Nov. 5, 1940. F. W. HARTMAN 2,220,447

REFRIGERATING APPARATUS

Filed June 26, 1937 2 Sheets-Sheet 1

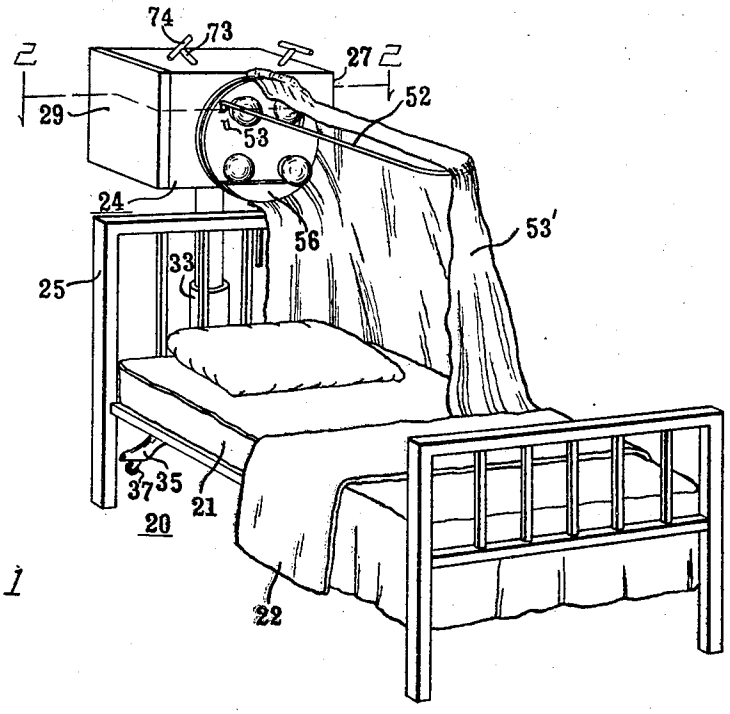


Fig 1

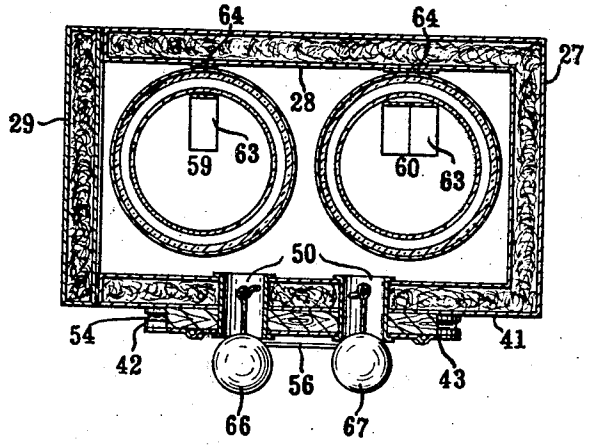


Fig 2

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Fig 3

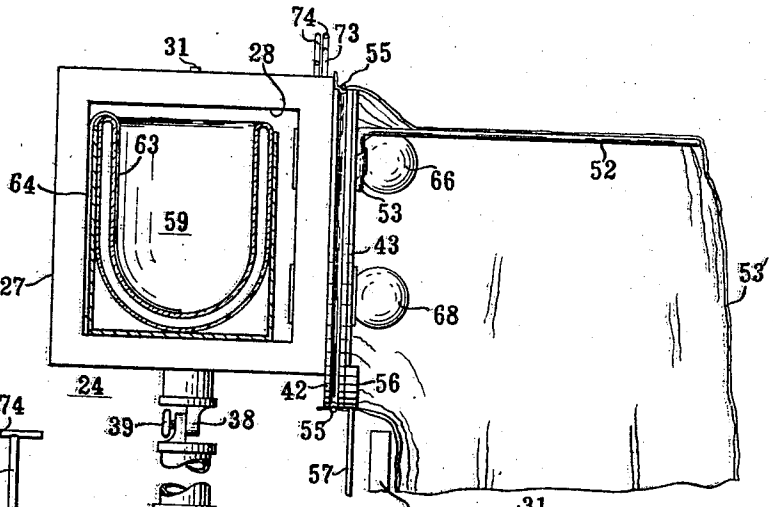


Fig 6

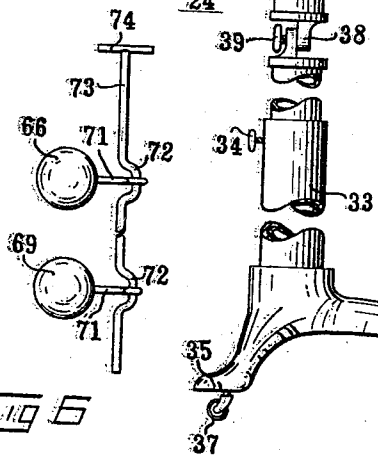


Fig 8

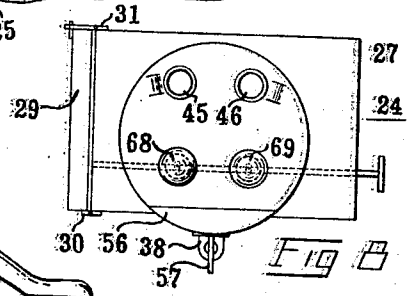


Fig 5

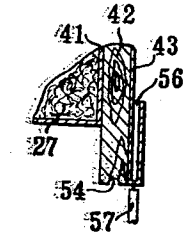


Fig 7

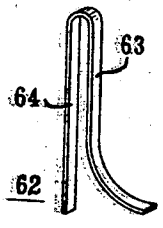


Fig 4

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Patented Nov. 5, 1940 2,220,447

UNITED STATES PATENT OFFICE

2,220,447

REFRIGERATING APPARATUS

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14 Claims. (Cl. 128—191)

The present invention relates to the art of refrigeration of tents and particularly to refrigerating and supplying oxygen to oxygen tents. One of the objects of the present invention is to provide an improved method of and apparatus for refrigerating tents by cooling the circulating medium by a liquid low enough in temperature so that the noxious gas, given off by the occupant of the tent, is condensed by the liquid.

Another object of the invention is to cause the circulating medium of the tent to flow in heat exchange relation with liquid air and liquid oxygen and to cause the gas from these liquids to be circulated in the tent.

In carrying out the foregoing object it is a further object to control the relative rate of vaporization of the liquid air and liquid oxygen.

