

[54] SELF-COMPENSATING THERMAL INSULATION GARMENTS

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[51] Int. Cl. B63c 11/08

[58] Field of Search.....2/81, 82, 2, 2.1 R, 2.1 A, 2/79

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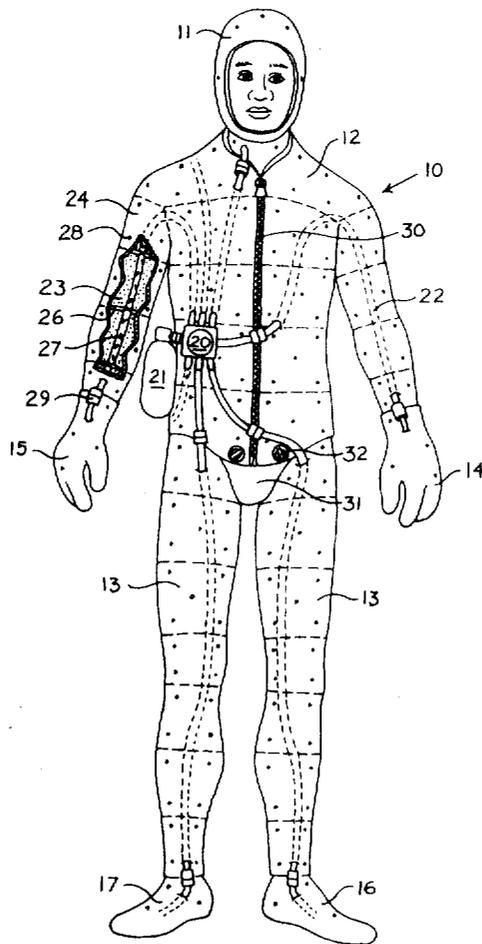
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[57] **ABSTRACT**

Self-compensating thermal insulating garments are found useful for protecting the body of a user from hostile temperature environments. The garments each comprise a plurality of compartments with each compartment having a heat insulating core of a flexible porous material. Outer and inner continuous resilient sheets span the compartments and preferably seal the cores against unwanted passage of gas and liquid in conjunction with barrier means for each compartment which form gas and water barriers. Preferably tubular means pass into and through the cores to deliver a gas at a predetermined pressure to maintain each of the compartments at predetermined internal pressures preventing compression of the compartments due to pressure differentials.

