Nov. 3, 1964 M. L. HIRSCHHORN 3,154,926

COOLING BLANKET

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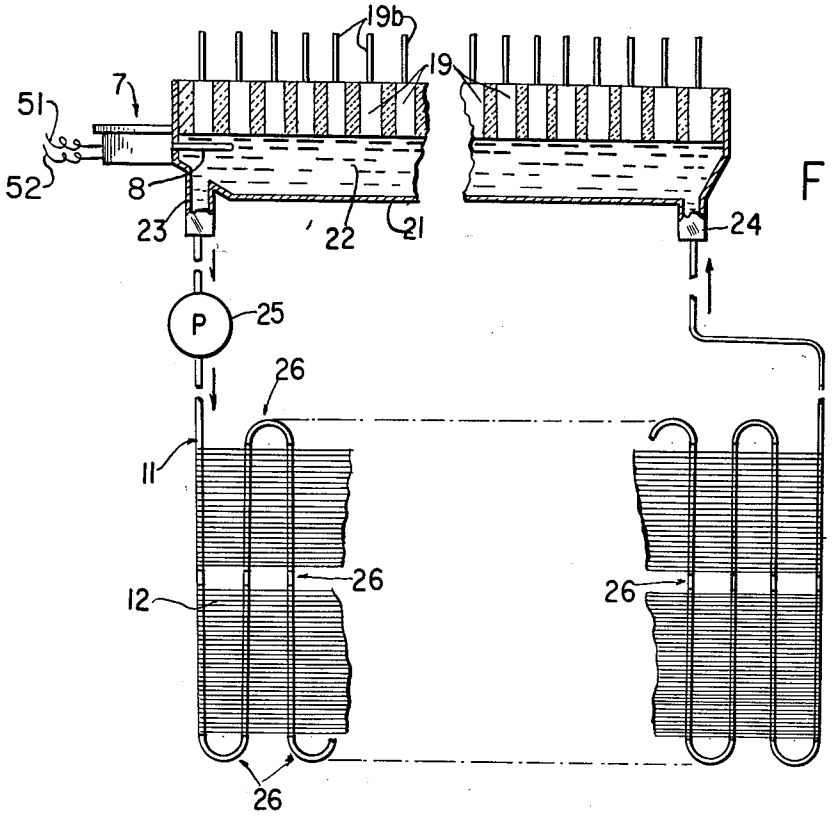
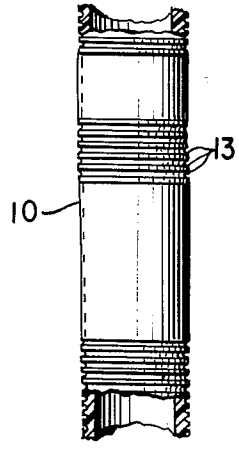


