United States Patent

Esposito

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[54] GARMENT COOLING SYSTEM

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[73] Assignee: **The United States of America as represented by the Secretary of the Navy**

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[52] **U.S. Cl.**.....**62/167**, 62/384, 62/259, 62/188, 128/142.5

[51] **Int. Cl.**.....**F25d 3/12**

[58] **Field of Search**.....62/56, 165, 166, 167, 168, 62/259, 188, 384

[56] **References Cited**

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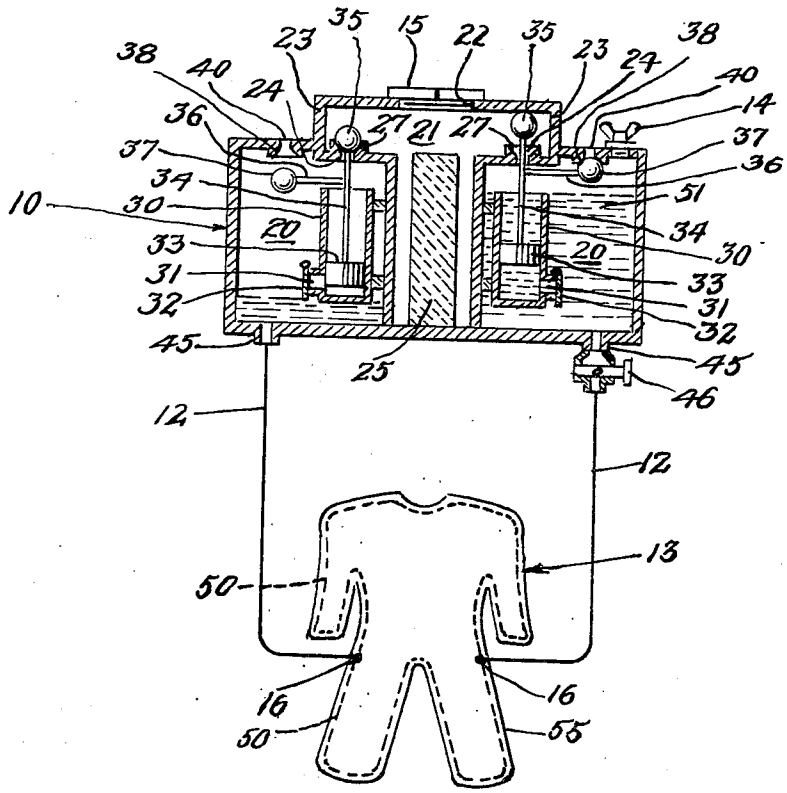
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[57] **ABSTRACT**

A protective garment for providing cooling including a network of flexible tubing completing a loop between two chambers thermally connected to solidified carbon dioxide. Heat transfer fluid alternately flows between the chambers to transfer heat from the garment to the heat sink. The pressure generated by gasification of the carbon dioxide as heat is absorbed in each chamber causes the alternate flow. A float valve in each chamber controls the admission and exhaustion of the gaseous carbon dioxide.

3 Claims, 2 Drawing Figures



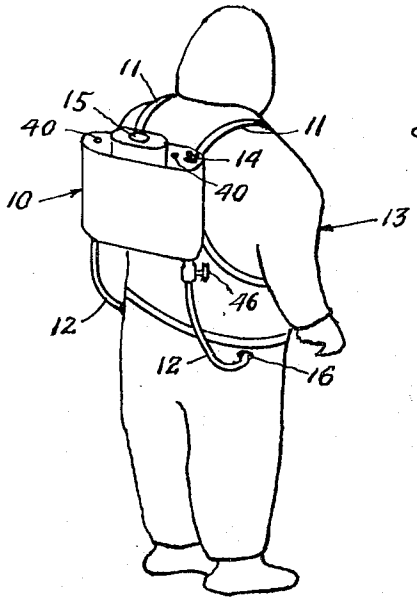


Fig. 1.

