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E. W. GOUGH

3,296,819

SELF-CONTAINED COOLING SYSTEM

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2 Sheets-Sheet 1

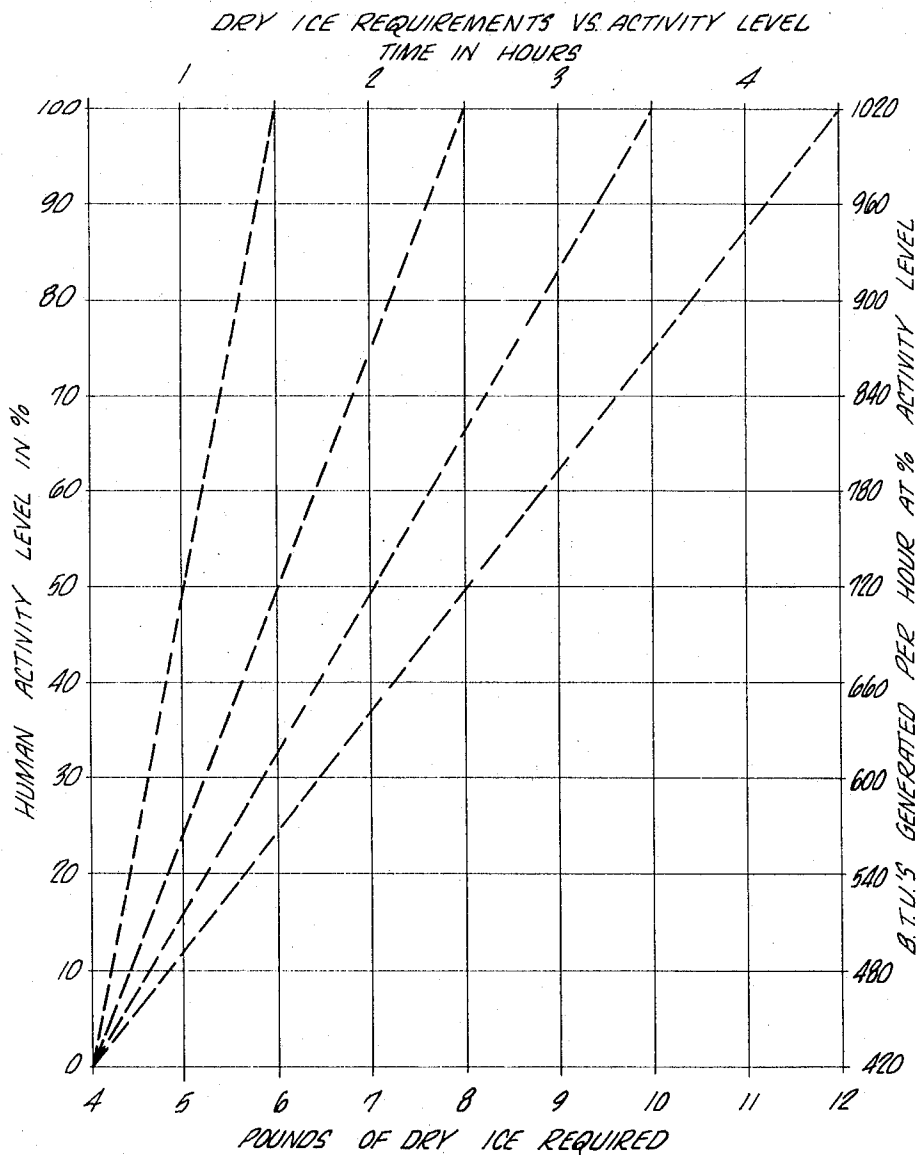


FIG. 1

INVENTOR.

EDWARD W. GOUGH

BY

Christie, Parker & Dale
ATTORNEYS.

