Dec. 27, 1966 A. P. BOEHMER ETAL 3,294,088

COOLING APPARATUS FOR OXYGEN TENTS

Filed Jan. 2, 1964 2 Sheets-Sheet 1

Fig. 1

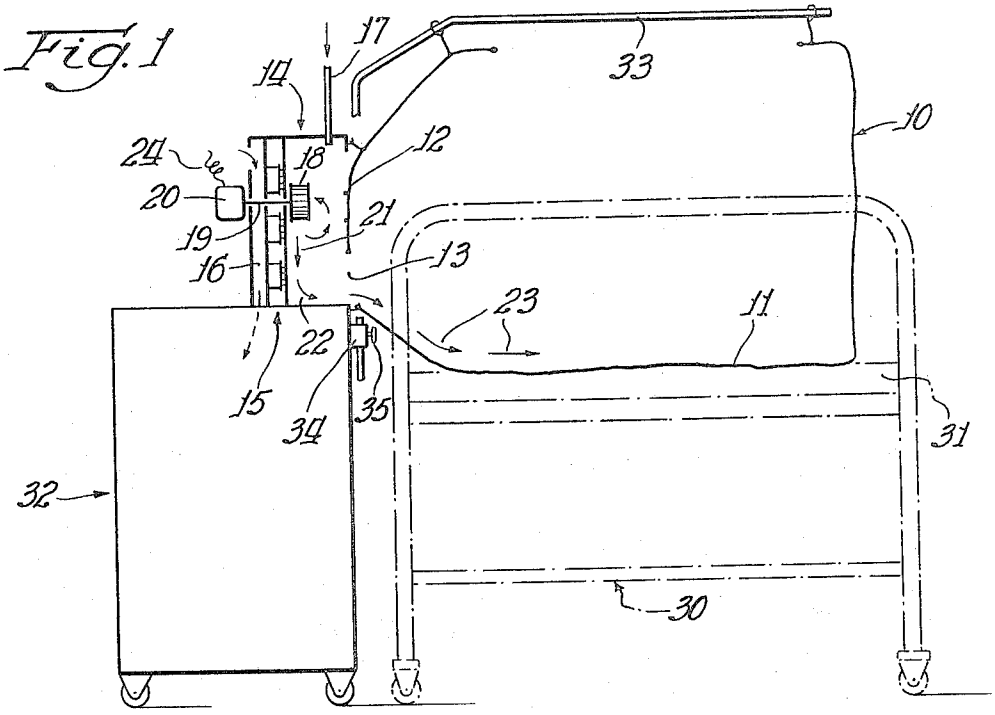


Fig. 4

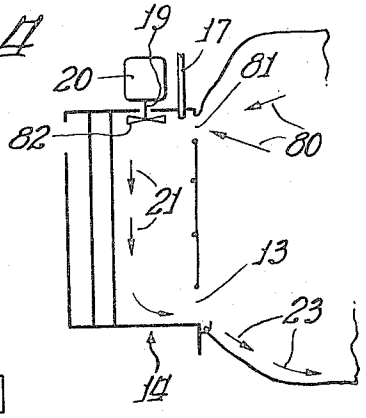
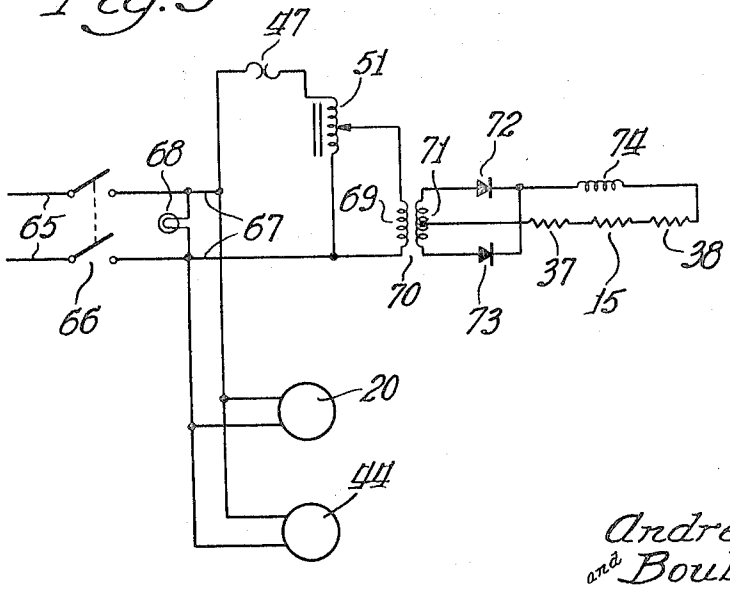