11 Claims, 5 Drawing Figures



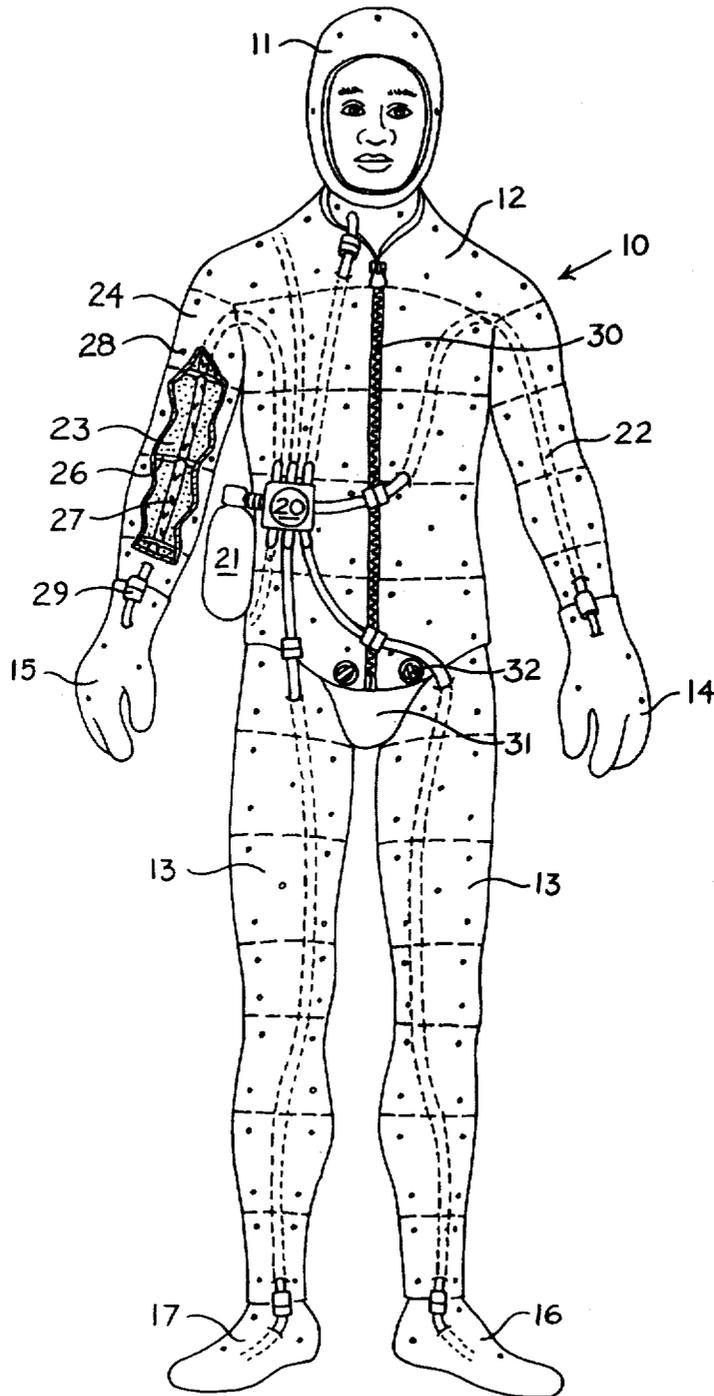


FIG. 1

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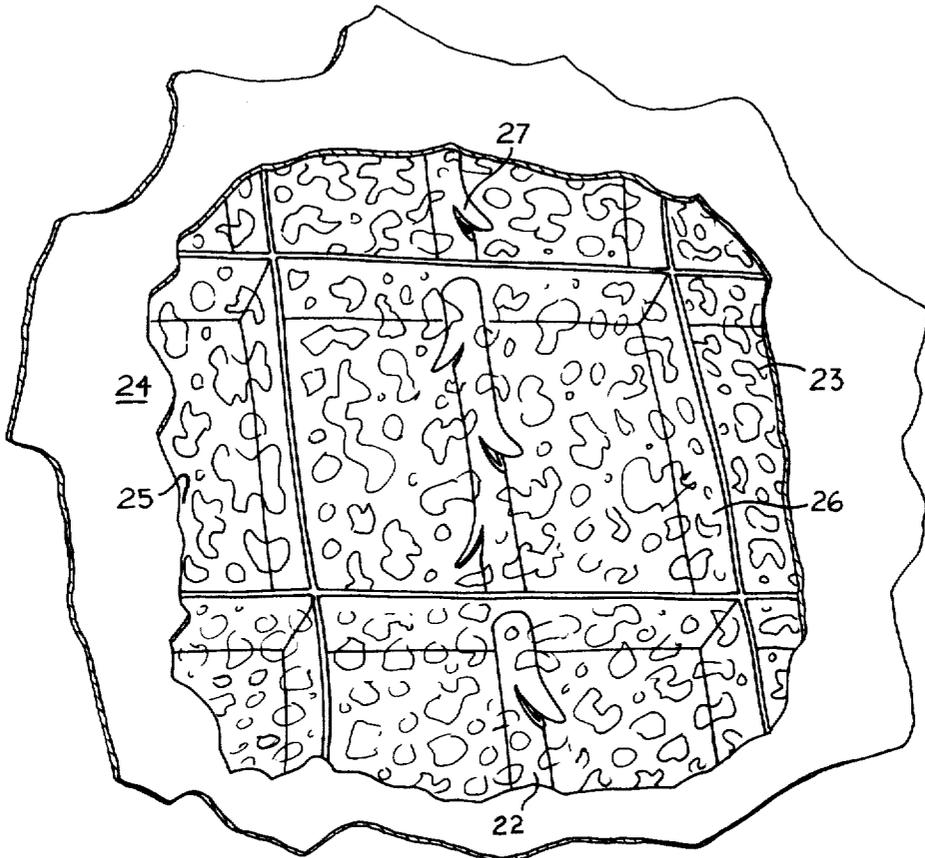


