May 3, 1966 V. STARK 3,248,897

AIR CONDITIONING DEVICE

Filed March 30, 1965 3 Sheets-Sheet 1

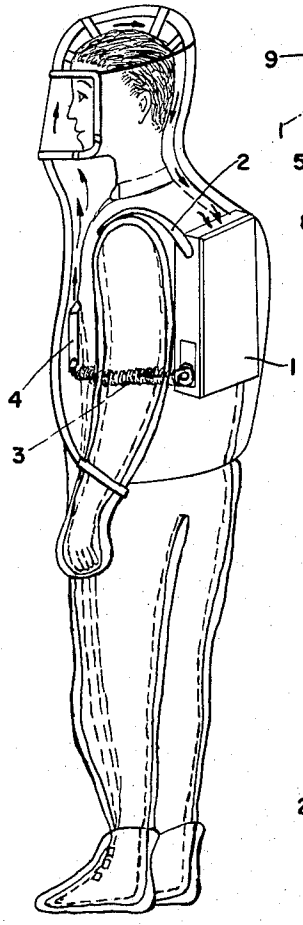

FIG.1.

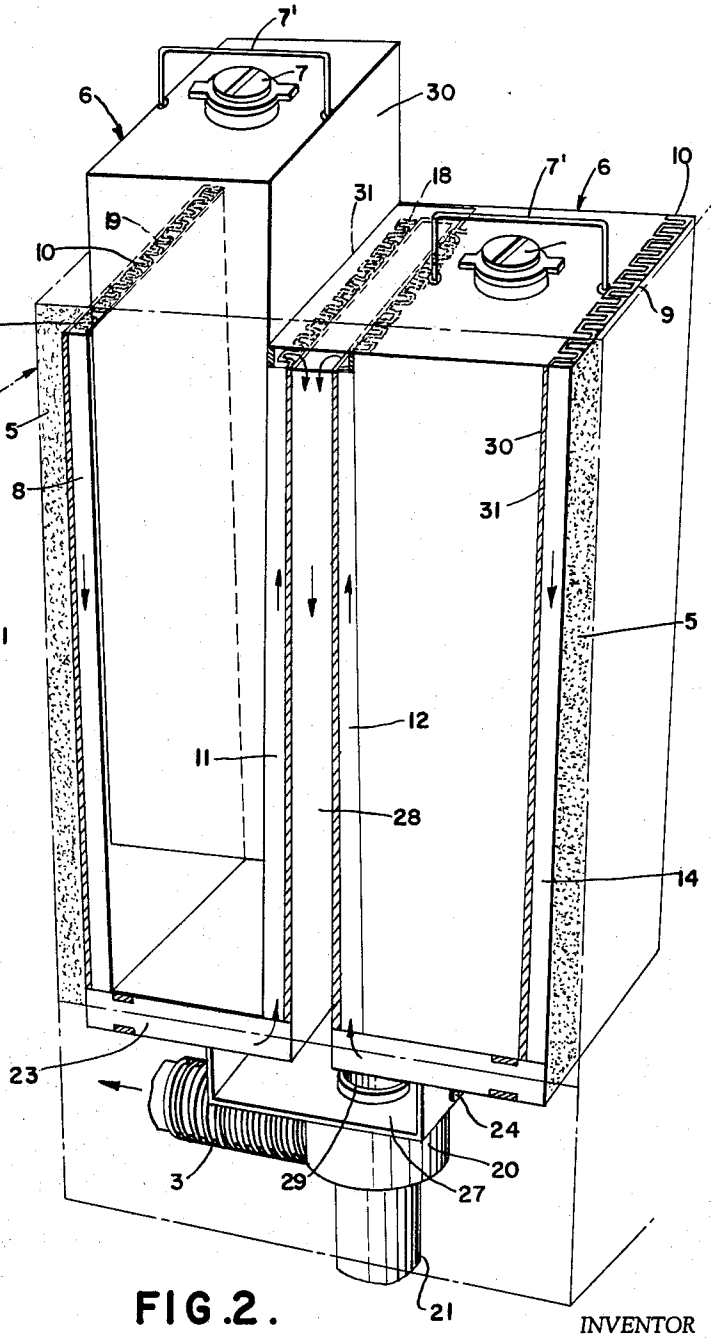

FIG.2.

