

[54] **PASSIVE MICROCLIMATE CONTROL SYSTEM**

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[51] Int. Cl. F25d 23/12

[58] Field of Search 62/530, 293, 259

[56] **References Cited**

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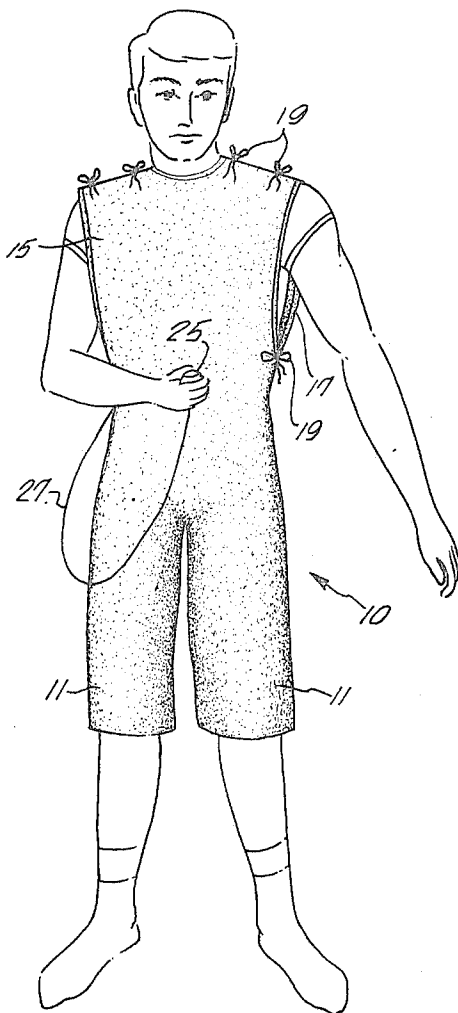
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[57] **ABSTRACT**

A microclimate control system is disclosed for controlling the removal of metabolic heat from a person's body. The system comprises a self-contained refrigerant garment worn over a variable insulation garment whose thermal conductance is controlled at will by the wearer. The refrigerant garment comprises a plurality of tubes attached to a network of webbing adapted to fit at least over the upper torso of the wearer. Each tube is filled with water and sealed at 4-inch intervals to form a string of individual water compartments. The water-filled tubes are then frozen to provide a refrigerant having a large thermal capacity. The insulation garment comprises an open cell foam material sandwiched between two outer layers of airtight material. The outer layers are sealed about the periphery of the garment to make an airtight garment. Vacuum means are provided to evacuate the interior of the garment and gradually reduce the thickness of the insulation layer in order to vary the heat conductance of the garment according to the varying metabolic demands of the user.