A further object is to provide a heat absorber of a relatively higher temperature than the liquid refrigerant but which is maintained at a temperature below the dew point of the moisture in the circulating medium so as to condense the moisture from the circulating medium, and to position this heat absorber so that the circulating medium flowing toward the liquid refrigerant first comes in contact with the heat absorber.

It is a still further object of the present invention to yieldingly connect the tent with the refrigerated cabinet.

Other and further objects and advantages will be apparent from the following description, reference being had to the accompanying drawings wherein a preferred form of embodiment of the present invention is clearly shown.

In the drawings:

Fig. 1 is a view in perspective showing the invention as applied to a bed, a part of the tent being cut away;

Fig. 2 is a sectional view of the cooling apparatus, the section being taken on line 2—2 of Fig. 1;

Fig. 3 is a side view of the cooler with the door thereof removed; the tent is shown attached and a part of the tent is cut away; a receptacle is shown in longitudinal cross section;

Fig. 4 is a front view of the cooler with the door partly open;

Fig. 5 is a fragmentary sectional view of the lower front part of the cooler showing the drip trough and drain, the section being taken on line 5—5 of Fig. 4;

Fig. 6 is a detailed view of one of the valves and the mechanism for actuating the same;

Fig. 7 is a perspective view of one of the heat conductors which straddles the rim of a refrigerant receptacle; and

Fig. 8 is a front view of a preferred form of the invention.