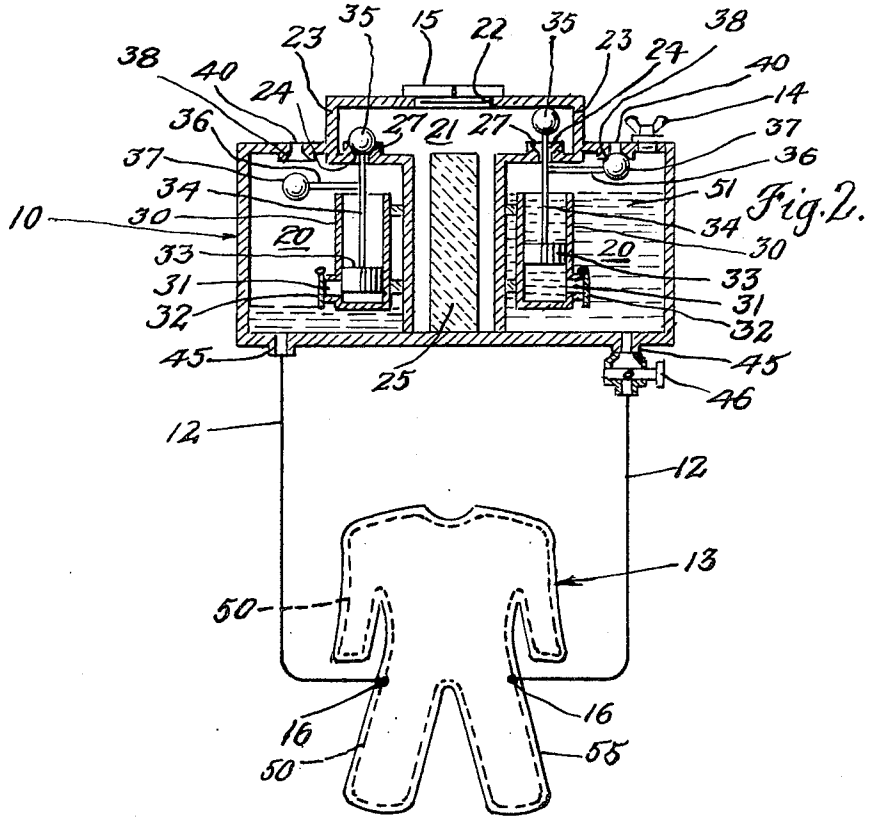


Fig. 2.

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GARMENT COOLING SYSTEM

STATEMENT OF GOVERNMENT INTEREST

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

BACKGROUND OF THE INVENTION

The present invention relates to garment cooling systems, and more particularly to an active heat sink garment cooling system which automatically recirculates cooling fluid through an integral flexible tubing network without any external power supply.

Various means have been devised in the prior art for augmenting the human body cooling mechanisms and fall generally into two classes, i.e., a passive system such as an insulated garment, and an active system utilizing powered cooling cycles. Of these the former is typically characterized by its bulkiness thereby reducing the wearer's mobility, particularly in the areas of limb protection. The latter class typically relies on complex powered mechanisms generally including either a refrigeration cycle or a passtive heat sink where the heat sink requires a separate power source to circulate heat transfer fluid throughout the cooling cycle.

SUMMARY OF THE INVENTION

Accordingly, it is the general purpose and object of the invention to provide an improved garment cooling system which utilizes and which converts a portion of the thermal energy generated by the wearer to circulate the heat transfer fluid. Another object of the invention is to provide an active cooling system which is relatively simple in construction and operation, and to provide an active cooling system which incorporates a common and readily available heat sink.

These and other objects are accomplished according to the present invention with two cooling chambers, one at each end of a flexible tubing network distributed within a protective garment or suit, each cooling chamber having one side in common with a vaporizable or sublimatable heat sink (such as solidified carbon dioxide) housing and a manifold connecting the housing with the cooling chambers. A valved manifold alternately connects either of the cooling chambers with the housing for pressurizing the respective cooling chambers by vapor or gas formed in the process of absorbing heat, the opposite chamber being vented. A volume of heat transfer fluid thus flows between the cooling chambers through the network.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 represents an angular view of a garment cooling system constructed according to the invention; and

FIG. 2 is a schematic diagram of the system of FIG. 1 showing the system in more detail.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIG. 1 a back pack cooling unit **10** is suspended by straps **11** on the outside of a protective suit **13** on the back of the wearer. Right and left flexible hoses **12** are respectively connected between the bottom end of cooling unit **10** proximate the lateral sides thereof and fittings **16** disposed laterally on either side of the waist line of suit **13**. A cover **15** on the upper surface of cooling unit **10**, attached by means known in the art, provides access to cooling unit **10**. A filter cap **14** on the upper end of cooling unit **10** proximate the right lateral side thereof together with a manual shutoff valve **46** on the bottom side of unit **10** intermediate the right hose **12** and unit **10** provides for filling and shutoff in a manner described hereinafter.

