

Aug. 11, 1970

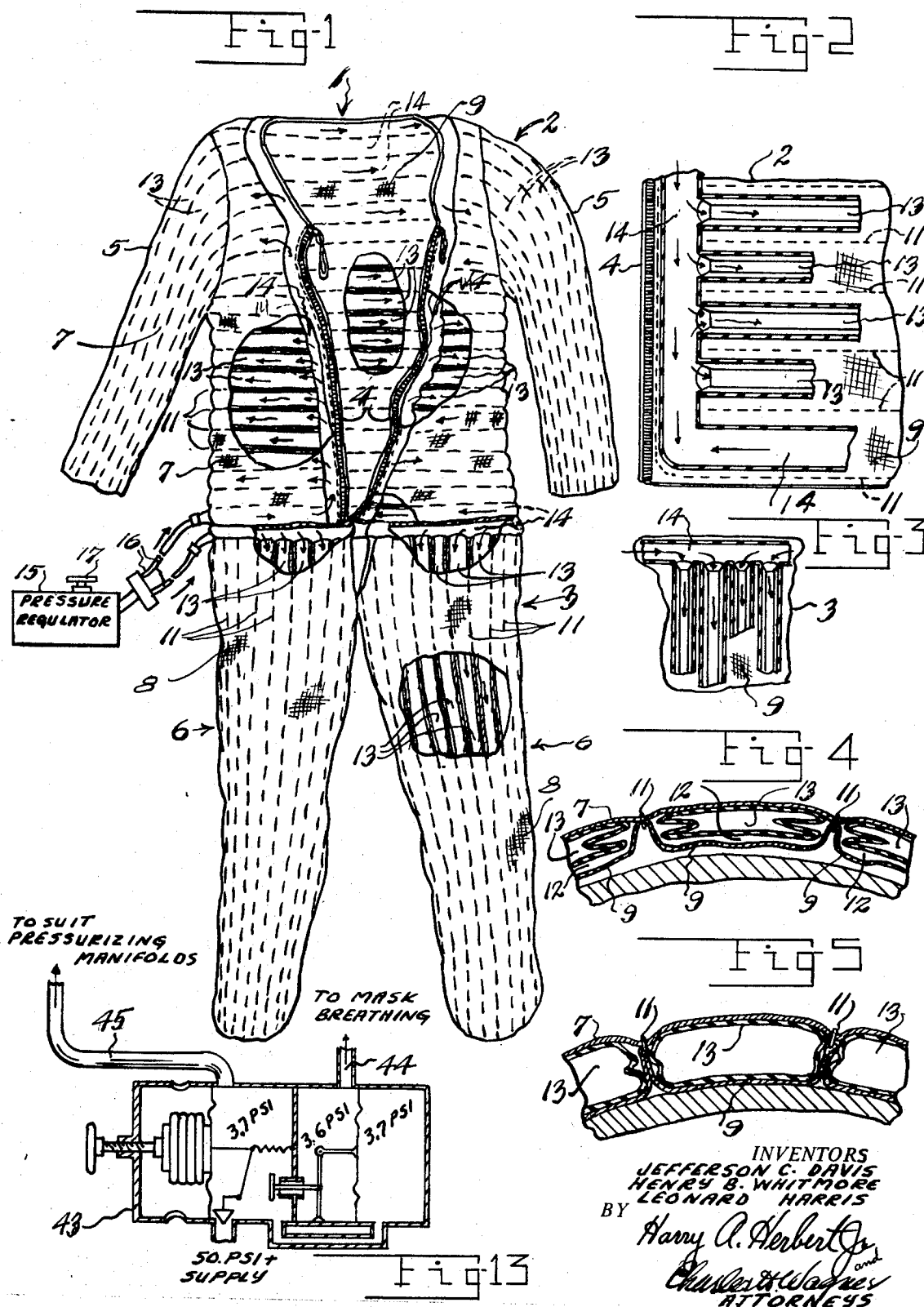
J. C. DAVIS ET AL

3,523,301

PASSIVE AND ACTIVE TUBULAR PRESSURIZATION SUIT

Filed Oct. 4, 1968

2 Sheets-Sheet 1



INVENTORS
JEFFERSON C. DAVIS
HENRY B. WHITMORE
LEONARD HARRIS
BY *Harry A. Herbert Jr.*
Charles H. Wagner
ATTORNEYS