Referring to the drawings, the present invention is illustrated with a bed to which it is particularly applicable. Referring to the drawings the bed is shown at 20 carrying a mattress 21 and other bedding 22. The cooler 24 is preferably placed in back of the head 25 of the bed 20. The cooler comprises an insulated cabinet 27 having an inner metal lining 28 and an insulated side door 29. This door is preferably hinged at the bottom on hinges 30 and is latched in position by a latch 31 at the top. The cabinet 27 is supported by a telescoping type stand 33 which is adjustably set at the desired height by a set screw 34. The stand 33 is provided with two relatively short legs 35 and a relatively long front leg 36, each of which is supported by a rubber tired wheel 37. The cabinet 27 is hinged to the stand 33 by an adjustable clamp 38 which is tightened in position by a screw 39. In this manner the cabinet 27 can be tilted sidewise. The front 41 of the cabinet 24 carries a wooden plate 42 having a sheet metal face 43. The front 41 of the cabinet 27 is also provided with four sleeved opening 45, 46, 47 and 48. The sleeve 50 of each is preferably formed of insulating material. Openings 45 and 46 are disposed above openings 47 and 48 and the former provide inlet openings to the cabinet while the latter provide outlet openings therefor.

A hairpin shaped support 52 includes inwardly and downwardly extending projections 53. These projections 53 are suitably carried by the plate 43 so that the support 52 extends forwardly and when in the position shown, projects over the head portion of the bed. This support 52 carries a tent 53'. This tent is preferably formed of thin transparent rubber or rubberized material. The bottom of the tent is open so that it can be placed about the patient in the bed and the lower edges thereof are then tucked under the bedding so as to substantially seal the bottom of the tent. The rear of the tent is formed with a circular shaped opening arranged to fit over the plate 42 on the front of the cabinet. This plate 42 is provided with a groove 54 and a resilient band 55, preferably formed of rubber, surrounds the tent adjacent the rear opening thereof and forces that portion of the tent into the groove 54 to thereby substantially seal this opening. Thus the interior of the insulated cabinet and the interior of the tent, with the aid of

the bedding, form means for providing a closed circulatory system.

When it is desirable to supply oxygen to the patient, I prefer to employ liquid oxygen. This liquid oxygen will be placed in the interior of the cabinet **27**. When this is done, the warm gas from the tent will pass through passages **45** and **46** and will be cooled by the cold interior walls of the cabinet and by the receptacle containing the liquid. The cooled air will then pass through the openings **47** and **48** to the interior of the tent. The liquid oxygen receptacle being at a lower temperature than the CO_2 gas, given off by the patient, will cause condensing and freezing of the CO_2 on the receptacle. Due to the fact that cold gas passes adjacent face **43** on the front of the cabinet, it will be cooled to below the dew point of the moisture in the gas and therefore moisture will be condensed on the face **43**. A trough **56** is carried on the bottom of the face **43** for catching the drip and this condensate is drained from the trough **56** by a tube **57** extending to the interior of the tent.

It is desirable to supply air as well as oxygen to the patient and in order to accomplish this I also place liquid air in the cabinet **27**. The gas given off by the liquid air is mixed with the oxygen gas and this mixture circulates as previously described. The liquid oxygen and the liquid air are contained in open top receptacles of the vacuum type. The liquid air receptacle is shown at **59** and the oxygen receptacle is shown at **60**. The liquid air being colder than the liquid oxygen normally would tend to boil off faster than the liquid oxygen and in order to control the boiling off of these liquids and to maintain the desired percentage of oxygen in the gas mixture, I control the amount of heat conducted to the liquids as will be explained hereinafter. Strips of metal **62** extend into the liquids for conducting heat thereto and in order to maintain a relatively large heat absorbing surface having a relatively small temperature gradient between different parts thereof, the strips are placed in intimate heat exchange relation with the lining **28** of the refrigerated cabinet. One of these heat conducting strips **62** is shown in Fig. 7. These strips **62** are adapted to straddle the upper part of the receptacles **59** and **60** and the lower parts of the inside legs **63** thereof are bent to conform to the rounded shape of the receptacles. The outside legs **64** of strips **62** are placed against the lining **28**. The heat from the circulating medium will be absorbed by the lining and conducted from the strip **62** to the liquid. It will of course be understood that the receptacles **59** and **60** are colder than the lining **28** and that heat will be absorbed directly by the receptacle.

