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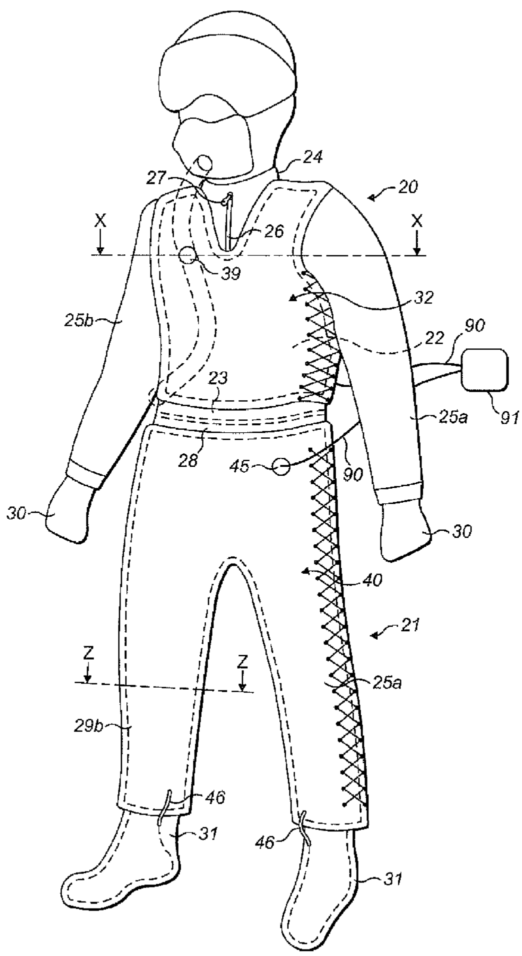

FIG. 1

(57) Abstract: An aircrew ensemble comprising a garment (20, 21) for covering at least a part of a body of a wearer and an inflatable counter-pressure bladder (33, 41), carried by the garment (20, 21). The inflatable counter-pressure bladder (33, 41) is formed from a moisture permeable material allowing the passage therethrough of perspiration from the wearer's body.

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AIRCREW ENSEMBLES

The invention relates to aircrew ensembles worn by aircrew in flight.

Aircrew such as pilots wear an ensemble including a protective suit when flying in aircraft. Traditionally the suit is either a single piece suit combining both jacket and trousers in a single garment or it is a two piece suit with a separate jacket and trousers.

The ensemble may include also special equipment (aircrew life support equipment – ALSE) that protects the wearer against the effects of g-acceleration or altitude and other potentially damaging factors. In this case, the ensemble provides an outer layer that holds and positions and restrains inflatable counter pressure bladders. These bladders can provide counter pressure to the legs when the wearer is being accelerated to reduce the effect of blood pooling in the lower limbs and/or can provide counter pressure to the chest to counteract the effect of breathing pressurised gas when at altitude. Examples of this are shown in WO-A-2007/111981 and in US-A-6325754.

An inflatable chest counter pressure bladder is either incorporated into a vest or a jacket type garment which is worn by the pilot over the flight suit, or the bladder is incorporated into the jacket part of the flight suit. Inflatable lower G bladders are either incorporated into a lower G garment, which is typically worn over the flight suit, or the bladders are incorporated into the trouser section of the flight suit.

In some cases the bladders are made of a textile (nylon or polyester) which is coated with an air-holding layer of an air impermeable material such as synthetic rubber (e.g. neoprene) or thermo-plastic materials such as polyurethane (PU). Most bladders are now made of a PU coated fabric type because PU is a thermo-plastic material which can be easily welded using high frequency or radio frequency or ultrasonic welding. (Materials such as neoprene need to be glued using a solvent based adhesive which is labour intensive and has health and safety problems).

There are broadly two types of lower G bladder assemblies. First, there is a full cover bladder assembly where the inflatable area of the bladder coverage is almost all of the lower limbs and abdomen. Such an inflatable bladder assembly can also be connected at ankle level to an inflatable lining of a flight boot or an inflatable sock lining the boot, or the boot can incorporate an inflatable lining. The counter pressure can be applied directly to the limbs by providing the assembly with a restraining cover with the bladder inflating underneath the restraining cover and the restraining cover allowing the expansion of the bladder only in a direction towards the limbs. Secondly, there is a partial cover bladder assembly (also called a “skeletal” or “five bladder” assembly). In this case two or more bladders (up to 5) cover respective parts of the lower body and are positioned for example, over the leg bone (hence skeletal) and also have a bladder area over the abdomen. In this case, each bladder applies tension to a restraining cover of the assembly as it inflates, which in turn then applies the counter pressure to the limbs through the tensioned cover material.

Such bladder assemblies can be integrated into the trousers of a suit rather than being incorporated into a separate garment, as shown in WO-A-2007/111981.

All counter pressure assembles whether jackets or vests or lower G bladder assemblies of the above types have a problem of placing an excessive thermal burden on the wearer. The full cover lower G assembly is the worst in terms of the thermal burden and also has a problem of being excessively bulky. Excessive thermal burden and the consequent hyperthermia on the aircrew increases their fatigue as well as sweat loss and dehydration and reduces aircrew concentration and mission endurance. Increased core temperature also reduces tolerance to the effects of G acceleration.

According to the invention, there is provided an aircrew ensemble comprising a garment for covering at least a part of a body of a wearer and an inflatable counter-pressure bladder, carried by the garment, the inflatable counter-pressure bladder being formed from a moisture permeable material allowing the passage therethrough of perspiration from the wearer's body.

The following is a more detailed description of some embodiments of the invention, by way of example, reference being made to the accompanying drawings, in which:-

Figure 1 is a general view of an aircrew ensemble including a chest counter-pressure assembly and full cover lower G assembly,

Figure 2 is a section on the line X-X of Figure 1,

Figure 3 is a cross-section on the line Z-Z of Figure 1,

Figures 4a and 4b are alternative partial cross-sections on the line X-X of Figure 3 showing the passage of sweat through the lower G assembly in respective first and second different regimes,

Figure 5 is a similar view to Figure 1 but showing a partial cover lower G assembly,

Figure 6 is a cross-section on the line Y-Y of Figure 5 through a lower G bladder of the assembly of Figure 5,

Figures 7a and 7b are cross-sections on the line X-X of Figure 2 showing, deflated and inflated respectively, a second form of lower G bladder of the assembly,

Figures 8a and 8b are cross-sections on the line X-X of Figure 2 showing, deflated and inflated respectively, a third form of lower G bladder of the assembly,

Figure 9 is a similar view to Figure 1 but showing an aircrew ensemble with an alternative form of chest counter pressure assembly and full cover lower G assembly,

Figure 10 is a schematic view of a grill bladder for the ensemble of Figure 9,

Figure 11 is a schematic view of a finger bladder for the ensemble of Figure 9,

Figure 12 is a cross-section on the line X-X of Figure 9 showing the inflation of a chest bladder of the chest counter pressure assembly of Figure 9, Figures 13a and 13b are cross-sections on the line Y-Y of Figure 9 showing a bladder of the lower G assembly respectively deflated (13a) and inflated (13b),

Figures 14a, 14b, 14c and 14d are partial cross-sectional views of an alternative embodiment of bladder for the ensemble of Figure 9 in which the bladder is self-tightening, Figures 14a and 14c showing the bladder un-inflated and Figures 14b and 14d showing the bladder inflated,

Figure 14e is a similar view to Figures 14a, 14b, 14c and 14d but showing a known non-self tightening bladder,

Figure 15 is a similar view to Figure 1 but showing an aircrew ensemble with detachable bladders,

Figure 16a is a schematic view of a detachable chest bladder for the ensemble of Figure 15,

Figure 16b is a schematic view of a detachable leg bladder for the ensemble of Figure 15,

Figure 16c is a section on the line X-X of Figure 16a and showing the bladder of Figure 16a mounted on a jacket of the ensemble of Figure 15,

Figure 16d is a section on the line Y-Y of Figure 16b and showing the bladder of Figure 16b mounted on a lower G garment of the ensemble of Figure 15,

