May 16, 1967 P. F. CUMMINS 3,319,260

SURVIVAL GARMENT

Filed June 10, 1964 2 Sheets-Sheet 1

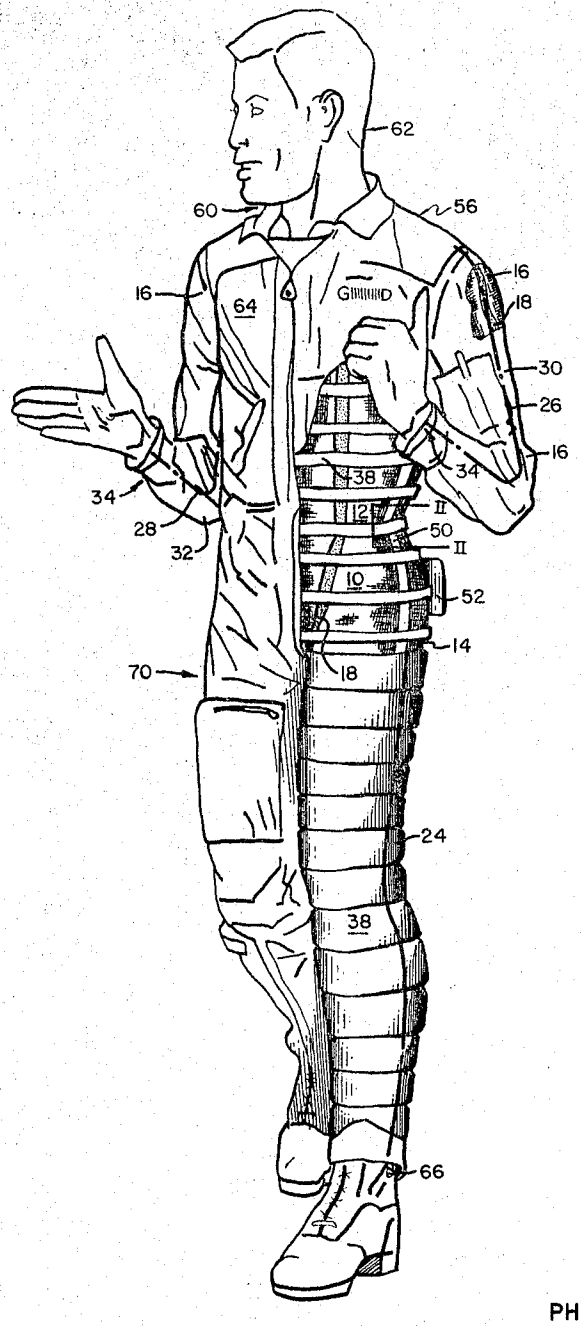


Fig. 1

PHIL F. CUMMINS
INVENTOR.

BY Charles M Woodward
ATTORNEY

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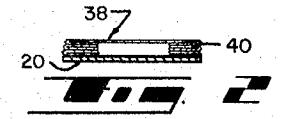


Fig. 2

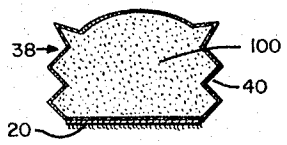


Fig. 3

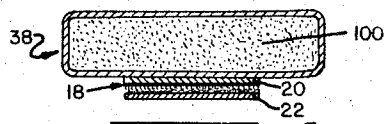


Fig. 4

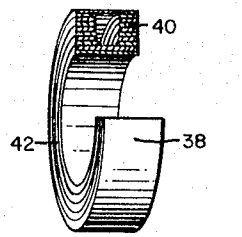


Fig. 5

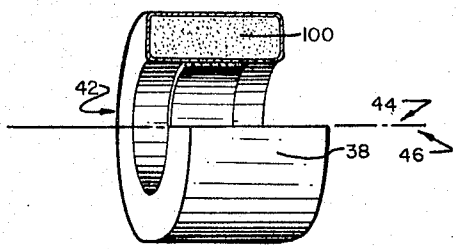


Fig. 6

PHIL F. CUMMINS
INVENTOR.

