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Saint-Martin

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[54] **PROTECTIVE CLOTHING FOR AN OPERATOR WORKING IN A HERMETIC ENCLOSURE**

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[52] **U.S. Cl.** **128/142.5**

[51] **Int. Cl.** **A61b 19/00**

[58] **Field of Search** ..... 128/142.5, 1 A, 142.4, 128/142.7, 297, 298, 204, 132, 134, 1 R, 1 B; 312/1, 3, 4; 2/2.1 R, 2.1 A

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[57] **ABSTRACT**

The invention is concerned with improvements in protective clothing for use by an operator working in a hermetic enclosure which is at a positive pressure to the ambient atmosphere. The clothing comprises a hermetic garment which has two walls which define an inflatable zone the inner wall being in contact with the operator and the outer wall forming part of the enclosure wall. A permanent leak is provided from the inflatable zone to the inside of the protective clothing by way of permeable means disposed on the inner wall. Means is also provided for permitting and adjusting the rate of leakage flow from inside the protective clothing either to the ambient atmosphere or to the inside of the hermetic enclosure.

10 Claims, 4 Drawing Figures

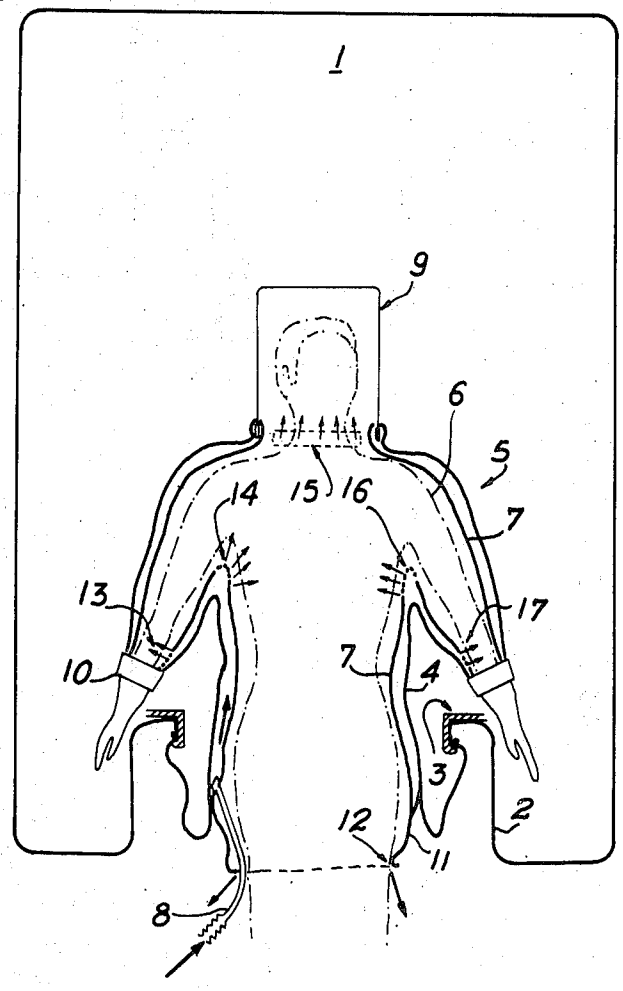


FIG.1

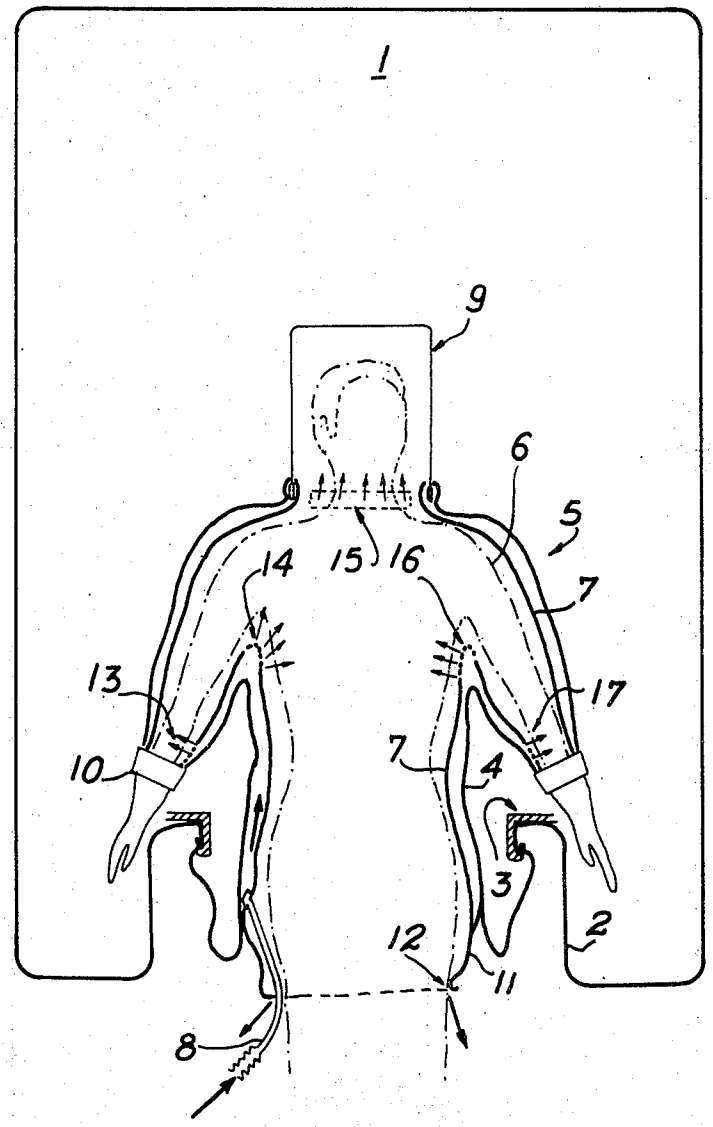
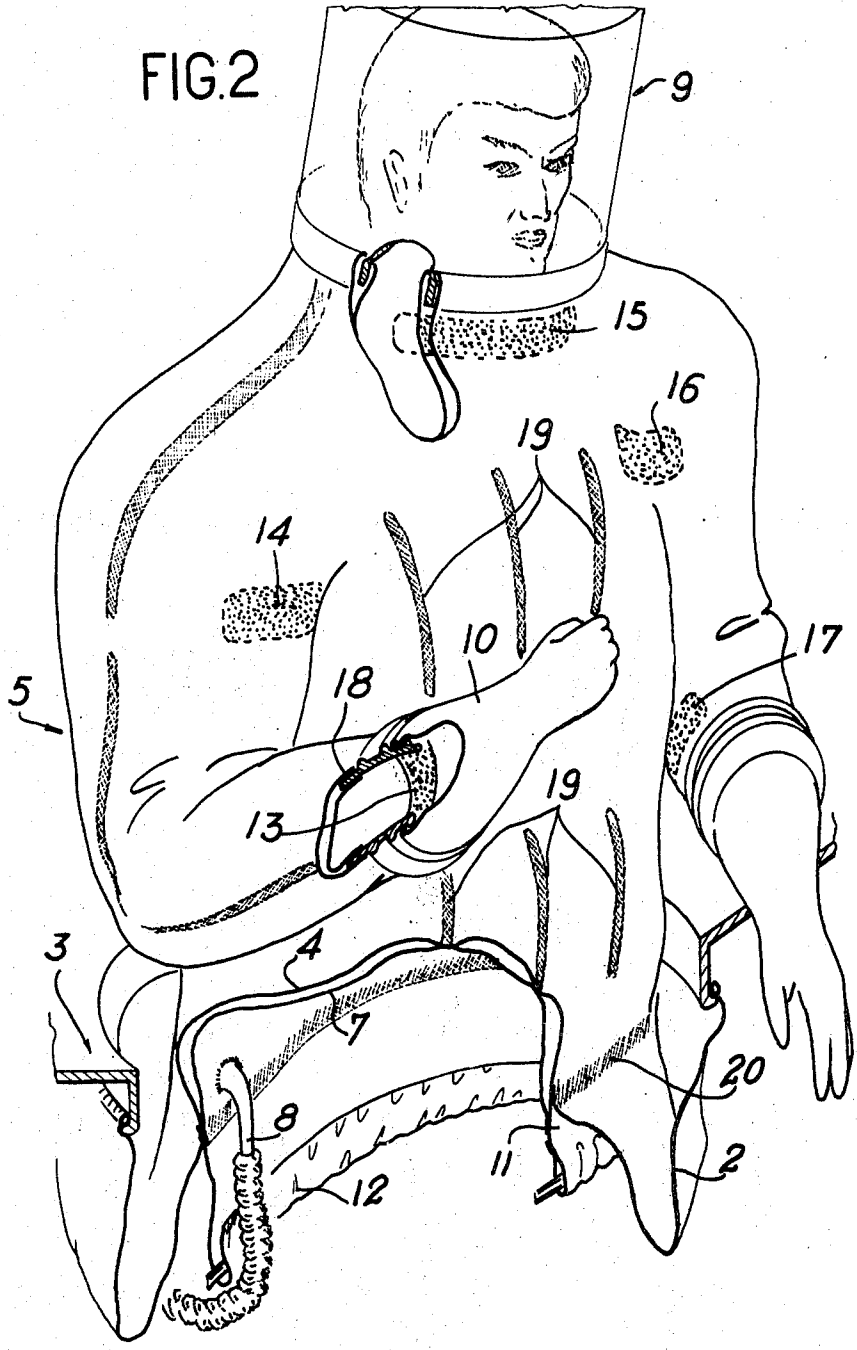