FIG. 2

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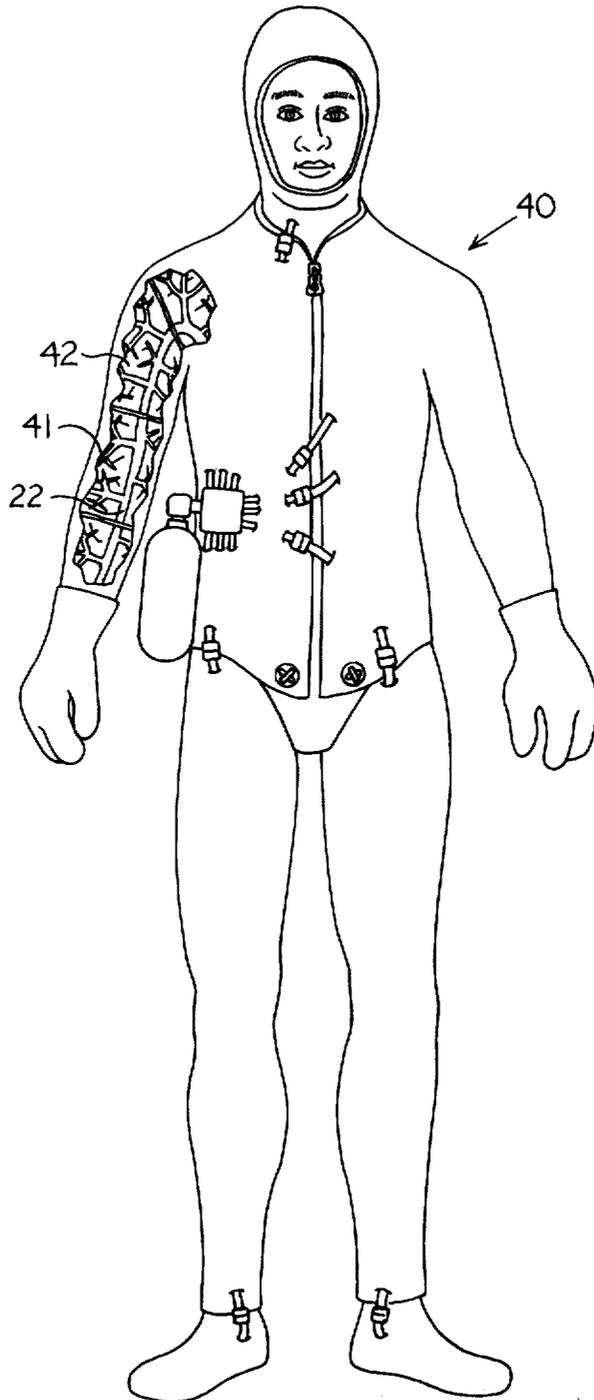


FIG. 3

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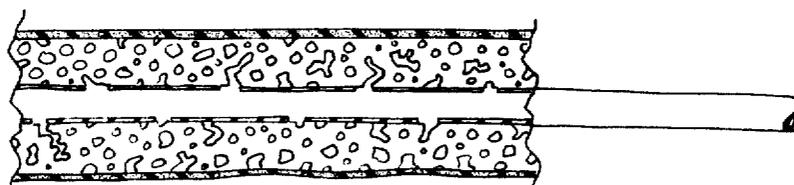
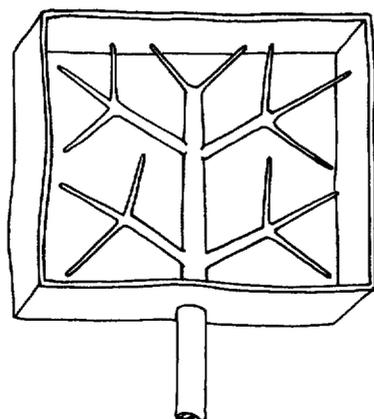