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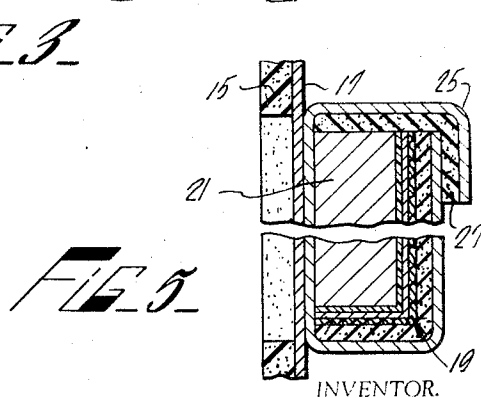
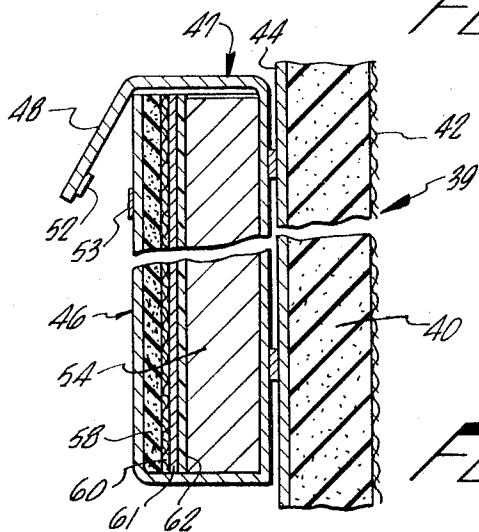
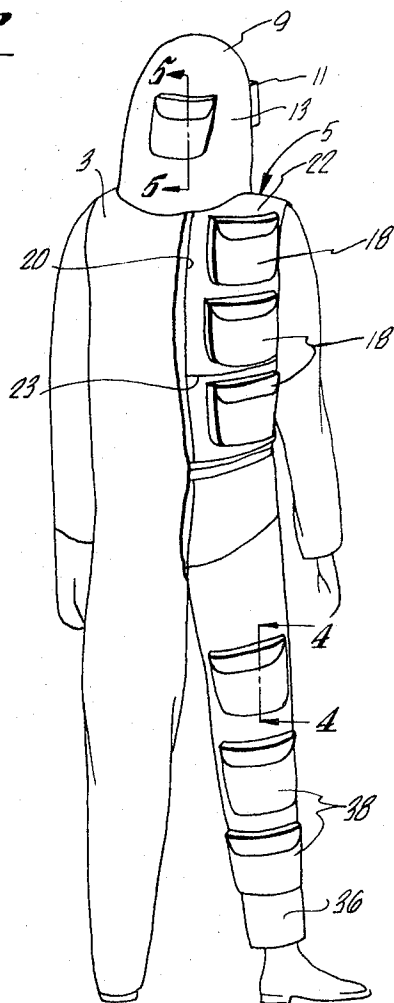
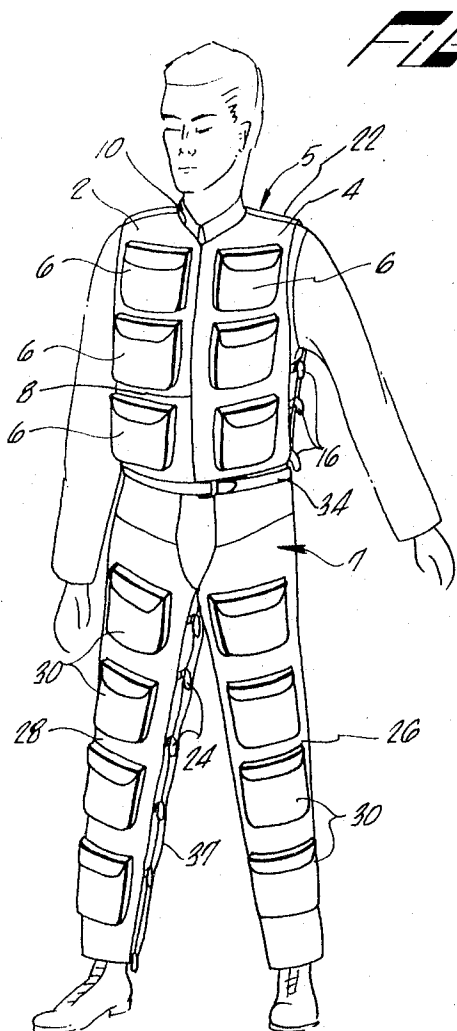
E. W. GOUGH

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2 Sheets-Sheet 2



INVENTOR.
EDWARD W. GOUGH

BY
Christie, Parker & Hale
ATTORNEYS

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SELF-CONTAINED COOLING SYSTEM

Edward W. Gough, Sierra Madre, Calif., assignor to Protection, Inc., Gardena, Calif., a corporation of California

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4 Claims. (Cl. 62-259)

This is a continuation-in-part of application Serial No. 411,222, filed November 16, 1964, and now abandoned. The present invention relates to insulated wearing apparel and in particular to wearing apparel for providing self-contained cooling of persons exposed to elevated temperature environments such as jet aircraft pilots, firemen and racing car drivers.