Figure 17 is a schematic side elevation of an aircrew in an ejector seat of an aircraft an wearing an ensemble for countering G forces of any on the kinds shown in Figures 1 to 16d and showing the flow of body fluids under G_z forces,

Figure 18 is a section on the line X-X of Figure 17 showing schematically blood vessels of the aircrew of Figure 17 in an undistended position,

Figure 19 is a similar view to Figure 18 but showing the blood vessels in a distended position as a result of G_z forces,

Figure 20 is a similar view to Figure 19 and showing the effect of a full cover lower G garment,

Figure 21 is a schematic section through part of a lower leg and ankle carrying an inflatable lower G assembly with inflation proceeding towards the ankle,

Figure 22 is a similar view to Figure 21 but showing inflation starting from the ankle,

Figure 23 is a similar view to Figure 22 but showing the progression of inflation from the ankle and the use of an inlet at the ankle,

Figure 24 is a similar view to Figure 23 and showing the further progression of inflation from the ankle,

Figure 25 is a similar view to Figures 21 and 22 but showing the application of a residual pressure to the leg,

Figure 26 is a schematic front elevation of an aircrew ensemble including a lower G bladder assembly providing the ankle inflation and residual pressure of Figures 22, 23 and 24 and showing a first form of air supply,

Figure 27a is a similar view to Figure 26 but showing a second form of air supply,

Figure 27b is a section on the line X-X of Figure 27a,

Figure 28 is a schematic front elevation of an aircrew wearing an environmental protection layer undergarment,

Figure 29 is a cross-section through part of a first form of the undergarment of Figure 28,

Figure 30 is a cross-section through part of a second form of the undergarment of Figure 28, and

Figure 31 is a cross-section on the line Y-Y of Figure 28 showing a “pass through”.

Referring first to Figure 1, the aircrew ensemble includes a flight suit that comprises an upper suit portion 20 and lower suit portion 21. The upper suit portion 20 and the lower suit portion 21 are preferably made from an inherently fireproof fabric such as NOMEX®. The upper suit portion 20 has a torso portion 22, a waist 23, a neck opening 24 and left and right arm portions 25a, 25b, respectively. The upper suit portion also has a front opening 26 closed by, for example, a zipper 27. The lower suit portion 21 has a waist 28 and left and right leg portions 29a, 29b. The suit is completed by gloves 30 and boots 31.

The upper portion 20 and the lower portion 21 may be formed in one-piece with a front central longitudinal zip or may be formed as separate parts and connected at the waist as described in our co-pending UK patent application No: 1016375.6.

The upper portion 20 carries a chest counter pressure assembly in the form of a jacket 32 containing a chest counter pressure bladder 33. Referring next to Figure 2, the jacket 32 is formed of inner and outer layers 34, 35 of non-elastic but moisture-vapour permeable material that hold the bladder 33 between them located on the chest 36 of a wearer. As seen in Figure 2, the outer layer 35 is formed by front and rear portions 35a, 35b that are interconnected by two rows of side lacing 38a, 38b located at respective opposite sides of the outer layer 34 to allow the circumferential length of the jacket 32 to be adjusted to the correct fit for a wearer. This is important for reasons that will become apparent below. The bladder 33 is formed of a moisture vapour permeable material that allows sweat to evaporate through the material. The bladder 33 has an inlet 39 for connection to an inflation hose that, in turn, is connected to an inflation system for supplying air under pressure to the bladder 33, in a manner to be described below. The inflation system may be part of a breathing system for the wearer.

Referring once again to Figure 1, and also to Figure 3, the lower portion 21 carries a lower G asssembly 40 assembly a lower G bladder 41. The lower G assembly 40 is formed by inner and outer layers 42, 43 of non-elastic but moisture vapour permeable material that hold the lower bladder 41 between them and located around the legs of a wearer (one of which is shown in Figure 3) and over the abdomen of the wearer. As seen in Figure 3, the outer layer 43 is formed with a side opening whose edges are interconnected by a row of side lacing 44 located to allow the circumferential length of the jacket outer layer 43 to be adjusted to the correct fit for a wearer. This is important for reasons that will become apparent below. The bladder 41 is formed of a moisture vapour permeable material that allows sweat to evaporate through the material. The bladder 41 has an inlet 45 for connection to an inflation hose 90 that, in turn, is connected to an inflation system 91 for supplying air under pressure to the bladder 41, in a manner to be described below.

The lower G bladder 41 has also an outlet 46 at each ankle connected to respective bladders (not shown) in respective boots 31.

In use, an aircrew such as a pilot dons the suit with the jacket 32 and lower G garment 40. The lacings 38a, 38b and 44 are tightened to ensure that the jacket 32 and the garment 40 are a close fit around the torso and the lower body portion respectively of the wearer so that, when inflated, the bladders 33, 41 apply a required restriction (see below). The inlet 39 to the chest bladder 33 is connected via a G valve (not shown) to a source of pressurized air that, as described above, which may also be the aircraft breathing circuit. The inlet 45 to the lower G bladder 41 is also connected via a G valve (not shown) to a source of pressurized air. Whilst in flight, the chest bladder 33 and the lower G bladder 41 are pressurised and depressurised through the aircraft's pressurisation system and the

G valve. This happens as the aircraft experiences G and the valves open and close at pre-determined values of G.

Since the material of the two bladders 33, 41 is a moisture-vapour permeable or "porous" or "semi permeable" material, it is possible for sweat to evaporate through the layers and therefore to provide evaporative cooling even when the bladders are not connected to an air supply. See Figure 4a in which the arrow 47 shows the passage of sweat vapour through the G garment 40. This cooling effect can be further enhanced in other ways. When air is supplied to the bladders 33, 41, this ventilates the G garment bladders 33, 41 and increases the evaporative effect through them, since the material being used is moisture vapour permeable. If the lower G bladder 41 is connected to an air pump or blower when not in flight, this can also be used to ventilate the lower G bladder 41 and again increases the evaporative cooling effect. This is shown in Figure 4b where arrows 48 shows circulating air moving sweat vapour around the bladder 41 before it passes through the bladder 41.

Referring next to Figure 5, an alternative form of the lower G bladder has the lower G bladder 49 in the form of a partial cover bladder. Parts common to Figures 1 to 4 and to Figure 5 are given the same reference numerals and will not be described in detail.

The partial cover lower G bladder 49 is formed by a first bladder portion 49a that extends across the front abdomen of a wearer and then down the front of the thighs of the wearer to just above the knee. Second and third bladder portions 49b, 49c extend over respective left and right shins of the wearer. These bladder portions 49a, 49b and 49c are interconnected and connected to a source of pressurised air as described above in relation to Figures 1 to 4.

Referring next to Figure 6, the shin bladders 49b, 49c extend only around the front of the leg 50 of the wearer. When the bladders 49b, 49c are inflated, the diameter of the outer layer 43 increases and so draws the non-elastic outer layer 43 against the rear of the leg 50 of the wearer. This, together with the pressure applied by the bladder 43b, 43c to the front of the leg, provides the constriction necessary to counter G forces.

In the embodiments of Figures 1 to 4, the bladder 41 is sized to extend exactly around the associated body part. This need not be the case. If the material of the bladder 41 is inelastic, the bladder 41 may be sized so that when uninflated the bladder 41 is of greater diameter than the body part it encircles (see Figure 7a). Thus, when inflated, the bladder 41 is not subject to hoop stress (see Figure 7b) and the tension is taken up by the seams of the outer layer 43 and not by the seams 41a of the bladder 41, which are weaker than the seams of the outer layer 43.

Alternatively, if the bladder 41 is made from an elastic material, it can be sized so that, when uninflated, it is of lesser diameter than the limb 50 it encircles so as to reduce the bulk of the garment (see Figure 8a). When inflated (see Figure 8b), the circumferential length increases to surround the limb 50.