FIG.2



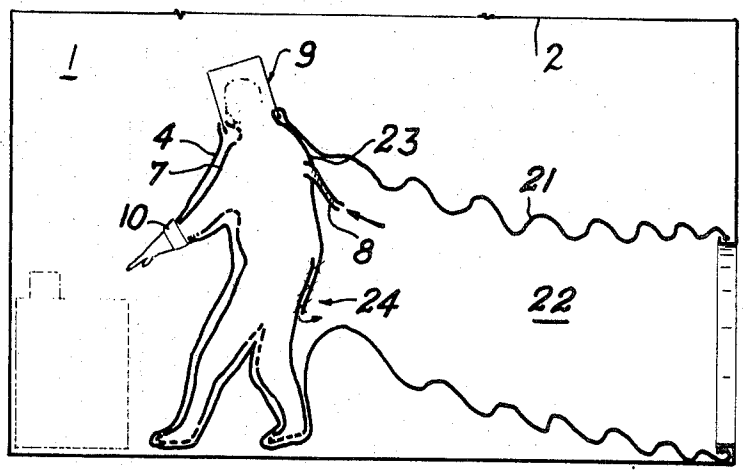


FIG.3

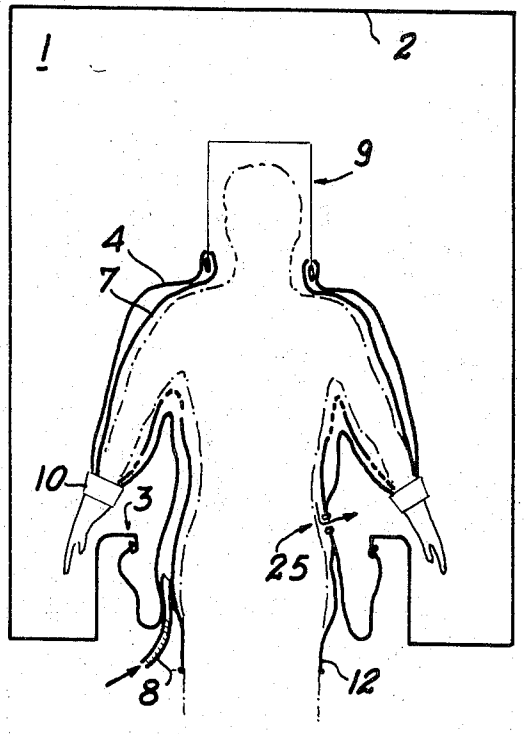


FIG.4

PROTECTIVE CLOTHING FOR AN OPERATOR WORKING IN A HERMETIC ENCLOSURE

This invention relates to protective clothing for protecting an operator who has to work in a hermetic enclosure or chamber or the like.