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AIR CONDITIONING DEVICE

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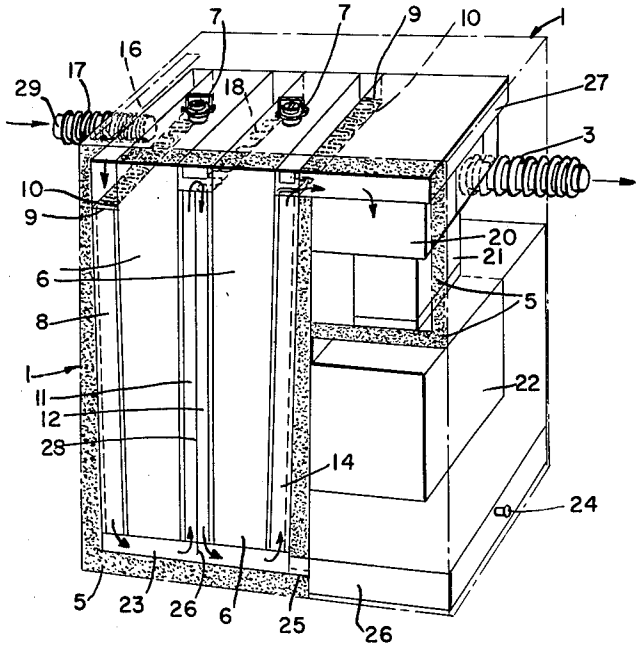

FIG. 3.

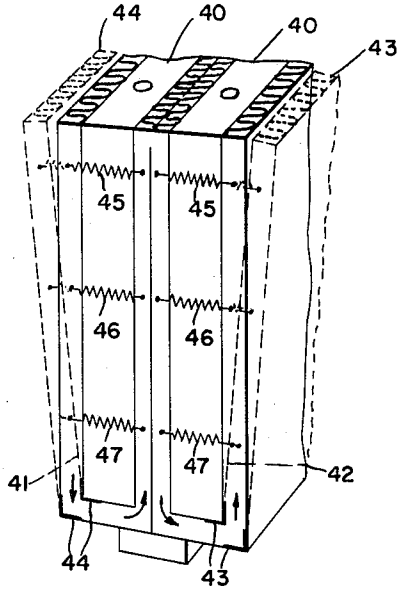

FIG. 4.

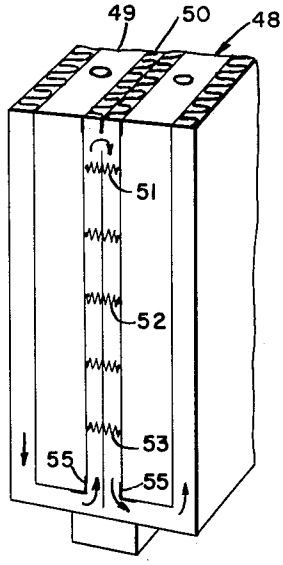

FIG. 5.

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AIR CONDITIONING DEVICE

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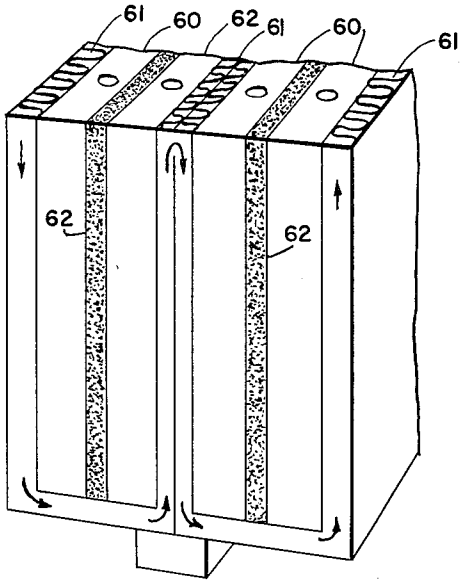

FIG. 6.

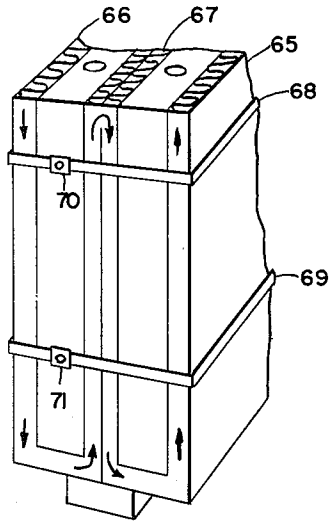

FIG. 7.