The principles described above with reference to Figures 7a, 7b and 8a, 8b are not limited to bladders such as the lower G bladders 33, 41 that, when inflated, extend all around a body part. The same principle could be applied to other bladders, such as the chest compression bladder 33, by containing the bladder in a pocket formed in the associated garment. Where the bladder is of inelastic material (such as in Figures 7a, 7b), the pocket is smaller than the uninflated bladder so that, when inflated, the inflated bladder is confined by the pocket and tension is taken by the material of the garment. If the bladder is of elastic material (Figures 8a, 8b) then the pocket is larger then the uninflated bladder, with the bladder, on inflation, expanding to fill the pocket.

There are a number of ways of designing a bladder 33, 41 to reduce further the thermal burden. These can be used with or without the permeable materials previously described.

Referring next to Figure 9, parts common to Figures 1 to 8 and to Figure 9 are given the same reference numerals and will not be described in detail. In this embodiment, the chest bladder 33 and the lower G bladder 41 are provided with elongate slots 51 to form "grill" bladders 33, 41 – seen schematically in Figure 10. Alternatively, as seen schematically in Figure 11, they can be formed as a series of inter-connected bladder tubes 52 ("fingers") connected by a manifold such that there are spaces formed by the bladder slots 51 or by spaces 52a between the fingers 52b that allow air movement through the spaces 51, 52a when the bladder 33, 41 is deflated and therefore evaporative cooling of sweat is assisted when uninflated. This is shown in more detail in Figure 12 for the chest bladder 33 where it will be seen that, when the bladder 33 is uninflated, evaporative cooling can take place through the slots 51 or spaces 52a. .

However when inflated, the bladder 33, 41 expands laterally and outwardly to provide the continuous counter-pressure needed (seen in broken line in Figure 12 for the chest bladder 33 and in Figures 13a (uninflated) and 13b (inflated) for the lower G bladder 41).

In these embodiments, therefore, the bladder 33, 41 has an uninflated area and is formed, inwardly of the periphery of that area, with one or more open gaps that allow air movement through the gap or gaps to increase evaporative cooling. The or each gap closes or substantially closes on inflation of the bladder 33, 41.

Referring next to Figure 14a to 14e, the grill or finger bladders 33, 41 can be made with an outer layer 53 of non-stretch material and an inner layer 54 of elastic material. When such a bladder 33, 41 is inflated, the outer layer 53 will bulge (because it is non-stretch) and so reduce the circumferential length of the bladder 33, 41. The inner layer 54 will stretch (rather than bulge) and so apply even pressure to the flesh (see Figures 14b and 14d). This helps to reduce a problem of traditional G bladders made wholly of non-stretch materials that, when they are inflated, the cover of the bladder "balloons" both inwardly and outwardly. This "ballooning" causes restriction in the cockpit due to the bulk of the inflatable section increasing and can interfere dangerously with the pilot controls. This effect is greatly reduced in this dual material "finger" or "grill" bladder design. It is only by the inner layer 54 being elastic that the inner/internal space is filled and the pressure surface is then applied evenly to the body part. If this is not applied evenly then this leads to petechial haemorrhaging (see Figure 14e) where the surface vessels burst under the skin in the areas where uneven pressure produces areas of insufficient pressure to counteract the increased internal pressure in the vessels.

In the embodiments described above with reference to Figures 1 to 14, the bladders 33, 41, 49 are all carried between inner and outer layers 34, 35 and 42, 43 of a jacket 32 or lower G garment 40. In the case of partial cover bladders 49a, 49b and 49c, the bladders 49a, 49b and 49c are secured by, for example, stitching to the outer layer 43. This is not necessary.

Referring next to Figures 15 and 16a, 16b, 16c and 16d, parts common to these Figures and to Figures 1 to 14 are given the same reference numerals and will not be described in detail. In this embodiment, the jacket 32 and the lower G garment 40 are formed from a single layer of material. The chest bladder is formed by a single front bladder 56 that is attached to the jacket 32 by releasable fastenings 57 such as press studs or touch close fasteners or zippers or other mechanical means (see Figure 16b). Similarly, the lower G bladder 41 is attached to the lower G garment 40 by releasable fastenings 57 such as press studs or touch close fasteners or zippers or other mechanical means (see Figure 16b).

As seen in Figures 16c and 16d, the bladders 56, 41 may be covered with an inner lining 59 that forms a pocket with the associated garment that can be opened at one side 59a to allow insertion of the bladder 54, 41.

If the bladders 33, 41 of the suit described above with reference to Figures 1 to 14 are damaged or punctured, then the suit becomes non functional and normally has to be replaced in its entirety or has to be stripped down into component parts and reassembled when the faulty part is replaced. The bladders 33, 41 may need to be taken apart and then replaced as the suit is being rebuilt. The bladders 33, 41 are particularly vulnerable to damage caused by wear and tear as they are constantly being inflated and deflated and being worn in a suit in which mechanical action inside the cockpit can easily damage the bladders 33, 41.

The arrangement of Figures 15 and 16a, 16b, 16c, 16d, in which the bladders 56, 41 are of modular design such that they can be easily replaced or exchanged by hand and without any special tools, reduces substantially the cost of servicing and maintenance of such bladder counter pressure systems. In addition, it allows the ensemble to be worn either with or without bladders 56, 41 so making the ensemble more widely functional.

The feature of removable bladders of Figures 15 and 16 can also be used in conjunction with the bladders 33, 41 of the full cover suit of Figures 1 to 4.

Referring next to Figures 17, 18, 19 and 20, when an aircrew in an aircraft that experiences high G_z acceleration is subjected to high G forces when in a curved flight, then the body fluids (in particular the blood, more particularly venous blood) are accelerated in the z direction (i.e. from head to toe) (see Figure 17). As the mass of the fluid is increased by the acceleration, so the hydrostatic pressure of the fluid is increased progressively and linearly in the z direction (see also Figure 17). As the walls of human blood vessels 65 are essentially "elastic", then the volume of the vessels 65 is increased in the z direction progressively and linearly i.e. in the lower limbs (see Figures 18 and 19). As a consequence of this, the volume of blood overall is increased in the lower limbs (blood pooling) and decreased in the upper part of the abdomen as the volume of blood in the body is constant. Decreasing the volume of blood in the upper part of the abdomen also leads to a decrease of blood volume in the head. At the same time as the blood is being accelerated in the z direction, the heart, aorta and other large vessels of the abdomen are also displaced in a z direction which adds to a further reduction in the total blood volume in the upper part of the body and therefore in the head. (This is known as the caudal effect). As a consequence of reducing the available blood pressure and volume in the brain (and in particular the supply of blood to the eyes), a dangerous lowering of the blood oxygen concentration in the brain occurs. This leads first to a loss of colour in the vision and then a loss of peripheral vision (grey out and tunnel vision). Ultimately G induced loss of consciousness (GLOC) occurs. This clearly has a detrimental affect on the aircraft pilot and ultimately the loss of the aircraft and the death of the aircrew may follow.

To counteract this negative affect of blood pooling in the lower limbs, counter pressure garments to cover the lower limbs have been developed as described above and, for example, with reference to Figures 1 to 16 and in WO 2007/111981 and US-A-6325754. As seen in Figure 20, the effect of such a garment 66 is to restrict the leg blood vessels 65 and so force blood back into the upper part of the body.

As well as the use of counter pressure garments, aircrew are trained to carry out physiological manoeuvres (Anti-G Straining Manoeuvres – AGSM) and this is done by tensing the voluntary muscles and pressurising the chest/lungs, the action of both of these being to reduce the effect of G acceleration on the body. This is, however, very tiring and limits the G endurance that can be tolerated and it also limits voice communication and voice command whilst straining under AGSM. The goal of a G protection garment and its development is to limit the amount of pilot effort required by maximising the protection offered by the garment and therefore increasing overall G endurance. Additionally, pilots can also breathe pressurised gas (Positive Pressure Breathing for G, PPBG) such that the thoracic pressure/thoracic blood pressure is increased causing more dissolved oxygen to be carried to the brain.