Various existing techniques require the use of an enclosure which is separated off and sealed off from the normal environmental atmosphere. This state of affairs is found *inter alia* in nuclear engineering, for handling dangerous articles which may emit radioactive particles or poisonous gases in a special chamber, and for treating patients suffering from very infectious diseases; in the latter case the hermetic enclosure is at a negative pressure in relation to atmosphere since the contamination protection is being provided for the atmosphere. On the other hand, some forms of medical therapy call for complete biological protection of the environment from a hermetic cell or the like containing a patient. One of the commonest forms of the latter case is the one in which, after a patient has temporarily become hypersusceptible to bacteriological contamination, he is placed for a time in an enclosure which is at a slightly higher pressure than atmosphere, to ensure that any leaks occurring are always from inside the enclosure to atmosphere, so that no pathogenic agents can enter the treatment cell or chamber or the like.

However, so that there may be access to facilities in enclosures of this kind and so that essential work may be carried out therein, a common technique is to use protective clothing not unlike a diving suit and permanently connected to the superficial area of the hermetic enclosure along an orifice in the walls thereof. Conventionally, protective clothing of this kind comprises a hermetic garment for covering the body, head, arms and hands; the hands are also placed in removable rubber or plastics gloves hermetically secured to the arms of the hermetic or insulating garment; consequently, after he has put on the protective clothing the operator can carry out the various operations needed inside the enclosure.

Protective clothing of the kind just outlined is very disadvantageous in cases where the operator has to work in a hermetic enclosure at a slightly higher pressure than atmospheric pressure, since even a pressure slightly above atmospheric pressure forces the protective clothing into intimate engagement with the operator's body and thus makes it very difficult for the operator to put the clothing on.

It is precisely the aim of this invention to provide protective clothing which can be used for working in a hermetic enclosure or cell or chamber or the like and which makes it possible, when the operator works in an overpressure chamber, to extend or unfold the clothing readily and to provide satisfactory working conditions for the operator — i.e., it facilitates his movements and breathing.

In the protective clothing according to the invention, of the kind comprising in known manner a hermetic garment forming an integral part of the enclosure wall and having a transparent helmet to protect the head and interchangeable gloves;

the hermetic garment has two walls — an inner wall in contact with the operator and an outer wall common to the enclosure wall, the two walls co-operating to bound an inflatable zone;

a permanent leak from the inflatable zone to the inside of the protective clothing exists by way of permeable means disposed on the inner wall, and means for permitting and adjusting the rate of leakage flow from inside the protective clothing to the ambient atmosphere are provided at at least one place of the hermetic garment, preferably near the waist or at the back.

According to the invention, therefore, injecting a breathable gas mixture into the inflatable zone has two purposes — to inflate the protective clothing and to supply the operator with breathable gas, since the clothing inner wall is formed over all or some of its surface with porous zones through which sufficient gas to enable the operator to breathe can leak into the inside of the clothing.

The usefulness of a facility of this kind will be clearly apparent; thanks to the inflatable zone, the protective clothing can be stiffened even in a slight overpressure atmosphere and thus facilitate the operator's work, since his body is not in intimate engagement with the entire superficial area of the inner wall; in some embodiments the latter can be embodied by a better material than the plasticized films normally used; in some cases, the clothing inner wall can be embodied by close-woven permeable cloth.

According to another feature of the invention, inflation of the inflatable zone between the inner and outer walls is limited by the two walls being interconnected at a number of places, for instance, by weld lines distributed over the garment surfaces.