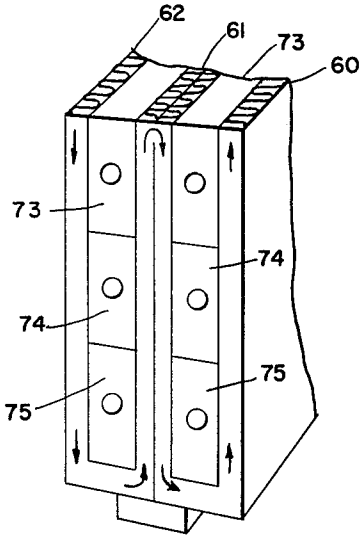

FIG. 8.

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United States Patent Office

3,248,897
Patented May 3, 1966

3,248,897

AIR CONDITIONING DEVICE

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Filed Mar. 30, 1965, Ser. No. 443,972
17 Claims. (Cl. 62—259)

The present invention relates to an air conditioning device of the type disclosed in my prior Patents No. 2,731,808, No. 2,963,881, No. 3,000,190 and No. 3,000,-191 in which air conditioning equipment is used for conditioning a suit or enclosures of limited capacity.

The object of this invention is to obtain protection and cooling for the human body in environments with or without high humidity, or in contaminated ambiences..

The human body is protected by an insulated garment spaced from the body as described in the above-mentioned patents, and as shown in FIG. 1. Such a garment is spaced from the body and allows an intermediate space between the body and the garment, allowing the circulation of air.

Heat is dissipated on one side by the metabolism of the human body. In very hot ambiences, some heat is also transferred through the protective garment. The object of this device is to cool the air in the space around the human body and in the garment, and to keep the body comfortable.

This device provides a self-contained cooling process, and achieves this by insulated clothing in combination with a portable heat sink which cools the air circulating around it and the body. Thermal equilibrium is maintained for the individual by absorbing the heat generated by the body and transferred by the surroundings.

The heat sink consists of a metallic container filled with a frozen refrigerant.

The system of this device allows effective cooling through the medium of a self-contained refrigerating unit that is worn on the individual's back under or over insulated reflective clothing, or carried as a valise by the user.

The principle of this device is simple and economic. Replaceable aluminum containers inserted in an insulated box are filled with a frozen refrigerant, as shown hereafter. The refrigerant solution in such containers is frozen to about −10° F. in a deep freeze remote from the location of use. The refrigerant cools the metallic walls of the container to about 30° F. The metallic walls cool in their turn aluminum fins attached to a metallic plate in contact with the walls of the container. These fins are cooled to about 35° F. The air is circulated through the aluminum fins and is cooled to about 50° F.

The cold air is then blown by a blower through a distributing manifold into the space between the human body and a protective insulated garment spaced from the body.

The garment is made, preferably, of aluminized insulated cloth with a visor. For environments under 120° F., an insulated jacket, covering only the upper part of the body, may be sufficient. The blower is driven by a miniature motor and rechargeable battery. A rheostat can control the velocity of the motor and the volume of air.

The cool air, introduced at about 50° F., is heated up to about 70° F. by the heat developed by body metabolism, and whatever heat is introduced from the outside hot environment through the garment.

In this way, if the ambient air is, for instance, 350° F., the air circulated around the body which is protected by the insulated garment, will only be about 50° to 70° F. At this temperature, the body dissipates heat mostly by convection and radiation, but not by evaporation resulting from perspiration.

In environments with high relative humidity, the cooling of the air reduces its moisture holding capacity, and

the moisture, which is in excess of saturation (related to the newly created temperatures) is removed from the air by condensation and is removed within the unit. Thus, comfort conditions are obtained for both high temperatures and high humidity conditions.

With an increase in the velocity of circulating air, the rate of heat dissipation from the body is augmented and comfort is increased.

The refrigerant preferably consists of an eutectic solution frozen in a container as described hereafter. Other refrigerants such as Dry Ice, liquid oxygen, liquid air, or a combination of refrigerants can be used in the containers.