As shown in FIG. **2**, cooling unit **10** includes two lateral chambers **20** disposed on either side of a coolant housing **21** and having common surfaces therewith. Coolant housing **21** at its upper end includes an opening **22** closed by the access cover **15** which, when removed, allows for the insertion of a block of solidified carbon dioxide **25** and which, when installed, traps the sublimated carbon dioxide gas within housing **21**. Other low-temperature vaporizable or sublimatable fluids or solids may be used without departing from the invention. Solidified CO_2 is particularly suitable due to its temperature and its relative safety in use. Proximate the upper end of housing **21** on either side thereof there is extending a manifold **23** connecting through corresponding openings **24** the upper end of the coolant housing **21** with the respective upper ends of the lateral chambers **20**. Openings **24** are formed in respective lower horizontal surfaces of manifold **23** with the upper sides thereof forming respective ball seats **27**. Two cylindrical float guides **30** each disposed in a generally vertical direction are attached within the respective lateral chambers **20**, each central axis thereof being generally aligned with the corresponding central axes of openings **24**. Each float guide **30** is open at its upper end and closed at its lower end having lateral drain openings **31** proximate the lower ends thereof externally closed by corresponding flapper valves **32**. Each float guide **30** contains a float **33** attached to a rod **34** which extends through opening **24** where it terminates in a ball valve **35** within manifold **23**. Intermediate opening **24** and the upper end of float guide **30** rod **34** is attached to one end of a horizontal rod **36**, the other end of rod **36** attaching to a second ball valve **37**, ball valve **37** being disposed in a generally upward direction from rod **36**. Ball valve **37** is formed to seat against a ball seat **38** formed on the lower side of a vent opening **40** through the upper external surface of the corresponding chamber **20**. The length of rod **34** is determined according to desired flotation level of float **33** within float guide **30** as described herein below; the length of rod **36** is determined by the distance between the central axes of openings **24** and **40**. Each lateral chamber **20** includes hose fittings **45** formed on the respective bottom surfaces thereof having corresponding one ends of flexible hoses **12** attached thereto. The other ends of hoses **12** connect to a left and right waist fittings **16** on suit **13**. A flexible tubing network **50** is contained within a lining **55** of suit **13** contiguously attached thereto forming parallel loop sections between the right and left waist fittings **16**, the loop sections connecting the respective hoses **12** thereby completing a loop between the right and left lateral chambers **20**. Either one of the chambers **20** includes a filler cap **14** through which a predetermined quantity of heat exchange fluid **51** is introduced into the system. A manually operated valve **46** is formed within the corresponding fitting **45** such that the fluid **51** is initially contained within the chamber **20** provided with a filter cap **14**.

In operation heat exchange fluid **51**, such as water or water mixed with alcohol, is introduced into one of the lateral chambers **20** through filler cap **14** and the solid CO_2 **25** is placed within the coolant housing **21** following which the access cover **15** and the filler cap **14** are closed. The heat exchange fluid then transfers its heat through convection and conduction to the solid CO_2 sublimating it and producing carbon dioxide gas. The amount of heat transfer fluid originally introduced into one of the lateral chambers **20** is sufficient to overflow the upper end of float guide **30** displacing float **33** upwards and thereby raising ball valve **35** away from seat **27** and at the same time closing ball valve **37** against ball seat **38** such that the gaseous carbon dioxide being continuously formed within the coolant housing **21** by the heat transfer process is free to enter the filled lateral chamber **20** pressurizing said chamber. When the chamber **20** is pressurized valve **46** is opened the heat exchange fluid **51** is pushed through the tubing network **50** into the other chamber **20**. In the other chamber flapper valve **32** remains closed until the fluid level reaches the upper end of the float guide **30**, thus float **33** is raised and ball valve **35** is opened initiating a new cycle only when fluid **51** is completely transferred to the other chamber **20**. In the first chamber **20** flapper valve **32** allows the fluid inside float guide **30** to drop thereby allowing ball valve **35** to