FIG. 4

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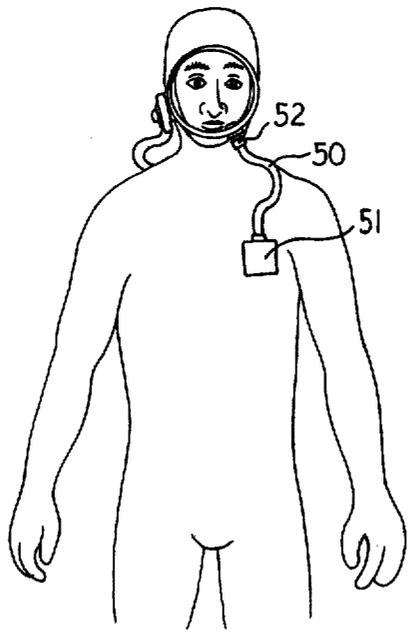
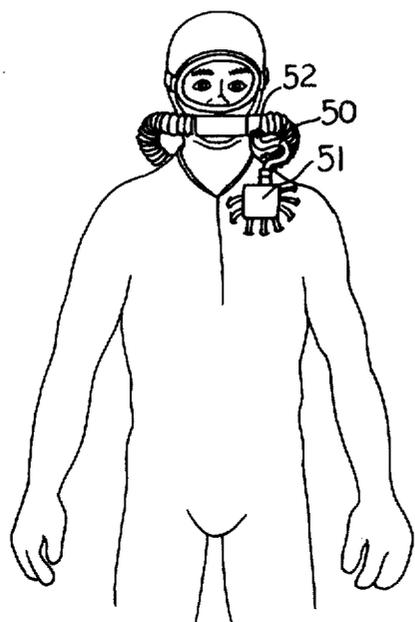


FIG. 5

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SELF-COMPENSATING THERMAL INSULATION GARMENTS

BACKGROUND OF THE INVENTION

A number of thermal insulating underwater diving garments have long been used in the underwater diving art. Often such garments are formed of closed cell neoprene or other resilient organic foam materials which have high insulating values and maintain body heat thus protecting the body of the diver against low temperatures encountered at depths. Such organic foam garments also provide buoyancy to the user and require use of diving weights. However, at depths encountered as at from 40 to 60 feet of water or greater, the water pressure is sufficiently high to compress the resilient organic foam. Compression changes the buoyancy value of the foam and impairs the insulation value so that there is significant loss of buoyancy and insulation value exposing the diver to uncomfortable and sometimes dangerous conditions.

Various solutions have been proposed to provide thermal insulating garments useful underwater at high pressure conditions. Such solutions have often introduced alternative problems including difficulty of suit construction and over pressure gas conditions.

It is an object of this invention to provide thermal insulating garments useful for protecting the body of a user from hostile temperature environments as at underwater diving conditions.

Another object of this invention is to provide thermal insulating garments in accordance with the preceding object which are self-compensating to provide predetermined organic foam thickness and insulating value at varying underwater depths.

Still another object of this invention is to provide thermal insulating garments in accordance with the preceding objects which prevent destructive compensating gas buildup in the garments.

Still another object of this invention is to provide thermal insulating garments in accordance with the preceding objects which permit proper operation of portions of the garments even when other portions thereof may have lowered insulating values.

SUMMARY OF THE INVENTION

According to the invention, thermal insulating garments useful for protecting the body of a user from hostile temperature environments are constructed and arranged to conform to the contours of a body with which they are to be used. The garments comprise a plurality of individual compartments. Each of the compartments has a heat insulating core of a flexible porous material which is preferably an open cell resilient organic foam having inner and outer surfaces. Inner and outer continuous sheets span the compartments and seal the inner and outer surfaces against unwanted passage of gas and liquid. Barrier means for each compartment form gas and water barriers defining sides of the compartments. Gas pressure relief means are provided for removing gas from the compartments. Tubular means pass into and through the cores to deliver a gas at predetermined pressures to maintain each of the compartments at predetermined pressures preventing compression of the compartments due to pressure differentials between the inner and outer surfaces.

Preferably the gas pressure relief means comprise pinholes in the outer surface sheet. Preferably the tubular means are provided with one-way valves for permitting passage of gas to each compartment but preventing backflow of gas from each compartment.

In some embodiments, compensating gas is provided through an automatic regulator while in other embodiments, the compensating gas can be obtained directly from exhaust breathing gases produced by an underwater diver.