12 Claims, 5 Drawing Figures



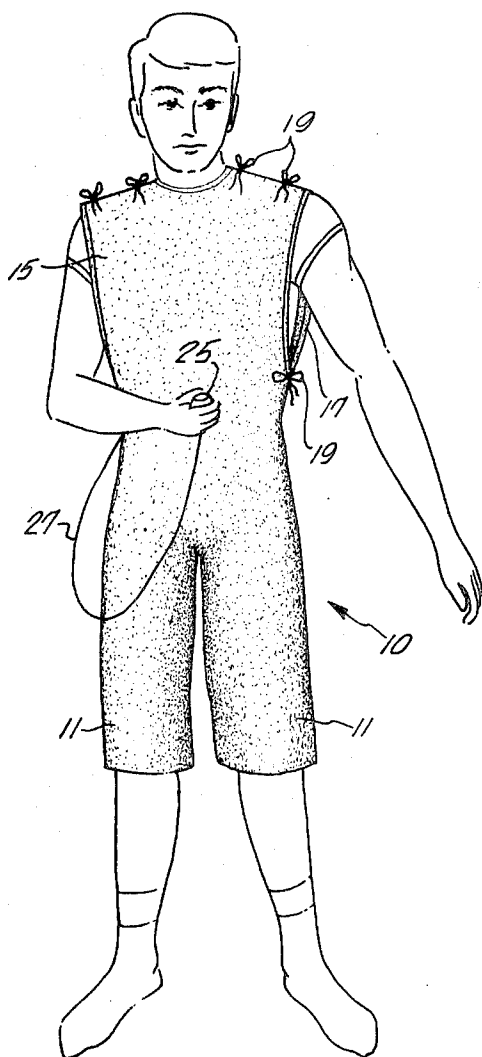


FIG. 1

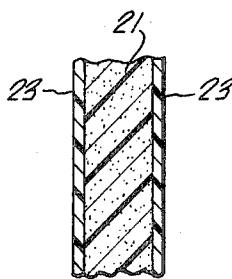


FIG. 2

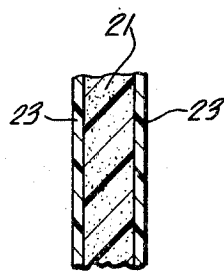


FIG. 3

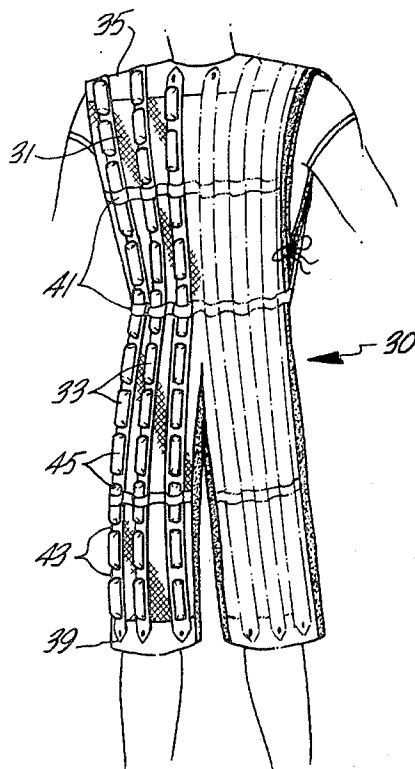


FIG. 4

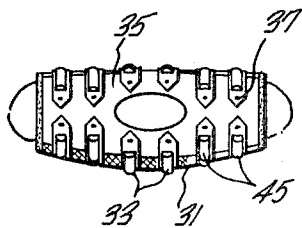


FIG. 5

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PASSIVE MICROCLIMATE CONTROL SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to microclimate control systems, and more particularly to garments having means for dissipating the metabolic heat of a person exposed to extreme environmental conditions.

2. Description of the Prior Art

Many types of garments have been proposed for controlling the microenvironment of the human body. Most of these garments involve the circulation of a fluid through a system of containers and tubes. In many cases such a system includes a network of plumbing supplying fluid at a desired temperature from an external source. In some systems the recirculating fluid is fed by external pump means to an outside heat exchanger. Some systems have also been designed in which the pump means and heat exchangers are portably carried on the user's back.

The advantage of recirculating fluid systems is that the rate of circulation of the fluid and its temperature can be adjusted to accommodate the varying metabolic demands of the user.

Obvious disadvantages of the fluid recirculating systems are that the systems are quite complex, very expensive to manufacture, and highly immobile. Even the units that are portably carried are very cumbersome and impractical under extreme working conditions.

Other garments in the form of jackets or vests have been developed which utilize self-contained cooling means. A typical jacket includes a layer of insulating material, such as foam, disposed adjacent to the user's body. Attached to the layers of foam are pockets containing a refrigerant, preferably solid carbon dioxide.

The obvious advantage of the vest is that it provides a self-contained system, independent of the need for plumbing or umbilical cords which must be connected to a fluid source.

The main disadvantage of this approach is the absence of control capability, for the fluid can not be maintained at a constant temperature nor varied to suit the varying metabolic demands of the body. Moreover a disadvantage of the foam insulation is its lack of response to varying thermal conditions. If the refrigerant is very cold, the insulation may not be sufficient to prevent over-chilling. Moreover, if the refrigerant begins to warm up, the insulation may be too thick, which would substantially reduce the effectiveness of the refrigeration.

SUMMARY OF THE INVENTION

The present invention obviates the obvious above-mentioned shortcomings by providing a passive cooling system that has all of the advantages of a self-contained unit while still having accurate microclimate control capabilities.