Aug. 11, 1970

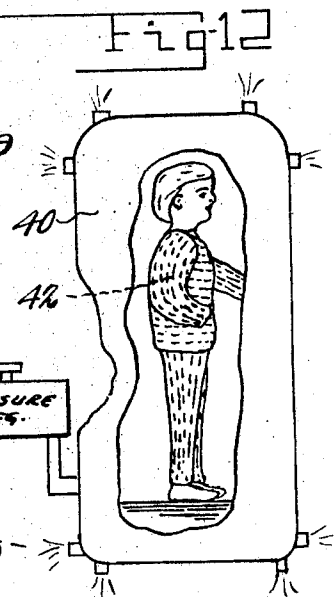
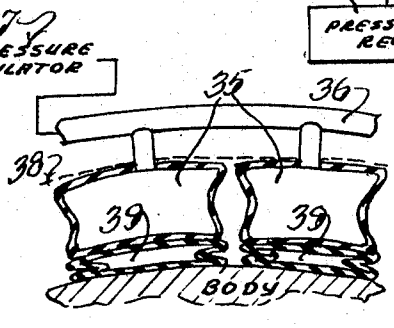
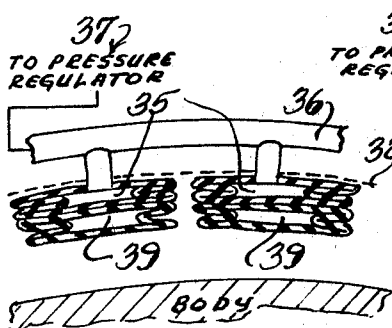
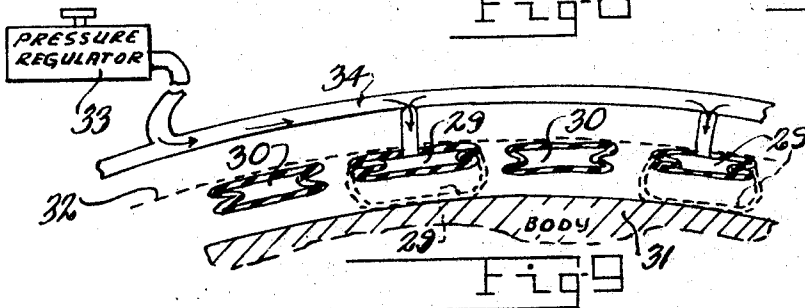
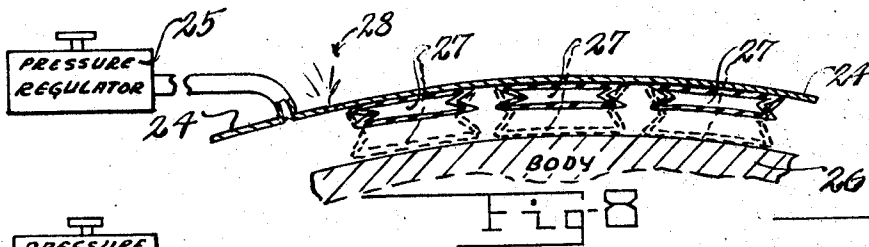
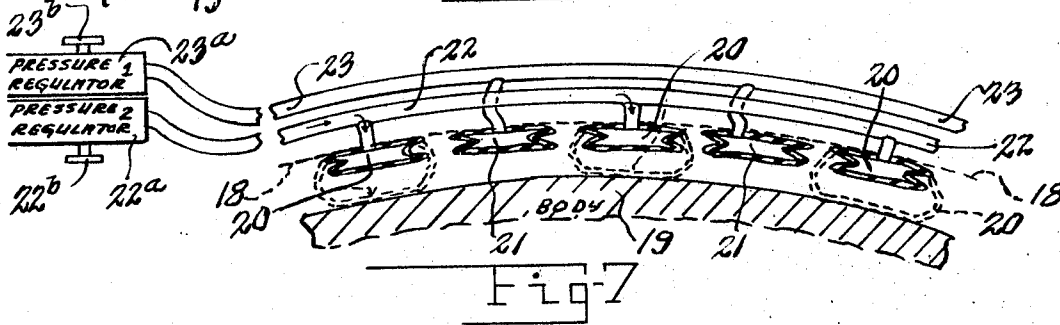
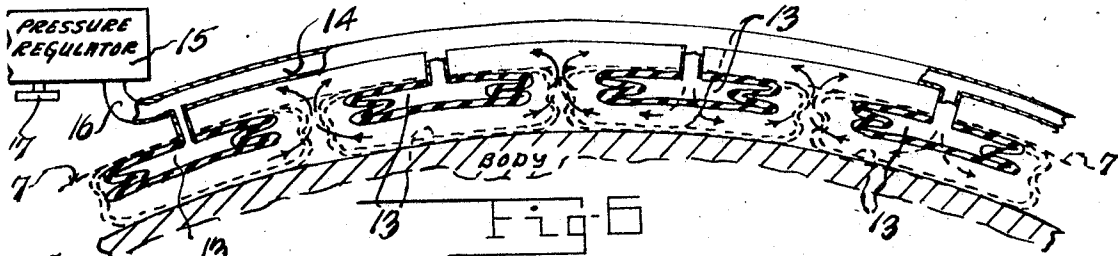
J. C. DAVIS ET AL