In present day high speed aircraft it is axiomatic that some means for cooling the cockpit must be provided due to the sizeable amounts of heat which build up within the cockpit as a result of air friction on the fuselage and wings. To provide this cooling a plane is normally equipped with some form of mechanical air conditioner or heat exchanger connected to a pilot's flight suit. Such cooling means are disadvantageous in several respects. Use of such mechanical equipment means a significant additional weight requirement in a situation where weight is normally critical in its effect on range and speed. The equipment is also cumbersome in that it requires plumbing which must be connected and disconnected from the flight suit each time he enters and exits from the cockpit.

In a similar fashion there is a need for providing cooled protective clothing for use by firemen. There are occasions in combating fires whether they be in structures or brush and forest when it is necessary for firemen to expose themselves almost directly to the flames in order to extinguish them. In situations of this type it is common to provide such a firefighter with an asbestos suit. However, with the intense and unrelieved heat surrounding the suit, only a very limited exposure to this heat can be endured before the firefighter is prostrated by it. To provide some means of cooling in the conventional manner again requires plumbing similar to that used for airplane pilots. Added disadvantages would be present in that much longer lengths of plumbing would be required. The attendant possibilities of fouling and snagging of the lines makes such an approach impractical.

A third instance of a situation where cooling or air conditioning means would have a significantly salutary effect in terms of lives saved is in high speed race car driving. In the typical racing car the driver is confined to the barest minimum of space since these cars are designed to provide a maximum of power with a minimum of weight. With the high octane gasoline fuels that are currently being used in racing it is reasonable to expect that accidents such as occurred in the 1964 Memorial Day 500-mile race in Indianapolis will reoccur. In that case it will be recalled that five or six cars were involved in an accident in which flaming gasoline was spewed across the race track and onfollowing cars were forced to drive directly into the flames. Due to the extreme heat two drivers were killed. Although both were wearing protective suits, the suits were ineffective in preventing high heat buildup within the suit.

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The present invention proposes a solution to the problems outlined above. One outstanding advantage is that it provides a self-contained cooling system independent of the need for plumbing or umbilical cords which must be connected to a source of air conditioning. A second advantage is that it is self-regulating, the amount of cooling provided depends on the heat environment in which the wearer finds himself. Depending on the heat outside the suit and the wearer's activity the amount of cooling provided automatically increases and decreases.

The present invention provides a self-contained cooling system for a human body. The system includes an insulated protective garment and a plurality of porous containers for accepting charges of a vaporizable refrigerant disposed inside the suit. Means are interposed between the refrigerant and the suit for insulating the refrigerant from heat from the exterior of the suit. A non-insulating open cell foamed plastic is interposed between the refrigerant and the wearer's body to space the refrigerant a predetermined distance from the body and to aid the circulation of cooling vapors from the refrigerant adjacent to the body.

Preferably this self-contained cooling system is provided in the form of a jacket or vest that can be worn under an insulated impermeable garment with a plurality of containers for a refrigerant such as solid carbon dioxide disposed on the side of the vest opposite the wearer's body. The vest comprises a layer of an open cell foam adapted to be disposed adjacent to the wearer's body and attached to this layer of foam are containers for maintaining the cooling medium in a particular orientation with respect to the body. The effectiveness of the container is enhanced by including within it a layer of closed cell foam on the side of the refrigerant opposite the open cell foam on which is disposed an aluminized Mylar sheet. This layer further insulates the refrigerant from sources of heat external to the suit. The layers of material located between the refrigerant and the wearer's body are woven cloth or other porous material to permit the relatively free circulation of cooling vapors through these layers and the open cell foam to enhance the cooling effect of the system.

These and other features of the invention will be more readily understood in conjunction with the following description and drawings in which:

FIG. 1 is a graph relating the quantities of Dry Ice needed for effective cooling to the activity of the user;

FIG. 2 is a front view of a man wearing a vest and trousers in accordance with the invention;

FIG. 3 is a view taken from the rear showing also a section of the insulated suit worn externally of the vest and trousers and a hood to be worn with the suit;

FIG. 4 is a section taken along lines 4-4 of FIG. 3 of one of the containers of the invention; and

FIG. 5 is a section taken along lines 5-5 of FIG. 3 of a container provided in the hood.