Porosity of the inner wall can be provided in various ways, always provided that the perviousness of the inner wall to the breathable gas responsible for inflation is sufficient to produce a pressure loss high enough for the operator to breathe at a pressure very slightly above the pressure in the enclosure.

In a first variant, the porous inner wall of the garment consists entirely of a close-woven cloth pervious to the respiratory gas responsible for inflation. In a second variant, the garment inner wall comprises a hermetic material, such as a plasticized film or a plastics-coated cloth, over most of its superficial area but in some regions has cloth zones for the local passage of the respiratory gas responsible for inflation. In a third variant, the garment inner wall is hermetic and perviousness to the respiratory gas responsible for inflation is by way of a number of apertures. Advantageously in the two latter variants, the local leakage zones for the respiratory gas are disposed under the armpits, at the wrists, near the neck, on the thighs and at the ankles — i.e., at the places usually associated with the heaviest transpiration.

According to the invention, the clothing interior must communicate by way of a slight and controlled leak with the environmental atmosphere for evacuation thereto of the respiratory gases and of the operator's sweat. There are various ways and means of achieving this according to the invention. For instance, communication between the inside of the clothing and the ambient atmosphere can be by way of a calibrated valve disposed on the garment inner wall, the valve being calibrated to maintain the internal pressure at the required value very slightly above the pressure in the chamber. This solution is very useful, more particularly when the protective clothing covers the entire body and is closed hermetically thereon. More particularly in cases in which the protective clothing covers only the top of the

body outside the chamber, limitation of the rate of flow of the breathable gas responsible for inflation as necessary to keep the inside of the clothing at a slightly higher pressure than the enclosure can be achieved by means of a bib or apron which is welded to the clothing and which engages around the operator's hips and has an elastic band at the bottom. In this embodiment the rate of leakage flow can be controlled by varying the tightness with which the elastic band grips the operator. A similar system — i.e., an apron welded to the clothing and having an elastic band — may also be advantageous in cases where protective clothing which completely covers the whole body is in two separate parts — i.e., a blouse-like part and trousers. In this case the trouser band or belt can perform the function of the elastic band described with reference to the previous embodiment.

In addition to its chief advantage provided by inflation of the structure, the protective clothing according to the invention has the two following advantages;

the breathable gas responsible for inflation can be supplied to the between-walls space at a low pressure because the area on which the pressure is operative is so large. In practical terms, this means that the inflatable zone can be supplied by means of an ordinary fan and no compressor is needed. Also, since the inflatable zone can, if required, be supplied with biologically filtered respiratory gases, there is no risk of contamination of the hermetic enclosure should the garment outer wall be accidentally torn.

Although the protective clothing according to the invention is of use more particularly for working in an enclosure in which the pressure is above the environmental atmosphere, it can also be very useful for working in a hermetic enclosure in which the pressure is below the pressure of the ambient atmosphere. In negative-pressure working the operator breathes at a pressure below the pressure of the ambient atmosphere, and the consumed respiratory gases must leak away directly from inside the clothing to the inside of the hermetic enclosure, for instance, by way of a valve providing a direct communication between the inside of the clothing with the inside of the enclosure. In this case, therefore, there must be no leakage from atmosphere to inside the clothing, and so the clothing must contain the operator's body — or that part thereof covered by the clothing — in a very sealing-tight manner. There are various ways of achieving this state of affairs, *inter alia* by means of sticky tapes. One advantage of operating in this way is that very considerably negative pressures can be used, the only limitation being physiological and not mechanical, for inflation of the inner zone considerably offsets the risks of the protective clothing bursting due to the negative pressure.

The invention will in any case be better understood from the following non-limitative description of three embodiments, reference being made to the accompanying drawings wherein:

FIG. 1 is a basic diagram serving to give an idea of pressure distribution in protective clothing for protecting just the top half of the operator working in an enclosure at a slightly higher pressure than the ambient atmosphere;

FIG. 2 is a detailed view of the protective clothing of FIG. 1;

FIG. 3 shows an alternative embodiment of the protective clothing according to the invention for use in an overpressure chamber, the clothing being a full suit which fully covers the operator's whole body, and

FIG. 4 is a pressure distribution diagram for a half-suit for working in an enclosure at a pressure slightly below the ambient atmosphere.