The advantages of the heat insulating garments of this invention include a self-compensating feature whereby the over pressure relief means automatically exhausts gases as a diver ascends while the gas inlet tubing provides for automatic gas

buildup during descent. The compartmental nature of the garments is particularly useful to prevent complete loss of insulating value should a section of the garment malfunction or be penetrated. Thus, if the sections are maintained small enough, impairment of the insulating properties of a single compartment does not greatly affect the diver.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, advantages and features of the present invention will be better understood from the following specification when read in connection with the accompanying drawings in which:

FIG. 1 is a front view with portions cut away illustrating a preferred embodiment of the invention;

FIG. 2 is a front perspective view thereof showing an individual compartment;

FIG. 3 is a front view of an alternate embodiment thereof;

FIG. 4 is a front view of a detail thereof;

FIG. 5 is a front perspective view of an alternate method of obtaining a gas supply in the garments of this invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

With reference now to the drawings and more particularly FIGS. 1 and 2, a preferred self-compensating thermal insulating underwater diving suit 10 is illustrated comprising a head portion 11, a body or jacket portion 12, leg portions 13, mitten portions 14 and 15 and boot portions 16 and 17.

A series of flexible tubes 22 extend to the suit portions and are interconnected with a pressure regulator 20 which is in turn interconnected with a gas supply means 21.

The partitioning of all of the suit portions and interconnection of compartments of each suit portion is substantially identical with only the contour and shape of the portions varying, therefore only the jacket portion 12 will be fully described.

The jacket portion 12 is basically formed of a plurality of compartments, each of which has a core of flexible porous material and preferably open cell neoprene foam 23 preferably having substantially uniform thickness throughout the jacket portion. Other organic resilient, open cell foams can also be used. Open cell neoprene foam is particularly desirable since it has suitable insulating properties and allows passage of gas freely throughout the foam. A smooth surface sheet material 24 forms the outer or surface skin of the garment portion while a similar smooth sheet material 25 forms the inner surface thereof. The sheets 24 and 25 are preferably formed of thin rubbery material such as solid neoprene which is gas and water impermeable in normal usage. The foam core between the sheets 24 and 25 is divided into compartments by partitions such as 26 which form gas and water barriers at the edges of each compartment and prevent flow of liquids or gases therethrough.

Preferably a plurality of compartments are used in each suit portion with the compartments maintained at small sizes as for example having surface areas of approximately 5 to 6 inches square. Since each compartment is self-contained, if any one compartment is ruptured during normal usage, there will be no transfer of fluids to another compartment of the suit. The partitions or barrier layers 26 can be formed in any desired manner as by the use of solid neoprene sheet materials sealed to edges of the core and to the inner and outer surface skins. Alternatively, the foam core 24 itself can be heat and/or pressure treated to make its compartment edges impermeable to gas and fluid transfer. Fluid impermeable coatings can also be used to seal the foam cores. Preferably the compartments extend transversely around the body of the user and around the arm and leg portions as illustrated by the dotted outline shown in FIG. 1.

Each of the compartments is linked with other compartments by the flexible tubing 22 which carries gas from the regulator 20. The tubing 22 passes between the compartments and has gas outlets 27 therealong with at least one outlet in

each compartment through which it passes. The gas outlets 27 can be formed as by the use of an angled cut in the flexible tubing. The angled cut is desirable to provide a one-way valve for each compartment allowing gas flow out of the tube but preventing gas or liquid flow back to the tube when the pressure in the compartment builds up above the pressure provided by the regulator 20. In the preferred embodiment, 15 compartments are used in the jacket portion although the number can vary greatly.

Over pressure relief valves 28 are provided for each compartment. These valves can comprise simple pinholes in the outer surface skin 24. The pinholes provide for escape of gases when pressure in each compartment builds up beyond a predetermined value as for example when high pressure has been introduced into the compartments at great depths and the diver then ascends. The over pressure relief valves such as pinholes 28 thus provide a self-compensating feature to the suit providing for removal of excess gas pressure. Conversely, since the pinholes are extremely small, water cannot enter through the pinholes in normal usage. In some cases, the over pressure relief valves 28 need not be pinholes in the outer surface skin but can be other conventional one-way gas valves if desired.

The tubes 22 each have an end linked to the regulator and preferably have ends passing out of the jacket portion to quick disconnects 29 for interconnecting tubes with corresponding tubes of the mitten and head portions as well as with the leg portions 13.

The jacket portion 12 can be provided with a suitable conventional zipper 30 and an integral crotch tab 31 extending integrally from the rear (not shown) of the jacket portion and buttoned to the front halves at 32, as in a conventional wet suit.