The refrigerant mixture is preferably so composed as to obtain the desired temperatures and to produce the highest cooling effect by taking advantage of a number of physical phenomena which occur when the mixture melts. When the chemical solution is cooled below the freezing point, the water freezes and the chemical dissolved in the water crystallizes. The freezing point of the liquid is below that of pure water, and can be further lowered by the addition of alcohol. When the mixture is warmed, the heat absorbed melts the ice and the liquid thus formed redissolves the chemical and the cooling effect obtained is composed of the following:

(1) The sensible or specific heat of the substance cooled below its freezing point is the heat necessary to raise the temperature of the solid to the melting point.

(2) The heat of fusion (which is the amount of heat necessary to produce changes from the solid to liquid without change in the temperature).

(3) The negative heat of solution of the soluble salts in liquids (such as water and alcohol). During freezing of the salt solution, the hydrated salt separates from the frozen solution. When the liquid is formed from the unfrozen solution during melting, the salt will redissolve in the liquid, absorbing the negative heat of solution generated during this process and resulting in an additional refrigeration.

(4) The specific heat of the solution from the melting point up to the point at which no significant cooling of the incoming air is obtained.

The refrigerant is inexpensive and readily available in all locations. It is not consumed, as the same charge is submitted within the replaceable finned container to periodical freezing as required.

The containers can be frozen and stored in any conventional ice cream freezer, deep freezer, Dry Ice, etc. A thawed container may be replaced by a freshly frozen one in a matter of seconds.

Several containers can be stored in a portable insulated box for ready replacement. The freezing can be done at a central location during the night.

The device described in the previous patents had a replaceable container provided with aluminum fins brazed to it, and through which the air was circulated for cooling.

The various features of novelty which characterize this invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention however, its advantages and specific objects obtained with its use, reference should be had to the accompanying drawings and descriptive matter in which have been illustrated and described a preferred embodiment of the invention.

In the drawings:

FIG. 1 is a side view of a mannequin wearing a garment partially broken away to disclose the cooling means according to this invention.

FIG. 2 is a perspective view of the cooling means of this invention.

FIG. 3 is a perspective view partially in section showing a modification of the device shown in FIG. 2.

FIG. 4 is a perspective view partially in section showing a modification of the device shown in FIG. 2.

FIG. 5 is a perspective view partially in section of the device shown in FIG. 4.

FIG. 6 is a perspective view of a modification of the device shown in FIG. 2.

FIG. 7 is a perspective view showing a modification of the use of straps to releasably hold the containers in assembled position.

FIG. 8 is a perspective view showing a small type container.

This invention relates to a new type of device, as typically illustrated in FIGS. 2 and 3. In this model, the containers have no fins, but the plain aluminum surface of the container **6** is pressed against separate aluminum outside compartments **8** and inside compartments **11** which contain inside aluminum fins **9** and preferably also another set of fins **10**. The air to be cooled is circulated in these compartments. The heat absorbed from the air by contact with the cold metallic surfaces of the fins is transmitted through the metallic walls of the compartment to the adjacent surface of the plain container, and thus to the refrigerant, which finally absorbs the heat and melts the frozen solution. The air can be circulated in through a set of two finned compartments, or, if so designed, through more than two finned compartments for cooling at lower temperatures. The containers **6** are filled through capped openings **7** provided with handles **7'**.

The finned compartments are placed on one or both lateral sides of the removable containers **6**. The air can be introduced at the top of the outside compartments **8**, also if so desired through middle opening **18**, or through one or more hoses connected to the side openings **29** and/or the top opening **18** connected to the garment if no outside air is admitted; the air then circulates downward into a manifold **23**, and then upwardly in a second inside finned compartment **11**, where it is cooled by the container. It then proceeds downwardly through **28** into a collection chamber **27** before entering the small blower **20** driven by a miniature electric motor **21** and controlled by a rheostat, the motor being connected to a rechargeable battery. As an alternate, a device with a jet and one or more containers with air or oxygen under pressure, as described in Patent No. 3,000,191, can replace the blower, electric motor, and the battery.