seat and ball valve 37 to open when the fluid is below the flotation level of the float determined by the length of rod 34. The amount of heat exchange within each cycle is generally related to the volume of gas generated by solid CO_2. Accordingly, it is contemplated that various heat balances can be accommodated by appropriate means of adjusting the heat transfer path from the fluid to the solid CO_2, e.g., selection of the contact area of the solid CO_2 25 with the housing 21 thereby selecting the conductive area and the heat transfer rate within the system.

Some of the many advantages of this invention should now be readily apparent. The invention provides a simply accomplished heat transfer means across a large temperature gradient of a passive heat sink, such as solid CO_2, at a temperature level acceptable for human comfort at the same timing utilizing the product of the heat exchange, i.e., the carbon dioxide thus generated, to power the heat exchange cycle.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. A personal cooling system for protecting a human from high temperature exposure comprising, in combination:

an outer garment;

heat sink means operatively disposed on the outside of said garment for exchanging heat during vaporization, and including an expendable mass of cryogenic matter for vaporizing into gas in the process of heat exchange;

heat transfer means disposed within said garment thermally connected at either end to said heat sink means for transferring heat from said garment to said heat sink means, and including a flexible tubing network disposed within said garment forming a plurality of parallel loop sections commonly joined at the corresponding ends thereof, two closed chambers operatively connected one at each end of said tubing network, said chambers being thermally connected to said heat sink means, and a quantity of heat transfer fluid contained within the volume formed by said network and said chambers; and

pressurization means enclosing said heat sink means connected to the ends of said heat transfer means for powering said heat transfer means with the vaporization of said heat sink means, and including a closed housing formed between said two chambers and having respective sides in common therewith, a manifold connecting the upper end of said housing with respective upper ends of said chambers, two floats deployed in respective ones of said chambers and carried by said fluid, two first ball valves operatively connected to respective ones of said floats formed to close said manifold at a predetermined lower level of said fluid within said chambers, two second ball valves each respectively connected to said floats formed to open and vent said chambers at said predetermined lower level of said fluid, and limiting means disposed within said chambers for maintaining said floats at respective lower levels until said fluid reaches a predetermined higher level.

2. A personal cooling system according to claim 1, further comprising:

said limiting means including cylindrical float guides vertically disposed within respective chambers containing said floats, said float guides being open at the upper end thereof and having respective lateral passages at the bottom end thereof, corresponding externally closed flapper valves disposed across said passages, whereby an increase in fluid within said chamber is excluded from the inside of said float guides until the fluid level reaches the upper end thereof.

3. A cooling system comprising:

vaporizable heat sink means for exchanging heat during vaporization, and including an expendable mass of cryogenic matter for vaporizing into gas in the process of heat exchange;

heat transfer means adapted to be thermally connected to an object to be cooled and thermally connected to said heat sink means for transferring heat from the object to said heat sink means, and including a tubing network adapted to be disposed in thermal contact with the object, two closed chambers operatively connected one at each end of said tubing network, said chambers being thermally connected to said heat sink means, a quantity of heat transfer fluid contained within the volume formed by said network and said chambers; and

pressure utilization means enclosing said heat sink means and operatively connected to said transfer means for powering said transfer means with the pressure produced by vaporization of said heat sink means, and including a closed housing formed between said two chambers and having respective sides in common therewith, a manifold connecting the upper end of said housing with respective upper ends of said chambers, two floats deployed in respective ones of said chambers and carried by said fluid, two first ball valves operatively connected to respective ones of said floats formed to close said manifold at a predetermined lower level of said fluid within said chambers, two second ball valves each respectively connected to said floats formed to open and vent said chambers at said predetermined lower level of said fluid and cylindrical float guides vertically disposed within respective chambers containing said floats, said float guides being open at the upper end thereof and having respective lateral passages at the bottom end thereof, corresponding externally closed flapper valves disposed across said passages, whereby an increase in fluid within said chamber is excluded from the inside of said float guides until the fluid level reaches the upper end thereof.

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