To more fully understand the adaptability of this type of cooling for the purposes disclosed it is worthwhile to examine in some detail the dynamics of heat generated by the human body in conjunction with the graph of FIG. 1. Depending on its degree of activity the human body generates approximately 350 to 1020 B.t.u.'s per

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hour. When the temperature of the environment in which the wearer is located does not exceed 150° F., the primary task of the cooling vest of this invention is to absorb the heat generated by the body to prevent a temperature buildup within an insulated garment worn externally of the vest. By providing quantities of solid CO₂ or other vaporizable refrigerant distributed at least over the upper part of the wearer's torso the vest is capable of absorbing this heat for extended periods even when he is engaged in maximum physical activity. In those situations where the wearer is subjected to temperatures exceeding 150° F. the time duration of protection is reduced due to the additional amounts of heat which must be absorbed by the Dry Ice. However, even at these higher temperatures the temperature inside the protective outer garment can be maintained at reasonable levels for a significant length of time.

The preferred embodiment of this invention is illustrated in FIGS. 2 and 3. In those figures articles of wearing apparel, specifically a vest 5 and leg coverings 7, are adapted to be worn by the user beneath an outer suit 3. The suit is a protective and insulated covering such as an asbestos suit which resists the effects of heat applied externally of the suit and confines the vapors from the sublimated refrigerant to the area immediately adjacent to the wearer's body for efficient cooling.

Referring now to FIG. 2 the invention is shown in the form of a vest 5 and leg coverings 7. In the particular embodiment shown, the front of the vest 5 consists of panels running vertically along the front of the upper torso. The leg coverings 7 are likewise provided with vertical panels 26, 28, 36 and 37 running along the front and back of each leg. The exact distribution of the various refrigerant containers 6, 18, 30 and 38 varies depending on the area of the body to be cooled and the body position which the wearer will normally assume.

As shown in FIG. 2 the vest 5 comprises panels 2 and 4 provided with slots or pockets 6 adapted to receive charges or blocks of Dry Ice. The vest is closed in the front by a zipper 8 and panels 2 and 4 join the back panel 22 of the vest to define an opening 10 for the wearer's head. Running down each side of the vest are several adjustable belts 16 attached to front panels 2 and 4 and the larger back panel 22. These belts can be lengthened or shortened depending on the size and girth of the wearer.

Viewed from the rear as depicted in FIG. 3, the vest consists of one solid panel or piece of material on which vertical rows of containers 18 for the refrigerant have been located. A vertical seam 20 and a horizontal seam 23 are provided to hold the filling material with which the vest is stuffed in position relative to the skin fabric of vest to which the pockets are attached. The relationship of these various materials will be examined in more detail in conjunction with the description of FIG. 4. When provided in the form of a vest the invention has an appearance very much similar to kapok life preservers found on large passenger carrying vessels.

The embodiment of the vest shown is capable of handling twelve discrete packages of refrigerant. The pockets in this particular vest are capable of handling slabs of refrigerant approximately 6 inches by 6 inches by ¾ inch. Each slab weighs approximately one pound thereby enabling the wearer to carry approximately twelve pounds of refrigerant in the vest.

In many applications contemplated for this invention, where the temperature outside the suit is in the 150° F. range or less, the vest alone carries enough refrigerant to satisfactorily cool the interior of the suit for a length of time which can be determined by reference to FIG. 1. This can be traced to the fact that the sublimed carbon dioxide gas (where Dry Ice is the refrigerant) is heavier than air and tends to absorb perspiration given off by the wearer to make it even heavier. This heavier gas tends to settle into the lower extremity cavities of the

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outer suit and carries the cooling effect of the gas to this part of the body as well. In situations where the level and duration of the physical activity of the wearer can be accurately forecast the amount of Dry Ice provided can be tailored accordingly. Even where extra amounts are provided to accommodate unforeseeable problems or where the level of activity is lower than expected, the system still performs without discomfort due to the complementary self-regulating effects of the body and the Dry Ice.

Other advantages attendant on the use of Dry Ice include the fact that the carbon dioxide is non-toxic and nonirritating to human skin. Pressure buildup within the suit is avoided because the suit is never perfectly air tight thereby permitting the gas to escape through zippers, seams, and arm and leg holes. However, by virtue of the presence of the gas within the suit a positive out-pressure tends to build up and prevent the entry of toxic gases therein.