The design as shown in FIG. 2 shows the collection chamber **27**, blower **20**, and motor **21** at the bottom of the unit, whereas in the design shown in FIG. 3, they are placed on a lateral side of the unit. A plastic box **1** lined with insulation **5** contains the cooling device. This box is held by straps **2** on the back of the wearer (FIG. 1), the box being placed either inside or outside the garment. It can also be carried as a valise by the user. The blower placed inside the box is connected by a flexible insulated hose **3** to a manifold **4** placed on the chest of the wearer, which gently blows air toward the face of the user and distributes the air to different parts of the body under light pressure.

In both typical designs, shown in FIGS. 2 and 3, the cooling of the air can be done with only two streams, each circulated in two sets of parallel compartments as shown in FIG. 2. The cooling can be done in sequence by four compartments as illustrated in FIG. 3. In the second case, the temperature of the cooled air will be lower and the time of use longer. In the first case, the volume of the circulated air will be larger. However, in the design as shown in FIG. 3, the cooling can be changed by admission of additional air through an opening **18** in the middle compartment. In this case, the set of compartments nearest to the blower will circulate and cool not only the air cooled by the first set of opposite compartments, but also the additional air introduced at **18**.

In the design as shown in FIG. 2, the operation in sequence can be obtained by placing on the top of the apparatus a device which changes the circulation of the air so that the air from the inner compartment **11** is conducted to the outside compartment **14**, and after flowing downwardly in this compartment, it flows upward through the compartment **12**, and then downwardly through the inner column **28** to the collection chamber **27** and the blower **20**.

The water condensed is accumulated as shown in FIG. 3 in a collector **26**, being allowed to enter from the bottom chambers **23** through small openings **25**. The water can be taken out through a little cock **24**. In the designs as shown in FIG. 2, the water is collected in the manifold chamber **27** and taken out by an opening with cock **24**. However, a plate **29** is placed above the opening to the blower **20** so as not to allow the water to enter the blower.

The fins in the compartments can be single, double, or more sets. A set of fins **9** is fixed on one side of the wall of the compartment such as **8** or **11**. A second set of fins **10** can be set on the opposite side wall of the compartment and touch the first set of fins transmitting heat to such fins, thus increasing the cooling surface.

Refrigeration can be controlled in three ways:

(1) By a rheostat that allows varying the speed of the motor driving the blower, and thus changing the volume of air circulated.

(2) By warm air which can be introduced into the circuit by an opening **18**.

(3) By the circulation of air in two or more subsequent finned compartments as mentioned above.

There are several alternate methods of having close contact and pressing the wall of the metallic container filled with refrigerant against the metallic walls of the compartment containing the fins so as to allow for an efficient transfer of heat.

One of the preferred systems is to make one or several walls of the container instead of vertical under an angle such as **30**, and counter angle such as **31**. As shown in FIG. 2 and FIG. 3, the width of the upper end of the container will then be larger than the lower end. The weight of the refrigerant and of the container will make the metallic container press against both adjacent finned compartments, and facilitate removal and replacement of the containers in the space between such compartments.

Another method is to use rectangular shaped containers **40** having outside compartments **41** and **42** with flexible side connections **43** and **44** and transversal springs **45**, **56** and **47** to connect them to the center compartment, as illustrated in FIG. 4 showing the inside cooling device. The outside compartment **41** or **42** will be pressed out to remove the refrigerant container **40**, and thereafter press the compartment against the adjacent container.

Another method using rectangular shaped containers **48** and **49** is to make the center compartment **50** with flexible connections **54** at the top and bottom **55** and with inside springs **51**, **52**, **53** such as in a mattress, as illustrated in FIG. 5. The central compartment will be compressed when containers are moved in or out, and thereafter exert pressure against the containers allowing for good contact.

Another method of using rectangular shaped containers **60** is to have a compartment with an elastif foam **62** between two containers, preferably four containers, forming an elastic compartment in between allowing the containers to move in and out, and pressing them against heat transfer compartments **61**, as illustrated in FIG. 6.

Another alternate method of pressing the sides **65** and **66** of the container against one or more finned compartments **67** is to use one or more straps **68** and **69** provided with buckles **70** and **71** around the cooling device or box with detached side panels that can be tightened after the

container is inserted and can be loosened when the container is removed (FIG. 7).