One type of counter pressure (anti-G) garments is gas pressurised by inflating gas holding bladders from an aircraft compressor or compressed gas supply and which are restrained around the lower limbs and lower abdomen by covers which apply a counter pressure as described above with reference to Figures 1 to 16 and therefore limit the "blood pooling" in the lower limbs and limit the z displacement of the heart and major blood vessels (caudal effect) (see Figure 20). Referring next to Figure 21, in such a suit, an inflation pressure front 80 travels down the lower G bladder 41, 49, moving in a direction opposite to that of the venous blood to apply the pressure to the leg (see also Figure 20) that limits blood pooling.

Referring next to Figures 22 and 23, the suit described above with reference to any of Figures 1 to 20 may be modified so that the air supply applies the gas inflation/pressurisation to the lower G bladder 41, 49 at the ankles first ("ankle inflation") rather than applying the pressure first at the abdominal level. This benefits the wearer by tending to increase the venous blood return up the lower limbs and thereby increasing the blood volume/pressure in the upper body and head. The pressure point 81 from the applied air thus starts at the ankle (see Figure 22) and continues up the leg (see Figure 23) in the same direction as the venous blood until the bladder reaches an operating pressure.

In addition, the air supply may be modified to apply continuously a residual "gas pressure" to the lower G bladders 41, 49 and thus constriction to the lower limbs such that blood pooling is continuously reduced in the lower limbs. (This is termed "start-pressure" and is less than the operating pressure). This is shown in Figures 24. This benefits the wearer by continuously reducing blood pooling and overcomes the "lag" phase in the G garment inflation system. This may be supplied automatically or may be controlled by the wearer utilizing a squeezable bulb 73 (see Figure 25).

Referring next to Figure 26, the air supply to the ankles may be through two external hoses 60a and 60b connected by a single hose 61 to the air supply. Each hose 60a, 60b runs along a respective leg of the lower G garment 41 to a respective inlet 62a, 62b at an associated ankle. Alternatively, as seen in Figures 27a and 27b, the hoses 60a, 60b may run through the interior of the lower G bladder 41 (see Figure 27b) to the respective inlets 62a, 62b.

Traditionally aircrew who have to leave an aircraft in an emergency (ejection or bail out etc.) are protected by special garments against the effects of cold water and cold air exposure which are worn as part of the aircrew's ensemble, if the aircrew is expected to be at risk.

These are normally of three types – a thermal protection undergarment, which is normally worn as underwear whenever the aircrew is flying in very cold conditions, a thermal protection over garment (normally called a winter land coverall) and is worn if the aircrew is flying over cold land or an immersion protection garment which is worn if the aircrew are flying over water. Therefore the aircrew selects the type of garment ensemble required to meet a range of mission requirements (e.g. over land or over water) and the relevant environmental conditions (hot or cold climate etc.). A considerable number of different ensembles are therefore required in order to meet different mission roles and to accommodate different aircraft types. This leads to an excessive logistical burden and cost as well as the problems of incompatibility between the different garment ensembles and the flight equipment as well as the different aircraft types.

In any of the embodiments of the invention described above with reference to the drawings, or in similar known ensembles, a single protection undergarment may worn whenever the environmental conditions require it (hot or cold climate) and is suitable for any mission role and in any aircraft type ("multi mission/multi platform commonality"). This single undergarment, which is called an Environmental Protection Layer – EPL therefore fulfils the multiple roles of the other garment ensembles and therefore has a number of specialised aspects to it.

Referring to Figure 28, the undergarment 63 is made of a material that is relatively elastic and includes a "four-way stretch". This allows it to be donned easily but at the same time is not over-size and therefore can be made as a slim-fitting garment. This is very important as it is worn underneath the flight suit and cannot afford to be bulky. Because the material is elastic, the garment can be slim fitting but will not restrict the body movement of the wearer.

The undergarment 63 covers the torso, arms and legs of the wearer and is provided with a neck seal 69, wrist seals 70 and ankle seals 71. Alternatively, as seen on the right-hand leg in Figure 28, the undergarment 63 may be formed with integral socks 72. A zipper 73 allows the undergarment 63 to be donned and doffed.

The material of the undergarment 63 is moisture vapour permeable (MVP) but at the same time waterproof and therefore allows perspiration to pass through so that when an aircrew is wearing the undergarment 63 there is not an excessive heat burden that could lead to hyperthermia. For example if an aircrew is in an aircraft on a hot sunny day but flying over cold water, then he/she could become hyperthermic before he/she enters the cold climate area.

Referring next to Figure 29, the MVP film 66 is combined with a thermal barrier 67 into one material to create the undergarment 63. The thermal barrier 67 may be merino wool knit coated with the MVP film 66, for example an MVP polyurethane film. This allows the garment to be easily welded rather than being sewn and then sealed with waterproof tape. Merino wool has a number of particular benefits but other types of thermal insulation material could be used. Merino wool provides very effective thermal insulation against cold even when damp or wet. In addition, it has a relatively low thermal burden when worn in a hot climate. Merino wool is a “hollow microfibre” which contributes to its excellent qualities. Further, it is naturally biostatic and therefore does not smell, it has a good feel next to the skin and good “drape” and it launders well without “pilling”.

Referring next to Figure 30, if the undergarment 63 is required to be fire retardant (flame proof), then an outer layer 67 of an inherently flame proof material (e.g.

Nomex) can be applied to the bilaminate of the MPV film 66 and the thermal layer 67 (as an a trilaminate). This outer layer 67 is not normally required as the EPL is worn underneath the flight suit, such as described in our co-pending UK Patent Application No. 1016375.6 which provides the required protection against flame, dirt, grease, etc.

The material of the undergarment 63 can also be made to be resistant to chemical, biological and warfare agents (CBRN) and the undergarment 63 can therefore provide protection against environmental conditions as well as against CBRN. The chemical, biological repellency can be created by using various types of plasma enhancement or other associated nano technologies.

There are also a number of other features that can be included in the undergarment 63. There are "pass throughs". These are a means of making a waterproof connection from an item worn on the inside of the suit to the exterior of the suit. Referring again to Figure 27, this might include a liquid or air cooling garment 64 worn underneath the undergarment 63 and connected to a power unit worn on the exterior allowing for a cooling capability to the aircrew. In addition, referring to Figure 30, a bladder relief device (BRD) 68 can be worn under the undergarment 63 and can be connected to a disposal bag worn on the exterior of the undergarment 63.

If the undergarment 63 is going to be worn in exceptionally cold conditions, then an additional thermal undergarment can be worn underneath the undergarment 63 or an electrically heated (electro-resistive) pad or panel or vest can be worn beneath the undergarment 63 and run off a power source such as a battery and can therefore provide additional heating in extreme conditions. This pad or panel or vest can be attachable/detachable to the undergarment 63 or it can be integrated into it or indeed it can be included as a separate garment.

Having such a single undergarment 63 that allows for a multi mission/multi role commonality reduces substantially logistical burden and cost as well as reducing the overall bulk of the garment ensemble that is worn. Traditionally, immersion protection garments are made over-size so that they can be easily donned (this is difficult because of the seals and waterproof zippers etc.). Also the garments need to be over-size so that there is no restriction to movement. These disadvantages are avoided in the undergarment 63 described above with reference to the drawings.

CLAIMS

1. An aircrew ensemble comprising a garment (20,21) for covering at least a part of a body of a wearer and an inflatable counter-pressure bladder (33, 41, 49, 56), carried by the garment, the inflatable counter-pressure bladder (33, 41, 49, 56) being formed from a moisture permeable material allowing the passage therethrough of perspiration from the wearer's body.

2. An ensemble according to claim 1 in combination with an inflation system (90) for inflating the bladder (33, 41, 49, 56) when a threshold G-force is detected acting on the wearer's body, the inflation system (91) also being operable in the absence of said threshold G-force to ventilate the bladder (33, 41, 49, 56) to increase the evaporative cooling effect on the wearer's body.

