FIG. 1

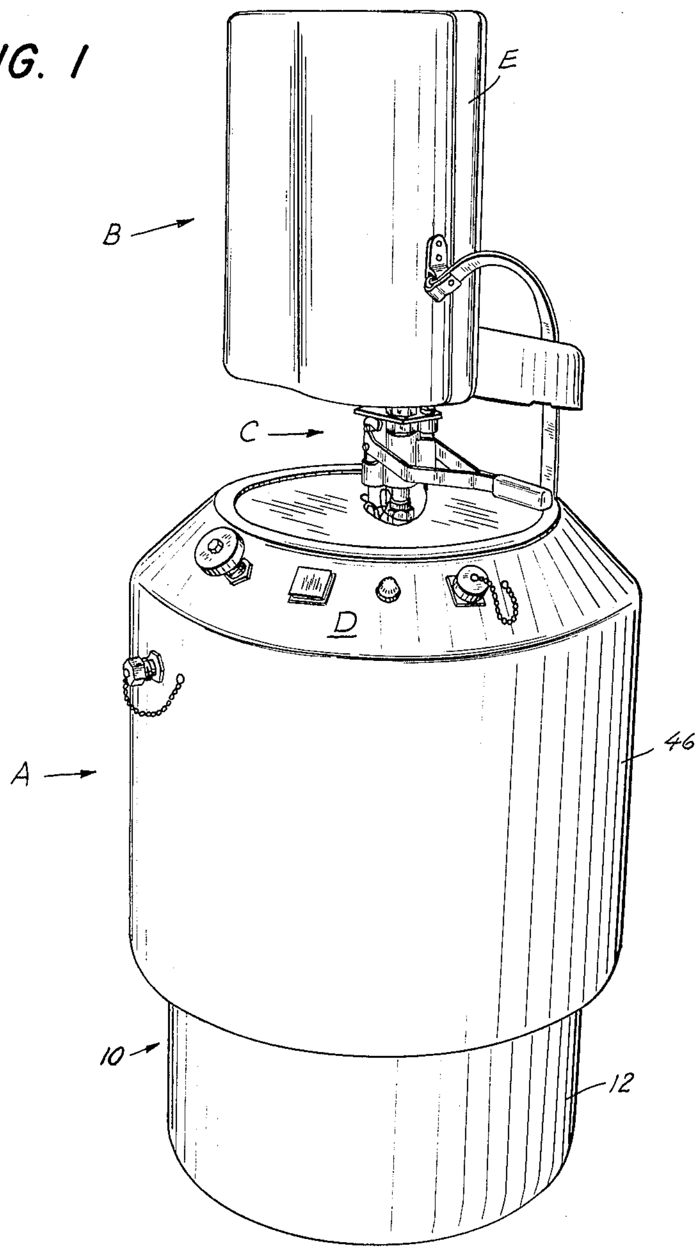

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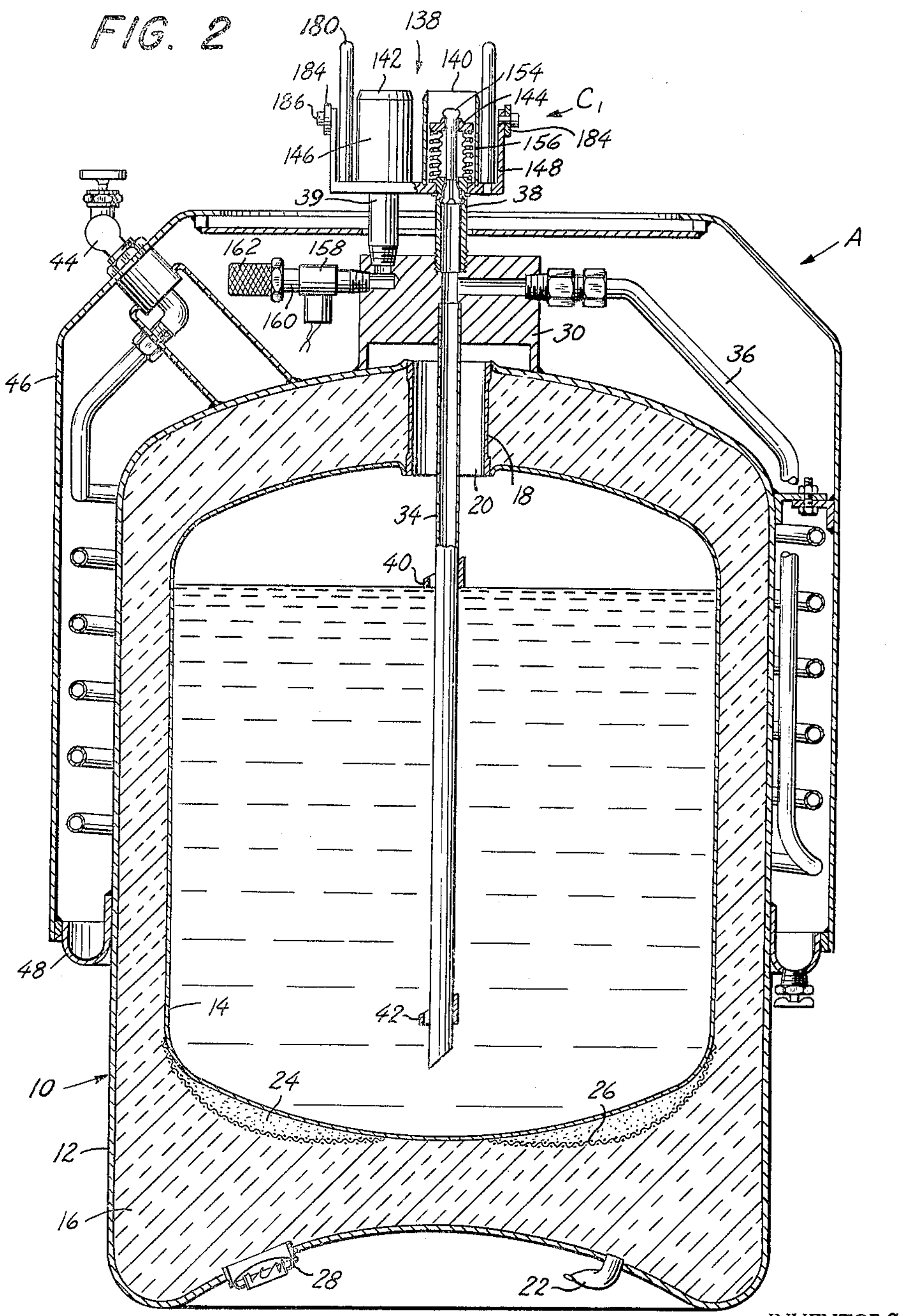
FIG. 2