Fig.1

Fig.2



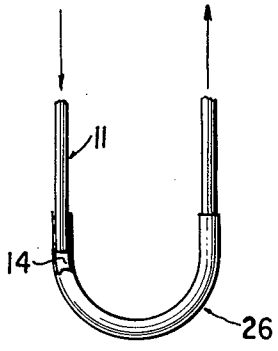


Fig. 4

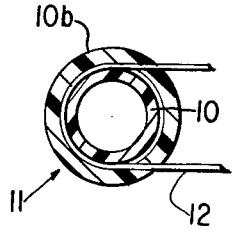


Fig. 3

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Fig. 5

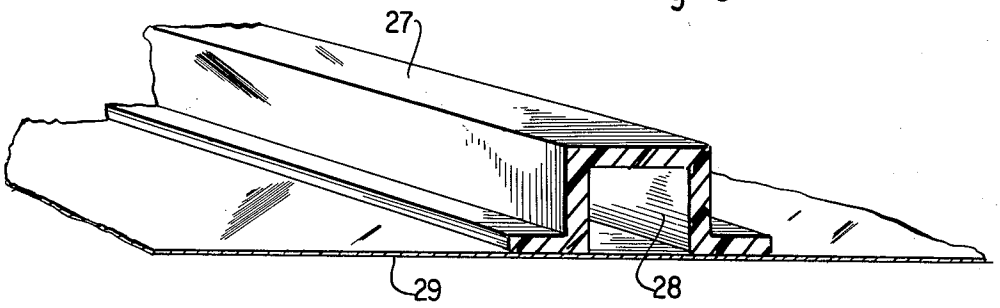


Fig. 6

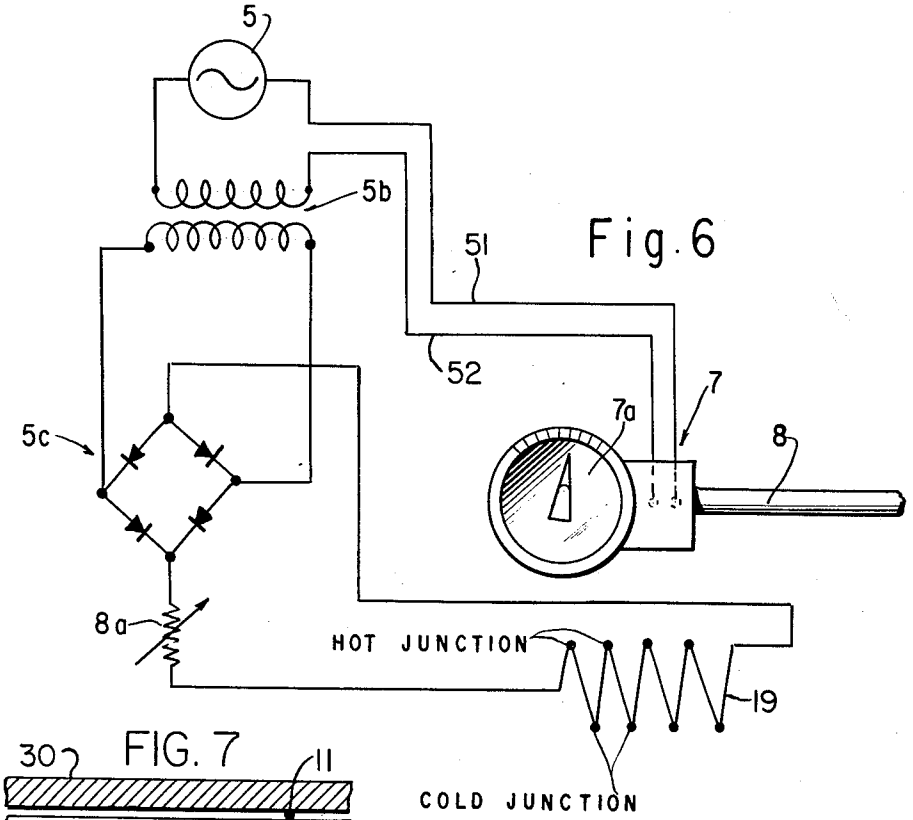
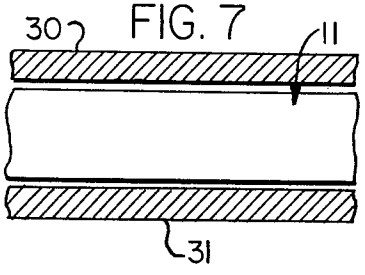


FIG. 7



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United States Patent Office 3,154,926 Patented Nov. 3, 1964

3,154,926

COOLING BLANKET

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Filed Sept. 25, 1962, Ser. No. 226,092
4 Claims. (Cl. 62—3)

The present invention relates to a flexible cooling blanket device for the control of animal body temperature.

It has been suggested that a refrigerated blanket be utilized to cool the body in hot climates and in connection with surgical operations. Such blankets include devices which pump cooled air into the blanket and out through holes in one of its sides, blankets which are cooled by Peltier cells woven into the blanket, and blankets which are cooled by flexible plastic tubing wound within the blanket. These blankets have proven to be either inefficient in terms of heat transfer, cumbersome or expensive.

In accordance with the present invention, a cooling blanket is provided in which cold fluid is pumped through a plurality of rigid metal tubes. The ends of these rigid tubes are connected by flexible tubing and mass of flexible metal wires or strips are connected between them. The metal tubes and the metal connecting wires or strips provide efficient heat transfer from the pumped cooling liquid to the body and the blanket is flexible in one direction.

It is an objective of the present invention to provide a relatively economic and efficient (in terms of cooling power) cooling blanket.

Other objectives of the present invention will be apparent from the below detailed description taken in conjunction with the accompanying drawings, in which:

FIGURE 1 is a top plan diagrammatic view of an electric blanket of the present invention together with its associated refrigerating and control systems;

FIGURE 2 is an enlarged partial side plan view of the portion of the tubing of the blanket of FIGURE 1 without its insulation and attached wires;

FIGURE 3 is a top plan sectional view of the tubing of FIGURE 2 covered with insulation and attached to a wire;

FIGURE 4 is an enlarged top plan view of the curved joints of the blanket of FIGURE 1;

FIGURE 5 is a perspective partial view of another embodiment of the tubing of the blanket;

FIGURE 6 is a circuit diagram of an electrical circuit utilized with the blanket of FIGURE 1; and

FIG. 7 is a fragmentary sectional view of the blanket taken along a line parallel with the tube showing the relation of the outer and inner layers of the blanket to the coolant tube.