In higher temperature situations it may be desirable or necessary to augment the capacity of the vest by providing additional supplies of refrigerant. As shown in FIG. 2 leg coverings 7 comprising front panels 26 and 28 are provided with four refrigerant containers 30. The panels 26 and 28 begin at approximately the upper thigh and are secured at the waist by a belt or harness arrangement 34. In the back the arrangement is similar to that of the front only in this instance the two panels are each provided with three refrigerant containers 38. This is normally done to prevent the location of refrigerant directly beneath the wearer when he is in a sitting position thereby avoiding the sensation of cold spots and preventing unnecessarily high dissipation of the refrigerant due to the enforced close proximity of the wearer's body to the container of refrigerant. Belts 24 similar to those used with the vest can be provided to draw the front and rear leg panels snugly against the wearer's leg.

In addition to a suit covering the torso and limbs, a protective covering for the wearer's head and shoulders in the form of a hood 9 is provided. The hood is preferably fabricated from a protective insulated material similar to that used in the fabrication of the suit 3. A transparent window 11 of plexiglass or similar material attached to the front of the hood permits the wearer to have a substantially unobstructed view. On the rear of the hood and exteriorly thereof a container 13 is provided similar to the containers provided on the vest 5 and leg coverings 7. Container 13 is likewise adapted to receive a block or slab of refrigerant for cooling the interior of the hood. Depending on the size and disposition of the container chosen it is possible to locate more than one such container on the hood in those instances where provision for additional cooling appears warranted.

Examining the construction of a typical refrigerant container of this invention as depicted in FIG. 4, a section view taken along lines 4—4 of FIG. 3, we find that it is constructed in the following manner. The basic element is a layer 40 of an open cell foam preferably ½ to ¾ inch thick. This material has sufficient rigidity and incompressibility to give shape to the garment and serves as the foundation to which the other parts of the garment are attached.

An open cell foamed plastic such as polyurethane foam has been found to be satisfactory in this capacity. There are, however, no specific restrictions on the type of foam used. It is preferable that it be 75% to 90% void because in addition to providing form and body for the piece of protective clothing, the foam is also important in permitting circulation of cooling vapors within the protective outer suit to provide more uniform generalized cooling and prevent the occurrence of cold spots.

In one embodiment, a panel 39 comprising the layer of foam 40 is encased between a piece of loosely woven Dacron 42 and a piece of some more substantial material 44 such as a somewhat more closely woven nylon

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or Dacron. While the use of loosely woven Dacron and nylon on the interior side of the foam is not a rigid requirement, it is preferable in order to provide a highly permeable layer next to the wearer's body in order to permit optimum circulation of cooling vapors.

The use of woven or other porous materials around the foam and between the charges of vaporizable refrigerant and the foam permits circulation of the cooling vapors between the fibers of the weave and allows the vapors to pass from the refrigerant containers through the rear layer of the container and the two layers covering the foam to the wearer's body. The more permeable or porous the materials between the refrigerant and the body the greater the transmission of the cooling vapors from the refrigerant charges to a point adjacent to wearer's body. Hence the preference for using a loosely woven or gauze-like layer as shown in FIG. 4 between the foam and the wearer's body. A closer woven material is used in layer 44 to provide added garment strength.

Affixed to the panel 39 is a container 46 in the form of a pocket. The pocket material which may be of the same material as the outer covering 44 of the foam is provided with a flap 48 and means for securing the flap to the pocket such as a self-adhering zipper, the zipper comprising a fibrous strip 52 on the flap 48 the fibers of which are adapted to be hooked by a plurality of small hooks on the strip 53 attached to the pocket. One type of such a zipper is marketed by the E. I. du Pont de Nemours & Company under the trademark Velcro. As a partial liner for the pocket and located on the side of a slab of refrigerant 54 opposite the foam layer 40 is a second insulating layer 47. In one embodiment, this insulating layer comprises a layer of closed cell foam 58 to which has been affixed a multi-layer arrangement comprising a layer of rayon cloth 60, a thin gauge sheet of aluminum 61 which has been adhesively secured to the rayon and a film of Mylar (polyester film) 62 coated on the aluminum. This assembly of foam, rayon, aluminum and Mylar are sewn together into the container 46. A refrigerant or source of cooling vapors 54, such as a charge of Dry Ice, is inserted in the pocket just prior to use.

The closed cell foam 58 which may be another variety of foamed plastic such as a vinyl foam is preferably 1/4 inch thick and serves to insulate the refrigerant from heat from the external side of the container and the exterior of the protective suit to prevent accelerated dissipation of the refrigerant. The aluminum sheet 61 also retards dissipation of the refrigerant by reflecting radiant heat away from the refrigerant 54. The Mylar film 62 is coated over the aluminum sheet for strength and durability and to prevent damage to the aluminum when a slab of refrigerant is being inserted in the pocket.

In FIG. 5, a section view of the container 13 provided in the hood 9, the disposition of the various elements is substantially the same as that of the containers provided in the vest 5 and leg coverings 7. In this instance, however, the hood is not provided with a liner of open cell foam. Instead it is lined with a protective layer 15 such as a closed cell foam except in the area adjacent container 13. The container is attached to the exterior side of the material 17 from which the hood is fabricated and is lined on the side of the refrigerant opposite the interior of the hood with an insulating layer 19 such as the closed cell foam-rayon-aluminum-Mylar layer previously described. The container, which can be fabricated from the same material as the hood, is adapted to receive a charge of refrigerant 21 and is closed by a flap 25. Flap 25 is also lined with a layer 27, preferably a closed cell foam, to improve the insulation of the charge of refrigerant 21.

In brief, the system of the present invention provides a cooling system for a human body which is self-contained and easily portable. By virtue of its unique design, circulation of cooling vapors within the interior

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or inner boundary layer of a protective, insulated, preferably impermeable outer garment is accomplished. Further, due to the relationship of the refrigerant containers and the wearer's body and the choice of the various materials spacing the refrigerant from the body, the vaporized coolant is permitted to circulate over the wearer's body separated from the skin only by whatever layers of clothing the wearer has on. This is to be contrasted with prior art systems wherein an insulated and impermeable layer is deliberately interposed between the vaporized coolant and the body.

A vest as depicted in the preceding disclosure is effective at temperatures up to 150° F. for approximately four hours when the wearer is engaged in maximum physical activity. As activity is reduced below maximum the length of serviceability is extended. In addition to being used by pilots, firemen and race car drivers, other application contemplated for this type of wearing apparel are various industrial uses where there is a need to enter high temperature environments and military applications such as on aircraft carrier flight decks for protecting both the pilot and flight deck crew in case of crash landings.

In addition to being useful for extending periods at temperatures of approximately 150° F., this invention is suitable for safe use at temperatures between 350° F. and 400° F. for shorter periods of time, on the order of 30 minutes.

What is claimed is:

1. A container for a solid vaporizable refrigerant adapted for use in an insulated, self-contained, cooling system in the form of a covering for the human body, the container comprising:

a refrigerant charge-receiving portion;

a layer of insulating material defining an external wall of said charge-receiving portion for shielding the charge-receiving portion from heat sources located externally of the body covering;

a layer of an open cell foamed plastic of a predetermined thickness defining an interior wall of said charge-receiving portion for spacing a charge of refrigerant placed within the charge-receiving portion a predetermined distance from a wearer's body while permitting the passage of cooling vapors there-through;

vapor permeable receptacle means for disposing the refrigerant charge between the external and interior walls of the receiving portion; and

mounting means for disposing said container between the body covering interior and the wearer's body with the interior wall of the container portion being located closest to the wearer's body.

2. A container according to claim 1 wherein the layer of open cell foamed plastic is a layer of polyurethane foam having at least 75% voids.

3. A container according to claim 1 wherein the external wall of the container portion comprises a layer of a closed cell foam material and a layer of aluminized polyester film affixed to the side of the closed cell foam material adjacent the refrigerant charge.

4. A self-contained cooling system for the human body comprising:

an impermeable protective first garment adapted to cover the entire body;

a permeable second garment adapted to be worn interiorly of said first garment;

at least one vaporizable refrigerant container, said container comprising:

a refrigerant charge-receiving portion;

a layer of insulating material defining an external wall of said charge-receiving portion for shielding the charge-receiving portion from heat sources located externally of the system;

a layer of an open cell foamed plastic of a predetermined thickness defining an interior wall of

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said charge-receiving portion for spacing a charge of refrigerant placed within the charge-receiving portion a predetermined distance from a wearer's body while permitting the passage of cooling vapors therethrough;
vapor permeable receptacle means for disposing the refrigerant charge between the external and interior walls of the receiving portion;
means for closing the container portion to hold the refrigerant charge therewithin; and
mounting means for disposing said container between the first garment interior and the second garment exterior with the interior panel of the container portion being located closest to the wearer's body.

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W. E. WAYNER, *Assistant Examiner*.