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OXYGEN THERAPY SYSTEM

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FIG. 3

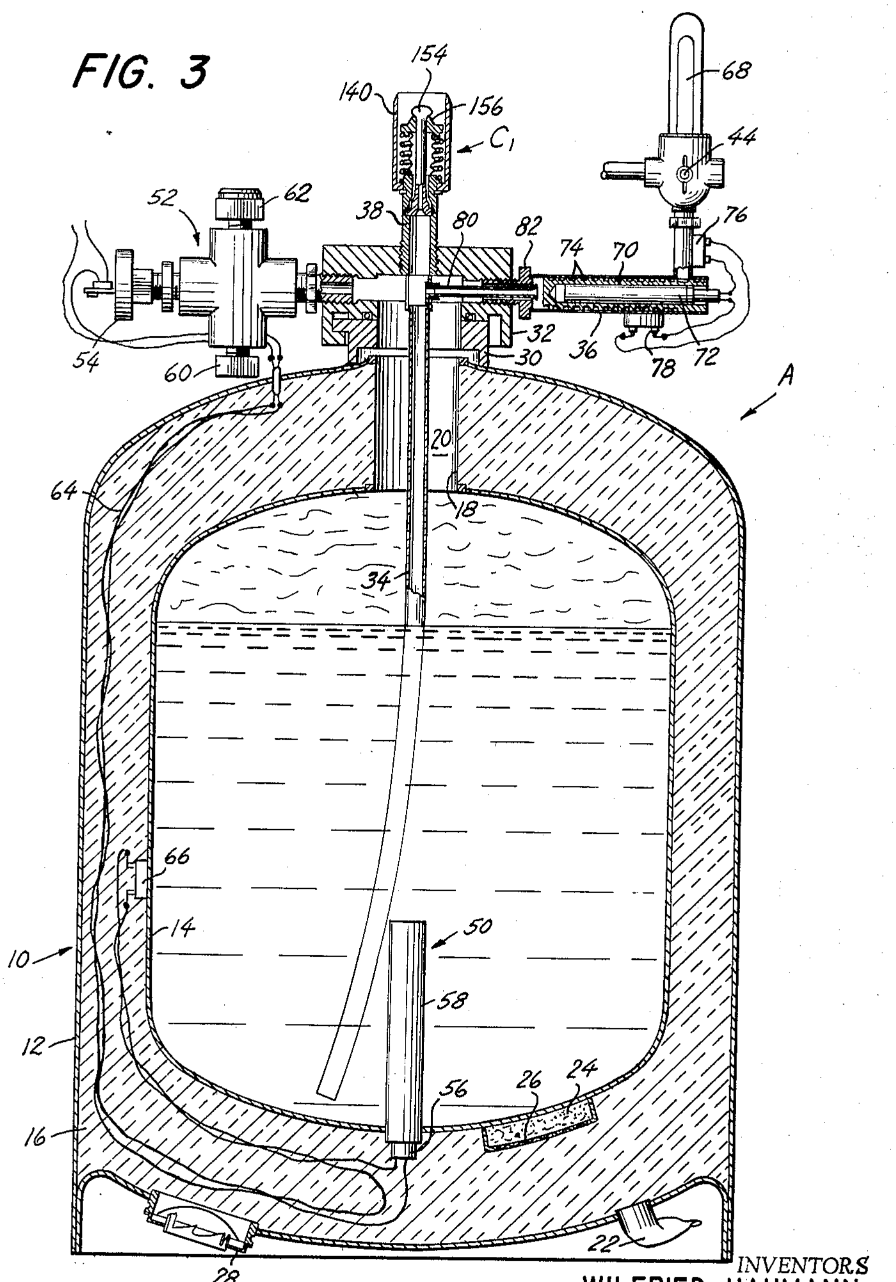

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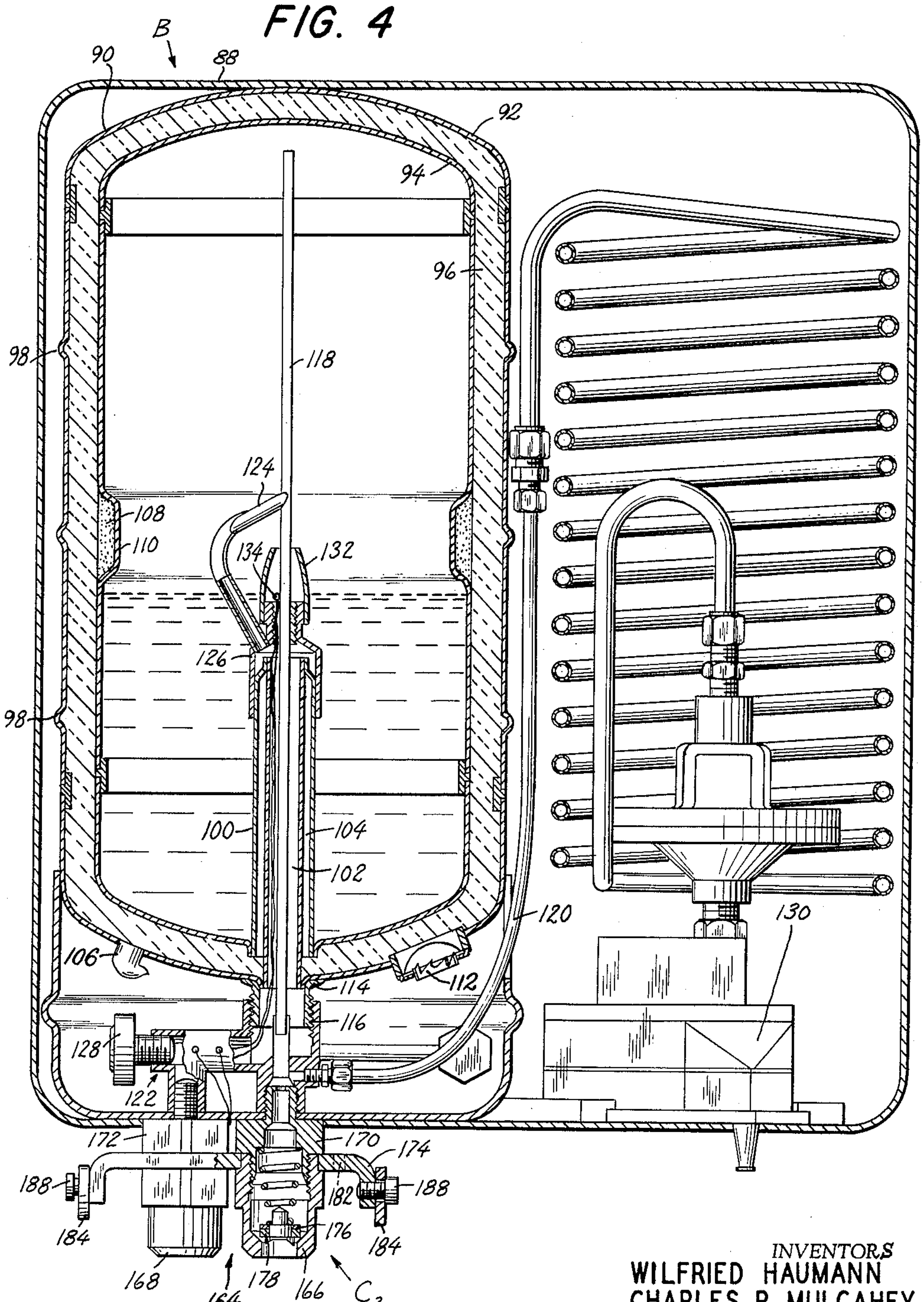
FIG. 4



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3,199,303
OXYGEN THERAPY SYSTEM

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16 Claims. (Cl. 62—50)

The present invention relates to a therapeutic system for supplying oxygen as a breathing atmosphere and more particularly to a system for use in medical therapy of pulmonary and cardiac disorders.

Physicians are increasingly prescribing physical exercise to the aged to encourage blood circulation, oxygen intake, and to normalize blood pressure and pulse. In many cases, such prescriptions are not followed because the patient becomes short of breath, easily tires, and develops pains and other discomforts. By inhaling oxygen-enriched air in such cases, these discomforts may be greatly reduced or eliminated enabling the patient to continue his exercise and eventually resume activities of his normal life pattern. This is an increasingly important key point in the medical treatment of pulmonary and cardiac disorders.

Unfortunately, however, present day medical oxygen-therapy systems are either immovable fixed-in-place types or so heavy as to be immovable from a practical standpoint. Consequently, such therapy, if available at all, is confined to special areas in a clinic or hospital set aside for that purpose. The necessary flexibility in exercise patterns is not available when the patient is confined to such a special area. Furthermore, at-home therapy is eliminated because of the lack of an oxygen-enriched breathing atmosphere source. Also, when oxygen is needed for patients confined to their beds, either at home or in a hospital, present day medical oxygen-therapy systems are handicapped because of their bulk and complexity.