In FIGURE 1 a cooling blanket of the present in vention is connected to a source of cooling liquid. This source includes a plurality of Peltier cells 19, each of which has a cooling fin 19*b* attached to its hot end.

In the Peltier effect a direct current passes through a junction of two dissimilar conductors and heat is absorbed or generated at the junction, depending on the direction of the current. A number of combinations of dissimilar conductors exhibit the Peltier effect including two different metals, a semi-conductor with a metal, a p-type or n-type semi-conductor with a metal, and a p-type semi-conductor with an n-type semi-conductor. Preferably the combination of conductors has large thermoelectric power, low thermal conductivity, high electrical conductivity, and the materials should be inexpensive, readily formable and easy to solder and weld.

Power for the Peltier cells comes from an A.C. source 5 which leads into the primary of the transformer 5*b*.

The secondary of transformer 5*b* is connected to a full-wave D.C. rectifying bridge 5*c* which supplies D.C. current to the Peltier cells, see FIG. 6.

The cold side of the Peltier cells 19, i.e., the end of the cell which absorbs heat is in direct physical contact with a non-flammable cooling fluid 22, such as a methylene glycol water solution or a sugar solution, which is suspended within the bath 21. The bath 21 has an exit port 23 and an entry port 24 so that the fluid 22 may be circulated. A low-pressure continuous operating pump 25 circulates the cooling liquid from the bottom of the bath 21 at port 23, pumps it into the tubes of the cooling blanket and returns the fluid back into the bath through port 24.

The cooling blanket comprises a plurality of rigid tubes 11 of a thermal conductive metal, such as silver, pure copper or a copper alloy. Each of tubes 11 includes a central hollow elongated tube 10 running the length of the tube and a spiral groove 13 cut on the exterior face of tube 10, see FIGS. 2 and 3. Each tube is preferably about one foot long. A large number of flexible heat conductive metal wires 12 are wound about the tubes within the helical groove 13 and from one tube to another to provide an array of wires thermally interconnecting tubes 11. The outside of the tubes are encapsulated in a heat insulative material 10*b*, such as an epoxy resin plastic, to retain the wires in the grooves and to thermally insulate the tubes. Encapsulation of the tubes enables the heat absorption function, i.e., cooling to be performed by the wires and not directly by the tubes themselves, so that the cooling effect is distributed throughout the blanket and is not localized around the tubes. The tubes 11 are connected end-to-end as a continuous series conduit by flexible tubing 26, for example, of French woven nylon. The flexible tubing 26 is used both in straight segments and in U-shaped curves as shown in FIG. 1. Tubing 26 is preferably flexible enough to be slipped over the end portions of tubes 11 and the hollow portions 14 of the sleeve tubing will thereby establish communication with the hollow portions of tubes 11. A firm and permanent connection between the flexible joints 26 and the rigid metal tubes is preferably made with epoxy resin plastic or a suitable equivalent so that the tubing is liquid tight throughout the series coolant carrying conduit.

In the embodiment of tubing and conductive material shown in FIGURE 5, the tubing 27 consists of a channel-shaped heat insulative member, preferably of molded nylon, having an open side. A thin heat conductive metal sheet 29 is fastened over this opening and forms an elongated fluid carrying cavity 28 running the length of the channel-shaped member. The metal sheet 29 may alternatively be cut into ribbons so as to run perpendicular to the length of the channel-shaped members to provide additional structural flexibility in the blanket. The ends of tubes 27 are joined end-to-end by appropriate flexible tubing, not shown, into an array so that the tubes 27 are parallel similar to the parallel array of tubes 11 shown in FIG. 1. Metal sheet 29 is preferably a foil of pure copper about 1/16 of an inch thick. The lower face of sheet 29, as seen in FIG. 5, is disposed toward the body to be cooled and serves a similar function in the blanket as the wires 12 of the embodiment of FIG. 1, i.e., to distribute the heat absorption function rather than to depend on the concentration of heat absorption in the immediate vicinity of tubes 27.

In both embodiments, a temperature control device 7 having a dial 7*a* is placed adjacent to the bath 21 (FIG. 1). This device functions to control the temperature at which the blanket is to be kept. The manually

operated dial 7*a* is operatively connected to a thermostat unit, of the usual bimetallic type such as used in refrigerating systems, housed within a thermally-conductive hermetically-sealed housing 8. The housing 8 is positioned in the coolant 21 as seen in FIG. 1 whereby the thermostat is rendered responsive to the temperature variations of the coolant. The desired temperature of operation of the thermostat is selected manually by dial 7*a* which is calibrated in the usual manner. The contacts of the thermostat are connected by conductors 51 and 52 to the A.C. source in series relation with the source 5 and the primary of transformer 5*b* to function as an "on-off" switch for the system. The thermostat thus will render the cooling circuit inoperative when the temperature of the coolant is within the desired range and render the cooling circuit operative when the temperature of the coolant is without the desired range.