The regulator 20 can be a conventional ambient pressure activated gas regulator such as on a standard open circuit scuba preferably with a manual over pressure adjust such as is used on a Desco Face Mask diving rig. Thus, as the diver descends and the water pressure builds up, gas pressure passed into each compartment is increased automatically. Similarly, as the diver ascends, the surface skin pinholes permit gas to flow outwardly when the internal pressure in the compartments builds up.

While a plurality of tubes 22 are used, the particular number of tubes can vary as for example a single tube can be used doubled back over itself where required to permit interconnection with each of the compartments of the suit. While it is preferred that the entire suit be compartmented and formed as described above, in some cases, only certain portions of the suit are formed in accordance with the preferred embodiment. In all cases, the self-compensating feature providing equalization of gas pressure within the resilient plastic foam core 23 provides for noncompression of the suit and maintenance of insulating value and buoyancy as required.

The specific shape of the individual portions can vary greatly in accordance with known practice. One-piece body fitting suits can be formed. Multi-piece suits in a variety of configurations for each body portion can be used if desired. In the preferred embodiment, conventional stretch material cuffs are used at all joint portions so that the compartments fully cover the body and in some cases, overlap slightly in accordance with known principles of neoprene foam wet suits. The shape of each compartment need not be generally rectangular but can vary as desired.

In a specific example of a diving suit formed in accordance with the preferred embodiment shown in FIGS. 1 and 2, the cores 23 are formed of open cell neoprene foam having a density of 25 to 45 lbs per cubic foot. Sheets 24 and 25 are each continuous solid resilient neoprene sheets having a thickness of 10 to 30 mils. The jacket portion 12 comprises several compartments extending internally about the jacket, thus a compartment on the torso portion of the jacket extends from the zipper 30 completely around the back of the suit and back again to the zipper 30. Edges of the jacket portion are sealed

by seals formed between the sheets 24 and 25. The compartments are separated by partitions formed of solid neoprene sealed to the cores and the top and bottom sheets 24 and 25 by a rubber cement. The regulator 20 is ambient water pressure activated such as the well known second stage of a single hose scuba regulator and a one to 4 liter gas supply bottle 21 is interconnected with the regulator. An alternate embodiment is to supply gas to the suit directly from the diver's scuba regulator via a hose from the scuba regulator to the suit at any convenient point, provided said regulator is adjusted to provide gas at 0.25 to 1.0 p.s.i. over ambient pressure. Seven tubes 22 extend from a common manifold of the regulator 20 and are passed into the suit as shown in FIG. 1 passing through a number of compartments. Holes 27 are one-hundredth to one-fourth inch 45° cuts in the tubes 22 which are formed of rubber, neoprene or plastic and have inner diameters of one thirty-second to one-half inch and outer diameters of one-eighth to five-eighth inch. At least two pinholes 28 are provided in each compartment. It is found that a suit so formed maintains its insulating value and buoyancy at underwater depths of from 0 to 60 feet with substantially constant thickness of the suit throughout these steps.

Turning now to another embodiment of this invention illustrated in FIGS. 3 and 4, a multi-portion suit 40 is formed substantially as previously described. However, in this embodiment, the tubing 22 is varied so that the one-way valves 27 are not used. Instead, the tubing 22 has branches 41 in each compartment leading to smaller and smaller diameter integral tubes diagrammatically illustrated at 42. As the diameter of the tubing decreases as at 42, a capillary type ending is formed. This capillary type ending permits gas to flow out of the tube ends in each compartment under pressure from the regulator but provides for collapse of the very thin capillary ends when over pressure is present in the core materials 23 of each compartment. Thus the branching and narrowing of the tubes provides for a one-way valve feature. The over pressure relief valve in each compartment can comprise the pinholes such as described at 28 or alternatively conventional one-way gas valves can be used in each compartment. While branching and narrowing of the tubes 22 can be used to provide the one-way mechanism for each tube 22, in some cases simple holes in the tubes 22 are used. The simple holes are similar to holes 28 and provide for flow of gas out of the tubing and prevention of gas or liquid flow back into the tube since over pressure conditions in the core may collapse the tube itself or seal the holes.