It is an object of the present invention to provide a medical oxygen-therapy system that is more convenient to employ than present day systems. A further object is to provide an easily portable medical oxygen-therapy system that an exercising patient may carry through his exercises. Another object is to provide a bedside medical oxygen-therapy system that is less bulky than present day systems and is also more convenient to operate. These and other objects and advantages will be apparent from the following description and accompanying drawings, in which:

FIGURE 1 is a perspective view of the complete medical oxygen-therapy system of the present invention;

FIGURE 2 is a view of a cross-section with some parts in elevation of a portion of a medical oxygen-therapy system embodying principles of the present invention;

FIGURE 3 is another view of a cross-section with some parts in elevation of another portion of a medical oxygen-therapy system embodying principles of the present invention;

FIGURE 4 is still another view of a cross-section with some parts in elevation of another portion of a medical oxygen-therapy system embodying principles of the present invention.

COMPLETE THERAPEUTIC SYSTEM

The present invention comprises a system for supplying oxygen as a breathing atmosphere at a controllable rate from a compact and easily operable source. The apparatus of the present system includes a primary source of oxygen which is useful as a bedside medical oxygen-therapy system, a secondary source which is filled with oxygen from the primary source and is useful as a walk-around medical oxygen-therapy system, and connecting means for effecting the transfer of oxygen from the primary source to the secondary source which is convenient and safe to employ for that purpose.