3. An ensemble according to claim 1 or claim 2 wherein the garment (20, 21) includes at least one layer of inextensible material (35, 43) inflation of the bladder (33, 41, 49, 56) causing the bladder (33, 41, 49, 56) to act against the layer to apply counter-pressure to the wearer's body.

4. An ensemble according to claim 3 wherein the garment includes two layers (42, 43), the inflatable bladder (33, 41, 49, 56) being located between said two layers (42, 43).

5. An ensemble according to claim 3 or claim 4 wherein the inflatable bladder is a chest compression bladder (33) and the garment (20) covers the torso of a wearer.

6. An ensemble according to any one of claims 3 to 5 wherein the inflatable bladder is a lower G bladder (49) and the garment (21) covers the abdomen and legs of a wearer.

7. An ensemble according to claim 6 wherein the lower G bladder (41) extends across the abdomen and around the legs of the wearer.

8. An ensemble according to claim 6 wherein the lower G bladder includes a first portion (49a) for extending over the abdomen and thighs of a wearer and second portions (49b, 49c) extending over respective shins of a wearer.

9. An ensemble according to any one of claims 3 to 8 wherein the bladder (41) is made from an elastic material so that, when the bladder (41) is deflated, the bladder extends only partially over an associated body part of a wearer to allow evaporative cooling from the uncovered body part, inflation of the bladder causing elastic lengthening of the bladder to extend the bladder over the whole area of the associated body part.

10. An ensemble according to any one of claims 3 to 8 wherein the bladder (41) is made from an inelastic material, the bladder (41) having an area greater than area of the associated body part of the wearer and being confined by the garment (21) so that, when inflated, the bladder has the area of the associated body part, so that the material of the bladder is untensioned, the tension being taken by the garment (21).

11. An ensemble according to claim 9 or claim 10 wherein the bladder is a lower G bladder (41), and the associated body part is a leg of a wearer, and the area is the circumference of the leg.

12. An aircrew ensemble comprising a garment (20, 21) for covering at least a part of a body of a wearer and an inflatable counter-pressure bladder (33) carried by the garment, the bladder having an uninflated area and being formed, inwardly of the periphery of that area, with one or more open gaps (51, 52a) to allow evaporative cooling there through, the or each gap (51, 52a) closing or substantially closing an inflation of the bladder (33).

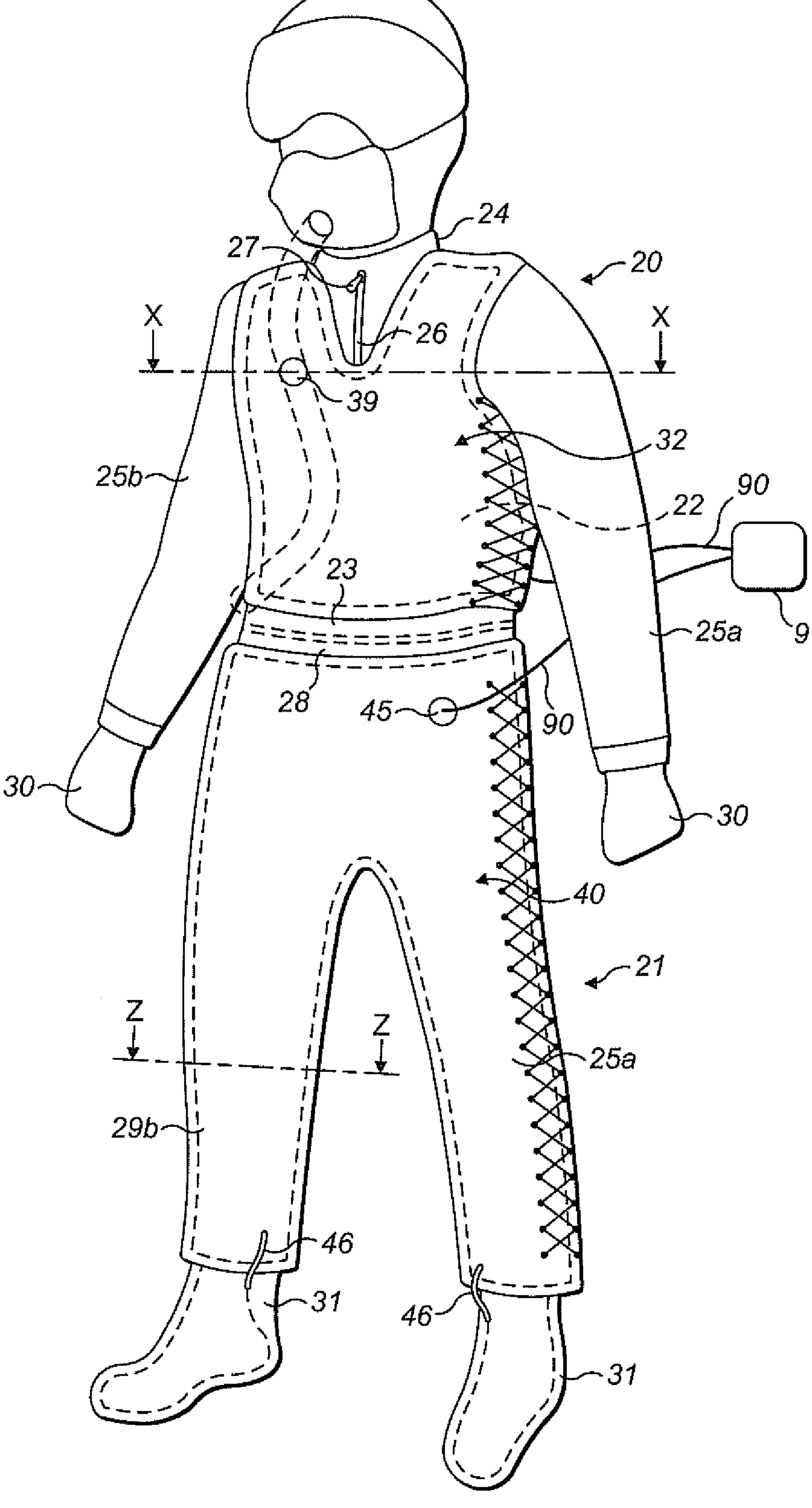
13. An ensemble according to claim 12 wherein the bladder (33) is formed with one or more slots (51), the or each slot (51) defining a respective open gap when

the bladder (33) is uninflated, the or each gap (33) closing on inflation of the bladder (33).

14. An ensemble according to claim 12 wherein the bladder (33) is formed with two or more tubes (52b), adjacent tubes (52b) being separated by an associated said gap (52a) when uninflated, the gap closing on inflation of the bladder (33).

15. An ensemble according to any one of claims 12 to 14 wherein the bladder (41) is for extending around a leg of a wearer and is formed from connected inner and outer layers (53, 54), the inner layer (54), in use, being closer to a wearer's body than the outer layer (53), the inner layer (54) being made of an elastic material and the outer layer (53) being made of an inelastic material, so that, an inflation around a leg of a wearer, the outer layer (53) bows and so decreases the circumferential length of the bladder (41) to tighten the bladder (41) around a leg and to close or substantially close the or each gap, the inner layer (54) conforming elastically to the shape the portion of the leg contacted by said inner layer (54) to apply pressure evenly to said leg portion.

16. An ensemble according to any one of claims 12 to 15 wherein the material of the bladder is in accordance with any one of claims 1 to 11.