An alternate possibility is to use, instead of one container filled with refrigerant pressed against one or more finned compartments, several smaller containers, **73**, **74**, **75**, either two, four, six, or more, such as those available in the trade, for instance with a content of about 16 ounces each, and as illustrated in FIG. 8.

Any of the devices shown above can also be designed for different environmental conditions by adjusting the size of the containers and the finned compartments. The containers, if designed for a larger quantity of refrigerant, can also be used only partially filled with eutectic solution.

This device can be made as an air-tight device and only circulate the air inside an air-tight garment without introducing any ambient air. In this case the air is introduced at **29** (FIG. 3) and possibly **18**, by short hoses from the suit into the outside compartment **8** and respectively in **12**. The outlet cooled air from the blower is then introduced by a short hose **3** into the garment. This device can be designed to be worn on the back of the user, inside the garment, or carried as a valise type unit. The removable containers can be changed without any interference with the circulating air and without allowing any outside air to enter the garment. The compressor can be so designed as to obtain a pressure inside the garment higher than atmospheric pressure so that no outside air can enter into the pressurized garment.

This allows the device to be used in contaminated or vitiated environments, together with a separate provision for breathing.

The contamination can result from gases of the psychochemical type or from nerve gases such as Sarin, for example. Such gases, when in contact with any part of the body, paralyze body functions and produce lethal effects by putting the person to sleep. Air-tight garments can protect the body against such contamination; however, the heat developed by body metabolism would make the wearer feel uncomfortably hot.

This device represents a solution for such cases providing cooling by circulating the air through a device around the body without any admission of outside air. This allows the use of this device by the Armed Forces, Chemical Warfare Corps, missile units, chemical plants, fire fighting, etc.

The device, as described in the preceding pages, can be used as an air conditioner for confined spaces, as described in Stark Patent No. 2,963,881. However, instead of Dry Ice, a eutectic solution can be used as a refrigerant in replaceable containers. Such containers and the cooling finned compartments can be made in any size. This represents an economic possibility for such air conditioning; the reusable refrigerant would be a eutectic water solution.

The air can be circulated either by gravity, or possibly air movement collected, as described in the above-mentioned patent, by a collector in case of application to an automobile, or by using the movement of air around the enclosure.

This can be combined with air compression by means of either one of the systems previously described, or as described in Stark Patent 3,000,191.

This application can be made on tents or beds, especially for moving hospitals in hot and/or humid areas, as desert or jungle, or in automobiles. In the latter case, the air of the moving automobile can be collected and cooled and/or combined with a blower and motor connected with the battery of the automobile.

The present invention shows improvements in the cooling device by:

(1) Allowing better cooling of air at lower temperatures.

(2) A more efficient utilization of the refrigerant.

(3) A longer period of utilization between change of replaceable containers.

(4) A better heat transfer between the refrigerant walls, fins, and air.

(5) A simplification in the containers, which are made with flat walls without fins.

(6) A larger flexibility in variation of temperature and the volume of air cooled.

(7) The possibility of using an air-tight cooling device without any introduction of ambient air allowing its usage in contaminated environments, including lethal or toxic gases with the possibility of obtaining a pressure in the air-tight garment higher than atmospheric pressure as not to allow outside vitiated air to enter into such garment.

(8) The possibility of designing the air conditioning device to any size desired, and its possible usage in confined spaces such as tents, beds of moving hospitals, automobiles, etc., possibly combining an outside collected air flow and gravity of cold air, and also compression for the air movements.

What is claimed is:

1. A portable device for maintaining a protective and comfort promoting intermediate environment between a human body and the ambient atmosphere comprising in combination:

(a) a suitable body encompassing garment providing a space at least in part surrounding the body upon which it is adapted to be worn,

(b) a portable air cooling device causing thermal circulation of air in the intermediate environment surrounding the body, said air cooling device being provided with

(c) metallic, compartment defining walls, having fins attached thereto within an air transfer compartment,

(d) at least one replaceable container having therein a frozen refrigerant, said container having plain lateral walls, forcibly contacting the exterior metal surface of said compartment defining walls, and

(e) means to cause the air to circulate through said compartment in heat exchange contact with said fins.

2. An apparatus as set forth in claim **1** wherein the replaceable container is narrower at the bottom than at the top and is thereby forcibly brought into contact with said compartment defining walls.