The primary source comprises a first double-walled container for receiving and storing oxygen in the liquid state and for delivering the same in a gaseous state as a breathing atmosphere at controlled rates upon demand therefor. The secondary source comprises a second smaller easily-portable double-walled container for receiving oxygen in the liquid state from the primary source and storing the same and for delivering oxygen in a gaseous state at controlled rates upon demand therefor. The connecting means comprises two sections, the first connected to the primary source and the second connected to the secondary source such that the secondary source may be positioned relative to the primary source quickly and easily. Use of such connecting means permits filling the portable secondary source without handling cold fittings and without using an inconvenient transfer hose arrangement. The connecting means also reduces frost formation and oxygen losses.

Both primary and secondary sources employ vapor venting means in gas communication with respective first and second container storage spaces to maintain the pressures therein below maximum permissible levels thereby preventing dangerous pressure buildups within the containers. Also, each source employs liquid oxygen vaporizing means to transform the liquid oxygen to a breathable atmosphere, and breathing atmosphere supply means connected to the respective liquid vaporizing means in gas communication therewith. In addition, the primary source may employ means for maintaining the liquid oxygen in the first container at predetermined operating pressure levels. The secondary source employs means for controlling liquid transfer into the second container.

Referring to FIGURE 1, the complete therapeutic system comprises a primary oxygen source "A," a second oxygen source "B," and a connecting means "C." Also shown in FIGURE 1 is a control panel "D" and a protective carrying case "E" which a patient may use to shoulder the portable secondary source "B" as he moves about. This complete system and its operation is described in more detail with references to FIGURES 2, 3 and 4.

Primary oxygen source

As shown in FIGURE 2, the primary source "A" comprises a storage container 10 having an outer jacket 12 spaced from an inner vessel 14 to define an evacuable insulation space 16 between the inner and outer surfaces of the outer jacket and inner vessel, respectively. Inner vessel 14 is suspended from outer jacket 12 by a thin, low-heat conductive neck tube 18 which defines an access passage 20 to the inner vessel interior. Insulation space 16 is evacuated through pinch-off tube 22 and preferably contains an opacified insulation of the type described in U.S. Patent Nos. 2,967,152 and 3,007,596 for protection against ambient heat inleak. Other insulation materials may be used but the opacified types are the most efficient insulations developed to date. A molecular sieve adsorbent 24, of the type described in U.S. Patent No. 2,900,800, contained in blister 26, is preferably used to maintain the vacuum within insulation space 16 by adsorbing residual gas traces remaining after insulation space 16 has been evacuated through pinch-off tube 22 by mechanical methods. A bursting disk 28, placed in outer jacket 12, prevents a dangerous pressure build-up from occurring within insulation space 16 should container 10 develop a leak.

Means are provided about the top of access passage 20 to gas tightly seal the interior of inner vessel 14 from the surrounding atmosphere such as a spud 30 (FIG. 2) or a spud 30 and cap 32 arrangement (FIG. 3). In the preferred embodiment of the primary source "A," a fluid transfer tube 34, a liquid vaporizing means 36, and the primary section of connecting means "C" (hereinafter called the "connecting means C_1") are connected to spud 30.

Primary source "A" is preferably filled with pressurized and saturated liquid oxygen through connecting means C. (For therapeutic applications, it is preferable that the stored liquid oxygen pressure be sufficient to supply gaseous oxygen at a pressure of about 50 p.s.i.g.) Liquid oxygen is transferred through connecting means C_1 and fluid transfer tube 34 into the bottom of inner vessel 14. Liquid level sensing means such as thermistors 40 and 42 are connected into a control circuit (not shown) to indicate the liquid level in container 10. This control circuit may be arranged to control the filling of primary source "A" automatically from a liquid storage supply (not shown) if desired.

When supplying oxygen to a patient, it is essential that only liquid oxygen be withdrawn from primary source "A" through fluid transfer tube 34 to prevent an increase in hydrocarbon impurities found in even the highest purity oxygen. If vapor were withdrawn, the higher-boiling hydrocarbon impurities in the remaining liquid would increase in concentration and could deleteriously affect the oxygen as a breathing atmosphere. Also, build-up of hydrocarbons in the liquid could cause a combustion hazard. By withdrawing only liquid oxygen, the purity of the remaining liquid is always maintained at a high level inasmuch as the saturated liquid oxygen and vapor in the primary source "A" are maintained at substantially uniform and constant purity.

When the primary source "A" is used to supply oxygen directly to a patient, pressurized and saturated liquid is withdrawn through fluid transfer tube 34 into liquid vaporizing means 36. Gaseous oxygen from liquid vaporizing means 36 is conducted through conduit manual valve 44 to a breathing device such as an oxygen mask (not shown).

Liquid vaporizing means 36 comprises an ambient air-warmed or "superheater" coil that extends from spud 30 down toward the bottom of primary source "A" and then winds upward around the outer jacket 12 to valve 44. The length of the liquid vaporizing means 36 must be sufficient to completely vaporize and adequately superheat the withdrawn oxygen to a breathable atmosphere. This length will depend on such factors as the maximum quantity that would be withdrawn at any time, the temperature to which the oxygen would be superheated, and the temperature of the surrounding atmosphere with which the oxygen in the superheater coil is heat exchanged. A hood 46 is positioned around liquid vaporizing means 36 in a manner such that the latter cannot be bumped into or touched but also such that sufficient air can circulate around the coils to vaporize and superheat the oxygen therein. A drip pan 48 collects condensed moisture from the coils.

Primary source "A" may be filled with liquid oxygen at atmospheric pressure and then pressurized such that the liquid oxygen therein is saturated at the desired working pressure. The embodiment of primary source "A" shown in FIGURE 3 provides this feature. Cap 32 in FIGURE 3 may be removed and liquid oxygen poured into the interior of inner vessel 14. If desired, primary source "A" may be filled with non-pressurized liquid oxygen through connecting means C_1 as in FIGURE 2 without removing cap 32. In either case, an inner vessel pressurizing means 50, as in FIGURE 3, in conjunction with a pressure controller 52 having a pressure switch 54 must be provided to pressurize the inner vessel and to maintain such pressure at a predetermined level.