24
27
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X
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25b
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Z
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29b
46
31
46
31

FIG. 1

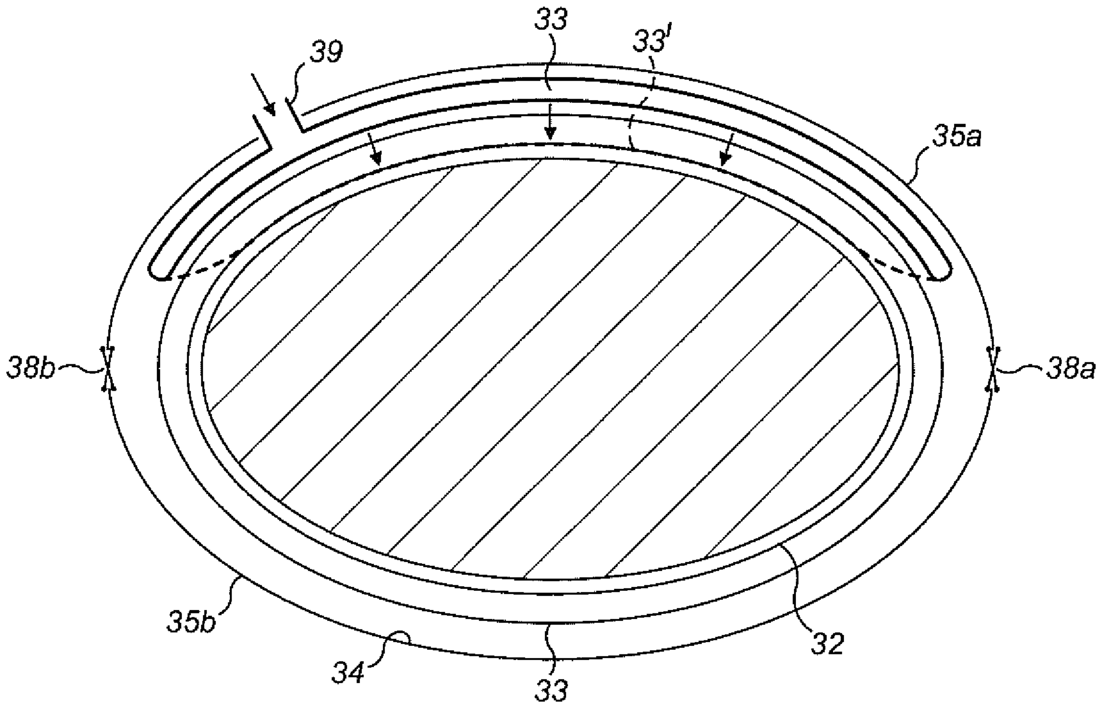

FIG. 2