3. A portable device as claimed in claim **1** wherein said compartment defining walls have lateral springs to force the exterior surface of said walls against said container.

4. A portable device as claimed in claim **1** having a center compartment with flexible springs inside thereof arranged to forcibly move said containers against said exterior surface of said walls.

5. A portable device as claimed in claim **1** wherein at least two rectangular shaped containers have an expandable plastic foam panel therebetween to force the exterior surface of said walls against said containers.

6. A device as claimed in claim **1** wherein said compartment defining walls are supplied with exterior straps having buckles thereon to forcibly move said containers against said exterior walls.

7. A portable device for maintaining a protective and comfort promoting intermediate environment between a human body and the ambient atmosphere comprising in combination:

(a) a suitable body encompassing garment providing a space at least in part surrounding the body upon which it is adapted to be worn,

(b) a portable air cooling device causing thermal circulation of air in the intermediate environment surrounding the body, said air cooling device being provided with

(c) metallic, compartment defining walls, having fins attached thereto within an air transfer compartment,

(d) means causing the positive circulation of the air through at least two finned compartments with a

parallel flow on opposite sides of the apparatus, a common collection chamber and common collection system for both air flows,

(e) at least one replaceable container having therein a frozen refrigerant, said container having plain lateral walls, forcibly contacting the exterior metal surface of said compartment defining walls, and

(f) means to cause the air to circulate through said compartment in heat exchange contact with said fins.

8. A device as claimed in claim 7 wherein the air to be cooled is circulated in sequence in the compartments.

9. A device as claimed in claim 8 wherein warm air is admitted to the air stream being cooled after the air stream has circulated through at least one compartment.

10. A device as claimed in claim 7 wherein said replaceable containers are partially filled with a frozen eutectic mixture.

11. A device as claimed in claim 10 wherein said eutectic mixture includes a salt having a negative heat of solution.

12. A portable device as claimed in claim 7 wherein the body encompassing garment and the air cooling unit are in a closed circuit and means is provided to replace the replaceable containers without admission of ambient air.

13. A portable device as claimed in claim 12 wherein additional gas containing oxygen under pressure is supplied to maintain body encompassing garment under super atmospheric pressure.

14. A portable device for maintaining a protective and comfort promoting intermediate environment between a human body and the ambient atmosphere comprising in combination:

(a) a suitable body encompassing enclosure,

(b) a portable air cooling device causing thermal circulation of air in the intermediate environment surrounding the body, said air cooling device being provided with

(c) metallic, compartment defining walls, having fins attached thereto within an air transfer compartment,

(d) means causing the positive circulation of the air through at least two finned compartments with a parallel flow on opposite sides of the apparatus, a common collection chamber and common collection system for both air flows

(e) at least one replaceable container having therein a frozen refrigerant, said container having plain lateral walls, forcibly contacting the exterior metal surface of said compartment defining walls, and

(f) means to cause the air to circulate through said compartment in heat exchange contact with said fins.

15. A portable device for maintaining a protective and comfort promoting intermediate environment between a human body and the ambient atmosphere comprising in combination:

(a) an enclosure providing substantially closed space surrounding the body,

(b) a portable air cooling device causing thermal circulation of air in the intermediate environment surrounding the body, said air cooling device being provided with

(c) metallic, compartment defining walls, having fins attached thereto within an air transfer compartment,

(d) at least one replaceable container having therein a frozen refrigerant, said container having plain lateral walls, forcibly contacting the exterior metal surface of said compartment defining walls, and

(e) means to cause the air to circulate through said compartment in heat exchange contact with said fins.

16. A device as claimed in claim 15 wherein said air circulating means includes the collection of outside moving air.

17. A portable device for maintaining a protective and comfort promoting intermediate environment between a human body and the ambient atmosphere comprising in combination:

(a) a suitable body encompassing shelter providing space surrounding the body,

(b) a portable air cooling device causing thermal circulation of air in the intermediate environment surrounding the body, said air cooling device being provided with

(c) metallic, compartment defining walls, having fins attached thereto within an air transfer compartment,

(d) at least one replaceable container having therein a frozen refrigerant, said container having plain lateral walls, forcibly contacting the exterior metal surface of said compartment defining walls, and

(e) means to cause the air to circulate through said compartment in heat exchange contact with said fins.

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