Referring to FIG. 1, it is required to protect a hermetic enclosure or chamber or cell or the like 1 from possible external contamination; to this end, chamber 1 is pressurized to e.g. about +15 mm water column above the outside pressure. Wall 2 of chamber 1 is formed with an aperture 3 around which outer wall 4 of protective clothing 5 engages hermetically; according to the invention, wall 4 forms an extension of wall 2 without any break in sealing tightness. The clothing 5 is a half-suit which covers the top half of an operator 6 and comprises a double-walled garment comprising the outer wall 4 previously mentioned and an inner wall 7. Between the two walls 4, 7 is an inflatable zone which a supply line 8 connects to the outside. Suit 5 also includes a rigid transparent helmet 9 which bears in sealing-tight manner on the operator's shoulders, rubber gloves 10 and, at the bottom of the bust, an apron 11 which extends the inner wall downwardly at the base of the bust and an elastic band 12 clamps around the operator's hips. According to the invention, inner wall 7 has a number of porous zones 13—17 through which there can be some gas flow between the inflatable zone and the inside of the clothing.

Pressure distribution throughout the system is as follows: if the chamber 1 is at a pressure of e.g. +15 mm water column relatively to the ambient atmosphere, respiratory gases are introduced through line 8 into the intermediate zone at a pressure of +40 mm water column; this pressure, which is appreciably higher than the pressure in chamber 1, immediately inflates and stiffens the protective clothing, thus enabling the operator to don it readily. Also, there can be a controlled leakage of the respiratory gases through the porous zones 13—17 into the inside of the clothing 5 where the pressure is about +18 mm water column. Exhaled gases and the operator's sweat can leak away to atmosphere via the joint provided by the elastic band on the operator's hips; as an indication, this rate of flow is of the order of from 10 to 20 m^3/h.

FIG. 2 shows the various parts of FIG. 1 in greater detail. More particularly apparent is the known two-groove system 18 for a hermetic and releasable securing of the gloves 10 to the sleeves of the clothing 5. Also visible are weld lines 19 along which, according to the invention, the clothing inner and outer walls are welded together to limit expansion of the intermediate inflatable zone. Also visible in FIG. 2 is a weld line 20 along which the apron 11 is secured to the double walls of the actual garment.

FIG. 3 shows an alternative form of protective clothing according to the invention for use in a chamber 1 at a higher pressure than atmosphere. In this embodiment the protective clothing 5 completely envelops the operator's body and the clothing outer wall 4 is extended by a flexible wall 21 bounding an access corridor or passage or the like 22 through which the operator can get into the clothing and which is deformable so that he can move about in the chamber 1. Means which are not shown in FIG. 3 can, if necessary, be provided to stiffen the passage 22 against the overpressure tending to compress the walls.

In this embodiment the clothing 5 closes on the operator's back by a diaphragm 23; the same is closed non-hermetically at a place 24 which is disposed in the passage 22 and through which the exhaled gases leak away to atmosphere.

In the example shown in FIG. 4 the chamber 1 is at a negative pressure of something like −20 mm water column relatively to atmosphere. The protective clothing 5 is closed hermetically, e.g. by means of adhesive tapes, along the line 12 around the operator's hips; the respiratory gas responsible for inflation is introduced through line 8 at a pressure of +20 mm water column, the operator breathes at a pressure of substantially −15 mm water column, and in this embodiment exhaled air leaks away to the hermetic chamber 1 through a valve 25, which accordingly provides direct communication between the inside of the clothing and the chamber 1 via the inner and outer walls of the garment. The advantage of a system of this kind over conventional single-walled clothing is that the negative pressure can be taken to the limit of physiological resistance without any risk of the clothing exploding, since the pressure variation between the inside of the clothing and the inside of the chamber 1 is always kept at a very reduced value.