A large part of the CO_2 gas which is condensed in the cabinet **27** will freeze on the metal covers of receptacles **59** and **60**. This solid CO_2 is preferably removed at the time that the receptacles are refilled. In order to control the oxygen content of the gas, the relative rate of vaporization of the liquid air and liquid oxygen is controlled by controlling the heat exchange between the liquids and the circulating gas. This is accomplished by varying the size or number of strips **62**. I have found that in order to maintain approximately 50% oxygen content of the circulating gas, two strips **62** should be used in connection with the liquid oxygen receptacle **60** and one strip should be used in connection with the liquid air receptacle **59**. It will of course be understood that this relationship must necessarily vary in accordance with factors which are different from those specifically shown in the present application.

It is desirable to control the rate of circulation within the system and for this purpose I provide valves **66**, **67**, **68** and **69** for controlling the flow of gas through passages **45**, **46**, **47** and **48** respectively. These valves are operated in pairs. That is, when valve **66** is being moved toward open or closed position, valve **69** will be moved toward open or closed position. Valves **67** and **68** are also coupled with one another. Each valve is connected by a link **71** to a crank **72**, of a crankshaft **73**. The cranks are located in the respective passages and both cranks extend to the exterior of the cabinet and are there provided with handles **74** for actuating the same. In this manner a close regulation can be maintained of the circulation of gas so that the temperature within the tent can be maintained 8° or 10° F. below room temperature. Preferably only one set of valves are provided; namely, valves **68** and **69** which control the flow of gas from the cooler to the tent, the openings **45** and **46** being maintained so that the flow of gas from the tent to the cooler is not impeded.

From the foregoing it will be seen that I have provided a method and apparatus for maintaining a relatively low CO_2 content of the gas in an oxygen tent. By employing liquid oxygen as an element for cooling the circulating gas and for supplying oxygen gas thereto, I have materially simplified the administration of oxygen to the patient while at the same time maintaining a cold gas. By employing liquid air and controlling the relative rate of vaporization of the liquid air and liquid oxygen, the oxygen content of the circulating gas can be maintained substantially constant and the liquid air also provides a medium for assisting in the cooling of the gas to be inhaled and simultaneously provides a condensing surface for causing solidification of the CO_2 gas given off by the patient.

By controlling the flow of the gas through the valves, any desirable temperature can be maintained within the tent. I have found that the valves can be regulated so that the temperature within the tent can be maintained at that normally desired, 8° or 10° F. below room temperature, and sufficient circulation is maintained so that the CO_2 content of the circulating gas is below 1%.

By providing the yielding connection between the tent and the insulated cabinet **27**, the tent can be pulled away from the cabinet very readily. In this manner an unruly or delirious person cannot overturn the cabinet because the yielding connection will permit the detachment of the tent from the cabinet by a slight jerk, since the resistance of the yielding connection is less than the energy required to overturn or upset the cabinet. To further safeguard against the upsetting of the cabinet, the long leg **36** is positioned at the forward side of the cabinet so that in case the cabinet is overturned, the contents thereof cannot strike the bed.

A further advantage of the present invention is that the entire apparatus may be placed at the back of the bed whereby the nurse may have access to the sides and foot of the bed.

It will be understood that when the apparatus is used as a bed cooler, the tent will extend from the head to the foot of the bed. In that case the lower edges of the tent will be tucked under the extreme edges of the bedding or mattress.

