de conservation (390).

9. Appareil selon la revendication 8, dans lequel le dispositif de conservation (390) délivre un écoulement régulier d'oxygène gazeux audit dispositif d'administration après ladite bouffée et jusqu'à ce que le patient exhale de nouveau.

10. Appareil selon l'une quelconque des précédentes revendications, dans lequel ledit appareil peut durer au moins 10 heures environ à un débit de retrait de gaz d'environ 2 litres par minute.

11. Appareil selon l'une quelconque des précédentes revendications, comprenant en outre un clapet antiretour (363) pour empêcher le reflux d'oxygène gazeux à travers ledit raccord de transfert d'oxygène gazeux entre unités (190).

12. Appareil selon l'une quelconque des précédentes revendications, comprenant en outre un conduit de retrait de liquide (326) et un conduit formant col (331), le conduit formant col comprenant un conduit de retrait d'oxygène gazeux (339) et un conduit d'évacuation (341), le conduit de retrait de liquide (326) et le conduit formant col étant en communication avec l'intérieur dudit réservoir.

13. Appareil selon la revendication 12, comprenant en outre une soupape d'évacuation (344) qui fait partie du conduit d'évacuation.

14. Appareil selon la revendication 13, dans lequel ladite soupape d'évacuation (344) peut être ouverte pendant le remplissage dudit réservoir portatif de LOX (302).

15. Appareil selon l'une quelconque des revendications 12 à 14 quand elle dépend de l'une quelconque des revendications 3 à 5, dans lequel le diamètre intérieur dudit conduit de retrait de liquide est dimensionné pour que, lorsque ladite soupape économique est ouverte, l'écoulement gazeux venant de l'espace libre dudit réservoir portatif de LOX est préféré par rapport à l'écoulement liquide à travers ledit conduit de retrait de liquide.

16. Appareil selon l'une quelconque des précédentes revendications, comprenant en outre au moins un élément parmi un serpentin de réchauffage de retrait de liquide (349) et un serpentin de réchauffage de retrait de gaz (352).

17. Appareil selon la revendication 16, qui comprend à la fois un serpentin de réchauffage de retrait de liquide (349) et un serpentin de réchauffage de retrait de gaz (352).

18. Appareil selon la revendication 16 ou la revendication 17, dans lequel le diamètre intérieur dudit serpentin de réchauffage de retrait de liquide (349) est supérieur au diamètre intérieur dudit conduit de retrait de liquide (326).

19. Appareil selon l'une quelconque des précédentes revendications, comprenant en outre un dispositif de régulation d'écoulement de demande (360) pour le réglage de l'écoulement de gaz à travers ledit raccord de transfert d'oxygène gazeux d'unité portative (384).

20. Appareil selon l'une quelconque des précédentes revendications, dans lequel ledit réservoir portatif de LOX comprend un conduit annulaire à canaux multiples.

21. Appareil selon l'une quelconque des précédentes revendications, dans lequel ledit réservoir portatif de LOX contient environ 0,45 kg de LOX quand il est totalement chargé de LOX.

22. Appareil selon l'une quelconque des précédentes revendications, dans lequel ledit appareil peut délivrer un débit de retrait de gaz d'environ 2 litres par minute avec un débit d'utilisation de LOX pouvant atteindre environ 0,0378 kilogrammes par heure.

23. Appareil selon l'une quelconque des revendications 6 à 9, dans lequel ledit dispositif de conservation délivre des bouffées d'oxygène gazeux.

24. Système (100) de grande efficacité destiné au stockage et à l'administration d'oxygène liquide (LOX), comprenant :

> l'appareil portatif (160) de grande efficacité destiné au stockage et à l'administration d'oxygène liquide selon l'une quelconque des revendications 1 à 23 ; et
> un appareil de stockage et d'administration de LOX à réservoir de base (205) qui est une source fixe d'oxygène et comprend un réservoir de LOX de base (226) relié au réservoir portatif de LOX (302) par l'intermédiaire du raccord de transfert de LOX d'unité portative (304), et relié au réservoir portatif de LOX par l'intermédiaire du raccord de transfert d'oxygène gazeux entre unités (190) ;

dans lequel, quand le raccord de transfert d'oxygène gazeux entre unités du réservoir portatif est relié à la source fixe d'oxygène située dans ledit réservoir de base, de l'oxygène gazeux peut être transféré vers le dispositif d'administration d'oxygène gazeux (90) pour être administré au patient à partir de la source fixe d'oxygène située dans le réservoir de LOX de base par le raccord de transfert d'oxygène gazeux entre unités.