I claim:

1. Protective clothing for an operator working in a hermetic enclosure at a positive pressure to the ambient atmosphere comprising a wall for the enclosure, a hermetic garment forming an integral part of the enclosure wall and having a transparent helmet to protect the head and interchangeable gloves,

two walls for said garment including an inner wall in contact with the operator and an outer wall common to the enclosure wall, the two walls co-operating to bound an inflatable zone;

permeable means disposed on the inner wall providing a permanent leak from the inflatable zone to the inside of the protective clothing, and means for adjusting the rate of leakage flow from inside the protective clothing to the ambient atmosphere are provided on the hermetic garment.

2. Protective clothing according to claim 1 said permeable means permitting permanent leakage from the inflatable zone to the inside of the protective clothing being a porous inner wall.

3. Protective clothing according to claim 1 wherein the means for permitting and adjusting the rate of leakage flow from inside the protective clothing to the ambient atmosphere is a calibrated valve disposed on the inner wall and through which the interior of the protective clothing communicate with the ambient atmosphere.

4. Protective clothing according to claim 1 wherein the means for permitting and adjusting the rate of leakage flow from inside the protective clothing to the ambient atmosphere includes an apron consisting of a downward extension of the inner wall from a point below the said inflatable zone and adapted to surround the base of the bust of the operator, and resilient clamping means adjacent the bottom of said apron for clamping the apron to the operator's hips.

5. Protective clothing according to claim 1 wherein the means permitting permanent leakage from the inflatable zone to outside the protective clothing are apertures in the inner wall.

6. Protective clothing according to claim 5 wherein the apertures are distributed in regions disposed in the areas of the garment adjacent the armpits, the wrists, the neck, the thighs, and the ankles of the operator.

7. Protective clothing for an operator working in a hermetic enclosure at a negative pressure to the ambient atmosphere, comprising a wall for the enclosure, a hermetic garment forming an integral part of the enclosure wall and having a transparent helmet to protect the head and interchangeable gloves,

two walls for said garment including an inner wall in contact with the operator and an outer wall common to the enclosure wall, the two walls cooperating to bound an inflatable zone;

permeable means disposed on the inner wall providing a permanent leak from the inflatable zone to the inside of the protective clothing, and means for adjusting the rate of leakage flow from inside the protective clothing to inside the hermetic enclosure are provided on the hermetic garment.

8. Protective clothing for an operator working in a hermetic enclosure at a positive pressure to the ambient atmosphere comprising a wall for the enclosure, a hermetic garment forming an integral part of the enclosure wall having a transparent helmet to protect the head and interchangeable gloves, two walls for said garment including an inner wall in contact with the operator and an outer wall common to the enclosure wall, the two wall co-operating to bound an inflatable zone, permeable means disposed on the inner wall providing a permanent leak from the inflatable zone to the inside of the protective clothing, means for adjusting the rate of leakage flow from inside the protective clothing to the ambient atmosphere on the hermetic garment said permeable means being a porous inner wall, said porous inner wall being a closewoven cloth perveous over its entire superficial area to the respiratory gas responsible for inflation.

9. Protective clothing for an operator working in a hermetic enclosure at a positive pressure to the ambient atmosphere comprising a wall for the enclosure, a hermetic garment forming an integral part of the enclosure wall and having a transparent helment to protect the head and interchangeable gloves, two walls for said garment including an inner wall in contact with the operator and an outer wall common to the enclosure wall, the two walls co-operating to bound an inflatable zone, permeable means disposed on the inner wall providing a permanent leak from the inflatable zone to the inside of the protective clothing, and means for adjusting the rate of leakage flow from inside the protective clothing to the ambient atmosphere on the hermetic garment said permeable means being a porous inner wall, the inner wall being a hermetic material having in some regions cloth zones for the local passage of the respiratory gas responsible for inflation.

10. Protective clothing according to claim 9 wherein the cloth zones are disposed in the areas of the garment adjacent the armpits, the wrists, the neck, the thighs, and the ankles of the operator.

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