The system comprises a cooling garment having a plurality of compartments mounted thereon containing a stored refrigerant, and a variable insulation garment whose thermal conductance is controlled at will by the wearer. The cooling garment comprises a plurality of tubes attached to a network of webbing adapted to fit at least over the upper torso of the wearer. Each tube is filled with water and sealed in 4-inch intervals along the tube to form a string of individual water compartments. The water filled tubes are then frozen to provide a refrigerant having a large thermal capacity. The tubes may be either permanently secured to the webbing or removably attached thereto with the entire garment adapted to be worn over the insulated garment. The compartments may also be formed by sealing together two flat sheets of plastic or rubber material in a gridlike pattern which are later filled with water.

The insulation garment is also patterned to cover at least the upper torso of the wearer, and comprises a layer of open cellular material, such as polyurethane foam, sandwiched between two outer layers of an airtight material, such as vinyl or other plastic sheeting. The outer layers are sealed around the periphery of the garment to make the whole assembly airtight.

Vacuum means, preferably in the form of a hand pump, is also provided to evacuate the interior of the garment. As a result the thickness of the insulation layer is progressively reduced to increase the conductance of the garment to meet varying metabolic demands of the user.

A principal object of the invention is to provide a microclimate control system which is completely self-contained, and easily adjustable at the will of the user.

Another object of the present invention is to provide a personal microclimate control system that is simple in construction and suitably designed for low-cost mass production.

The features of the present invention which are believed to be novel are set forth with particularity in the appended claims.

The present invention, both as to its organization and manner of operation, together with further objects and advantages thereof, may best be understood by reference to the following description, taken in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of the variable insulation garment of the present invention;

FIG. 2 is a fragmentary sectional view of the insulation layer at its normal operating thickness;

FIG. 3 is a fragmentary sectional view of the insulation layer in a partially evacuated state;

FIG. 4 is a perspective view of the stored refrigerant garment of the present invention; and

FIG. 5 is a top elevational view of the stored refrigerant garment.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings, FIG. 1 shows a variable insulation garment, generally indicated by arrow 10, which is patterned to be worn about the upper torso of the wearer with leg portions 11 extending downwardly to the knees. In its preferred configuration the leg portions 11 of the insulation garment 10 are integrally formed to be stepped into while the upper torso portion consists of front and back flaps 15 and 17 which are adapted to be tied together at the shoulders and sides by laces 19 or other suitable attaching means.

As more clearly shown in FIGS. 2 and 3, the variable insulation garment 10 is made of a layer of cellular material 21 sandwiched between two outer layers of an impermeable material 23. In the preferred form, the materials used for the two outer layers are sheets of vinyl, or other plastic material, whereas lightweight polyurethane foam, approximately three-eighth inch thick, is used for the inner layer. Other materials such as neoprene or other types of rubber or plastic material can be used for the outer layer while other types of soft open cell foam can be used for the inner layer. The outer layers 23 are dielectrically sealed around the periphery of the garment at the seams to make the entire assembly airtight.

A hand held vacuum pump 25 is provided for evacuating the air from within the variable insulation garment 10. The hand held pump 25 is typically in the form of a squeeze bulb which communicates through tubing 27 to the interior of the garment 10. The connection between the tubing 27 and the outer layer 23 is also made airtight by glueing or heat sealing techniques.

As shown in FIGS. 4 and 5, a cooling garment, generally indicated by 30, is adapted to be worn over the variable insulation garment 10. The cooling garment 30 comprises a network of webbing 31 patterned similar to the variable insulation garment 10 having a plurality of tubes 33 attached thereto. The upper portions of the tubes 33 are removably attached to a reinforced shoulder section 35 by snaps 37 or they may be permanently secured thereto. In a like manner, the lower end of the tubes 33 are removably attached to the reinforced knee sections by snaps 39. Moreover, each of the tubes are insertable through a plurality of loops 41 longitudinally spaced on the webbing 31.

The tubes 33 are filled with water, to which has been added antibacterial and fungicidal ingredients, are heat sealed at approximately 4-inch intervals 43 to form strings of individual water compartments 45. The techniques to accomplish this sealing are conventional in the packaging industry. In freezing the water within the compartments 45 the tubes 33 may be detached from the webbing and individually frozen or the entire cooling garment may be frozen.