3,523,301

PASSIVE AND ACTIVE TUBULAR PRESSURIZATION SUIT

Filed Oct. 4, 1968

2 Sheets-Sheet 2



INVENTORS
JEFFERSON C. DAVIS
HENRY B. WHITMORE
LEONARD HARRIS

BY

Harry C. Herbert Jr.
and
Charles H. Wagner
ATTORNEYS

1

3,523,301

PASSIVE AND ACTIVE TUBULAR PRESSURIZATION SUIT

Jefferson C. Davis, San Francisco, Calif., and Henry B. Whitmore and Leonard Harris, San Antonio, Tex.

Filed Oct. 4, 1968, Ser. No. 765,118

Int. Cl. B63c 9/16

U.S. Cl. 2—2.1

5 Claims

ABSTRACT OF THE DISCLOSURE

An inflatable high altitude pressure suit enclosure having a plurality of inflatable expansible and flexible, relatively small tubular members disposed around the interior in close adjacent side by side or superimposed substantially parallel relation to surround the body of a wearer. The tubular members are expanded when inflated to apply suitable body sustaining pressure on the body of a wearer within the enclosure when the exterior pressure surrounding the enclosure drops below a predetermined pressure.

BACKGROUND OF THE INVENTION

The high altitude pressure suit incorporating the invention is an important improvement over well known partial pressure suits as disclosed in the patent to Henry, No. 2,886,027, and conventional "inflatable full pressure" suits currently in use, as well as the more recent "passive pressure" suits of the type contemplated in the Ritzinger et al. Pat. No. 3,393,405 entitled Emergency Altitude Pressure Suit (Boyles Law Operated), and suits of the type contemplated in the patent application of Otto Schueller, Ser. No. 461,212, now Pat. No. 3,428,960, entitled Multicell Pressure Suit.

SUMMARY OF THE INVENTION

Briefly, the invention comprises a "fail safe" high altitude pressure suit. In one form a full pressure inflatable suit is employed with a tubular inflatable "passive pressure" system incorporated therein so that a puncture and loss or failure of air pressure inside of the inflatable full pressure suit, when predetermined surrounding low exterior pressure is present, the expansible tubular passive pressure system becomes automatically operable to supply the necessary sustaining pressure on the body of the wearer.

Another form of the invention combines an expansible tubular passive system and an expansible tubular active pressure system within a porous fabric high altitude suit. When the "passive" pressure system fails, because of puncture, or leakage, the "active" expansible tubular pressure system can be activated to apply the necessary body sustaining pressure on the wearer. This is also true where the "passive" pressure system is not fully operative to apply sufficient body pressure on the wearer due, for instance, to a partial loss of pressure, or to an inadvertently selected "improperly" fitting suit.

BRIEF DESCRIPTION OF THE DRAWINGS

Like reference characters refer to like parts on the several figures of the drawings, in which:

FIG. 1 is a front view in elevation of a high altitude full pressure suit incorporating one form of the invention, parts of the suit being broken away, or removed, or shown in section.

FIG. 2 is an enlarged fragmentary sectional view of a portion of the top or upper portion of the suit, as shown in FIG. 1, taken between the outer non-stretchable porous fabric of the suit and the inner porous loose or stretchable liner, showing the inflatable expansible parallel tubular members, not pressurized and collapsed.