25. Système (100) selon la revendication 24, dans lequel le raccord de transfert d'oxygène gazeux entre unités (190) est conçu de telle sorte que, quand le raccord de transfert d'oxygène gazeux entre unités du réservoir portatif (302) est raccordé à ladite source fixe d'oxygène située dans ledit réservoir de base (226), de l'oxygène gazeux peut être transféré vers le dispositif d'administration d'oxygène gazeux (90) pour être administré au patient à partir du réservoir portatif de LOX (302) et l'oxygène gazeux peut être transféré vers le dispositif d'administration d'oxygène gazeux à partir de la source fixe d'oxygène située dans le réservoir de LOX de base.

26. Système selon la revendication 24 ou la revendication 25, dans lequel l'appareil à réservoir de LOX de base comprend en outre un raccord de transfert de LOX d'unité principale (209) relié au réservoir de LOX de base pour introduire de l'oxygène liquide dans ledit réservoir de LOX de base et pouvant être relié au raccord de transfert de LOX d'unité portative (304) pour faire passer de l'oxygène liquide depuis le réservoir de LOX de base vers ledit réservoir portatif de LOX (302) ;
un raccord de transfert d'oxygène gazeux d'unité principale (213) pour transférer de l'oxygène gazeux depuis ledit réservoir de LOX de base, le raccord de transfert d'oxygène gazeux d'unité principale pouvant être relié audit raccord de transfert d'oxygène gazeux entre unités (190) pour ledit transfert dudit oxygène gazeux depuis ladite source fixe d'oxygène vers ledit appareil portatif (160), dans lequel ledit oxygène gazeux peut être transféré vers le dispositif d'administration d'oxygène gazeux (90) depuis ladite source fixe d'oxygène.

27. Système (100) selon l'une quelconque des revendications 24 à 26 quand elle dépend de la revendication 2, comprenant en outre une soupape de sûreté primaire d'unité principale (257) raccordée au réservoir de LOX de base (226) pour évacuer de l'oxygène gazeux hors dudit réservoir de LOX de base lorsque la pression de l'oxygène gazeux dans ledit réservoir de LOX de base atteint un niveau prédéterminé.

28. Système (100) selon la revendication 26, comprenant en outre un dispositif indicateur primaire (274) raccordé au réservoir de LOX de base (226) pour indiquer le contenu en LOX du réservoir de LOX de base.

29. Système (100) selon la revendication 26, dans lequel ledit oxygène gazeux est retiré du réservoir de base (226) pendant une période de retrait d'au moins 5 heures environ par jour, puis ledit appareil portatif de LOX (160) est rempli d'oxygène liquide à partir dudit appareil à réservoir de base (120), de telle sorte que la pression de l'oxygène gazeux dans ledit réservoir de LOX de base est réduite à un niveau tel que la pression peut augmenter à l'intérieur dudit réservoir de base pendant une période de mise sous pression du gaz d'environ 5 à 15 heures par jour sans que de l'oxygène liquide ou de l'oxygène gazeux ne soit retiré dudit réservoir de base et sans que de l'oxygène gazeux ne soit évacué dudit réservoir de base pendant ladite période de mise sous pression du gaz.

30. Système (100) selon la revendication 29, dans lequel ledit raccord de transfert d'oxygène gazeux entre unités (190) dudit appareil portatif de LOX (160) est relié audit raccord de transfert d'oxygène gazeux d'unité principale (213) dudit réservoir de base (226) de telle sorte que de l'oxygène gazeux peut être transféré depuis le réservoir portatif (302) vers le dispositif d'administration d'oxygène gazeux (90) pendant que l'oxygène gazeux est transféré vers l'appareil portatif à partir du réservoir de base à travers le premier raccord de transfert d'oxygène (190) pendant ladite période de retrait.

31. Système (100) selon la revendication 28, dans lequel ledit système est adapté pour fonctionner dans un cycle opératoire dans lequel ladite période de retrait est d'au moins 10 heures environ par jour.

32. Système (100) selon la revendication 26, dans lequel ledit dispositif d'administration d'oxygène gazeux (90) peut être relié audit raccord de transfert d'oxygène gazeux d'unité principale (213) pour transférer de l'oxygène gazeux depuis ledit réservoir de LOX de base (226) pour être administré audit patient.