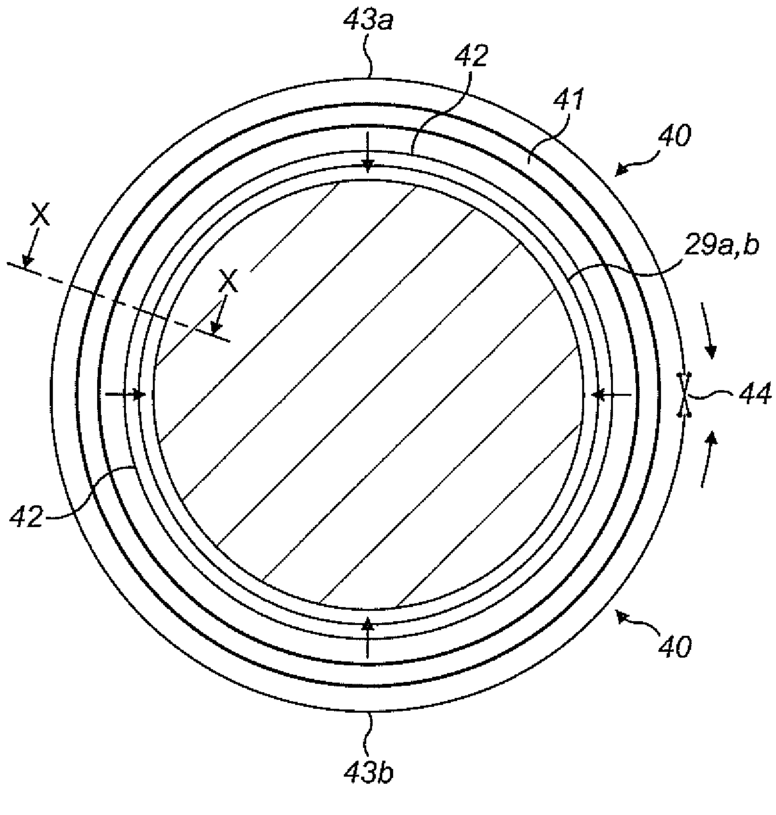

FIG. 3

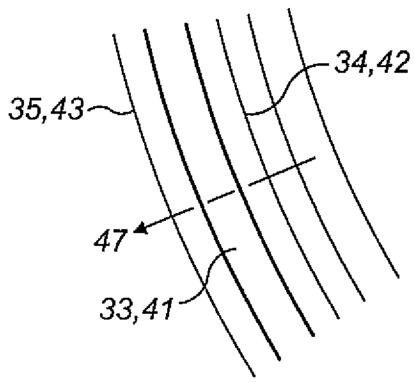

FIG. 4A

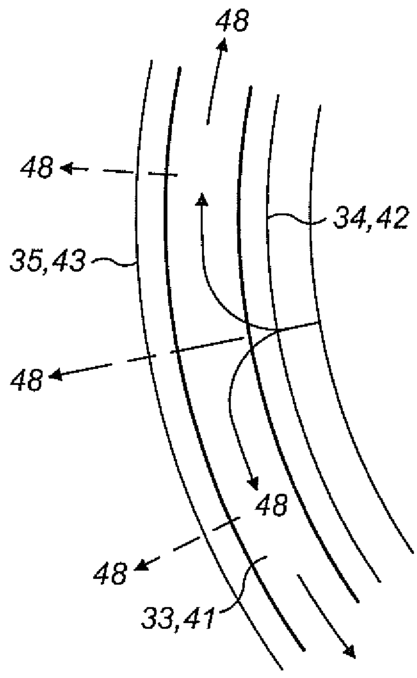

FIG. 4B

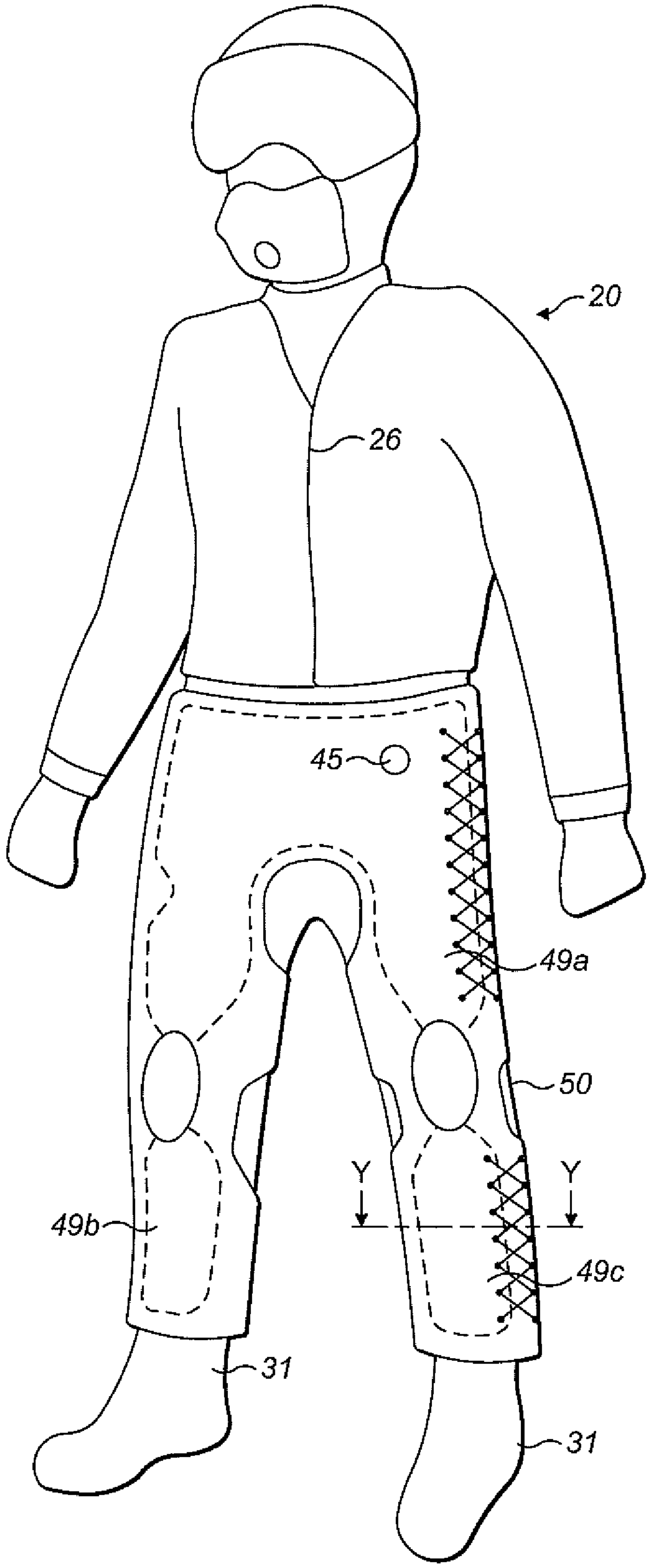

FIG. 5

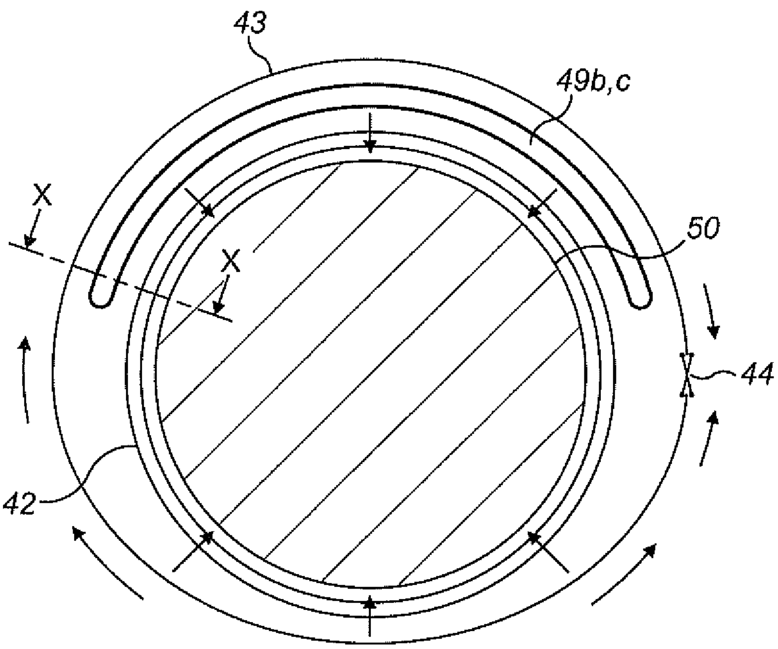

FIG. 6

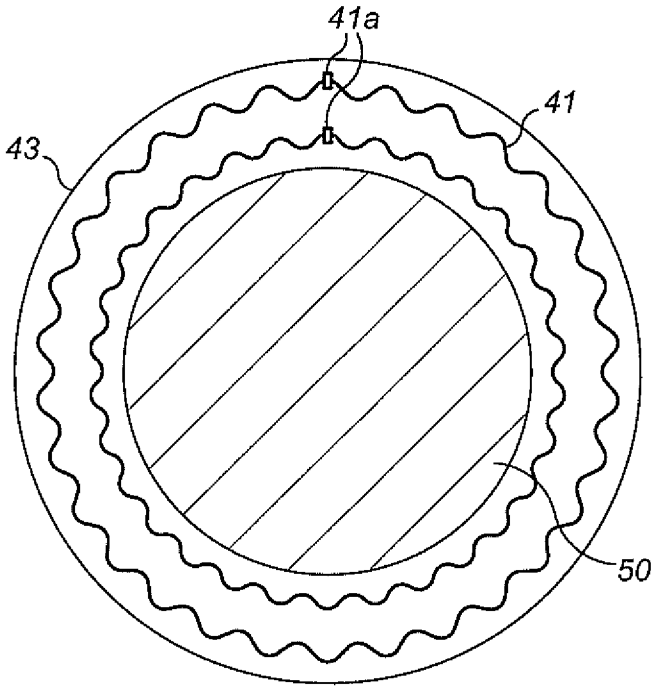

FIG. 7A

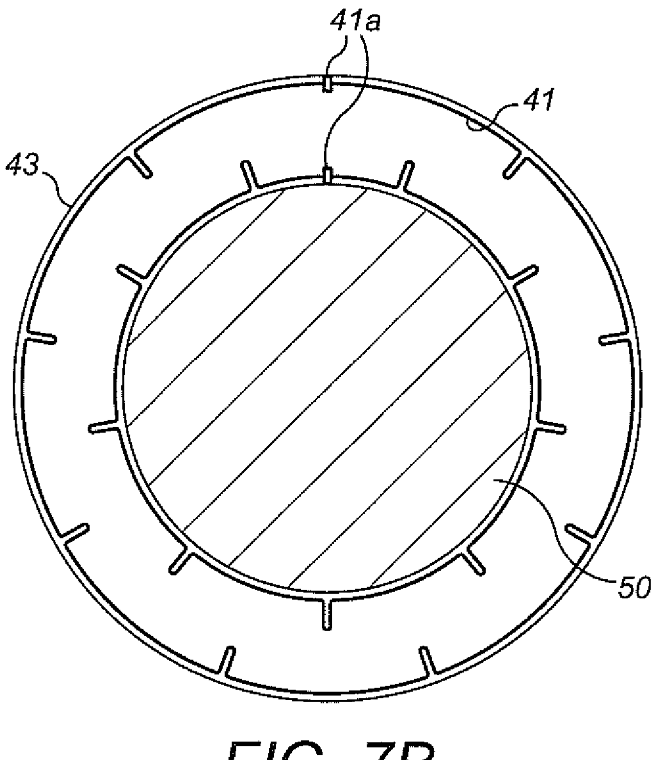

