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APPARATUS FOR EVAPORATING LIQUID OXYGEN

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Fig. 1

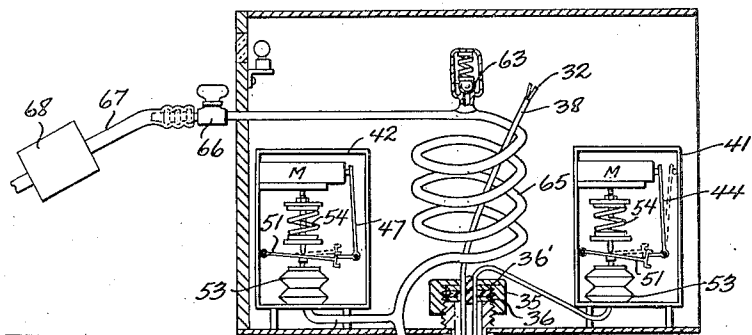


Fig. 2

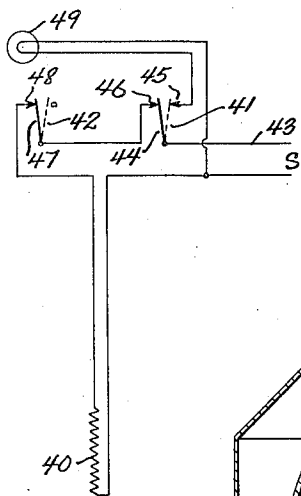
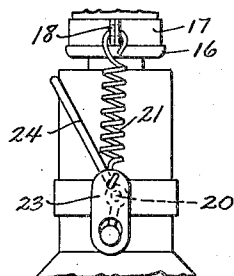


Fig. 3



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APPARATUS FOR EVAPORATING LIQUID OXYGEN

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6 Claims. (Cl. 219-39)

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This invention relates to an improved apparatus for supplying a controlled flow of gaseous oxygen under pressure by the controlled evaporation of liquid oxygen. More specifically, this invention is an improvement of our prior invention relating to a method and apparatus for evaporating liquid oxygen described and claimed in the United States Patent No. 2,158,458, of May 16, 1939.

Since our prior invention, above identified, has fairly established the feasibility of and the advantages in the method of dispensing gaseous oxygen from liquid oxygen by manually controlling its rate of evaporation, it now becomes desirable to utilize this method for supplying oxygen to the crew of high altitude aircraft. In adapting this prior method for use in this particular field, several important and novel features had to be incorporated in the apparatus previously employed to make its operation sufficiently satisfactory for use in its new environment. For example, it was found necessary to enclose the liquid oxygen in a container sealed against the vapor pressure present therein and to supply the gaseous oxygen under pressure. Furthermore, it was found that the pressure could be maintained substantially constant by utilizing a heating element to raise the temperature of the liquid oxygen thereby increasing its rate of evaporation and further to control the energization of the said heating element in response to variations in the vapor pressure acting on the surface of said liquid oxygen.

It is, therefore, a primary objective of this invention to provide means for dispensing gaseous oxygen by controlling the temperature and rate of evaporation of said liquid oxygen in accordance with the pressure of the vapor acting upon its surface.

As is well known, the vapor pressure acting upon a body of liquid is a function of its temperature and will increase as the temperature increases; consequently, the vapor may be caused to return to liquid by increasing the pressure of the vapor acting upon the liquid to a value in excess of that normally existing at a particular temperature when the vapor and the liquid are in equilibrium. Thus, by utilizing a heat exchange device in a dispensing conduit leading from the sealed container for said liquid oxygen to subject liquid oxygen escaping through the conduit to a temperature considerably in excess of the temperature of the liquid within the container it is possible to permit the apparatus to operate in an inverted position which is very