33. Système (100) selon la revendication 32, dans lequel un conduit de gaz flexible (110) peut être raccordé entre le raccord de transfert d'oxygène gazeux d'unité principale (213) et ledit dispositif d'administration d'oxygène gazeux (90).

34. Système (100) selon la revendication 26, dans lequel un conduit de gaz flexible (110) peut relier le raccord de transfert d'oxygène gazeux d'unité principale (213) au raccord de transfert d'oxygène gazeux entre unités (190) pour transférer de l'oxygène gazeux depuis ledit réservoir de base (226) vers ledit appareil portatif (160).

35. Système (100) selon la revendication 26, comprenant en outre un dispositif de conservation (390) de telle sorte que, lorsque ledit patient exhale, de l'oxygène gazeux s'accumule dans ledit dispositif de conservation, et lorsque ledit patient inhale, de l'oxygène gazeux est administré audit patient à partir dudit dispositif de conservation.

36. Système (100) selon la revendication 10, dans lequel ledit appareil de stockage et d'administration de LOX à réservoir de base (205) comprend en outre un dispositif indicateur de pression (274, 217) pour indiquer la pression interne de l'oxygène gazeux à l'intérieur dudit réservoir de LOX de base (226).

37. Procédé destiné à utiliser un système (100) de grande efficacité servant au stockage et à l'administration d'oxygène liquide (LOX) tel que revendiqué dans l'une quelconque des revendications 24 à 26, ledit procédé comprenant les étapes consistant à relier ledit raccord de transfert d'oxygène gazeux entre unités (190) dudit réservoir portatif (302) audit raccord de transfert d'oxygène gazeux d'unité principale (213) dudit réservoir de base (226), et retirer de l'oxygène gazeux dudit réservoir portatif (302) à travers ledit raccord de transfert d'oxygène gazeux d'unité portative (384) pendant que de l'oxygène gazeux est transféré vers le réservoir portatif depuis le réservoir de base à travers le raccord de transfert d'oxygène gazeux d'unité principale.

38. Procédé selon la revendication 37, comprenant en outre les étapes consistant à retirer de l'oxygène gazeux du réservoir de base (226) pendant une période de retrait d'environ au moins 5 heures par jour, puis à remplir ledit appareil portatif de LOX (160) d'oxygène liquide en provenance dudit appareil à réservoir de base de LOX (120) à travers ledit raccord de transfert de LOX d'unité portative (304) relié audit raccord de transfert de LOX d'unité principale (209), à déconnecter ledit appareil portatif de LOX dudit appareil à réservoir de base de LOX (120), et à retirer de l'oxygène gazeux dudit appareil portatif de LOX, de telle sorte que, pendant ladite période de retrait, la pression de l'oxygène gazeux à l'intérieur dudit réservoir de base de LOX est réduite à un niveau tel que, ensuite, la pression peut augmenter à l'intérieur dudit réservoir de base pendant une période de mise sous pression du gaz d'environ 5 à 15 heures par jour sans que de l'oxygène liquide ou de l'oxygène gazeux ne soit retiré dudit réservoir de base et sans que de l'oxygène gazeux ne soit évacué dudit réservoir de base pendant ladite période de mise sous pression du gaz.

39. Procédé selon la revendication 37, dans lequel, avant le retrait total de l'oxygène gazeux dudit réservoir portatif de LOX (302) pendant que ledit réservoir portatif de LOX est partiellement rempli de LOX, le raccord de transfert d'oxygène gazeux entre unités (190) dudit réservoir portatif de LOX est relié audit raccord de transfert d'oxygène gazeux d'unité principale (213) dudit réservoir de base de LOX, et de l'oxygène gazeux est retiré du réservoir portatif de LOX pendant que de l'oxygène gazeux est transféré vers l'appareil portatif de LOX à partir du réservoir de base de LOX (226) par le biais du raccord de transfert d'oxygène d'unité principale.

40. Procédé selon la revendication 39, dans lequel, pendant ladite période de retrait, ledit raccord de transfert d'oxygène gazeux entre unités (190) dudit réservoir portatif de LOX (302) est relié audit raccord de transfert d'oxygène gazeux d'unité principale (213) dudit réservoir de base de LOX (226) et de l'oxygène gazeux est transféré depuis le réservoir portatif vers le dispositif d'administration d'oxygène gazeux (90) pendant que de l'oxygène gazeux est transféré vers l'appareil portatif de LOX (160) à partir du réservoir de base de LOX par le biais du raccord de transfert d'oxygène gazeux d'unité principale.

41. Procédé selon la revendication 40, dans lequel, pendant ladite période de retrait, le raccord de transfert d'oxygène gazeux entre unités (190) est relié au raccord de transfert d'oxygène gazeux d'unité principale (213) par un conduit de gaz flexible (110).

42. Procédé selon la revendication 37, dans lequel, pendant ladite période de retrait, le raccord de transfert d'oxygène gazeux d'unité principale,, (190) est relié audit dispositif d'administration d'oxygène gazeux (90) par un conduit de gaz flexible.

43. Procédé selon la revendication 37, comprenant en outre un dispositif de conservation de gaz (390), de telle sorte que, lorsque ledit patient exhale, de l'oxygène gazeux s'accumule dans ledit dispositif de conservation, et lorsque ledit patient inhale, de l'oxygène gazeux est administré audit patient depuis ledit dispositif de conservation.

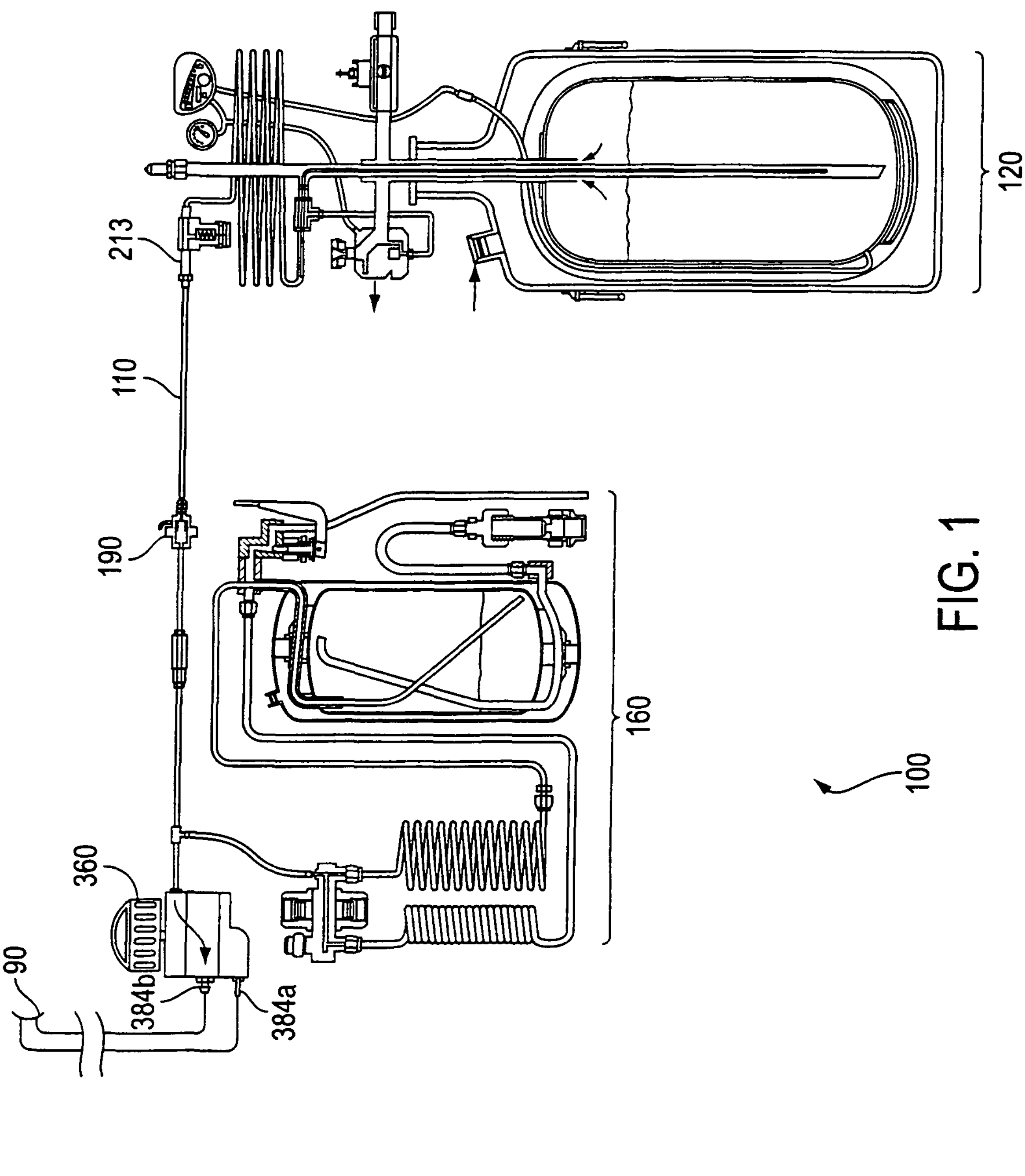
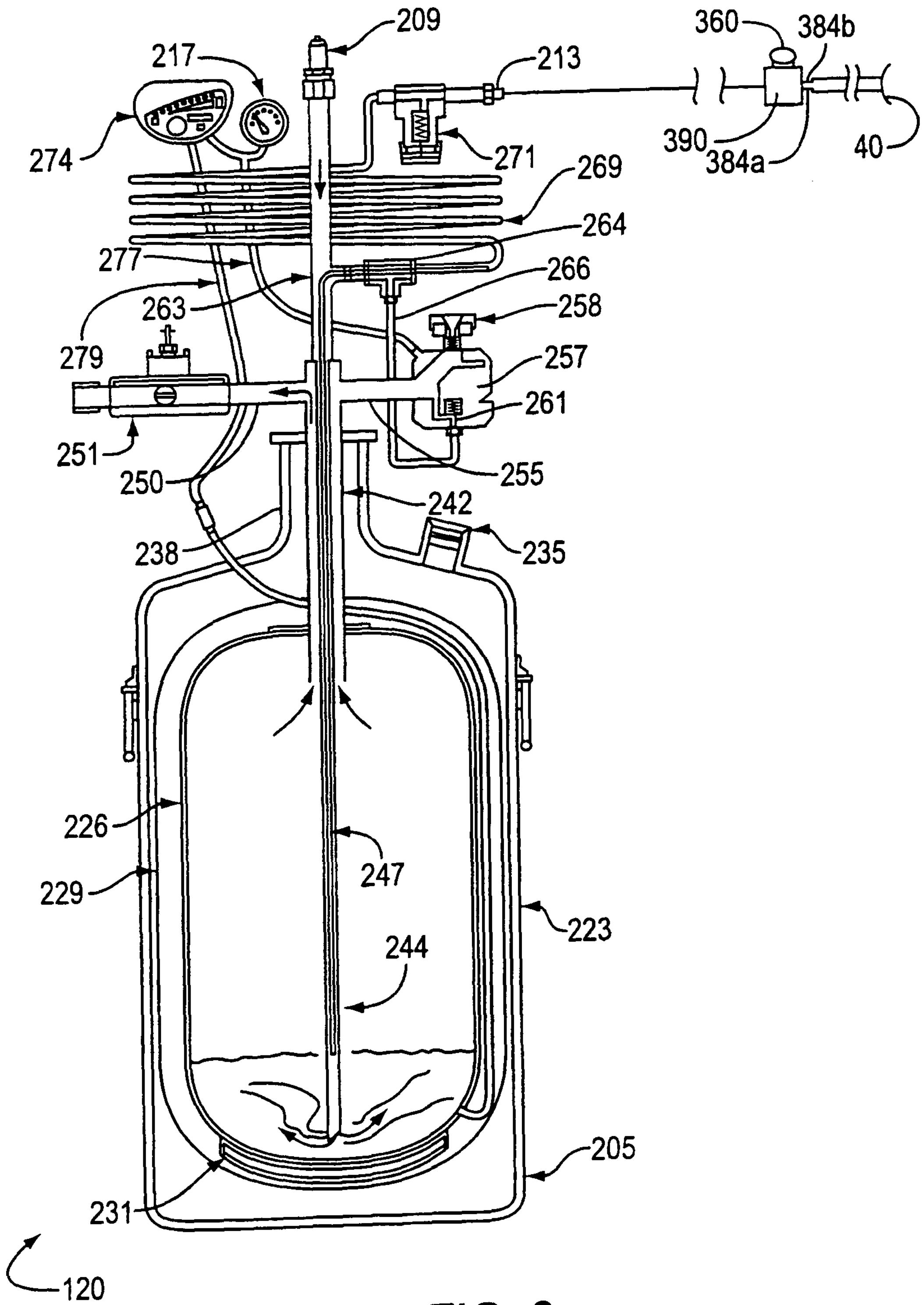


FIG. 1


209
217
213
360
384b
274
271
390
384a
40
269
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277
266
263
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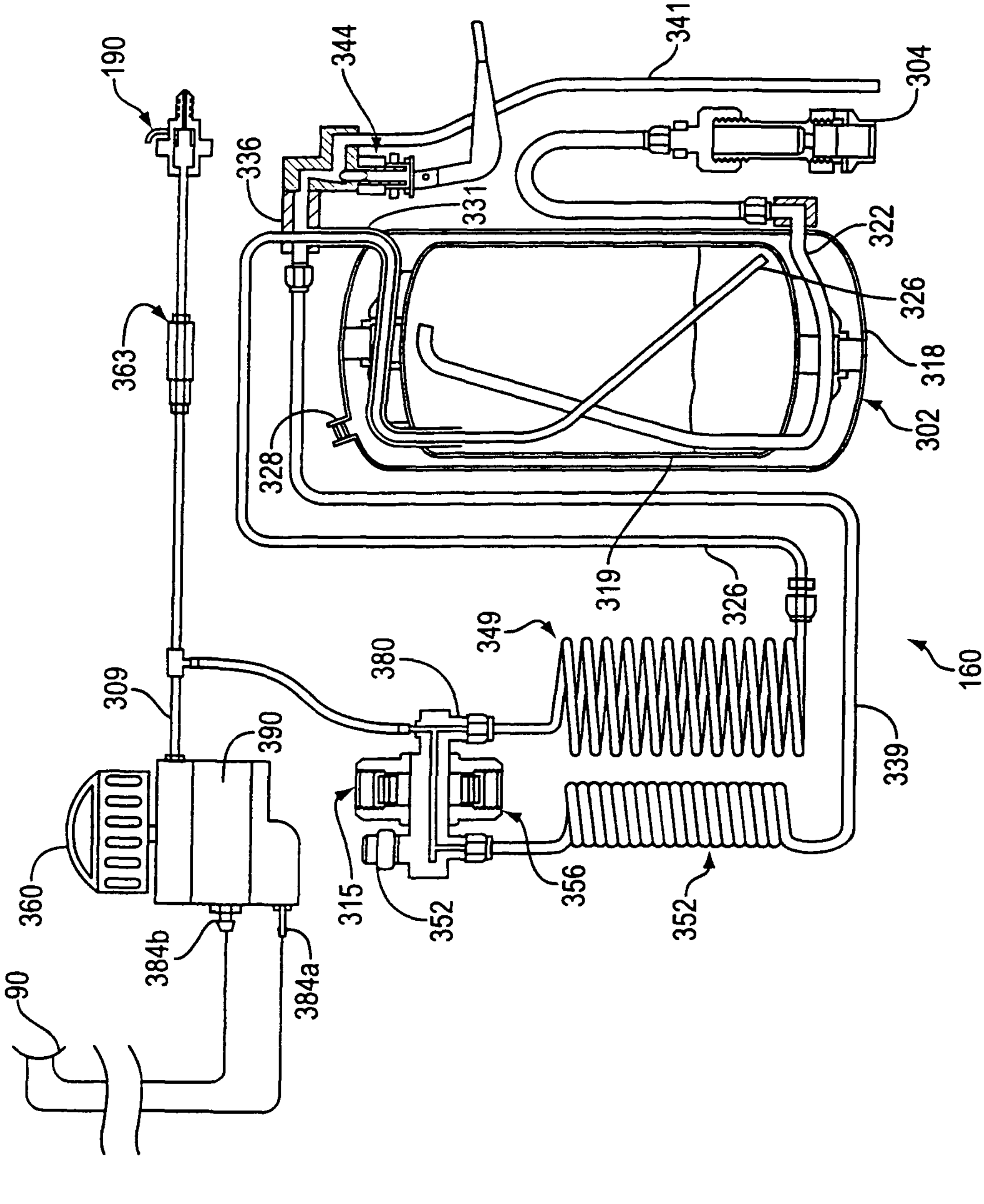
255
250
242
238
235
226
247
229
223
244
205
231
120

FIG. 2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341
304
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331
322
326
318
302
363
328
319
326
349
380
309
390
160
339
360
315
352
356
352
384b
384a
90

FIG. 3

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 4211086 A **[0008]**
- US 5360000 A **[0045]**