BY Charles M Woodward
ATTORNEY.

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3,319,260

SURVIVAL GARMENT

Phil F. Cummins, Fort Worth, Tex., assignor to General Dynamics Corporation, Fort Worth, Tex., a corporation of Delaware

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4 Claims. (Cl. 2—2)

The present invention relates generally to survival garments or apparel.

More specifically, the present invention relates to a comfortable, lightweight, composite garment having inflatable, interconnected bladder members which are normally in a deflated, plicated state, thus permitting normal body movement and ventilation as well as optimum personal efficiency. This construction provides protection to the wearer through inflation and expansion of each of the bladder members into faying relationship with adjacent bladders, such expansion resultant from employment of suitable expandable foams when required within the bladders.

To the present time, no one article of apparel has been evolved which can be worn for an extended period of time, and which will effectively protect an individual from the variety of detrimental environments experienced in the aerospace field.

The characteristic of extended wear without deleterious effect is extremely important if the wearer must remain in the apparel for substantial periods and must remain at peak efficiency during such periods.

Present aerospace crews may traverse several continents on a single flight, thus crossing deserts, jungles, arctics and oceans. The result is a very broad range of climates and environments in which they may have to survive in emergency. Further, such crews simultaneously face the possibility and resultant consequences of major vehicular failures, i.e., fire, cold, explosive decompression, and high-speed bailout.

Therefore, ideally, the equipment and apparel which such crews wear must afford them protection against substantially all extremes of environment detrimental to the human body, while simultaneously giving prime consideration to bodily comfort and freedom of movement.

The military has evolved survival apparel which will substantially protect their operating personnel against one condition, such as freezing, fire or atmospheric pressure differentials. However, in each such case personal comfort is greatly sacrificed. Further, to fulfill the requirement for full protection against many environments, the simultaneous employment of at least three and possibly four of the available individual garments is requisite. Such a combination is, of course, practically intolerable.

In addition to the above, no one practical garment has, as yet, been evolved to protect the wearer from fires or extreme heat; the only exception being the "bunker" or "entry" type suits which are extremely specialized garments unsuited to flight personnel. These suits weigh about 45 pounds and are constructed of an exceedingly stiff insulation material, and are thus totally unacceptable of any purpose other than specialized employment by fire fighting personnel.

The Navy recently has under development a lightweight fire survival suit for their crewmen. This garment comprises multiple layers of fire retardant, but not heat protective material which consequently precludes natural body ventilation even under the best operating circumstances. Therefore, if this suit is to be worn for any substantial period of time, an additional ventilation suit similar to the suit designated MA–2 or MA–3, illustrated in Report No. 58,259 published by the Wright Air Development Center, Aero Medical Laboratory, Wright-Patterson Air Force Base, Ohio, is required. This ventilation suit must be worn in addition to the fire retardant suit. Extensive tests have demonstrated that this latter suit allows the wearer approximately 4 seconds in which to escape the flames, yet still does not insulate from heat. After a 4 second duration in a flaming environment, serious burns are sustained and exposed portions of the suit disintegrate. Obviously, crew members generally do not wear this combination of garments, since the discomfort experienced during flight and the consequent lowering of efficiency materially offsets the brief 4 seconds of fire retardation permitted by the suit.

In the case of extreme cold, as may be experienced in the arctic or in arctic waters, bulky garments employing multiple layers of insulating material are utilized. Again, such garments similar to suits designated MD–1, MC–1 or MD–3A and illustrated in the above referenced report, result in a loss of individual efficiency due to their bulk and weight and cannot be employed efficiently in aircraft. This suit also requires a suitable ventilating garment to augment natural body ventilation.

The problem of flotation has not been improved since the development years ago of the individual life preserver or "Mae West." However, as with all apparatus employing a captivated gas or liquid, operability, maintainability and reliability are always questionable, while the device constitutes yet another "garment" which must be worn.

Explosive decompression of a pressurized cabin in an operational, high performance aircraft requires a pressure suit in order for crewmen to survive. These pressure suits are mandatory and must be worn by air crews who operate their aircraft above an indicated altitude. Such suits are uncomfortable and require an auxiliary ventilating system to provide for body ventilation.