Liquid oxygen saturation may be maintained in the FIG. 3 embodiment of primary source "A" by pressurizing means 50 which comprises a resistance heater 56 enclosed by a casing 58. Pressure switch 54, a pressure relief valve 60 and a pressure bursting disk 28 are connected to cap 32 such that they are in communication with the inner vessel interior. Pressure switch 54 is normally open when the stored-liquid pressure corresponds to a predetermined level and closes when the liquid pressure falls below this level. The closing of pressure switch 54 causes a current in wires 64 to energize heater 56. A thermal safety switch 66 is incorporated into the pressurizing circuit as a safety device to prevent heater 56 from over heating the inner vessel 14. If the liquid level is too low, and heater 56 is activated before the inner vessel is refilled, thermal switch 66 will be heated and break the pressurizing circuit before any damage results.

An alternative embodiment of liquid vaporizing means 36 in FIGURE 2 is also shown in FIGURE 3. When the primary source "A" of FIGURE 3 is used to supply oxygen directly to a patient, pressurized liquid is transferred through fluid transfer tube 34 into liquid vaporizing means 36. Gaseous oxygen from liquid vaporizing means 36 is conducted through manual valve 44 (which may include a rotometer 68 if desired) which controls the flow of oxygen to a breathing device such as an oxygen mask (not shown). Liquid vaporizing means 36 comprises a hollow tube 70 containing an electrical heater 72 and having external, helical grooves 74 for the passage of liquid and vapor. The helical portion 74 of tube 72 may be constructed from any thermally conductive material such as brass or aluminum. Thermal switches 76 and 78 control heater 72 to maintain a predetermined temperature level in the gaseous oxygen leaving liquid vaporizing means 36. Thermal switch 78 is preferably positioned adjacent heater 72 to provide better temperature control when the vapor flow is quickly reduced thereby preventing excessive heating of the vapor that could result if only thermal switch 76 were employed.

A tube 80 which connects liquid vaporizing means 36 with fluid transfer tube 34 is held in alignment by means of counterbored screw 82. The counterbore in screw 82 forms a "dead" gas space which comprises an air gap that prevents cap 32 from frosting. The head of screw 82 is joined to hollow tube 70 of liquid vaporizing means 36.

In the two embodiments of primary source "A" shown in FIGURES 2 and 3, the liquid vaporizing means 36 of each are interchangeable and the liquid pressurizing circuit of FIGURE 3 could be used in the FIGURE 2 embodiment. The preferred embodiment of FIGURE 2 is easier and more convenient to operate but, of course, there may exist situations where the FIGURE 3 embodiment would be preferable. For example, if liquid oxygen was not available in a pressurized and saturated form, a pressurizing circuit such as the one in FIGURE 3 would be necessary.

Secondary oxygen source

As shown in FIGURE 4, the secondary source "B" comprises a protective enclosure 88, a storage container 90 having an outer jacket 92 spaced from an inner vessel 94 to define an evacuable insulation space 96 between the inner and outer surfaces of the outer jacket and inner vessel, respectively. The outer jacket 92 is preferably convoluted as shown at 98 for greater strength. Inner vessel 94 is supported within outer jacket 92 by a double-walled low-heat conductive neck tube 100 which defines an access passage 102 to the inner vessel interior. The annular space 104 between the concentric tubes of neck tube 100 is in gas communication with insulation space 96. Insulation space 96 is evacuated through pinch-off tube 106 and preferably contains an opacified insulation of the type described in U.S. Patents 2,967,152 or 3,007,596 for protection against ambient heat in leak. A molecular sieve adsorbent 108 of the type described in U.S. Patent 2,900,800 is contained in blister 110 and maintains the vacuum within insulation space 96. A bursting disk 112 placed in outer jacket 92 prevents a dangerous pressure build-up within insulation space 96 from occurring should the container 90 develop a leak.

Means are provided about the top of access passage 102 to gas tightly seal the interior of inner vessel 94 from the surrounding atmosphere such as a spud 114 and cap 116 arrangement. In the preferred embodiment of the secondary storage source, a fluid transfer tube 118, a liquid vaporizing means 120, a pressure controller 122, and the secondary section of connecting means "C" (hereinafter called the "connecting means C_2") are connected to cap 116.

When the secondary source "B" is used to supply oxygen directly to a patient, he opens the flow control valve 130 so that pressurized liquid is transferred through fluid transfer tube 118 into cap 116 and vaporizer means 120 which includes an ambient air-warmed or "superheater" coil to a breathing device such as an oxygen mask (not shown). Flow control valve 130 is provided with a dial (not shown) to enable the patient to intelligently regulate the flow of gaseous oxygen.

To fill the secondary source, container 90 is inverted to the position shown in FIGURE 4 and placed on top of the primary supply source "A" shown in FIGURES 2 and 3, the primary and secondary connecting means C_1 and C_2 being joined in a manner to be described subsequently. When the two sections C_1 and C_2 of connecting means "C" are properly joined, pressurized liquid oxygen from the inner vessel 14 of primary source "A" will automatically flow through fluid transfer tube 34, connecting means "C," and fluid transfer tube 118 into inner vessel 94. During the filling of the secondary supply source "B," vapor is vented from inner vessel 94 to maintain a predetermined operating pressure level therein. Such vapor passes through a vent tube 124, and a neck tube extension 126 that connects vent tube 124 and neck tube 100, into access passage 102, and then to the atmosphere through cap 116 and the fittings attached to connecting means "C." A bursting disk 128 is connected to cap 116 to prevent damage to inner vessel 94 due to excessive pressures. When filling is first begun, a small amount of liquid may flow into vaporizing means 120 but inasmuch as a flow control valve 130 connected to liquid vaporizing means 120 will not be open, the pressure build-up within liquid vaporizing means 120 will quickly terminate such flow.

During this filling operation, the liquid will fall to the end of inner vessel 94 opposite the outlet of fluid transfer tube 118. As the liquid falls, a shield 132 connected to neck tube extension 126 will protect a liquid level sensing thermistor 134 positioned therein. As the liquid level rises, a portion of the liquid will pass into shield 132 through holes therein (not shown). On being contacted by liquid, thermistor 134 will deactivate a solenoid valve in connecting means "C" to terminate vapor exhaust from inner vessel 94 thereby permitting the vapor pressure therein to build-up to a sufficient level to prevent further liquid transfer into inner vessel 94.

When the secondary supply source "B" is removed from atop the primary source "A" on cessation of the filling procedure just described, container 90 will be inverted from the position shown in FIGURE 4. In this inverted position, as in the filling position, the vent tube 124 will always be positioned in the vapor space of inner vessel 94. This prevents any liquid from being vented through the exhaust line which is most important since the secondary supply source is designed to be carried by a moving patient and is relatively small (1.6 lbs. of available liquid). Considering the small size of the secondary source, any liquid loss would be highly undesible. Further, from the standpoint of safety, it would be very undersable for liquid to be vented during use by a patient because of the danger that the patient could be badly frost-bitten.

Connecting means

The primary connecting means C_1 is connected to the top of spud 30 (FIG. 2) or cap 32 (FIG. 3) of the primary source. Primary connecting means C_1 comprises a double valve assembly 138 connected to conduits 38 and 39. Valve assembly 138 comprises two valve housings 140 and 142, each containing a valve, and a guide framework 148. Since the valves are similarly constructed, valve 144 only is shown in detail in FIGURES 2 and 3 and described below to show the operation of both. (In FIGURE 3, valve housing 142 is behind valve housing 140 and therefore not shown.) Valve 144 is made up of a threaded fitting and a spider nut which supports a valve-headed stem 154. Valve housing 140 is connected to valve 144 such that valve-headed stem 154 and a spring biased movable valve seat 156 communicate with the interiors of valve housing 140 and conduit 38 to control fluid flow therebetween.

When the primary source "A" is used to fill secondary source "B" with liquid oxygen, liquid is transferred through fluid transfer tube 34, around valve-headed stem 154 and through valve seat 156 into the secondary connecting ameans C_2 attached to the secondary source "B." If the primary source is used to supply gaseous oxygen as previously described, the upper portion of fluid transfer tube 34 will be sealed from the atmosphere by the mating contact between valve-headed stem 154 and valve seat 156. It is readily seen that primary source "A" may be simultaneously used as a gaseous oxygen supply source and a liquid supply source for secondary source "B."

Valve housing 142 (FIG. 2) is a part of the gas venting system of secondary source "B" and, as such, is only used when sources "A" and "B" are connected for liquid transfer. During the filling of secondary source "B," vapor is vented through valve housing 142, valve 146, solenoid valve 158, relief valve 160, and gas diffuser 162. The operation of this portion of the primary connecting means will be described in more detail subsequently.

The secondary connecting means C_2 is connected to the top of cap 116 of the secondary source "B" (see FIGURE 4). This secondary connecting means C_2 comprises a double valve assembly 164 consisting of valve housings 166 and 168, which are attached to threaded fittings 170 and 172, one end of each of which threads into cap 116. A guide framework 174 is connected to fitting 170. Valve housing 166 is constructed such that a spring biased valve 176, enclosed therein, provides fluid communication to the interior thereof when displaced from a valve seat 178 in valve housing 166. Valve housing 168 is similarly constructed.

Valve housing 168 is part of the gas venting system of the secondary source and is only used when sources "A" and "B" are connected for liquid transfer. During the filling of the secondary source, vapor is vented from inner vessel 94 through vent tube 124, access passage 102, the interior of the cap 116 into valve housing 168 and into valve 146 of the primary connecting means C_1 attached to primary source "A." The operation of this portion of the second connecting means will be described in more detail subsequently.

To position the secondary source on top of the primary source for liquid transfer, the secondary source is inverted to the position shown in FIG. 4 and the secondary connecting means C_2 is seated on the primary connecting means C_1. In seating these two sections of connecting means "C," guide posts 180 of the primary connecting means guide framework 148 (see FIGURES 2 and 3) are mated through apertures 182 of the secondary connecting means guide framework 174 (see FIGURE 4). A pair of double-pronged levers 184 (part of which is not shown) is rotatably attached to guide framework 148 by bolt 186 (FIGURE 2), and engages bolt 188 (FIGURE 4) on guide framework 174 when these two sections are properly mated to hold the two tightly together. On positioning these two sections, valve housings 166 and 168 fit into valve housings 140 and 142, respectively, and on tightly fixing these two sections, the respective movable valve elements are displaced from their seats to permit fluid transfer therebetween.

After the two sources are so connected, the liquid in the primary source is free to flow into the secondary source. Because of the pressure differential between containers 10 and 90, the liquid will immediately begin to flow into container 90. However, pressure within container 90 will almost as quickly build up to the point where the needed pressure differential will be eliminated. To counteract this pressure build up tendency, relief valve 160 (see FIGURE 2) is set to open at some low pressure, such as 10 p.s.i.g. below the operating pressure of container 10, and excess vapor from container 90 is permitted to vent through connecting means "C" to the atmosphere. As long as the liquid level in container 90 is below thermistor 134, solenoid valve 158 will remain open and permit the excess vapor to vent through relief valve 160. However, when the liquid level reaches thermistor 134, solenoid valve 158 will be inactivated thereby causing the pressure within container 90 to build up to the point where liquid transfer is terminated. On termination of liquid transfer, the two sources may be disconnected.