In most applications an additional outer insulating garment (not shown) is worn to prevent heat gain to the ice from the outer atmosphere. This outer garment, however, is a standard product and is not particularly pertinent to the novelty of this invention. However, such a garment does improve the overall system efficiency.

In operation, the cooling garment 30 is positioned over the insulation garment 10. At the initial stage, the cooling garment 30 is at 0° Fahrenheit. Since the subject is only beginning to work, the maximum insulation for the insulation garment 10 is required. The maximum insulation is shown in FIG. 2, where air is permitted within the cellular structure 21 to allow the foam to expand to its natural thickness.

As the subject begins to work, the need for increased heat dissipation from the skin to the refrigerant layer 30 is met by a gradual reduction in the thickness of the insulation layer 10. This process is accomplished by the wearer by operating the hand vacuum pump 25. Each squeeze of the pump 25 removes a fixed volume of air from the insulation garment 10 and as the air is removed, outside air pressure collapses the foam 21 by a finite and evenly distributed amount. This decrease in thickness increases the thermal conductance of the insulation layer 10. It should be noted that in normal use, it is not until all the frozen solids have melted and the refrigerant layer begins to rise in temperature that the maximum reduction of the insulation barrier is needed. The maximum reduction in thickness is shown in FIG. 3.

It has been found that it is quite practical to distribute 10 to 15 pounds of water in the garment and that 2,000 B.t.u.'s of heat capacity would be available if the garment were stored in a freezer at 0° and used until the melted ice had reached a temperature of 70° Fahrenheit. This is within the normal operating range. This amount of heat capacity is sufficient for 1 to 2 hours of use by an individual engaged in moderate activity. As an example, in tests conducted with the subject walking on a treadmill at 3 miles per hour, the heat removal was adequate for 1½ hours in almost complete comfort.

A profound advantage of the cooling garment 10 is that all of the compartments 45 are self-contained and isolated from each other. As a result the puncture of one of the compartments affects only a small fraction of the garment's overall effectiveness.

It should also be noted that the variable insulation garment could also be made as an inflatable rather than a foam sandwich from which air has to be evacuated. In such a garment air could gradually be let out as required to reduce the insulation

barrier. It should also be noted that the variable insulation garment can also be used in combination with a heat source with little or no modification to the garment structure. Furthermore, the variable insulation garment can be utilized alone, without any outside garment, for the purpose of regulating the rate of heat loss from the body to the outside environment, under conditions where the environment is cold and the metabolic rate may vary from very low at rest to high during hard work.

As can be seen, a completely self-contained cooling system is provided that is highly mobile and capable of being adjusted to meet the varying metabolic demands of the user.

It should be noted that various modifications can be made to the apparatus while still remaining within the purview of the following claims.

What is claimed is:

1. A microclimate control system comprising:

cooling garment means for absorbing the metabolic heat of the wearer; and

garment means to be worn under said cooling garment means for thermally insulating the wearer from said cooling garment means, said garment means further having means for varying the thermal conductance of said insulating means.

2. The invention of claim 1 wherein the means for varying the thermal conductance of said insulating means includes means for varying the thickness of said insulating means.

3. The invention of claim 1 wherein said cooling garment means includes self-contained refrigerant means for absorbing the metabolic heat of the wearer.

4. The invention of claim 2 wherein said self-contained refrigerant means comprises individual water-filled compartments that are adapted to be frozen.

5. The invention of claim 4 wherein each of said individual compartments communicates with an adjacent compartment.

6. The invention of claim 4 wherein said water-filled compartments are formed from a plurality of tubes, each tube being sealed at longitudinal intervals to form said compartments.

7. The invention of claim 4 wherein said compartments are formed by sealing together two flat sheets of plastic or rubber material in a gridlike pattern.

8. The invention of claim 3 wherein said tubes are of a rubberlike material.

9. The invention of claim 3 wherein said tubes are of a flexible plastic material.

10. The invention of claim 3 wherein said tubes are secured to a network of webbing or fabric material.

11. The invention of claim 2 wherein said insulating means comprises a layer of resilient material sandwiched between a pair of outer layers of impermeable material.

12. The invention of claim 11 wherein said means for varying the thickness of said insulating means comprises means for evacuating the interior of said insulating means.

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