2

FIG. 3 is a fragmentary sectional view similar to FIG. 2, but taken through the tubes in a portion of the lower garment of the suit.

FIG. 4 is an enlarged transverse sectional view through a few of the resilient, flexible, expansible tubular members as shown in FIG. 3, to more clearly illustrate the outer non-stretchable and the loose inner flexible porous suit fabric with the inflatable and expansible tubes in collapsed condition to afford ventilation and free body movement of the wearer therein.

FIG. 5 is a fragmentary sectional view, similar to FIG. 4, but showing the tubular members expanded.

FIG. 6 is a schematic sectional view showing the resilient expansible tubular members in collapsed condition in full lines, and in expanded relation in dotted lines and with the tubular members connected by a common header or manifold to a regulated pressure supply means for the inflation thereof.

FIG. 7 is a fragmentary sectional view of a modified arrangement comprising alternately disposed side by side expansible tubular members connected to separate regulated pressure supply means comprising two groups of tubular members each group connected by a separate manifold conduit means to one of the pressure regulator systems for selectively supplying inflation pressure to one, or the other, of the inflatable tubular groups.

FIG. 8 is a transverse fragmentary sectional view, schematically illustrating a further modification comprising an inflatable "full pressure" suit having a non-porous outer garment lined inside with substantially parallel resilient expansible flexible tubular members of the "passive" type having a predetermined amount of gas trapped and sealed therein. Dotted lines illustrate the expansion of the tubular members into body sustaining pressure on the wearer's body when the inflatable full pressure suit is punctured and the pressure therein leaks out, or fails.

FIG. 9 is a fragmentary schematic sectional view of a portion of a suit, showing a further embodiment, employing a non-stretchable ventilated outer fabric enclosing the wearer and lined with spaced side-by-side expansible flexible tubular inflatable members comprising expansible members of the "passive" type alternately disposed between tubular members of the inflatable "active" type which are connected for inflation through a common conduit to a regulated pressure supply means.

FIGS. 10 and 11 are similar sectional views showing superimposed tubular expansible members of the "active" and "passive" types, in which the "active" expansible tubular members are secured in spaced side-by-side parallel relation around the inside of the outer porous fabric of the suit, and the "passive" expansible tubular members are each superimposed on one of the active type members. FIG. 10 shows both active and passive members collapsed, while FIG. 11 shows the active members expanded, to press the inner passive tubular pressure members into sustaining pressure relation on the body of the wearer, for instance when the passive pressure system fails or is not sufficient to apply the necessary sustaining pressure on the wearer's body.

FIG. 12 is a view in elevation, parts being broken away to show the use of a "passive" pressure suit, within a positive regulated pressure supplied capsule or enclosure, to automatically protect the occupant should the compartment or enclosure become punctured and decompression occur at altitudes where body sustaining pressure is necessary.

FIG. 13 is a somewhat diagrammatic sectional view through a pressure supply regulator for automatically supplying positive pressure to the expansible tubular members of the "active" or full body pressure supply type, such as shown in FIGS. 1 to 6.

3

Referring to FIGS. 1 to 6 the reference numeral 1 denotes a "high altitude" full pressure suit comprising an upper body enclosure portion 2, and a lower body enclosure portion 3, for enclosing the body, arms, and legs of a wearer therein.

The suit portions 2 and 3 may be provided with suitable closures for the access opening therein, such as a zipper or zippers 4.

The suit may be a one piece "overall" type or comprise the separate top and bottom suit portions 2 and 3 having the arm enclosure portion 5 and the leg receiving and enclosing portions 6, respectively.

The suit portion 2, as seen in FIG. 1, comprises an outer porous, non-stretchable fabric, for enclosing the body and arms of the wearer, and non-stretchable porous fabric leg or limb enclosing portions 8 in the lower body enclosing portion 3. It preferably has a loosely disposed slack or stretchable porous liner 9, best seen in FIGS. 4 and 5, and is fabricated to loosely and comfortably fit a wearer's body at low altitudes where body sustaining pressure on the wearer is not necessary. However, the outer porous fabric must be carefully fitted to dispose the same in predetermined closely spaced relation to the surface of the wearer's body.

The suit, as shown, is stitched through the outer fabrics 7 and 8, and the inner liners 9, in fairly closely spaced substantially parallel or equally spaced rows to form tubular passages or elongated compartments 12 which, preferably, terminate in close, but spaced relation to the edge of the access openings for the wearer.

Flexible resilient expansible tubular inflatable members 13 are loosely fitted in the tubular passages 12, from end to end, as shown, to confine the tubular members 13 therein, in substantially parallel relation to each other in the passages 12, to surround the body, arms and legs of the wearer.

The suit 1 is provided with a tubular gaseous pressure manifold member or members 14 which preferably extend around the edge of the suit, for instance next to the edge of the access opening and the zipper 4, and around the top of the lower suit portion 3.

The expansible tubular members 13 are open at their ends into communication with the interior of the pressure supply conduits or manifolds 14.

Any suitable pressure supply means may be provided, as indicated at 15, and connected to the manifolds or conduits 14 by suitable flexible conduit means 16, and are provided with suitable regulated pressure supply and control means 17, or an automatic pressure supply control means such as indicated at 18, in FIG. 13, may be used to control the pressure supplied to the manifolds 14, and the wearer's helmet (not shown) when the exterior pressure falls below some predetermined set value.

Under normal exterior pressure conditions, for instance, where the exterior pressure is not less than about 5 to 7 p.s.i. a sustaining pressure on the wearer's body is not normally required, and the inflation or pressurization of the tubular members 13 of the suit 1 is not necessary, as seen in FIG. 4, and in full lines in FIG. 6, and the suit remains fairly loose, comfortable, ventilated and can be easily worn over long periods of time. Also the porous non-stretchable outer fabric and porous and loose inner liner provide adequate ventilation for the wearer between the fully or partially collapsed tubular members 13.

When sustaining pressure on the body of the wearer is necessary, and the tubular members are inflated and expanded by air pressure from the pressure regulator 15, they are expanded inwardly against the wearer's body to supply the required body sustaining pressure on the wearer, as schematically shown in FIG. 5, and in dotted lines in FIG. 6.

Referring to FIG. 7, the suit, on the upper and lower garment portions thereof such as 2 and 3, each have an outer loosely fitting, non-stretchable porous fabric 18

4

which is fitted in predetermined closely spaced relation to the surface of the wearer's body 19, and provided with two sets or groups of alternately disposed side by side closely spaced resilient flexible and expansible tubular members 20 and 21, located between the outer porous non-stretchable fabric 18 and the surface of the wearer.

The inflatable and expansible tubular members 20, as shown, comprise a portion of one set, or one inflated system while the interposed tubular inflation members 21 constitute a second set or group of body sustaining pressure applying members or system. Either of the groups of alternately disposed tubular members 20 or 21, lining the suit can be or is an emergency "backup" system for the other, should the tubular members of the other system be punctured, or leak and fail.

The tubular members 20 in the first group or system are connected to one manifold or pressure supply conduit 22 (schematically shown in FIG. 7) while the other inflatable and expansible tubular members 21 of the second group or system are connected to a second pressure supply manifold or conduit 23. Each of the manifolds 22 and 23 are preferably supplied with pressure by separate regulated pressure supply means 22a and 23a, having controls therefor indicated at 22b and 23b.

One of the pressure supply devices such as 22a may be automatic, as shown in FIG. 13, while the other may be controlled manually or tripped by failure of pressure in the other automatic system.

The location, spacing, size and expansion characteristics of either set or group of tubular members lining the interior of the suit, when inflated, is sufficient to substantially cover and apply the necessary body sustaining pressure on the surface of the wearer's body when the exterior pressure surrounding the suit and wearer falls below a predetermined low value, for instance less than 5 or 6 p.s.i. Should one system fail or become insufficient the other emergency or "backup" system can, and is actuated to, provide the necessary alternate sustaining pressure on the body of the wearer.

FIG. 8 schematically illustrates an "automatic" emergency or "backup" pressure applying system incorporated in an inflatable "full pressure" suit.

In the drawings the inflatable non-porous suit fabric is indicated at 24 and the pressure supply means to inflate the suit is indicated at 25 for supplying the necessary inflation pressure to the interior of the suit and the sustaining pressure on the wearer's body 26.

The suit is lined with closely spaced substantially parallel flexible resilient expansible rubber-like tubular members 27 shown substantially collapsed in full lines and has a predetermined amount of expansible gaseous medium trapped and sealed therein at normal atmospheric pressure, for instance 15 p.s.i.

When the suit is inflated the internal pressure on the tubular collapsed members 27 (and on the wearer's body) is sufficient to balance or substantially balance the trapped pressure within the tubular members 27 so that they remain substantially collapsed as shown in full lines in FIG. 9.

When the outer fabric 24 is punctured or leaks, as indicated at 28 and the interior pressure drops, at low outside pressures the trapped gas within the tubes expands the tubular members 27 into pressure sustaining contact with the surface of the wearer's body 26.

Referring to the form of the invention shown in FIG. 9, a "positive" and a passive pressure system is shown schematically comprising closely spaced alternate "active" and "passive" pressure expansible flexible tubular members 29 and 30 surrounding the body, arms and legs in parallel relation, preferably carried on the inner surface of the non-stretchable fabric 32 of the suit. The "passive" tubular members, indicated at 30, are disposed between the "active" tubular members 29 and have a predetermined amount of gas trapped and sealed therein while the active tubular members 29 are preferably connected

to a suitable pressure supply manifold 34 adapted to be supplied with pressure from a pressure regulator 33 to inflate the active tubular members 29 and expand the same to sufficient body sustaining pressure on the wearer's body 31, should the passive pressure system fail or be insufficient, for instance, because of leakage or an improper size suit for the wearer.

In this construction the passive system comprising the spaced tubular members 30 will automatically expand with a sufficient drop in the exterior surrounding pressure but the active alternate tubular members 29 can be inflated and expanded as shown in dotted lines to replace or supplement the body sustaining pressure of the tubular members 30 on the wearer's body.

Referring to FIGS. 10 and 11, the tubular expansible members 39 of the "passive" system are superimposed on and carried on the tubular expansible "active" members 35.

The outer fabric 38 of the suit is non-stretchable and porous, and the tubular members 35 of the active system are secured in closely spaced side by side relation, when collapsed as shown in FIG. 10, on the interior of the fabric 38 and surround the body, arms and legs of the wearer somewhat similar to the tubular members 13 in FIG. 1.

The tubular members 35 are connected to a pressure supply manifold 36 adapted to be pressurized when necessary by a pressure regulator 37. When an emergency occurs and the passive pressure system fails to supply sufficient body sustaining pressure on the wearer, the members 35 can be pressurized, as seen in full lines in FIG. 11.

FIG. 12 illustrates the use of a passive pressure suit comprising tubular members with the predetermined amount of expansible gas therein and a pressurized capsule 40 normally supplied with adequate pressure by and through the pressure regulator 41.

Should the pressure in the capsule 40 fail, the passive pressure system of the suit 42 automatically becomes operative to supply the necessary body pressure.

While no helmet is shown it should be obvious that in all instances where body sustaining pressure is necessary some type of helmet or breathing apparatus must be provided in conjunction with the suit, to supply the wearer with oxygen necessary for breathing under suitable pressure.

FIG. 13 shows one form of "active" pressure regulator 43 for supplying pressure through conduit 44 to the wearer's mask or breathing apparatus for demand breathing, as well as for supplying pressure through the conduit 45 to the tubular expansible members of the "active" pressure supply system.

We claim:

1. A high altitude full pressure tubular flight suit comprising, an outer non-stretchable garment for enclosing the arms, legs and body of a wearer, having a closable access opening for receiving the wearer therein, resilient flexible normally collapsed expansible tubular members fixed within the outer non-stretchable garment in substantially closely spaced side by side relation to each other to completely surround the body, arms and legs of a wearer in normal predetermined closely spaced relation to the surface of the wearer's body and separate gaseous pressure inflation means for inflating and expanding the tubular members against the outer non-stretchable garment into body pressure sustaining contact with the outer surface of the wearer's body, said flexible resilient expansible tubular members comprising two groups of collapsed "active" tubular members disposed in alternate side by side parallel relation within said outer non-stretchable garment and said gaseous pressure inflation means includes separate and independent inflating and expanding gaseous pressure supply means connected to each group for selectively inflating and expanding each group of said collapsed resilient flexible expansible tubular members against the outer non-stretchable garment into body sus-

taining pressure engagement with the surface of the body, legs and arms of a wearer independently of the other group.