Thus, in summary, the deleterious characteristics of present suits reside primarily in the fact that individual garments possess only one protective capability, i.e., their operational scope is limited to a specific function. Therefore, it follows that survival, for flight and other operating personnel when such personnel are subjected to more than one of the above stated conditions, would require at least two of the present garments for protection and necessitate, in addition, a suitable ventilating system to provide some measure of both comfort and efficiency. Further, present equipment or garments provide substantially no protection from exposure to fire for any practical period. Obviously, an attempt to fully protect the crew of an air or spacecraft would subject the crew of such a craft to an intolerable physical and psychological strain. Such strain would effectively reduce their operational efficiency, and could possibly result in slow reflexes or mistakes caused by fatigue. Obviously, this may be as detrimental as the environmental extremes from which protection is desired.

The garment of the present invention obviates the shortcomings of the prior art and replaces all of the above referenced paraphernalia. It effectively provides indefinite floatation, positive fire and resultant thermal protection and substantial protection from severe cold. Further, the present invention may double as a pressure suit and impact shock absorber. All of these benefits are derived from the present invention without the use of an auxiliary ventilating system, since the survival suit of the present invention permits body breathing and is no heavier than an ordinary business suit, thus permitting a "shirt sleeve" environment.

The above is accomplished in one of the preferred configurations of the invention by employment of an air pervious, "net-like" or open weave suit having a system of spaced plicated, annular, or body conforming bladders which may be detachable, and interconnected by passages

or manifolds. Such bladder spacing is sufficient to allow proper body ventilation and insure comfort to the weaver. Expandable foam from a central container is channeled by means of the manifolds to each plicated bladder, causing the bladders to unfold and conjoin or conformingly, resiliently "bump" one another and thereby form a heat impervious, floatation sustaining, substantially incompressible envelope around the wearer. In many cases the bladders may be designed to serve additional specific prophylatic functions, as exemplified by a dorsal occipital bladder which expands to the curvature of the neck and thereby provides support to the cervical vertebrae, reducing the possibility of vertebra damage occasioned by shock forces. Another example of a specifically functioning bladder is the ventral rib cage bladder. This bladder is larger than the bladders on the dorsal side, thus insuring that the wearer will float face up and further affording shock protection to the chest and rib cage. Obviously, additional specific shapes and specialized functions are possible. A net overlay may be employed over the bladder system as part of the support garment. Over the above described system of bladders and support materials a lightweight, conventional flight suit may be worn to protect and cover the bladders and provide means for the normal zippers, pockets, clips, etc. desirable in flight suits.

Provision may be made for removal of the outer garment to permit laundering. Further, the bladder system may be removed if desired from the "net-like" undergarment and inspected, flushed out and cleaned.

A garment made according to the present invention may be used by personnel other than aircrews and firemen, examples being aircraft ground crews, navy flight deck operations personnel, forest fire fighters, petrochemical and refinery personnel, rescue teams, racing personnel, etc. The invention makes it possible for such personnel to move easily, remain comfortable and retain efficiency longer, while being assured of proper fire and other emergency protection.

Many tests have been conducted with various combinations of foam encapsulated within fire resistant materials according to the present invention. The results of these tests demonstrate the vastly improved protective qualities obtained with the present invention. In one embodiment, temperatures of 2500° F. and above were experienced and measured with chromel alumel thermocouples on the exterior of a typical section for periods in excess of five minutes. No deviation in the interior temperature above 1° F. was measurable by thermocouples. The above heat was supplied by an aerated acetylene torch. In other tests, another embodiment of the present invention having suitable thermocouples sewn inside the garment section was placed within a brazing furnace continually maintained at 1200° F. The exterior temperature rose immediately to 1200° F. while the interior temperature remained at 85° F. After 4 minutes of exposure at this concentrated extreme heat the interior rose to a temperature of 140° F. and remained at that temperature for an additional 4 minutes until ultimate failure. It was found upon investigation that the failure was primarily due to the decomposition of the threads employed to fabricate the section.

Therefore it is a primary object of the present invention to provide a substantially universal protective garment which is lightweight, flexible and permits natural body ventilation.

It is a further object of the present invention to provide a survival or protective garment which can be infused with various inert foams to provide protection to the wearer from extreme heat or cold, provide floatation, substantial impact shock resistance and exterior body pressure when requisite.

Although only the preferred embodiment of the present invention has been described above, it is not to be construed that the invention is limited to such embodiment. Other modifications may be made by those skilled in the art without departing from the spirit and scope of the invention as set forth.

FIGURE 1 pictorially illustrates the survival suit of the present invention with portions thereof cut away to better illustrate the construction and sequence of operation;

FIGURE 2 is a cross-sectional elevational view rotated 90° of a typical plicated bladder member taken on the line II—II of FIGURE 1;

FIGURE 3 is a cross-sectional elevational view similar to that of FIGURE 2 but showing a bladder member during foam induced expansion;

FIGURE 4 illustrates in cross-section the bladder member of FIGURE 1 fully expanded;

FIGURE 5 is a pictorial illustration, partly in section, of a typical bladder element such as that shown in FIGURE 2;

FIGURE 6 is similar to that of FIGURE 5 but illustrates the bladder thereof in its expanded state.

A preferred embodiment of the invention, as illustrated in FIGURE 1, comprises an air pervious "net-like" support garment **10** having body portion **12**, leg portions **14** and arm portions **16** and which may be worn like a coverall. Support garment **10** has affixed thereto attachment means, which means may comprise "hook and loop" nylon tape fasteners **18** as shown in U.S. Patent No. 2,717,437. This fastener comprises a hook portion **20** and loop portion **22** as generally illustrated in FIGURE 4. Loop portion **22** may be affixed to garment **10** to correspond with major body dimensions. For example, such tape portion **22** may be affixed along imaginary lines **24** generally corresponding to the inside and outside of leg portions **14**. Further, additional loop portions **22** of tape **18** may be interposed where necessary to provide positive support and securement for the bladders which are attachable thereto. The other portions of the garment **10** may be similar in construction as exemplified by fasteners **18** positioned along the imaginary lines **26** and **28** of the garment arm **16**, generally corresponding to the outer **30** and inner **32** portions (non-anatomical) of the arm and extending down the arm **16** on each side thereof to points **34** coinciding generally with the wrist on the corresponding side.

Hook portions **20** of nylon tape fasteners **18** are subsequently affixed to bladders **38** as illustrated in FIGURE 4. In this embodiment bladders **38** may be removably retained and supported on support garment **10**, yet may be removed for cleaning and replacement.

Bladders **38** are plicated (see cut-away of suit in FIGURE 1) in accordion-like pleats **40** (FIGURES 3 and 5) and may have an annular configuration **42** (FIGURES 5, 6) whose axis **44** corresponds to the main axis **46** of the portion of the body to which it is attached. Bladders **38** are so constructed as to permit them to expand laterally and radially, see FIGURES 3 and 6, while maintaining a substantially constant inside diameter, thus resulting in the fully expanded element illustrated in FIGURE 4 and FIGURE 6.

Bladder elements **38** are interconnected by manifolds or conduits **50** (as shown in FIGURE 1) which may also be of fire retardant material. Bladder elements **38** have apertures (not shown) which correspond to mating apertures (not shown) in manifolds **50**. Attachment of the bladder elements **38** to the manifolds **50** is achieved by pliable O-ring seals (not shown) and/or high temperature cement placed around the periphery of the apertures, or in any convenient and conventional manner. Bladders **38** are normally collapsed as shown in the upper cut-away of FIGURE 1 and FIGURES 2 and 5, and are connected through manifolds **50** to a pressurized cannister **52** located in any advantageous or readily accessible position. Generally, manifolds **50** may be positioned along the imaginary lines **24, 26, 28**, hereinabove described to

more readily permit manipulation, however, their location may obviously vary with individual conditions.

In operation, a pressurized expandable agent or foam **100** is stored in cannister **52**. One such agent, when released, expands at a ratio of 500 to 1. This expansion results in the rapid movement of the agent through the manifolds **50**, and into the bladders **38** through the intercommunicating apertures, thus inflating bladders **38** to their predetermined size. This action continues until the bladder has expanded to its full size and has collided with adjacent bladders as shown in the leg portion of FIGURE 1. Bladders located at the shoulders **56** of the garment extend around the neck of the wearer and thus may apply slight pressure to mandible **60** and occipital portion **62** of the head. In this manner damage to the cervical vertebra is precluded and flailing of the head is attenuated while automatically causing the head to assume and maintain the anatomical position. Bladders located over the chest **64** may be larger and thicker than the previously named bladders **38**, thereby assuring proper floatation, i.e., a face up position. Such large bladders also significantly add to the protection of the rib cage against shock forces.

In another embodiment the agent utilized may be of the catalyst type which partially solidifies into a "spongy" foam on activation. This insures positive floatation for long periods of time, although obviously precluding reuse of the bladders. Further, the employment of such a foam results in the material attenuation of arm and leg flailing during high speed bail-out, thus reducing arm, leg and shoulder dislocations and fractures.

Yet another embodiment (not shown) of the present invention comprises a bladder-foam combination similar to that described in detail above, with the exception that larger bladders may be used and the bladders may remain in their unfolded position. This configuration has especial utility and application for fire fighters and crash-rescue crews as a replacement of the "bunker suit" previously referenced. In that such personnel do not normally have to consider "shirt sleeve" comfort because of the relatively short periods of time during which they are "suited-up," the individual bladders need not be pleated down and spaced apart. Such an arrangement gives, in effect, a two-ply coverall-type garment which is exceptionally light in comparison with present garments. At the time of need, the insulating foam system is activated. While this adds no weight, it affords complete protection from either direct intense flame or heat for a period of time measured in minutes. The conventional "bunker coat," although partially resistant to flame because of its asbestos construction, is not a heat insulator. In addition, as previously noted, these garments are extremely heavy, precluding the lifting of the wearer's arms overhead, and prevent any rapid movements or even simple motions (such as unfastening canopies). The present garment obviates all of these difficulties, even when inflated. The flame resistance of the garment is further enhanced by the heat sink" capability of the foam filled bladders and does not necessarily depend on "material" to any extent. Following use, the garment can readily be flushed out by use of ordinary hose attachments and suit fitting **66** (FIGURE 1), thus forcing residual foam from vents (not shown), the garment then being prepared for further use.

This configuration may obviously have gloves attachable to the basic garment system and operative therewith. No special footgear is deemed to be necessary for fire fighting purposes since the flame and heat are generally above the foot area. However, such footgear is obviously within the scope of the invention when employed as a flight suit to prevent freezing, etc., and may readily be incorporated therein as a foot portion covering the wearer's shoes. A normal coverall **70** may be worn over the survival garment.

Due to the simplicity of this embodiment, it is considerably cheaper in both time and material than the "flight" configuration which is shown in FIGURE 1.

In summary, the present invention has made practical, for the first time, an economical utility garment which may be easily and readily manufactured, yet one which provides substantially complete protection against intense and direct flame, and thermally insulates the wearer for long periods of time against heat measurable in the thousands of degrees, against extreme cold, provides floatation, impact shock resistance, attenuates flailing, but still permits a "shirt sleeve" environment.

Compared to present and contemplated garments, it provides an increased protective capability several thousand times greater than prior garments. While capable of all the above, one configuration permits essentially "shirt sleeve" operation and affords the body a chance to breathe. In its second configuration, it serves as a general utility suit pending activation of the foam system, is light and pliable in use, and can be readily repaired, cleaned and maintained.

If agents employing water in their chemistry, or mechanical foams are utilized, pressure relief valves (not shown) will necessarily be employed at the extremities of the manifolds to relieve stem pressure as a result of extreme heating:

Flexibility of the garment is assured due to the novel integrated bladder system which automatically fills or relinquishes space as required for movement by compressing and displacing foam in one bladder while simultaneously allowing the foam pressure in the adjacent bladders to compensate therefor. The bladders thus maintain intimate contact between one another regardless of appendage movement.

I claim:

1. A survival garment comprising:

(A) a support means comprising a coverall-like inner garment substantially conforming in configuration to the object to be protected;

(B) insulation means comprising a plurality of separate substantially annular bladder elements expandable in at least two directions attached to said coverall-like inner garment and substantially conforming in configuration thereto,

(1) each said element in the expanded condition closely and conformingly abutting the adjacent operatively associated bladder element to provide an unbroken layer of insulating material about said inner garment,

(2) each said bladder element operatively associated with an insulative material generating and activating means; and

(C) means operative to activate and channel an insulating medium to said bladder elements.

2. The survival garment as defined in claim **1** wherein:

(A) said bladder elements comprise:

(1) individual, plicated, space defining strips supported on said inner garment in spaced-apart relation to permit ventilation therebetween when in the plicated form,

said strips expandable in at least two dimensions to close the space therebetween by close abutment with adjacent operatively associated bladder elements when in the expanded condition;

(B) said insulating medium channeling and activating means comprising a system of manifolds operatively associated with said bladder elements and a chemical foam insulating medium generating means operative to cause said bladder elements to expand into their insulating configuration.

3. Multipurpose survival apparel comprising:

(A) an inner, open-weave, coverall-type support garment defining a body portion, arm portions and leg portions, said support garment having affixed there-

to attachment means at predetermined locations on the exterior thereof for cooperative association with the elements to be supported thereon;

(B) a plurality of expandable, plicated, insulation receiving bladder members having means thereon for cooperative association with said support garment attachment means,

(1) said bladders attached to said support garment at spaced-apart locations and conforming substantially to said body, leg and arm portions thereof,

(2) said spaced-apart locations being such that said bladders in the plicated, unexpanded form expose substantial portions of said support garment to enhance body breathing and ventilation, but permit each said bladder to closely and resiliently abut the operatively associated adjacent bladder in the expanded form to thus constitute a complete cover to and insulation containing medium around said body, leg and arm portions of said support garment,

(3) said bladders having integral means therewith operative to permit the introduction of an expandable inert insulation means into said bladders; and

(C) means for activating said bladders to the expanded, insulation providing state, said means comprising a foam producing, pressure generating source operatively associated with a carrying and channeling means, said means including a manifold system in communication with said foam generating source and said bladder members in the body, leg and arm portions of said support garment; and

(D) an outer, fire resistant, coverall-type utility garment having body, leg and arm portions cooperatively configured to conform to and maintain relatively intimate contact with said bladders in the expanded state, thus providing a protective cover to said bladder and insulation system while permissive of operation and expansion of said system.

4. A multiple purpose survival garment comprising:

(A) an overall-like, air pervious support garment;

(1) said support garment having attached thereto the loop portion of a multiplicity of hook and loop tapes at predetermined points on the exterior of said garment positioned primarily along lines which correspond to the axial centerline of the torso of the human body and its appendages;

(B) a plurality of removable, plicated annular expandable bladder members,

(1) said bladder members being in a spaced relationship one to the other upon said support garment in a predetermined relationship in accordance with the pattern established by said loop tape portions,

(2) said bladder members having attached thereto the hook portion of said hook and loop tapes,

(3) said hook and loop tapes operative to support said bladder members upon said support garment in a spaced relationship when in the plicated form, but permitting said bladder members to resiliently abut the adjacent bladder members when expanded;

(C) said bladder members being interconnected by expandable manifold elements,

(1) said manifold elements having apertures therein corresponding to apertures in said bladder members to allow passage of an expanding foam into said bladder elements,

(2) said manifold elements being attached at one extremity to a suitable pressurized liquid containing cannister;

(D) said cannister containing a chemical expanding panding foam having a low rate of thermal conduction and high expansion ratio; said foam operative to form with said bladders an insulation medium for extreme temperatures, impact shock resistance, and a body pressure exerting means.

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JORDAN FRANKLIN, *Primary Examiner.*

J. R. BOLER, *Assistant Examiner.*