It should be noted that during filling, the vapors passing through relief valve 160 are diffused into the atmosphere by gas diffuser 162. Such diffusion is highly desirable since it will prevent a dangerous increase in oxygen concentration around the system and relieve any anxiety that might be caused in the patient. Another advantage of this pressurized filling system is that the vented vapor system is attached to primary source "A." This permits attaching solenoid valve 158, relief valve 160, and diffuser 162 to the stationary primary source "A" thus reducing the weight and size of the portable secondary source.

Although preferred embodiments of the invention have been described in detail, it is contemplated that modifications may be made and that some features may be employed without others, all within the spirit and scope of the invention as set forth in the disclosure and claims.

What is claimed is:

1. Apparatus comprising in combination a thermally insulated storage container having an access passage in the top thereof to a storage space within the container, means sealing said access passage and storage space from the ambient atmosphere, a fluid transfer tube connecting to the sealing means and extending through said access passage into said storage space and terminating adjacent the bottom thereof; vaporizing means connecting to said sealing means in fluid communication with said fluid transfer tube, and connecting means connected to said sealing means in fluid communication with said fluid transfer tube for joining said container to a second container to control fluid transfer between the two containers, said connecting means comprising a valve assembly having first and second valve housings, each containing a normally closed valve, and a guide framework, the first valve housing valve being constructed and arranged to permit liquid transfer through said fluid transfer tube and the interior of said first valve housing into said second container when said connecting means is joined to said second container, the second valve housing valve being constructed and arranged to permit vapor venting from said second container through the interior of said second valve housing when said connecting means is joined to said second container, and said guide framework being constructed and arranged to leak-tightly join said connecting means with corresponding means of said second container to permit the aforesaid liquid transfer and vapor venting through said valve assembly.

2. Apparatus according to claim 1, including means for controlling the pressure within said storage space comprising a fluid heating element case extending into said storage space and having an interior portion in communication with the space between the container walls, a fluid heating element in said fluid heating element case, and means for controlling said fluid heating element to maintain the pressure within said storage space at a predetermined level.

3. Apparatus comprising in combination a thermally insulated storage container having two spaced concentric walls and an access passage in the top thereof to a storage space within the container; a neck tube depending into said storage space having two spaced concentric inner and outer walls, upper portions of which being gas-tightly connected to the container inner wall and outer wall, respectively, inner and outer wall lower portions of which being gas-tightly connected together and the space between the walls of which being in communication with the space between the container walls, and the interior of said neck tube defining said access passage; means sealing said access passage and storage space from the ambient atmosphere; a fluid transfer tube connecting to the sealing means for filling and emptying said storage space extending through said access passage into said storage space and terminating adjacent the bottom thereof; vaporizing means connecting to said sealing means in fluid communication with said fluid transfer tube; and connecting means for joining said container to a second container comprising a valve assembly connecting to said sealing means in fluid communication with said fluid transfer tube to control fluid transfer between the two containers.

4. Apparatus comprising in combination:

(a) a thermally insulated primary storage container having an access passage in the top thereof to a storage space within the container, means sealing said access passage and storage space from the ambient atmosphere, a fluid transfer tube connecting to the sealing means and extending through said access passage into said storage space and terminating adjacent the bottom thereof; vaporizing means connecting to said sealing means in fluid communication with said fluid transfer tube;

(b) a thermally insulated secondary storage container having two spaced concentric walls and an access passage in the top thereof to a storage space within the container; a neck tube depending into said storage space having two spaced concentric walls, inner and outer wall upper portions of which being gas-tightly connected to the container inner wall and outer wall respectively, inner and outer wall lower portions of which being gas-tightly connected together, and the space between the walls of which being in communication with the space between the container walls, and the interior of said neck tube defining said access passage; means sealing said access passage and storage space from the ambient atmosphere; a fluid transfer tube connecting to the sealing means for filling and emptying said storage space extending through said access passage into said storage space and terminating adjacent the bottom thereof; vaporizing means connecting to said sealing means in fluid communication with said fluid transfer tube;

(c) and connecting means for joining the secondary container to the primary container comprising: a primary guide framework connecting to the primary container sealing means; a primary valve assembly connecting to said primary container sealing means in fluid communication with the primary container fluid transfer tube and having (1) a first valve housing connected to said primary container sealing means in communication with said primary container fluid transfer tube, (2) a first valve stem positioned in said first valve housing constructed to cooperate with a secondary valve assembly to open a normally closed second valve channel when the primary and secondary valve assemblies are cooperatively connected, (3) a first spring biased valve seat cooperatively positioned in said first valve housing to mate with said first valve stem to provide a first valve channel normally closed to the transfer of fluid from said primary container fluid transfer tube, (4) a second valve housing in communication with the surrounding ambient atmosphere, (5) a second valve stem positioned in said second valve housing and constructed to cooperate with a fourth valve housing when said primary and secondary valve assemblies are cooperatively connected to open a normally closed fourth valve channel, (6) a second spring biased valve seat cooperatively positioned in said second valve housing to mate with said second valve stem to provide a third valve channel normally closed to the surrounding ambient atmosphere; a secondary valve assembly connecting to the secondary container sealing means in fluid communication with the secondary fluid transfer tube and having (1) a third valve housing connected to said secondary container sealing means in communication with said secondary container fluid transfer tube and constructed to cooperate with said first valve housing when said primary and secondary valve assemblies are cooperatively connected, (2) a third spring biased valve seat cooperatively positioned in said third valve housing to mate therewith to provide said second valve channel normally closed to the transfer of fluid to said secondary container fluid transfer tube, (3) a fourth valve housing connected to said secondary container sealing means in communication with the secondary container access passage and constructed to cooperate with said second valve housing when said primary and secondary valve assemblies are cooperatively connected to open the normally closed third valve channel, (4) a fourth spring biased valve seat cooperatively positioned in said fourth valve housing to mate therewith to provide said fourth valve channel normally closed to the transfer of vapor from said secondary container access passage; and a secondary guide framework connecting to said secondary container sealing means, the primary and secondary guide frameworks being so constructed and arranged that said secondary container may be inverted and positioned relative to said primary container and said primary and secondary guide frameworks cooperatively connected to provide communication between the first and second valve channels and between the third and fourth valve channels;

(d) means for controlling liquid transfer from said primary container to said secondary container when said primary and secondary valve assemblies are cooperatively connected comprising means for venting vapor from the secondary container storage space into said secondary container access passage so as to maintain the secondary storage space pressure at a predetermined level below the incoming liquid pressure; and means for sensing the liquid level within said secondary storage space during the filling thereof and for terminating the venting of vapor from said secondary access passage through said third and fourth valve housings when the sensed liquid level reaches a predetermined height so the secondary storage space pressure will equalize with the incoming liquid pressure thereby terminating liquid transfer into said secondary storage space.

5. Apparatus according to claim 4 including: means for controlling the pressure within said storage space comprising a fluid heating element case extending into said storage space and having an interior portion in communication with the space between the container walls, a fluid heating element in said fluid heating element case, and means for controlling said fluid heating element to maintain the pressure within said storage space at a predetermined level.

6. Apparatus according to claim 2 wherein said means for controlling said fluid heating element to maintain the pressure within said storage space at a predetermined level comprises: pressure sensitive means connected to said sealing means in communication with said storage space for sensing the pressure within said storage space and controlling the operation of said fluid heating element in response to the sensed storage space pressure so as to maintain liquid stored within said storage space in a saturated condition at said predetermined level.

7. Apparatus according to claim 2 wherein said vaporizing means supplies vapor to breathing atmosphere supply means and comprises:

(a) elongated heating means having helical fluid passages along the longitudinal periphery thereof when liquid is vaporized and superheated;
(b) and means for controlling the temperature of the superheated vapor supplied from said vaporizing means to said breathing atmosphere supply means.

8. Apparatus according to claim 1 wherein said vaporizing means comprises an air-warmed superheater coil.

9. Apparatus according to claim 3 including means for controlling fluid transfer to said container which comprises:

(a) means for venting vapor from said storage space so as to maintain the storage space pressure at a predetermined level below the incoming liquid pressure;
(b) and means for sensing the liquid level within said storage space during the filling thereof and for inactivating the aforementioned vapor venting means when the sensed liquid level reaches a predetermined height so that said storage space pressure will equalize said incoming liquid pressure thereby terminating liquid transfer into said storage space.

10. Apparatus according to claim 5 wherein:

(a) said means for controlling said fluid heating element to maintain the pressure within the primary storage space at a predetermined level comprises pressure sensitive means connected to said primary conduit housing means in communication with said primary storage space for sensing the pressure within said storage space and controlling the operation of said fluid heating element in response to the sensed primary storage space pressure so as to maintain liquid stored within said primary storage space in a saturated condition at said predetermined level; and
(b) the primary vaporizing means supplies vapor to primary breathing atmosphere supply means and comprises elongated heating means having longitudinal peripheral helical fluid passages wherein liquid is vaporized and superheated and means for controlling the temperature of the superheated vapor supplied from said primary vaporizing means to said primary breathing atmosphere supply means.

11. Apparatus according to claim 4 wherein:

(a) said primary container guide framework comprises a plurality of vertical guide posts affixed to said guide post frame and means for locking said primary and secondary containers together;
(b) and said secondary container guide framework comprises a guide frame having a plurality of apertures therein to receive said primary framework guide posts and means for receiving the means for locking said primary and secondary containers together.

12. Apparatus according to claim 3 including vapor venting means which comprises a vent tube connected to the inner end of said neck and constructed and arranged to be positioned within the vapor space of said container in all attitudes of said container.

13. Apparatus according to claim 3 wherein said connecting means includes a guide framework connecting to said sealing means, said valve assembly and said guide framework being constructed and arranged such that said container may be inverted and positioned relative to said second container with said guide framework and said valve assembly cooperatively connected to a corresponding second container guide framework and valve assembly to provide fluid transfer therebetween.

14. Apparatus according to claim 13 wherein said valve assembly comprises a valve housing connected to said sealing means in fluid communication with said fluid transfer tube and a spring biased valve seat cooperatively positioned in said valve housing to mate therewith to provide a valve channel normally closed to the transfer of fluid in said fluid transfer tube, said valve housing and said spring biased valve seat being constructed to cooperate with said second container valve assembly to open said valve channel when the valve assemblies are cooperatively connected.

15. Apparatus according to claim 3 wherein said valve assembly comprises first and second valve housings, each containing a normally closed valve, and a guide framework, the first valve housing valve being constructed and arranged to permit fluid transfer from said second container through the interior of said first valve housing into said fluid transfer tube when said connecting means is joined to said second container, the second valve housing valve being constructed and arranged to permit vapor venting from said storage space through said access passage and through the interior of said second valve housing when said connecting means is joined to said second container, and said guide framework being constructed and arranged to mate said connecting means with corresponding means of said second container to permit the aforesaid liquid transfer and vapor venting through said valve assembly.

16. Apparatus according to claim 15 including means for controlling liquid transfer from said second container

when said connecting means is joined to said second container which comprises means for venting vapor from said storage space into said access passage so as to maintain the storage space pressure at a predetermined level below the incoming liquid pressure; and including means for sensing the liquid level within said storage space during the filling thereof and for terminating the flow of vapor from said access passage to the surrounding ambient atmosphere through said corresponding connecting means of said second container when the sensed liquid level reaches a predetermined height so said storage space pressure will equalize with said incoming liquid pressure thereby terminating liquid transfer into said storage space.

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