FIG. 5 illustrates another method of providing gas to the compartments. In this method, a gas inflow tube 50 is connected at one end with a manifold 51 for tubing 22 of a suit constructed as described in any of the previous embodiments. The other end 52 of the tube 50 is directly interconnected with either the breathing regulator of the diver or the exhaust of the diver. Thus, gas pressure is provided for equalizing the pressure in the compartments and the surrounding environment through either the gas supply source for breathing or the exhaust gas exhaled by the diver. In some cases, end 52 can be directly interconnected with a face piece or mouthpiece of the diver so that the diver can blow into the tube 50 and thus provide desired gas pressure in the compartments of the suit. As an alternate method the diver periodically takes his scuba mouthpiece out of his mouth and blows into tube 50. Tube 50 is fitted with a one-way valve to permit entrance of gas into tubes 28 and to prevent escape of gas via tube 50 while specific embodiments of the present invention have been described, many variations are possible. For example, the term "surface skin" is used in connection with sheet materials; however, any inner and outer surface barrier layers can be formed as by forming a skin directly on the foam material used. The surface sheets preferably are continuous over all portions of each suit section or portion although, the compartments may be completely individualized with additional outer and/or inner sheet layers interconnecting desired compartments when desired.

What is claimed is:

1. A self-compensating thermal insulation garment useful for protecting the body of a user from hostile temperature environments,

said garment being constructed and arranged to conform to the contours of a body with which it is to be used, said garment comprising a plurality of compartments, each of said compartments comprising a heat insulating core of a flexible porous material having outer and inner surfaces and barrier means forming gas and water barriers and defining sides of said compartments, outer and inner continuous resilient sheets spanning said compartments and sealing said outer and inner surfaces against unwanted passage of gas and liquid, gas pressure relief means for removing gas from said compartments when over pressure conditions exist, and conduit means passing into and through said cores to deliver a gas at predetermined pressures thereby maintaining each of said compartments at predetermined pressures preventing compression of said compartments due to environmental pressure suit constructed

2. A self-compensating thermal insulating garment in accordance with claim 1 wherein said porous flexible material is a resilient organic, open cell foam.

3. A self-compensating thermal insulating garment in accordance with claim 2 wherein said conduit means comprises a flexible gas tube interconnecting at least two of said compartments,

said gas tube defining gas inlet means for passing gas to said compartments and preventing backflow of liquids from said compartments.

4. A self-compensating thermal insulating garment in accordance with claim 3 wherein said gas pressure relief means comprises a plurality of pinholes in said outer continuous resilient sheet.

5. A self-compensating thermal insulating garment in accordance with claim 4 and further comprising an automatic ambient gas pressure regulator interconnected with said con-

duit means,

and gas supply means interconnected with said regulator.

6. A self-compensating thermal insulating garment in accordance with claim 1 and further comprising means for passing exhaust gas to the diver to said compartments interconnected with said conduit means.

7. A self-compensating thermal insulating garment in accordance with claim 1 and further comprising with means for passing gas to said compartments from a breathing pressure regulator used in conjunction with said garment by a diver, said means being interconnected with said conduit means.

8. A thermal insulation garment useful for protecting the body of a user from hostile temperature environments under varying environmental pressure and temperature conditions,

said garment being constructed and arranged to conform to the contours of a body with which it is used,

said garment comprising a plurality of individual compartments, each of said compartments comprising a resilient organic foam core and a fluid and gas impervious barrier layer surrounding each core,

means for increasing gas pressure in said foam of said compartments in response to increasing pressure exerted on said compartments,

and means for releasing gas pressure in said compartments in response to lowering of environmental pressure on said compartments.

9. A thermal insulation garment in accordance with claim 8 wherein said means for increasing gas pressure comprises a tube passing between said compartments.

10. A thermal insulation garment in accordance with claim 9 wherein said tube defines means for permitting gas flow into said compartments and means for preventing unwanted backflow of fluids to said tube.

11. A thermal insulation garment in accordance with claim 8 wherein said means for releasing gas pressure comprises a plurality of pinholes in said compartments.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,675,244 Dated July 11, 1972

Inventor(s) Kenneth E. Mayo, et al

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 2, line 59

Delete "any"

Column 5, line 20

Delete "suit constructed" and add --changes.--

Signed and sealed this 29th day of May 1973.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents