Nov. 3, 1953 A. M. KLEIN ET AL 2,657,396

AIR VENTILATED SUIT

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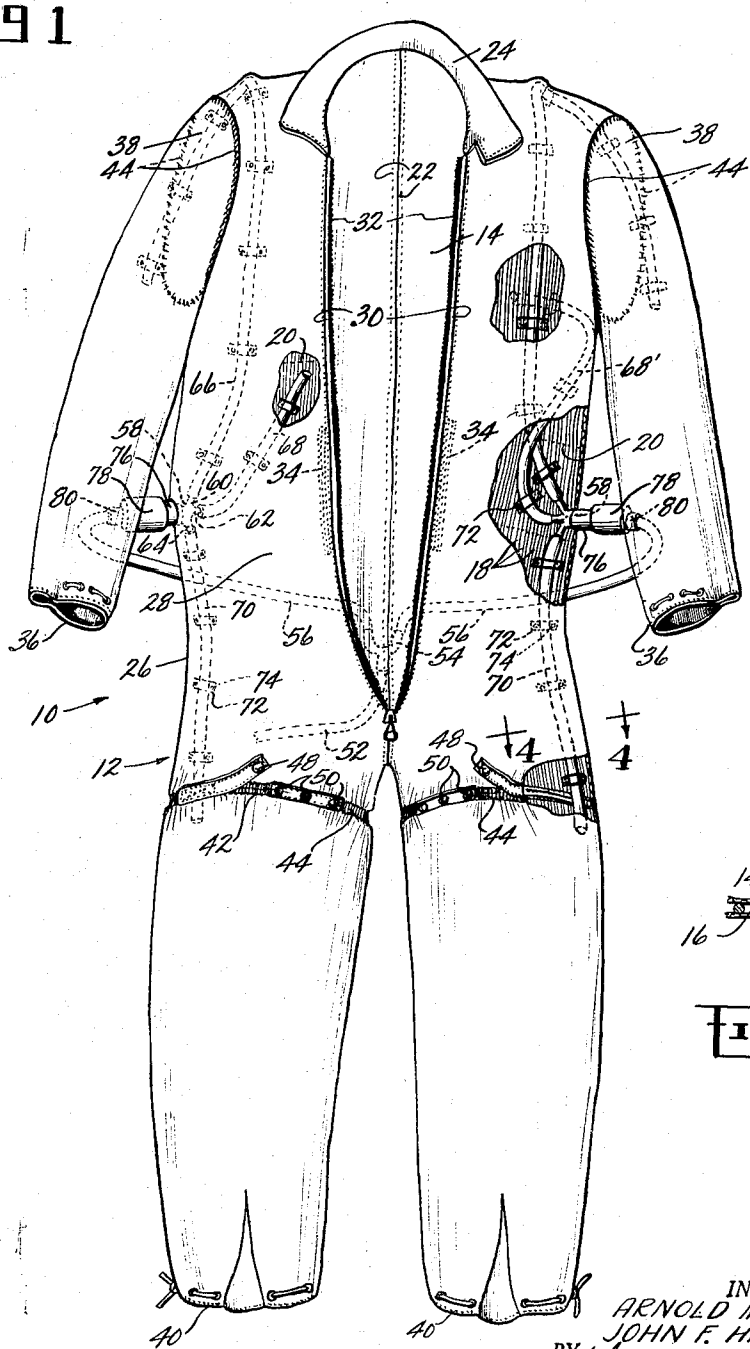
Fig 1



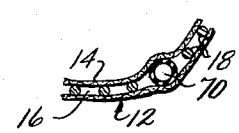


Fig 4

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Fig 2

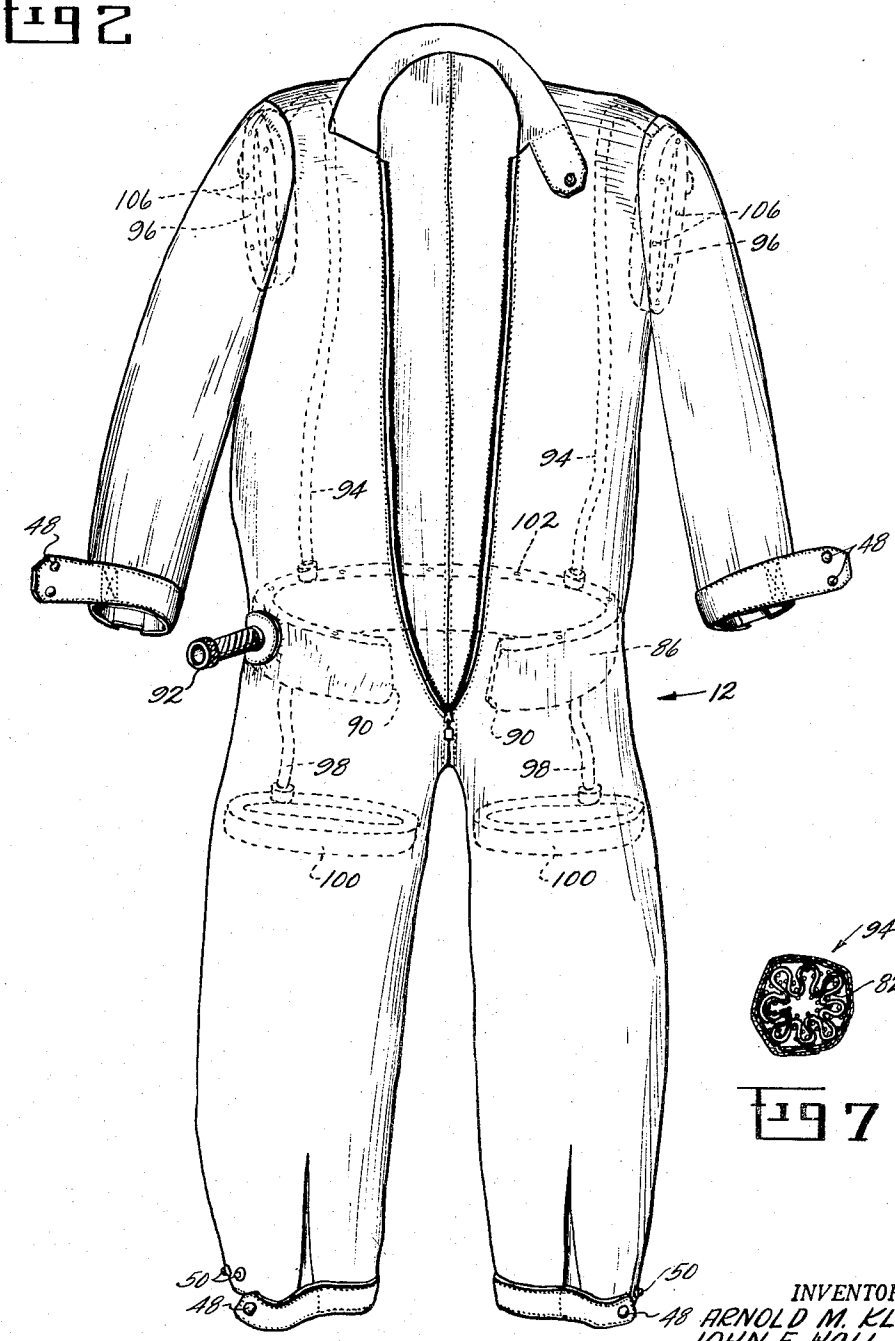

Fig 7

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Fig 3

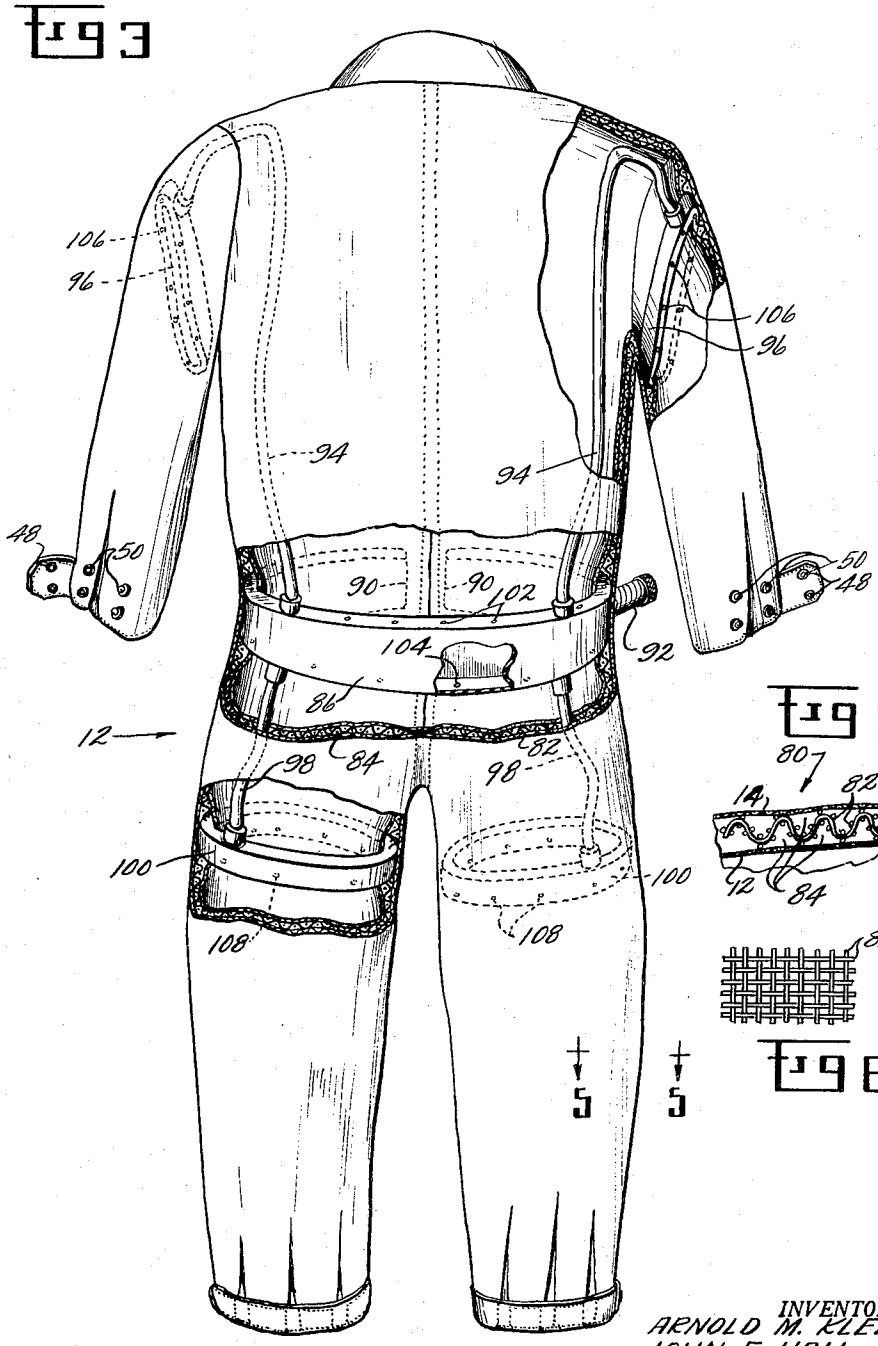
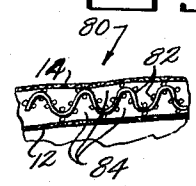


Fig 5



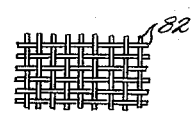


Fig 6

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Patented Nov. 3, 1953 2,657,396

UNITED STATES PATENT OFFICE

2,657,396

AIR VENTILATED SUIT

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Application March 9, 1951, Serial No. 214,806

3 Claims. (Cl. 4—160)

(Granted under Title 35, U. S. Code (1952), sec. 266)

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The invention described herein may be manufactured and used by or for the United States Government for governmental purposes without payment to us of any royalty thereon.

This invention relates to air conditioned garments and particularly to an improved coverall having means to insure more even distribution of the conditioned air over the human body.

Operators working in situations where the ambient air is excessively hot, as in cabs of aircraft, laboratory test ovens or the like, or where it is excessively cold, as in laboratory refrigerating rooms or places of like nature, find it necessary for efficient operation to wear some sort of garment through which conditioned air may be supplied over the body areas from some air conditioned source.

The difficulty heretofore encountered however in designing a suit of this character has been the unequal distribution of the conditioned air over all areas of the body.

Broadly the invention comprises (1) an outer air impermeable coverall, (2) an inner liner of fine sieve like mesh cloth, (3) a plurality of cords spaced apart on, and sewn at intervals to, the inner liner, a means of dividing the space between the coverall layer and the inner liner into a plurality of body areas, and (4) a manifold for conveying conditioned air from a source outside the coverall to the body areas.

It is therefore the prime object of this invention to so construct a ventilated garment that equal areas receive equal amounts of conditioned air equally spread over the areas so that the conditioned air may be distributed in a predetermined manner best suited to the work in hand.

Other objects will become evident as the invention is further described with reference to the drawings, wherein:

Fig. 1 is a front view of our invention in its simplest form part being open and part broken away for clearness.

Fig. 2 is a front view, partly open showing an improved modification of the device Fig. 1.

Fig. 3 is a rear view, part broken away, of the modification Fig. 2.

Fig. 4 is a fragmentary section taken at 4—4 of Fig. 1 showing how the outer and inner layers of the garment, Fig. 1, are spaced.

Figs. 5 and 6 are respectively a fragmentary cross section and a fragmentary plan of the spacing material used to keep the outer and inner layers of the modified garment Figs. 2 and 3 separated.

Fig. 7 is a cross section through one form of air distributing tube used in the modification shown in Figs. 2 and 3.

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Referring now to the drawings and more particularly to Fig. 1, the exemplification 10 of the invention comprises an outer impervious one-piece cover 12 which may be fabricated from neoprene coated nylon or its equivalent, and an inner one-piece liner 14 preferably made of a sieve like basket weave nylon dimensioned to leave space 16 between the cover 12 and the liner 14 which space is maintained by a plurality of vertically extending cords 18 which are spaced approximately one-half inch apart on the inside of the liner 14 and sewn thereto by horizontal stitching 20 spaced approximately two inches apart, the whole constituting a hollow wall as seen in Fig. 4.

In the back the cover 12 and the liner 14 are joined together by stitching 22 which extends from the collar 24 to the waistline 26 thereby dividing the trunk portion 28 into two symmetrical areas.

In the front the trunk portion is open, the edges 30 of the opening on each side comprising an edge of the inner layer or liner 14, an edge of the outer layer or cover 12 and one of the sides 32 of a zipper all sewn together, but since this treatment would preclude entry of the hand into the space between the outer cover 12 and the inner liner 14 for placement or adjustment of the manifold branches, a short zipper-closed opening 34 is provided on each side, adjacent the edges, for this purpose. The outer cover 12 and inner liner 14 should also be sewn together as at 36 at the cuff and as at 38 at the sleeve head on each arm, as at 40 at the leg cuffs and as at 42 around the thigh circumference seam.

Elastic strips 44, one inch wide, channeled, are sewn around the circumference of the sleeve head 38 on the liner 14 and around the thigh circumference seam 42. The elastic strips are of such circumference as will draw slightly but not enough to cause restriction of blood flow in the wearer. These elastic strips 44 are made adjustable by means of a female snap fastener 48 and three male snap fasteners 50 spaced one inch apart. This adjusting means will insure against mixing of the air between the several body sections. The same adjusting means 48, 50 may be used at the arm and leg cuffs for controlling outflow.

A main supply hose 52 brings the conditioned air from the source of supply (not shown) to the Y connector 54 where it divides, half flowing to

each half of the symmetrical body areas through adequately heat-insulated tubing 56 to the manifolds 58. The inflow stem of the manifold extends through a close fitting opening in the outer cover 12, the three branches 60, 62 and 64 of each manifold being extended by tubes 66, 68 and 70 respectively to the several body areas.

The manifolds are designed so as to partition the air flow to the arms, trunks, and legs on the basis of the total surface area involved. On this basis the division of the air flow is approximately 25 percent to the arm area, 25 percent to the trunk area and fifty percent to the leg area.

The tubing 66, 68 and 70 is attached to, and held positioned on, the inner surface of the outer cover 12 by a series of strips 72 of one-half inch wide by three inches long cotton tape, held in place by snap fasteners 74.

The tubes 66 supplying the arms are approximately 6.7 m. m. I. D. by 40 inches long and run along the inner surface of the outer cover 12 and over the shoulder as shown and then curve outward to run along the back seam of the sleeve for a distance of four inches from the shoulder circumference seam.

The tubes 70 supplying the legs are 13.7 m. m. I. D. and extend approximately thirteen inches along the lateral leg seams. The trunk tube 68' on the left side of the suit is so placed that its end is fixed approximately two and one-half inches from the medial distal line of the scapula. The right trunk tube 68, on the other hand is fixed three and one-half inches below the right nipple. Air therefore, is insured of circulating in both front and back trunk regions of wearer.

The trunk tubes 68 and 68' have an I. D. of 7.1 m. m. These tubes are kept in place by the elastic tapes 72 which are positioned at four inch intervals on the inner surface of the outer cover. In addition to serving as tube retainers these elastic tapes provide the flexibility necessary for changes in body position.

To prevent loss of air flow due to possible tube constriction, "flutes" have been placed on all internal air supply tubes. The flute consists of a one quarter inch V-shaped cut along the tube surface with the apex being proximal. One quarter inch more proximally along the same plane as the V-shaped groove, a circular opening is made in the tube one eighth inch in diameter. This is followed by a circular opening of the same diameter one quarter inch more proximally on the opposite surface of the tube. Thus if one or even two orifices are blocked, a sufficient air flow may nevertheless be maintained. All tubes are held fast to their positions by sewing (i. e.), sewing down each tube one sixteenth and two inches back from the distal tube end.

Plastic tubing or thick walled rubber tubing is preferable in order to resist compression. It is required, however, that the tubing permit maximum freedom of movement.

The manifold barrels 76 extend through openings in the sides of the cover 12 and are each provided with a female quick disconnect part 78 which in turn receives the male part 80 of the coupling, the male part being attached to the end of the insulated hose 56, whereby efficient and rapid engagement and disengagement of the two parts of the coupling may be made. The suit 10 and air manifold 58, including the female disconnects 78 comprise the portable part of the equipment, whereas the male disconnects 80, hose 56, Y part 54 and hose 52 make up the fixed part of the system.

The suit is divided into symmetrical halves; each half consisting of an arm, leg, and trunk region. Air from the air source not shown passes through the external supply lead system 52, 54, 56, through disconnects 78, 80, into the manifold external inlet tubes 76 to the manifold lead tubes 60, 62, 64, where it is partitioned to the arm, leg, and trunk regions via tubes 66, 70, 68 respectively. The internal ventilating system provides for an equal diffusion of air throughout any one region, due to the porous character of the inner mesh liner 14 and the air impermeability of the outer cover 12. Spacers 72 permit a more complete air flow, especially in areas subject to compression. Furthermore, segregation of areas within the symmetrical suit unit (i. e., separation of arm, leg, and trunk regions from each other) is accomplished by means of attachment of respective regions of liner 14 to outer cover 12. The elastic tapes 44 further insure against air loss or leakage from one region to another. Thus, a billowing effect occurs throughout the suit (between the mesh of the inner liner 14 and the inner surface of the outer cover 12). This effect tends to result in a more equal and even area-wide air distribution, providing, at the same time, an air pillow which yields a high degree of freedom of movement as well as increased comfort.

The present suit offers distinct advantages over that of other known existing types in that it provides thermal balance with a much greater efficiency, i. e., with less mass air flow. Furthermore, it is lighter in weight; has a simpler ventilating tube system and affords somewhat more freedom of movement than any air ventilated suit heretofore known.

The novel features of the air ventilated suit shown in Fig. 1 are:

(1) Use of tri-orifice manifolds which supply air to arm, leg and trunk regions of the order of 25%, 50%, and 25% of total flow respectively; the total flow partitioning being based on the surface area involved.

(2) Use of a fine porous mesh inner liner which serves as a diffuser for the air supplied, by means of manifold and tubing, to the various body areas.

(3) Use of small diameter spacer material to assist in adequate ventilation of all body areas.

(4) Simplification of air tube arrangement by dividing the suit into two symmetrical halves.

Referring now to the modification shown in Figs. 2 and 3, the basic concept is the same as is shown in Fig. 1. Both exemplifications include the following features:

(1) An outer air impermeable cover layer 12.

(2) An inner mesh porous cloth liner layer 14.

(3) A layer of flexbile material for maintaining the first and second layers in spaced relation, and

(4) An air distribution system so manifolded as to apportion the incoming air to the arms, trunk and legs on the basis of their respective areas.

In addition to the above features, the modification shown in Figs. 2 and 3 includes an improved porous spacing material for maintaining separation of the outer cover and the inner liner, an improved air manifold, and improved arm and leg bands, with improvements in the manner of distribution of the conditioned air.

The improved porous spacing material 88, used in the modification is shown in cross section in Fig. 5 and in plan in Fig. 6. It consists of a plastic thread cloth having alternate strips of

light then heavy warp, the heavy strips being corrugated as at 82, Fig. 5. This cloth is a commercially available product and for that reason is not further described in detail. It is used in the modification instead of the cords 18 of Fig. 4, to keep the outer impervious cover 12 separated from the inner liner 14, as at 84, Fig. 3 and for other purposes hereinafter appearing.

The manifold 86 used in the modification shown in Figs. 2 and 3 may preferably be first formed of the plastic spacing material 80 shown in Figs. 5 and 6, then completely covered inside, outside, edges and ends with an impervious cloth which may be of the kind used for the outer cover 12, then formed into an annulus which has the ends 90 at the front of the body spaced apart. An air supply tube 92, passes through an opening in the cover 12 into manifold 86 to bring the conditioned air into the suit. The manifold is cross stitched to prevent excess inflation at the higher mass air flows. Thus a relatively noninflatable, yet noncollapsible belt manifold is provided.

Tubes 94 extend from the upper side of the belt manifold 86 to the arm bands 96, while tubes 98 extend from the underside of the belt manifold 88 to the leg bands 100. The arm and leg bands 96 and 100 are constructed in substantially the same manner as the belt manifold 86 except that they are continuous annulae.

Tubes 94 and 98 (see Fig. 7) are first fabricated of plastic mesh material 80 by rolling up a strip as in Fig. 7 then covering it with a tube of air-impermeable cloth or other fabric. The air carrying capacity of tubes 94 and 98 and the air transfer capacity of the small holes 102, 104, 106 and 108 is predetermined so as to distribute the air in the ratio of twenty five percent to the arms, fifty percent to the legs and twenty five percent to the trunk or such other proportions as experience dictates.

Small openings 102 in the upper edge of the belt manifold 86 and similar small openings 104 in the lower edge of the belt manifold 86, both discharge conditioned air into the trunk area. Other small holes 106 in the outflow side of the arm bands 96, supply the conditioned air to the arm area and still other small holes 108 in the bottom edge of the leg bands 100 supply the conditioned air to the leg areas.

We claim:

1. An air conditioned suit having a body section, arm sections, and leg sections, each of said sections comprising an air impervious outer cover, an inner liner of porous fabric and fabric means intermediate said cover and liner maintaining them in continuous spaced relation and providing spaced channels therein, means connecting the respective sections and adjustable to maintain the sections distinct from each other, a manifold mounted in each side of the body section, each manifold having three branches respectively connected to an arm section, a leg section, and the body section, said branches being so constructed and arranged as to deliver approximately 25 percent of the conditioned air flow to the manifolds to the arm sections, 50 percent to the leg sections, and 25 percent to the body section through the spaced channels therein, and means connected to the manifolds to deliver conditioned air thereto whereby a predetermined temperature may be maintained.

2. An air conditioned suit having arm sections, leg sections and a body section, each of said sections comprising an air impervious outer cover, an inner liner of porous fabric, and fabric means intermediate said cover and liner and maintaining them in continuous spaced relation and providing spaced channels therein, means intermediate the respective sections and connected thereto maintaining them distinct from each other, manifold means mounted in the body section and having distributing branches respectively associated with the arm sections, leg sections and body section, the manifold branches being so constructed and arranged as to deliver approximately 25 percent of the conditioned air flow to the manifold to the arm sections, 50 percent to the leg sections, and 25 percent to the body section through the spaced channels therein and means connected to the manifold to deliver conditioned air thereto whereby a predetermined temperature may be maintained.

3. An air conditioned suit comprising arm sections, leg sections, and a body section, each of said sections comprising an air impervious outer cover, an inner liner of porous fabric and fabric means intermediate said cover and liner and maintaining them in continuous spaced relation and providing spaced channels therein, hollow annular elements separating the respective sections, maintaining them distinct from each other, manifold means mounted in said body section and having distributing branches respectively connected to the arm sections, leg sections, and body section through the hollow annular elements, the distributing branches being so constructed and arranged as to deliver approximately 25 percent of the conditioned air flow to the manifold means to the arm sections, 50 percent to the leg sections, and 25 percent to the body section and through the spaced channels therein, and means connected to the manifold means to deliver conditioned air thereto whereby a predetermined temperature may be maintained.

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