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desirable when the apparatus is installed in aircraft. That is, by utilizing such a heat exchange device in the said dispensing conduit, a small quantity of liquid may initially escape into the conduit when the container becomes inverted, but this liquid will be immediately evaporated by the heat supplied thereto through the heating exchange device and since the temperature of the heat exchange device exceeds the temperature of the body of liquid oxygen, the vapor pressure within the conduit produced by the evaporation of this small but sufficient amount of liquid will exceed the vapor pressure within the Dewar flask. The evaporated liquid thus raises the pressure within the flask and since the temperature of the liquid within the flask is not high enough to maintain such a vapor pressure, the vapor will return to liquid. Thus, no liquid can be dispensed through the conduit when the flask is inverted because in escaping into the conduit, the liquid evaporates building up a pressure in the conduit and flask higher than that which can be maintained by vapor in the flask at the temperature of the liquid mass therein, thereby destroying the conditions of equilibrium causing the vapor to return to liquid.

Consequently, we propose as an object of this invention to provide a heat exchange device in the dispensing conduit of a container for evaporating liquid oxygen to permit inverted operation of the said container.

It is a further object of this invention to dispense gaseous oxygen at substantially constant pressure irrespective of whether or not the liquid oxygen container is maintained in an inverted position or in any other position from an upright one.

A further object of the invention is to provide resilient means for capping the container which will act as a safety device to prevent excessive vapor pressure from being built up within the container.

Still another object is to provide an oxygen dispensing device from which relatively large amounts of oxygen may be drawn off over short periods of time without an appreciable difference in pressure.

Other objectives and advantages of the invention will become apparent from the specification as the specific features of this invention are hereinafter described in detail in connection with the accompanying drawing in which:

Fig. 1 is an elevational view of a vertical section showing the apparatus of the present inven-

tion installed upon a flask containing liquid oxygen;

Fig. 2 is a wiring diagram of the circuit connections for the electrical heating element; and

Fig. 3 is a side view in elevation of the capacity securing means for the flask.

Referring particularly to the drawing, the reference character 1 indicates the usual Dewar flask provided with the usual outlet neck 2. The flask is resiliently and insulatedly supported in a metallic housing 3 to prevent breakage resulting from sudden shock and to inhibit direct transmission of heat, by means of the spring 4 which as shown is resiliently compressed against the inside housing 3 and the outer surface of the flask 1 and by means of the compression spring 5 retained in position between the collar 6 secured to the neck portion 2 of the Dewar flask and the flange 7 supported within the neck portion 8 of the housing 3. The cap 10 has an inner frusto-conical surface 11 of ground brass which provides a gas-tight connection with the ferruled rim 12 of the flask 1. Secured to the cap 10 is a cabinet 15 which has an open end to permit the free circulation or convection of air there-through and an elongated brass tube 14. The brass tube 14 is preferably inserted into the cap 10 so that its flanged surface will securely hold the cabinet 15 in assembled position between the top lateral surface of the cap and the lateral surface of the flange.

Figs. 1 and 3 show in detail the construction means by which the ground surface 11 of the cap 10 is held in gas-tight contact with the ferruled rim of the flask to seal the cap and flask against the vapor pressure maintained therein. As illustrated, the cap 10 is provided with a cylindrically and radially extending flange 16 formed at its lower end against which is pressed the split collar 17 having a pair of projecting ears 18 and 19. To the ears 18 and 19 of the collar are attached the tension springs 21 and 22, respectively. Each spring has secured at its lower end a pendant 23 which is provided with an opening formed therein of a diameter large enough to permit the introduction of splayed ends 25 of the pivoted bail 24. In operation to release the spring tension and remove the cap and the tube from the flask, the bail is pulled outwardly and downwardly from its position shown in Fig. 3. When the bail 24 is initially moved downwardly, the ends 25 move inwardly toward the ears 18 and 19 of the collar to a position in line with the pivotal axis 20 of the bail 24 and the center line of said ears. In so moving the bail, the springs 21 and 22 are further tensioned since the ends 25 were originally in a position one side of the pivot 20. Further movement of the bail 24 reduces the spring tension since the ends 25 of the bail have now passed the pivot point 20. Obviously, the bail 24 is resiliently maintained in the position illustrated in Fig. 3 by virtue of the spring tension which acts upon the bail ends 25 tending to move the bail about its pivot in a clockwise direction as viewed in Fig. 3. This cap securing arrangement is useful for effectively inhibiting direct transfer of heat from the clamping device to the ferruled end of the Dewar flask. When the cap is so retained in position, the closed end of the brass tube 14 extends within the flask and into contact with the liquid maintained within the body portion of the flask. Supported within the closed end of the tube is an electrical heating element 40 and a thermo-responsive device 30 which comprises a bulb 31

filled with carbon dioxide or some other fluid suitable for expansion and contraction with temperature variations. The conductors 32 for connecting the electrical heating element 40 to a suitable source of electrical potential and the tube 33 which communicate with the interior of the carbon dioxide bulb 31 are each brought up inside of the brass tube. Since the closed end of the tube 14 is in contact with the cold liquid oxygen, it is desirable to prevent convection of atmosphere through the tube because the water vapor present in the atmosphere would condense upon contact with the cold surface of the tube and would eventually damage the heating element 40 located therein. In order to close off the end of the tube 14, there are provided a plurality of fibre washers 36 and 36', each having openings through their centers large enough to permit the passage therethrough of the conduit 38 for the conductors 32 and the tube 33 which communicate with the thermo-responsive device 30. The conduit 38 and tube 33 are each threaded through these washers which are placed at the upper end of the tube after having been thoroughly impregnated with liquid latex. A small amount of plastic gum rubber is wound about each of the conduit and the tube and a compression nut 35 is screwed down firmly on the threaded end of the flanged tube 14, compressing the fibre washers 36 and 36' between the nut and the tube and pressing the gum rubber firmly about the conduits to form a gas-tight seal of the interior of said tube. The free convection of the atmosphere being prevented by the sealing above described, there is provided in the tube a member 37 of high thermal conductivity which contacts both the heating element 40 and the bulb 31 to form a good heat-conductive path from the heating element to the thermo-responsive device.

Electrical power for energizing the resistance heating element 40 is obtained from a suitable source as shown in Fig. 2. The circuit for the heating element is complete through the serially connected switches 42 and 41. One conductor 43 leading from one terminal of the supply source is connected to the arm 44 of a single pole double throw switch 41. When the arm 44 is in the position shown in broken line and in contact with the switch terminal 45, the pilot light 49 is connected across the supply source and indicates that the series connection to the heating circuit 40 has been broken at the switch 41. When the switch arm 41 is in the position shown in full line, in contact with the terminal 46, the circuit is conditioned so that it may be completed through the switch contacts arm 47 and the terminal 48 of the switch 42.

As illustrated in Fig. 1, each of the switches 41 and 42 are pressure actuated. That is the pivot arm 51 of each of the switch actuating mechanisms is moved about its pivot in response to the movement of the bellows 53 against the action of the coiled spring 54. In the switch 41 the bellows 53 is connected to the conduit 33 leading from the thermo-responsive device 30, whereas the bellows 53 of the switch 42 is connected to the conduit 52 leading from the space defined between the cap 10 and the brass tube 14. The permanent magnet M of each switch is provided for the purpose of moving the arms 44 and 47 with a snap action.

The oxygen dispensing conduit 60 connects with an opening 61 formed in the side of the cap 10 above the ferruled edge 12 of the flask and leads

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into the cabinet 15 where it is coiled as at 65 to provide a large heat exchange surface. A safety valve 63 is provided in the conduit which extends from the warming coil 65 or heat exchange surface outwardly through the side of the cabinet to the manually operated valve 66 to which is connected a flexible conduit 67 leading to the pressure regulating valve 68.

When it is desired to use the apparatus disclosed in the present invention, the brass tube 14 is inserted into the connection of the Dewar flask containing the liquid oxygen. It should be noted here that this oxygen is then normally at a temperature of about -183° C. and at atmospheric pressure, these conditions being those under which liquid oxygen is commonly stored, transported and sold to the trade. The cap 10 is then securely clamped in position to provide a gas-tight seal at the ferruled edge of the flask and inner surface 11 of the cap. Now if the circuit shown in Fig. 2 is connected to a suitable source of electrical potential, the switch arms 44 and 47 of the switch 41 and 42, respectively, will take a position shown by the full lines of Fig. 2 completing a closed series circuit through the resistance electrical heating element 40. Due to the use of the regulating valve 68, the first result obtained by the application of heat to the liquid oxygen from heating element 40 is to raise the temperature of the oxygen and store heat within it. There will be no immediate substantial evaporation of the oxygen but a rise in vapor pressure will occur at its surface. After the temperature and vapor pressure have been built up considerably, the apparatus is then in condition to supply substantial quantities of gaseous oxygen. Now when valve 63 is opened, the gaseous oxygen evaporated from the liquid will then flow upwardly through the neck 2 to the outlet tube 60 through the warming coil 65, into the flexible dispensing tube 67 and outwardly through valve 63. As valve 68 allows escape of gaseous oxygen, the vapor pressure within the flask 1 is reduced above the surface of the liquid oxygen but remains at a substantially fixed level below its surface. This results in an immediate replacement from the liquid of gas withdrawn from the chamber and conduits above its surface.

The electrical current will continue to flow in the heating element 40 until the liquid mass contained within the Dewar flask attains a temperature to establish equilibrium for a vapor pressure equal to the pressure at which the pressure actuated switch 42 has been set to operate. When the vapor attains a pressure equal to or greater than the pressure setting of the switch 42, the bellows 53 will have expanded sufficiently to actuate the operating arm 51 to move the switch arm 47 from its position of engagement with the terminal 48 to open the circuit and interrupt the current flow to the electrical heating element 40. The switch 42 will remain in this latter position until the vapor pressure within the flask 1 drops below the point at which the switch 42 is adjusted to operate to close the series circuit for the heating element 40.

It is desirable to have the pressure actuated switch 42 opened to an absolute pressure rather than to relative pressure since variations in relative pressure would require variations in the absolute temperature of the liquid mass contained within the flask 1. The use of a regulating valve at the end of the flexible conduit 67 is necessary in order to allow the pressure to build up within the flask and in order to prevent a flow

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of oxygen in excess of that for which the apparatus is designed.

The provision of the thermo-responsive switch 41 in the circuit of the heating element 40 is a safety feature of the apparatus since as long as there is a sufficient amount of liquid oxygen within the flask, the temperature of the carbon dioxide within the bulb will be below its freezing point and the carbon dioxide will solidify reducing the pressure within the bellows 53 of the switch 41 causing the switch to remain closed. However, should the supply of liquid oxygen become nearly exhausted current would still continue to flow in the heating element were it not for the provision of the thermally actuated switch 41. Near exhaustion of the supply of liquid oxygen permits the temperature of the carbon dioxide contained within the bulb 31 to increase to a value wherein the pressure is sufficient to actuate the arm 44 of the switch 41 to interrupt the flow of current to the heating element and to connect the pilot light 49 across the supply source *s* to indicate to the operator the near exhaustion of the supply of liquid oxygen.

It should be noted that since the pressure above the liquid does not depend upon ebullition from the heating element itself but depends rather upon the vapor pressure of the liquid oxygen for the given temperature, therefore, large amounts of gaseous oxygen may be drawn off over short periods of time without an appreciable difference in pressure. Furthermore, when it is desired to conserve the oxygen gas and to prevent evaporation loss during the period of storage, it is better not to apply an electrical potential to the heating element and to allow the pressure to build up slowly over a period of days until need for the gas is about to occur. In this way there is no evaporation loss until the entire mass of liquid has attained a temperature sufficient to produce a vapor pressure over its surface sufficient to actuate the safety valve 63. In ordinary use this safety valve 63 would probably never function and is intended merely as further safety measure in order to prevent undue pressure from being built up within the Dewar flask.

It should also be noted that the bail operated spring means previously described also performs a safety function in that the cap 10 upon a sufficient increase in pressure will be caused to rise off its seat against the biasing action of springs 22 and allow the excess pressure to escape at this point.

While the present invention is particularly adaptable for supplying oxygen to aircraft or submarine personnel where weight and space are at a premium, it is not to be limited to these uses. In fact it may be used successfully in welding, cutting and for supplying oxygen tents. Its primary advantage lies in that it reduces the cost of gaseous oxygen.

It is contemplated that improvements will be made in the Dewar flask contained herein by providing an outer shell of a self-sealing material which may seal sufficiently against the low vapor pressures normally used to prevent total and instantaneous escape of the oxygen should the container be perforated by gunfire.

It will be understood that the particular form of invention disclosed is for purposes of illustration and not for purposes of limitation, reference being had for this latter purpose to the appended claims.

This invention described herein may be manufactured and used by and for the Government

of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

We claim:

1. An apparatus for evaporating liquid oxygen 5 comprising in combination a container for said oxygen, an electrical heating element in said container in heat transfer relation with said oxygen for increasing the temperature and rate of evaporation thereof, a source of electrical energy, circuit controlling means for connecting said source 10 to said heating element, a vapor dispensing conduit leading from said container, valve means in said conduit a heat exchange device connected to said conduit outside of said container and exposed to ambient temperature for subjecting any 15 liquid oxygen escaping thereto to a temperature higher than the temperature of the liquid oxygen whereby said device will be capable of operation in an inverted position.

2. The combination defined in claim 1 further characterized by the fact that said circuit controlling means includes, in series, a switch actuated in response to the temperature of said heating element, and a switch actuated in response 25 to the pressure of the vapor acting on the surface of said liquid.

3. An apparatus for evaporating liquid oxygen comprising in combination a container for said oxygen having a restricted opening leading to 30 the interior thereof, means sealing said opening comprising a cap, a tube having open and closed ends, means securing said cap to said tube at said open end so that the closed end will project from said cap into the interior of said container in contact with said fluid, sealing means for the 35 open end of said tube, an electrical heating element disposed within the closed end of said tube, a temperature responsive device within said tube, heat conductive means contacting said element and device to provide a conductive heat transfer path, circuit means for energizing said heating 40 element including a first series switch connected

therein and operated by the said temperature responsive device, an oxygen dispensing conduit leading from said cap, valve means in said conduit and a second series switch connected in said circuit, said second switch being pressure responsive and actuated by the vapor pressure within said conduit.

4. Apparatus for evaporating liquid oxygen comprising a container for said liquid oxygen, pressure responsive means actuated by the vapor pressure existing within said liquid for controlling said vapor pressure and supplying necessary heat as heat is lost by vaporization tending to maintain a liquid temperature which will provide a desired vapor pressure, a dispensing conduit leading from said container, valve means in said conduit, and a heat exchanger located outside of said container, said heat exchanger being in contact with surrounding air and connected to said dispensing conduit for causing the vapor pressure 20 to be increased to a value in excess of the vapor pressure existing on said liquid when said liquid and vapor are in equilibrium whereby to permit the inverted operation of said apparatus.

5. Apparatus for vaporizing liquid oxygen comprising an insulated container for said liquid oxygen, outlet means from said container, said outlet means including a heat exchanger located outside of said container in contact with the surrounding air, valve means in said outlet means, and means for applying heat to said liquid oxygen within said container.

6. Apparatus for vaporizing liquid oxygen comprising a container for said oxygen, said container having a neck portion, a cap member closing said neck portion, a dispensing conduit connected through said cap member into said neck portion, valve means in said dispensing conduit, and means resiliently holding said cap member 40 upon said neck portion.

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