While the form of embodiment of the present invention as herein disclosed constitutes a preferred form, it is to be understood that other forms might be adopted, all coming within the scope of the claims which follow:

I claim:

1. The method of administering oxygen to a person in an enclosure and removing the noxious gases of respiration from circulation in the enclosure which consists in directing oxygen gas, boiling off from liquid oxygen, into the enclosure and directing the gases of the enclosure, including the noxious gas given off by the respiration of the person, into heat exchange relation with the liquid oxygen to thereby cause condensation and precipitation of the noxious gas.

2. That step of administering oxygen to a person in an inclosure and removing the noxious gases of respiration from circulation which consists in directing the gases, boiling off from liquid oxygen and liquid air, into an enclosure, directing the gases of the enclosure, including the noxious gas given off by the respiration of the person, into heat exchange relation with the liquid oxygen and liquid air to thereby cause condensation and precipitation of the noxious gas, and controlling the rate of vaporization of the liquid air and liquid oxygen.

3. The method of administering oxygen to a person and removing noxious gases of respiration of the person from circulation which consists in directing oxygen gas, boiling off from liquid oxygen, into the presence of the person and directing the noxious gas given off by the person into heat exchange relation with the liquid oxygen to thereby cause condensation and precipitation of the noxious gas.

4. The method of administering gas to a person which consists in directing gas boiled off from its liquid state, to the person, and directing noxious gas given off by respiration of the person into heat exchange relation with the boiling liquid gas whereby the cooling effect of the boiling gas condenses and precipitates the noxious gas.

5. The method defined in claim 1 characterized by the fact that the gases are circulated due to convection.

6. The method defined in claim 1 in which the rate of flow of gases is controlled.

7. The method defined in claim 1 in which gases from liquid air are also directed into the inclosure.

8. The method defined in claim 1 in which the gases exhaled by the person are also brought in heat exchange relation with liquid air and the gases from the liquid air are also directed into the inclosure.

9. In combination, an insulated cabinet open for the inlet and outlet of a circulating medium, a tent associated with the cabinet to receive the circulating medium from the outlet and for discharging the circulating medium to the inlet, and an open receptacle containing liquid oxygen disposed within the cabinet.

10. In combination, an insulated cabinet open for the inlet and outlet of a circulating medium, a tent associated with the cabinet to receive the circulating medium from the outlet and for discharging the circulating medium to the inlet, and an open receptacle containing liquid oxygen and a receptacle containing liquid air each disposed within the cabinet.

11. In combination, an insulated cabinet open for the inlet and outlet of a circulating medium, a tent associated with the cabinet to receive the circulating medium from the outlet and for discharging the circulating medium to the inlet, an open receptacle containing liquid oxygen and a receptacle containing liquid air disposed within the cabinet, and means for controlling the relative rate of vaporizations of the liquid air and liquid oxygen.

12. In combination, a bed; a cabinet open for the inlet and outlet of a circulating medium, said cabinet being disposed to one side of and at a higher level than the bed; a tent support; a tent carried by the support above the bed, said tent being open at the bottom and adapted to be tucked into the bedding and being open for attachment to the cabinet about the inlet and outlet of the cabinet; and means for yieldingly and sealingly attaching the tent to the cabinet.

13. In combination, a bed; a cabinet open for the inlet and outlet of a circulating medium, said cabinet being disposed to one side of and at a higher level than the bed; a tent support; a tent carried by the support above the bed, said tent being open at the bottom and adapted to be tucked into the bedding and being open for attachment to the cabinet about the inlet and outlet of the cabinet; a shoulder surrounding the inlet and outlet of the cabinet; and a resilient band for yieldingly holding the tent against the shoulder.

14. The method of removing noxious gases and supplying conditioned atmosphere to a person in an enclosure which consists in directing the noxious gases of respiration of the person into heat exchange relation with a volatile liquid, the temperature of which liquid is below the condensation point of the noxious gases, to thereby cause increased volatilization of the liquid and supplying substantially all fresh gases for respiration from the liquid.

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