2. A full pressure high altitude suit comprising an outer non-stretchable fabric fitted to surround the outer surface of the body of a wearer of the suit in close predetermined spaced relation thereto, a first group of small flexible expansible resilient collapsible tubular members disposed around the inner surface of said outer non-stretchable fabric of the suit in side by side spaced relation adapted to normally surround the outer surface of the arms, legs and body of a wearer of the suit in closely spaced relation to the surface of the suit wearer's body, arms and legs when collapsed, a second group of small flexible expansible, resilient, collapsed similar tubular members disposed around the inner surface of said outer non-stretchable fabric of the suit in alternate interposed positions between the tubular members of said first group and when collapsed are in predetermined closely spaced relation to the surface of the wearer's body, a first regulated gaseous pressure supply means connected to the tubular members of said first group for inflation and expansion thereof against said outer fabric into body sustaining pressure relation with the surface of the arms, legs and body of a wearer of the suit, and second pressure means for inflating said second group of alternate interposed tubular members for expansion thereof into body sustaining pressure on the surface of the arms, legs and body of a wearer of the suit, independently of the inflation and expansion of the collapsible and expansible tubular members of the first group.

3. A tubular full pressure high altitude suit, substantially as set forth in claim 2, in which said outer non-stretchable fabric is porous, and said second group of flexible resilient expansible tubular members are closed at both ends and substantially collapsed in normal atmospheric pressure where body sustaining pressure on a wearer of the suit is not required, and said second gaseous pressure supply means for inflating and expanding said second group of alternate expansible tubular members comprises a predetermined quantity of an expansible gaseous pressure medium trapped and sealed in the second group of collapsed, closed, expansible tubular members sufficient to expand the second group of expansible tubular members into body sustaining pressure relation on the outer surface of the arms, legs and body portions of a wearer, within the suit, upon a predetermined reduction in surrounding atmospheric pressure on the tubular members of said second group that is less than a predetermined surrounding atmospheric pressure, when a sustaining pressure on the body of a wearer of the suit is not required.

4. A high altitude full pressure tubular suit, substantially as set forth in claim 3, including a loose, porous extensible liner within the suit, spaced substantially parallel rows of securing means between the porous outer fabric and said loose porous extensible liner, extending around the arms, legs, and body portions of the suit, to surround the arms, legs, and body of a wearer within the suit and forming elongated adjacent side by side tubular porous passages between the substantially parallel rows of liner securing means with said small flexible, expansible resilient collapsible tubular members of said first and second groups disposed in alternate fashion in said adjacent elongated tubular passages.

5. A high altitude tubular full pressure flight suit comprising, an outer flexible, non-stretchable porous garment for enclosing the body of a wearer thereof, a plurality of closely spaced collapsed inflatable, expansible flexible resilient tubular members lining the inside of said outer flexible, non-stretchable, porous garment in closely spaced side-by-side relation, for surrounding the body of a wearer of the suit in collapsed condition in predetermined spaced relation to the surface of a wearer of the suit, and expansible when inflated to apply body sustain-

7

ing pressure to the surface of the body of a wearer when enclosed within the suit, regulated pressure supply means connected to said collapsed inflatable tubular members for inflation and expansion thereof to apply body sustaining pressure on the body of a wearer of the suit, substantially collapsed closed flexible, expansible tubular members superimposed on said inflatable resilient collapsed tubular members, expansible inwardly from the outer non-stretchable porous garment and said inflatable tubular members into pressure sustaining relation on the body of a wearer of the suit, independently of the expansion or contraction of the inflatable tubular members on which they are superimposed, a predetermined quantity of expansible gaseous pressure medium trapped and sealed in said closed, substantially collapsed expansible tubular members, at a surrounding air pressure greater than predetermined exterior lower air pressure where body sustained collapsed tubular members being expansible by said gas-

5

10

15

8

taining pressure becomes necessary, said superimposed eous pressure medium trapped and sealed therein for applying body sustaining pressure on the surface of a wearer enclosed within the suit, when the exterior air pressure surrounding the suit and tubular members falls below said predetermined necessary body sustaining pressure.

References Cited

UNITED STATES PATENTS

1,430,194	9/1922	Schweinert	2—2.1
2,335,474	11/1943	Beall	128—1
2,495,316	1/1950	Clark et al.	128—1
2,886,027	5/1959	Henry	128—1
3,428,960	2/1969	Schueller	2—2.1

JORDAN FRANKLIN, Primary Examiner

G. H. KRIZMANICH, Assistant Examiner