Potentiometer 8*a* is adjustable to vary the resistance in the direct current portion of the circuit to regulate, in effect, the rate of cooling by the Peltier cells 19.

If desired, operation of pump 25 can be automatically under control of the temperature control device 7 with appropriate circuit connections as described above whereby the circulation of the coolant is synchronized with the operation of the cooling cells.

It is to be understood that other equivalent temperature controls may be used with the invention in order to regulate the blanket temperature to prevent the temperature drops below or the temperature rises above the desired level.

In using the invention as a blanket for cooling the body temperature of animals and the like, the array of tubes 11 or 27 and the interconnecting wires 12 or sheet 29 are covered with a quilt shown in fragmentary section in FIG. 7 made up of an outer layer 30 of heat conducting or insulating material and an inner layer 31 of heat conducting material. The heat conducting material may be a thin sheet of cotton, silk, linen or the like and the heat insulating material may be wool. The inner heat conducting layer is placed on the animal and allows the maximum heat transfer from the animal to the heat absorbing wires or sheet. The outer layer is preferably provided with heat insulation material to retard the transfer of heat from the ambient which otherwise would reduce the cooling efficiency of the blanket.

The remainder of the equipment is enclosed in appropriate containers remote from the animal.

In operation, the cooling fluid is circulated through the tubes in serial circuit, withdrawing heat from the animal by means of the distributed heat conductive wires 12 or sheet 29 to the coolant fluid 22 within the tubes. The fluid during its contact with the "cold" junction of the Peltier cell 19 is cooled by the action of the cell. The heat from the fluid is dissipated in the "hot" junction of the cell being carried away by natural convection or a forced blower such as a fan or the like.

The invention depends on the fact that metal, and particularly copper and silver, are excellent conductors of cold. The comparative thermal conductivity in B.t.u. for certain material is as follows: copper 0.759, silver 0.81, lead 0.067, nickel 0.18, and aluminum 0.43. The distributed metal portions absorb the heat from the body. By distributing the heat conductive material over the entire surface of the animal the heat absorption is substantially uniform.

The invention thus provides a means of adjusting the temperature of the body or portions of the body. A flexible blanket having good cooling efficiency is provided which is of especial benefit in operative uses in which it is desired to cool the body temperature to as much as 30 or 40° below its normal temperature.

I claim:

1. In a cooling device including:
a reservoir having entrance and exit ports for refrigerating fluid,
a system of fluid-tight tubing rigid portions connected in series, the series connected at one of its ends to the entrance port and at its other end to the exit port,
a pump having its rotor in the fluid to circulate the fluid through the tubing, and
refrigerating means adjacent the reservoir to cool the fluid,
the improvements comprising:
a plurality of flexible tubing segments connecting the rigid tubing segments, and
a plurality of thin, flexible, good thermally conductive metal members attached to the rigid tubing,
said flexible tubing segments and said fluid-tight tubing rigid portions being substantially covered with thermally insulative material sufficiently to thermally insulate said tubing, and said flexible members being covered with said thermally insulative material at the connections to the tubing, whereby the flexible metal members only absorb heat from the ambient and transfer the absorbed heat to the refrigeration fluid through said tubing.

2. A cooling blanket comprising:
a liquid reservoir having entrance and exit ports,
a plurality of rigid copper tubes covered with a thermal insulation material and connected together by short flexible plastic tubing segments,
an electric liquid pump whose rotor is immersed in the liquid to circulate the liquid through the tubing,
a plurality of Peltier cells adjacent the reservoir having its cold ends in contact with the liquid,
a source of direct current electricity connected to the Peltier cells, and
a plurality of thin, flexible copper members attached to the rigid tubes through the insulative covering.

3. A cooling blanket comprising:
heat insulated means for conducting a fluid coolant,
a fluid coolant in said means,
heat conductive means and means thermally connecting the heat conductive means to the coolant,
said heat conductive means being generally distributed throughout a plane of the blanket.

4. An article of manufacture suitable for controlling the temperature adjacent a living body and adapted to be placed in contact therewith, comprising a blanket having an inner supporting flexible material of high thermal conductivity for contact with the living body and an outer supporting flexible insulated material, a series of rigid insulated fluid conduits arranged in a substantially parallel array disposed between said inner and outer material, flexible tubing segments connecting the ends of said conduits in serial serpentine arrangement, a plurality of thin flexible thermally conductive metal members attached to said tubing through the insulation thereof, means connecting the respective ends of said tubing to refrigeration means remote from said blanket, refrigerant in said conduits and means for circulating said refrigerant through said conduits.

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