Fig. 3



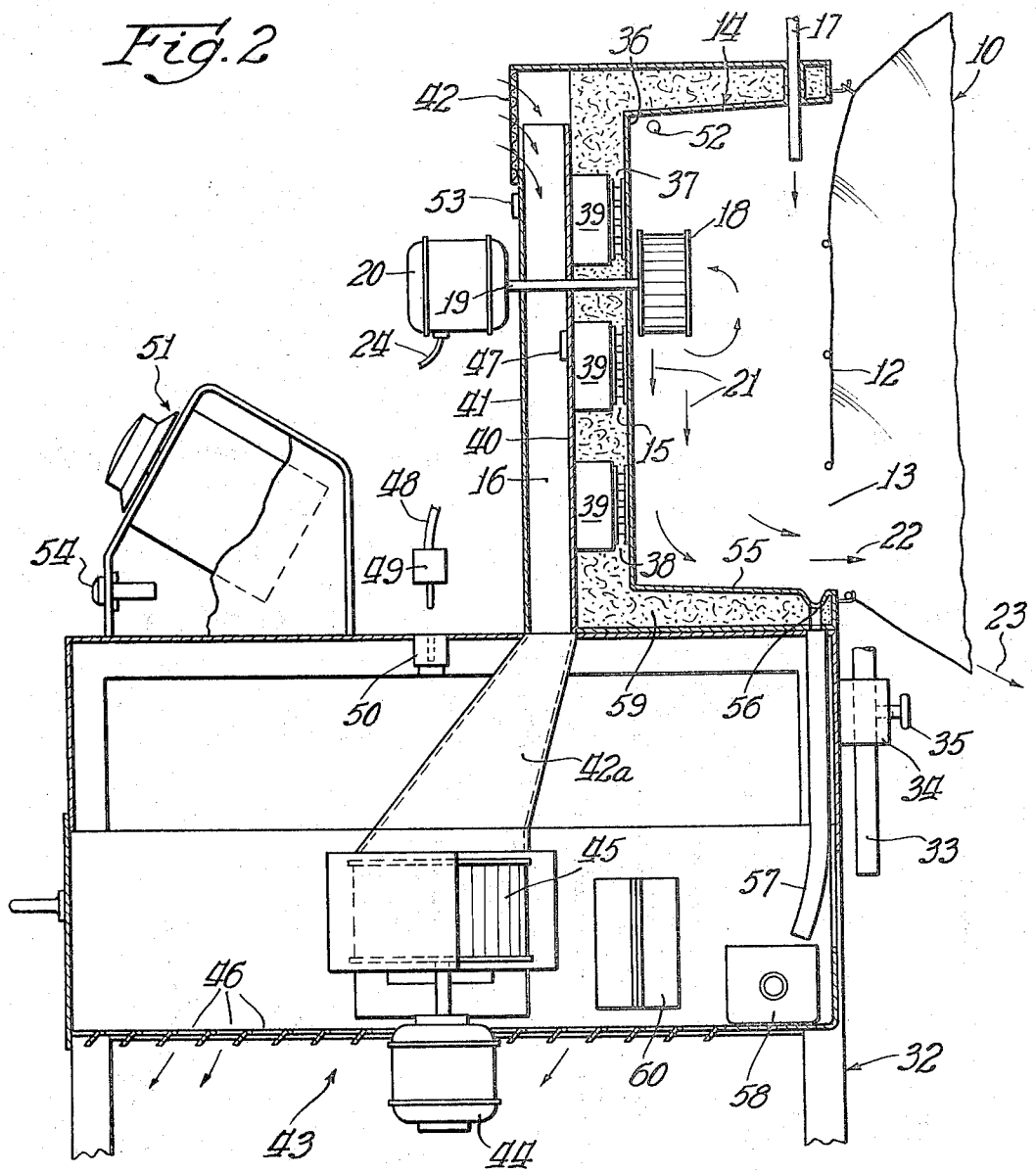
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COOLING APPARATUS FOR OXYGEN TENTS

Filed Jan. 2, 1964 2 Sheets-Sheet 2

Fig. 2



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United States Patent Office 3,294,088 Patented Dec. 27, 1966

3,294,088

COOLING APPARATUS FOR OXYGEN TENTS

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Filed Jan. 2, 1964, Ser. No. 335,085
6 Claims. (Cl. 128—191)

This invention is directed to an apparatus for effecting the cooling of an atmosphere within an enclosure, and more particularly to the cooling of such an atmosphere enclosed by an oxygen tent.

For certain illnesses it is desirable to maintain a patient within a carefully regulated atmosphere to sustain life or accelerate recovery. In some cases it is desirous to provide an oxygen-rich atmosphere for the patient, rather than the conventional air mixture generally present near the earth's surface. To effect this control an "oxygen tent" of a plastic material, such as a polyvinyl material of approximately 5 mil thickness, is frequently provided. The plastic material can be secured to an overhead support, to hang downwardly and rest on the patient's mattress, thereby providing a tent-like enclosure for the patient. In such arrangement a small aperture is provided in the tent, and connected by a suitable conduit to an oxygen storage means adjacent the tent to provide the requisite introduction of oxygen to enrich the atmosphere within the tent.

Frequently it is desirous not only to enrich the enclosed atmosphere with oxygen but also to maintain such atmosphere at a predetermined temperature, lower than the ambient temperature of the surrounding space. One general approach to the solution of this problem includes the interposition of a cooling means, such as the coils of a conventional cooling arrangement, in the inlet stream through which the incoming oxygen must pass. Accordingly, the oxygen is cooled prior to entering the enclosure, and the cooled fluid then provides both the oxygen enrichment and the requisite cooling of the enclosed space. If this arrangement is followed the incoming oxygen must be reduced to a very low temperature in order to supply the cooling requirements of the tent.

Another common method of cooling an oxygen tent is to provide a cooling circuit with a blower and cooling coil. Air is pulled out of the canopy, passes through the blower, across the extended fins of a cooling coil (refrigeration evaporator) and is discharged back into the tent. Such a system causes large turbulence in the tent and in general is not used with an open top tent. Another undesirable characteristic of such a cooling system is that drafts, which cause patient discomfort, are prevalent in the tent. However, to achieve the desired cooling it is generally necessary to force a considerable volume of oxygen into the tent, to counteract the heat leakage through the oxygen tent.

The interposition of the coils or other cooling medium directly into the cooling air system also leads to a serious problem with respect to the requisite antiseptic conditions which should be maintained in such an environment. That is, the coils or other apparatus become dirty over a period of time and not only can introduce impurities into the enclosure but also reduce the efficiency of the cooling system. Such units have proved cumbersome to dismantle and clean, even in more recent innovations where a separate mixing chamber is provided, but the coils or other units are still directly exposed to the cooling medium. Complicated cleaning techniques, such as disconnection of the mixing chamber and the filling of the chamber and lead-in passage with an antiseptic liquid or vapor to clean the coils, have been practiced. It is toward the simplification of the cooling and oxygen enriching arrangement, easier maintenance of an antiseptic, oxygen-rich atmosphere, and practical elimination of any turbulence within the tent itself (even to the point of permitting the use of open top tents), that the present invention is directed.

The present invention finds particular utility in an arrangement for cooling the atmosphere within an enclosure defined by an oxygen tent including a lower portion disposed at a reference level, which in practice is established by the lowest portion of the oxygen tent resting on a mattress. The tent is not continuous but defines an entrance aperture, preferably at one side thereof, with the bottom portion of the aperture positioned at a preassigned distance above the reference level, or bottom of the tent. Because of the entrance aperture, and because the present invention finds utility with an oxygen tent which is not closed at the top but completely open to permit an attendant to minister to the patient, the descriptive terms "tent," "enclosure," and related terminology used to describe the general oxygen tent structure do not define a completely enclosed space.

In accordance with the present invention, an air mixing chamber is positioned adjacent the entrance aperture of the tent, and thus has communication with the tent through this aperture. The chamber has continuous, smooth surfaces on its interior wall portions so that there is no projection to catch lint or impurities and ultimately decrease the cooling efficiency and require specialized cleaning techniques. Further in accordance with the present invention, heat exchange means, which in the preferred embodiment may comprise one or more thermoelectric modules, is positioned adjacent at least one of the smooth wall surfaces of the mixing chamber to remove heat from the chamber. Air displacement means is disposed within the mixing chamber itself, and upon energization displaces the air in a first direction adjacent the cooled wall surface of the chamber to cool the atmosphere within this chamber. Upon cooling, this air becomes heavier and descends to the bottom of the mixing chamber, whence it flows through the entrance aperture in a second direction which is substantially normal or perpendicular to the first direction in which the high velocity cooling stream is directed. Thus the cooled air, after passing through the entrance aperture, descends gently to the reference level of the oxygen tent, cooling the atmosphere within the oxygen tent. The cold air which exits the entrance aperture is replaced by lighter, warmer air from the tent and thus a circulatory air pattern is set up. Means for enriching the atmosphere within the tent enclosure is provided, and the oxygen may be admitted either into the mixing chamber or directly into the main portion of the tent. Means are also provided for energizing the heat exchange means and the air displacement means of the invention.

The present invention will be better understood upon reference to the following description taken in conjunction with the accompanying drawings, in the several figures of which like reference numerals identify like elements, and in which:

FIGURE 1 is a side view illustrating one embodiment of the invention, in conjunction with a hospital bed and hospital tent arrangement;

FIGURE 2 is a side view, partly in section and taken on an enlarged scale, of a portion of the structure shown generally in FIGURE 1;

FIGURE 3 is a schematic diagram of one form of power supply suitable for energizing the present invention; and

FIGURE 4 is a simplified showing of another embodiment of the invention.

As shown in FIGURE 1, an oxygen tent **10** has an upper portion supported from a hanger **33** and a lower or bottom portion **11** disposed at a reference level, in practice established by support on mattress **31** which rests on hospital bed **30**. The uppermost portion of tent **10** may be open as shown, or may be closed across the top. A wall portion **12** of the tent is apertured, as referenced by numeral **13**, to define an entrance or inlet aperture having a lower portion at a preassigned distance above reference level **11**. A mixing chamber **14** is disposed adjacent the oxygen tent, and in the illustrated showing, wall portion **12** is common both to mixing chamber **14** and to oxygen tent **10**. Likewise aperture **13** provides communication between the interior of mixing chamber **14** and the main portion of tent **10**. A console **32** for supporting the mixing chamber power supply, and other components of the inventive system, is shown adjacent hospital bed **30**, and overhead hanger **33** is supported at one side by the hospital bed (in a manner not shown) and at the other side is affixed to console **32** by passing through a collar **34** and being secured by an adjusting screw **35** in an obvious manner.

In accordance with a salient feature of the present invention, mixing chamber **14** includes wall surfaces which are continuous and smooth on the interior thereof. That is, the cooling elements do not extend into the chamber for direct contact with the moving air stream. Instead, a heat exchange means **15** is positioned adjacent at least one wall surface of the mixing chamber, and in the illustrated embodiment heat exchange means **15** may comprise a thermoelectric module. The construction and operation of such modules are now well-known and understood in this art, and complete modules or assemblies are commerically available. Briefly, upon energization by passage of a unidirectional electrical current through the thermoelements, heat is absorbed at one surface of the thermoelectric module and heat is liberated at the other surface. In the showing of FIGURE 1, the surface adjacent mixing chamber **14** is the heat-absorbing surface, and the heat liberated at the opposite or warmer surface passes by conduction to a plurality of fins **16**, for dissipation to the adjacent atmosphere. A conduit **17** is provided to direct the flow of oxygen from a source (not shown) containing oxygen under pressure through conduit **17** into mixing chamber **14**. It will be evident to those skilled in the art, that in lieu of being injected into the mixing chamber, the oxygen could also be directed into the interior of oxygen tent **10**.

Also shown in FIGURE 1 is a fan **18**, positioned within mixing chamber **14** and arranged to be driven over shaft **19** as motor **20** is energized. In accordance with another important aspect of the present invention, air displacement means **18** directs the air within mixing chamber **14** in a first direction, referenced by arrow **21**, to pass adjacent the same wall surface which is cooled by thermoelectric module **15**. Thus an efficient heat transfer is effected within mixing chamber **14** where a high turbulence can be tolerated. As the air within the chamber is cooled, it falls downwardly to the bottom of this chamber, and passes in a second direction, as indicated by arrow **22**, at substantially right angles to the first direction in which cooling is effected, through aperture **13** into the main portion of tent **10**. Thereafter, as referenced generally by arrows **23**, the cooled air descends gently downwardly along the inclined portion of the tent to the reference level established by portion **11**, thus cooling the atmosphere within the tent without creating turbulence to chill the patent.

A conventional cord arrangement **24** is shown for transferring electrical energy from a conventional electrical outlet (not shown) to motor **20** and to thermoelectric module **15**. If a source of direct-current (D.C.) energy is available, the circuit could be provided as indicated, with motor **20** being a D.C. motor. However, if an alternating-current (A.C.) energy source is provided, a rectifier arrangement must be provided between the plug and thermoelectric module **15** in a well-known manner. Such arrangement will be explained more fully hereinafter in connection with FIGURE 3.

Considering the illustration of a preferred embodiment, as shown in FIGURE 2, the interior of the mixing chamber **14**, in accordance with the present invention, has continuous and smooth wall surfaces without the protrusion of any cooling elements. Instead the heat is "pumped out" or removed from one wall surface **36** of the mixing chamber by energization of thermoelectric module **15** and of the two other modules **37** and **38**. It will be appreciated that the precise number of modules requisite to effect a given cooling operation will depend upon the amount of air to be cooled, and the temperature to be maintained within the main portion of tent **10**. A suitable heat-conduction path or spacer block **39** is provided between the heat liberating (hot side) surface of each module and the hot fin base plate **40**. Fins **16** are rigidly affixed to hot fin base plate **40**. Wall **41** is an air shroud which forces the air to pass between adjacent fins of fin assembly **40, 16**. Spacer block **39** is only the size (area) of the modules, and is used to permit the placement of a thick layer of heat-insulating material adjacent block **39**, to confine the heat-removal path to the desired area. Fins **16** must be much larger, particularly if they are to operate as natural convection modules (chimney effect). Fins **16** are designed for forced convection (fan cooling) and therefore a fan is provided to bring air into entrance grill **42** through the passages defined by hot fin base plate **40** and shroud **41**, and downwardly through an enlarged passage **42*a*** under the impetus of a fan arrangement **43**, which comprises both a motor **44** and a fan blade arrangement **45**. Air is drawn downwardly as motor **44** is energized to rotate fan blade **45**, and the air passes through a series of louvers **46** and is displaced away from console **32**. In the event that the path of the air movement becomes blocked or there is some other unexpected equipment malfunction, the temperature of hot fin base plate **40** may rise. Accordingly, a high temperature cut-out unit **47** is positioned on plate **40** to effectively interrupt the provision of electrical energy to the system should an unexpected high temperature situation occur. Each of the electrical conductors **48**, provided to pass energy from the lower portion of the console upwardly to the thermoelectric modules and motor **20**, is made with a male plug **49** for receipt in a corresponding female socket **50** to facilitate removal of the mixing chamber from the lower or base portion of the console. In general motor **20** is an A.C. motor, so there is no commutator sparking near the oxygen tent. Thus, conductors **48** and plug **49** would be 4 prong conductors; 2 for D.C. energy for the modules, and 2 for A.C. energy for motor **20**.

A variac unit **51** is provided at the left portion of the console, and this variac is included in the power supply arrangement which supplies energy to the thermoelectric modules. Accordingly, the exact level of energy provided, and thus the level of the temperature maintained within the tent, can be precisely regulated. To assist such regulation, a thermometer arrangement can be provided with a temperature bulb **52** disposed within mixing chamber **14**, and an indicator or gauge **53** positioned externally of the mixing chamber to provide an attendant with a visible indication of the exact temperature maintained within the chamber. An on-off switch **54** is provided below variac **51**. Other components, such as a pilot light, removable fuse, etc., can also be provided in the same area as the variac and on-off switch in a well-known manner.

It is noted that the lower surface **55** of the mixing chamber slopes slightly to the right, and a drain channel **56** is provided to pass condensed moisture downwardly, through a tube **57** into a drip pan **58**. The pan can be emptied periodically as the unit is operated adjacent an oxygen tent. The insulation material **59**, shown between

the innermost and outermost portions of mixing chamber **14**, can be polyurethane or another well-known insulating material frequently used in such an environment.

Also shown in FIGURE 2 is a choke or filter coil **60**, a common device used in a single phase D.C. power supply to reduce the A.C. ripple component, which forms a portion of the power supply for a preferred embodiment of the invention. It is noted that choke **60**, and other components of the power supply (not shown), is disposed to have its exterior surface cooled by air passing downwardly through channel **42***a* and out through the louvers **46**.

In FIGURE 3 one form of power supply arrangement suitable for use with the invention is illustrated. Provision is made for coupling input conductors **65** to a conventional commercial source of alternating-current energy (not shown). An on-off switch **66** is provided and, when closed, effects intercoupling between conductors **65** and conductors **67**, between which a pilot light **68** is connected. Thus the pilot light is illuminated responsive to closure of switch **66**.

Connected across, or in parallel with, conductors **67** are the winding of motor **20**, the winding of motor **44**, and a third circuit comprising high temperature cut-out unit **47**, variac **51**, and primary winding **69** of a transformer **70**, which also comprises a secondary winding **71**. The opposite ends of secondary winding **71** are coupled to a pair of diodes **72** and **73**, and the cathodes of these diodes are coupled together. This circuit is then coupled through a filter choke **74** to one end of thermoelectric module **38**, represented as a simple resistance to facilitate the showing of the circuit. The other end of module **38** is coupled through module **15** and module **37** to the center tap connection of secondary winding **71**.

It is thus manifest that an adjustment of the position of the movable connection of variac **51** effects a consequent regulation of the amount of electrical energy transferred over transformer **70**, rectified in the circuit including diodes **72** and **73**, and used to energize modules **37**, **15**, and **38**. Accordingly, the temperature within mixing chamber **14** is regulated to consequently govern the temperature maintained within oxygen tent **10**. In this manner the desired degree of control is maintained by a simple adjustment of the physical position of the movable tap on variac **51**.

With the embodiment depicted in FIGURE 2, it is apparent that in addition to the cooled air leaving through aperture **13**, some of the warmer air within the oxygen tent necessarily enters mixing chamber **14** through the upper portion of aperture **13**. FIGURE 4 depicts another embodiment of the present invention, one in which the air from the oxygen tent is returned from the main body of the tent as indicated by arrows **80**, passes through an entrance aperture **81**, is cooled within mixing chamber **14**, and passes outwardly through aperture **13** after being cooled. With this configuration, the radial fan assembly **18** is removed and a simple propeller **82** or other type of axial fan blade is affixed to the end of shaft **19**, now mounted in the upper portion of the mixing chamber. Accordingly, when motor **20** is energized and fan blade **82** is rotated, the air is returned from the oxygen tent, passes through inlet aperture **81**, is displaced downwardly under the impetus of fan blade **82** to pass in a first direction along the cooled wall portion of the mixing chamber, and then is deflected to pass in a second direction, substantially normal to the first direction, outwardly and downwardly into the oxygen tent. The arrangement depicted in FIGURE 4 has also proved efficient and effective in providing an oxygen-enriched atmosphere within an oxygen tent, and maintaining precise control at a desired temperature without causing turbulence in the vicinity of the patient.

The present invention has proved highly efficient with a construction including an aperture **13** (FIGURE 2) approximately 4 inches in height, and the bottom of aperture **13** being disposed approximately 9 inches above the bottom portion **11** of the oxygen tent. With this arrangement, the high turbulence is confined to mixing chamber **14**, to provide adequate heat transfer between the smooth surface of chamber **14** and the air, with only a gentle and non-disturbing movement of the cooled air downwardly into the oxygen tent. So gentle and unnoticed is this movement that an open-top oxygen tent can be used in the practice of the invention, and even with an open top, oxygen concentrations greater than 60 percent have been readily obtained. This is in marked contradistinction to prior techniques which, by reason of the high turbulence introduced within oxygen tent, have had difficulty in maintaining oxygen concentrations in the range of 45 to 50 percent. For many therapeutic treatments, it is desirous to maintain concentrations in the range of 50 to 60 percent of oxygen, easily achieved by practice of the present invention.

Another salient advantage of the instant invention is that there are no coils or other cooling protuberances which extend into the cooling air stream, or are hidden from view in ordinary operation of the equipment. Thus there are no areas to be flooded with disinfectant or to undergo a similar cumbersome clearing process. Instead a mixing chamber with continuous and smooth surfaces is provided so as to avoid any clogging with dirt or lessening of efficiency as the equipment is used to maintain the desired atmosphere within the oxygen tent.

While only particular embodiments of the invention have been described and illustrated, it is manifest that modifications and alterations may be made therein. It is, therefore, the intention in the appended claims to cover all such modifications and alterations as may fall within the true spirit of the scope of the invention.

1. In an arrangement for cooling the atmosphere within an oxygen tent, said tent having a lower portion positioned at a reference level and said tent difining an aperture disposed at a preassigned distance above said reference level, the improvement which comprises:

an air mixing chamber in communication with the tent through said aperture adjacent the lowest point of the mixing chamber, said chamber having continuous and smooth surfaces on the interior thereof;

cooling means positioned adjacent the one of said smooth surfaces of the mixing chamber which is opposite said aperture to cool said one surface;

air displacement means for moving the air in a turbulent flow within said mixing chamber in a first direction parallel to the cooled surface to cool the atmosphere within said chamber, the cooled air descending to the bottom of the mixing chamber and passing through said aperture in a quiescent flow in a second direction substantially perpendicular to said first direction, whence the cooled air descends gently to the bottom of the oxygen tent to cool the atmosphere within the tent;

means for enriching the atmosphere within said tent with oxygen; and

means for energizing said cooling means and said air displacement means.

2. In an arrangement for cooling the atmosphere within an enclosure defined by an oxygen tent including a lower portion disposed at a reference level, said tent further defining an aperture at a preassigned distance above said reference level, the improvement which comprises:

an air mixing chamber, positioned adjacent said aperture and communicating with said tent through said aperture adjacent the lowest point of the mixing chamber, said chamber having continuous, smooth wall surfaces on the interior thereof;

heat exchange means positioned adjacent the one of said smooth wall surfaces of the mixing chamber which is opposite said aperture to remove heat therefrom;

air displacement means, positioned within said mixing chamber, for moving the air in a turbulent flow in a first direction parallel to said one surface to cool the atmosphere within said chamber, the cooled air descending to the bottom of the mixing chamber and passing through said aperture in a quiescent flow in a second direction substantially normal to said first direction, whence the cooled air descends gently to the reference level of said oxygen tent to thereby cool the atmosphere within said oxygen tent;

means for enriching the atmosphere within said tent with oxygen; and

means for energizing said heat exchange means and said air displacement means.

3. In an arrangement for cooling the atmosphere within an enclosure defined by an oxygen tent including a lower portion disposed at a reference level, said tent further defining an entrance aperture at a preassigned distance above said reference level, the improvement which comprises:

an air mixing chamber having a wall portion in common with said tent and communicating with said tent through said entrance aperture adjacent the lowest point of the mixing chamber, said chamber having continuous, smooth wall surfaces on the interior thereof;

thermoelectric heat exchange means positioned adjacent the one of said smooth wall surfaces of the mixing chamber which is opposite said aperture to remove heat therefrom;

fan means, positioned within said mixing chamber, for moving the air in a turbulent flow in a first direction parallel to said one surface to cool the atmosphere within said chamber, the cooled air descending to the bottom of the mixing chamber and passing through said entrance aperture in a quiescent flow in a second direction substantially normal to said first direction, whence the cooled air descends gently to the reference level of said oxygen tent to thereby cool the atmosphere within said oxygen tent;

means for enriching the atmosphere within said tent with oxygen; and

means for energizing said thermoelectric heat exchange means and said fan means.

4. A cooling arrangment as set forth in claim 3 and further comprising means for adjusting the level of energization of said thermoelectric heat exchange means, whereby the temperature of the atmosphere within the oxygen tent is corrspondingly regulated.

5. In an arrangement for cooling the atmosphere within an enclosure defined by an oxygen tent including a lower portion disposed at a reference level, said tent further defining an entrance aperture at a preassigned distance above said reference level, the improvement which comprises:

an air mixing chamber communicating with said tent through said entrance aperture adjacent the lowest point of the mixing chamber, said chamber having a plurality of wall portions, one of said wall portions being in common with a wall portion of said tent, and all of said wall portions having continuous, smooth wall surfaces on the interior thereof;

a thermoelectric module positioned adjacent the one of said smooth wall surfaces of the mixing chamber which is opposite said aperture to remove heat therefrom;

a first fan, positioned within said mixing chamber, for moving the air in a turbulent flow in a first direction parallel to said one surface to cool the atmosphere within said chamber, the cooled air descending to the bottom of the mixing chamber and passing through said entrance aperture in a quiescent flow in a second direction substantially normal to said first direction, whence the cooled air descends gently to the reference level of said oxygen tent to thereby cool the atmosphere within said oxygen tent;

a second fan, positioned outside said mixing chamber, for carrying away the heat removed by said thermoelectric module;

means for enriching the atmosphere within said tent with oxygen; and

means for energizing said thermoelectric module and said first and second fans.

6. In an arrangement for cooling the atmosphere within an enclosure defined by an oxygen tent including a lower portion disposed at a reference level, said tent further defining an exit aperture at a preassigned distance above said reference level, the improvement which comprises:

an air mixing chamber, positioned adjacent said exit aperture and communicating with said tent through said aperture adjacent the lowest point of the mixing chamber, said chamber having continuous, smooth wall surfaces on the interior thereof;

means, including at least part of a wall portion common both to said tent and to said mixing chamber, for defining an entrance aperture for passing air from said tent to the interior of said chamber;

heat exchange means positioned adjacent the one of said smooth wall surfaces of the mixing chamber which is opposite said apertures to remove heat therefrom;

air displacement means, positioned within said mixing chamber, for moving the air in a turbulent flow in a first direction parallel to said one surface to cool the atmosphere within said chamber, the cooled air descending to the bottom of the mixing chamber and passing through said exit aperture in a quiescent flow in a second direction substantially normal to said first direction, whence the cooled air descends gently to the reference level of said oxygen tent to thereby cool the atmosphere within said oxygen tent;

means for enriching the atmosphere within said tent with oxygen; and

means for energizing said heat exchange means and said air displacement means.

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