FIG. 7B

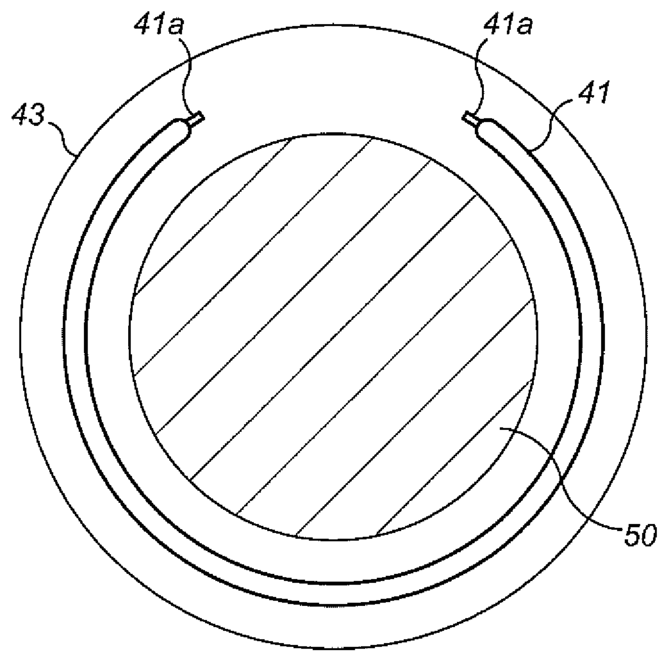

FIG. 8A

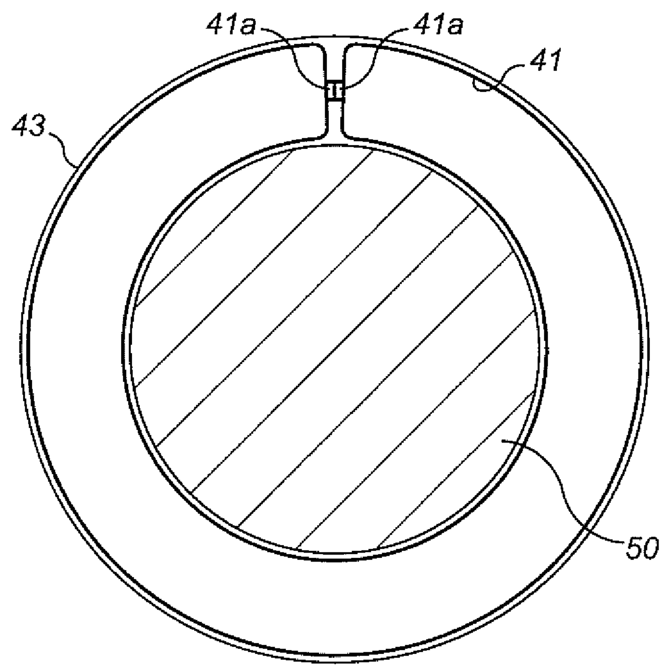

FIG. 8B

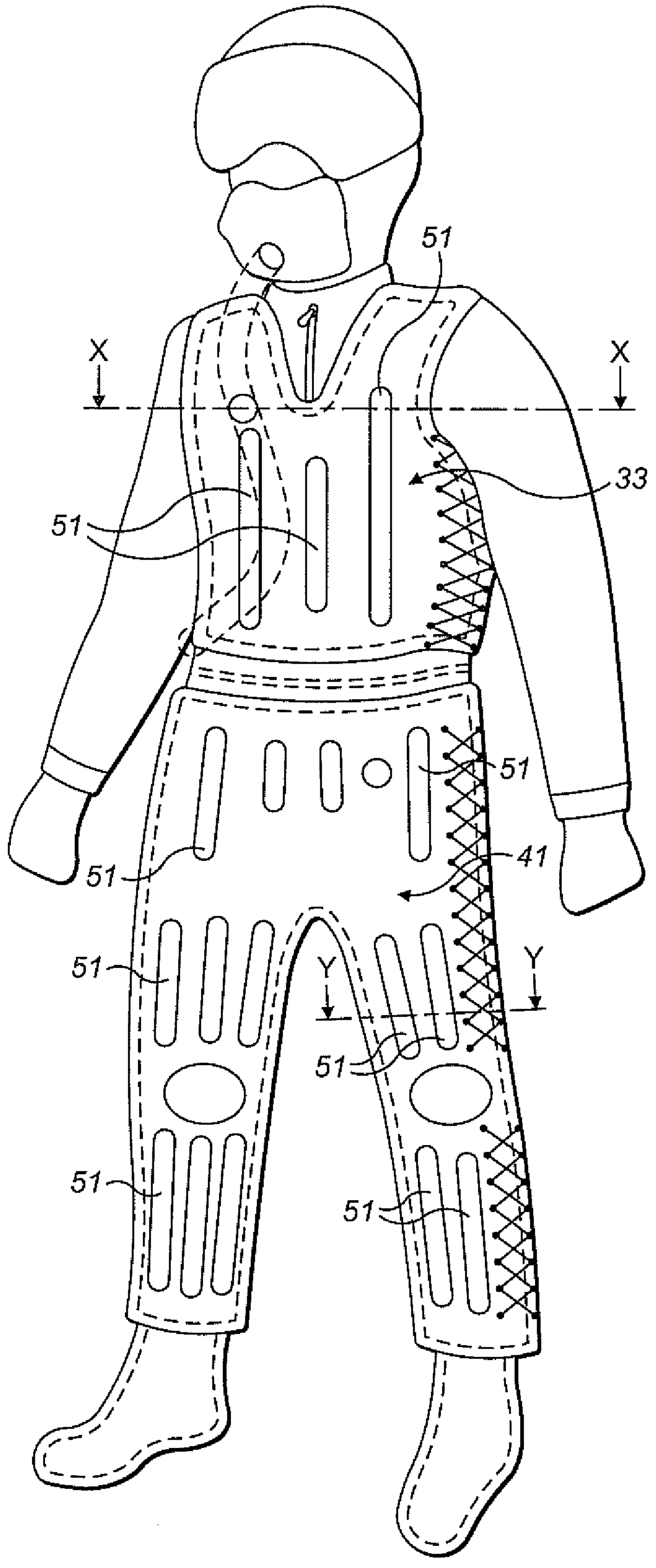

FIG. 9

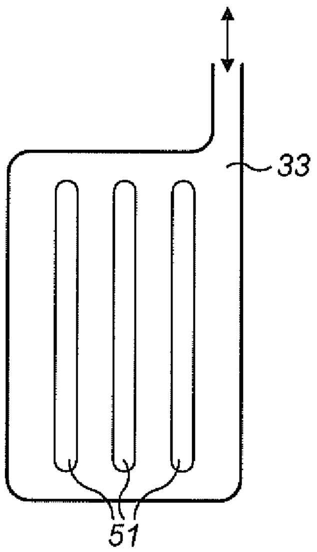

FIG. 10

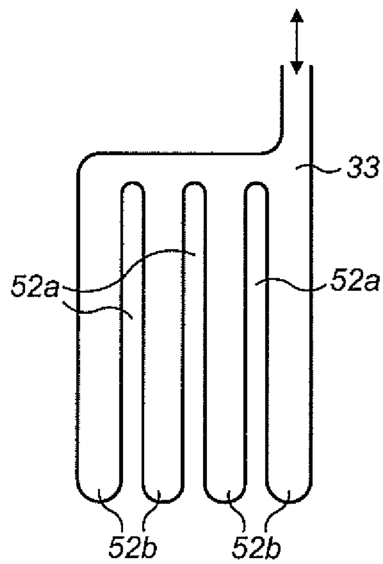

FIG. 11

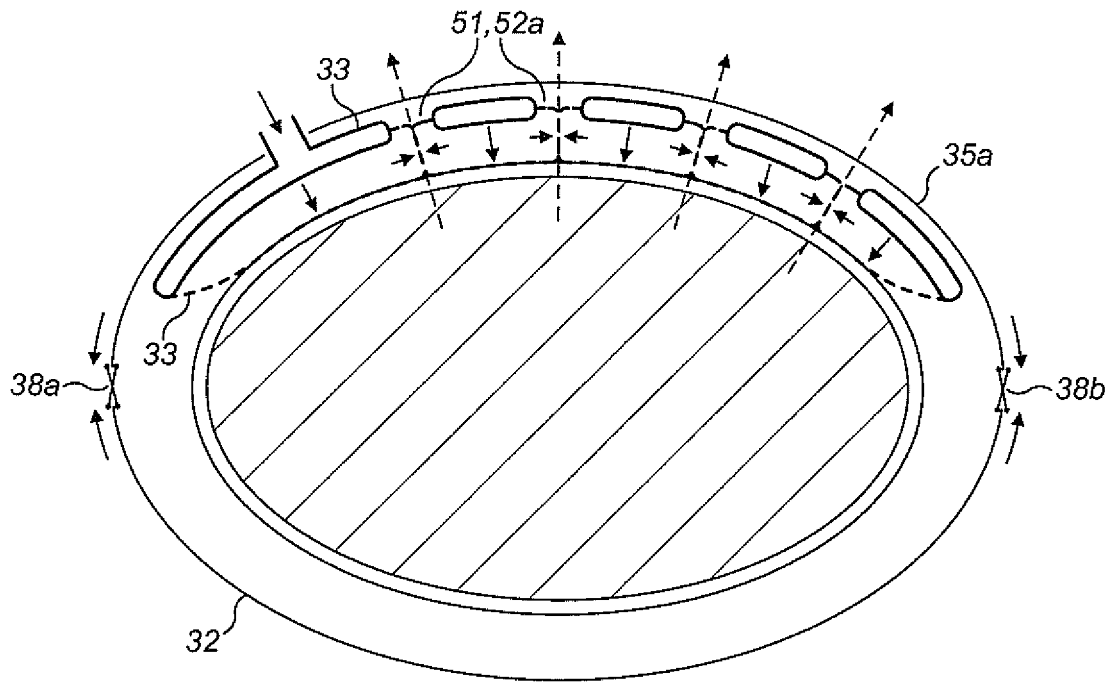

FIG. 12

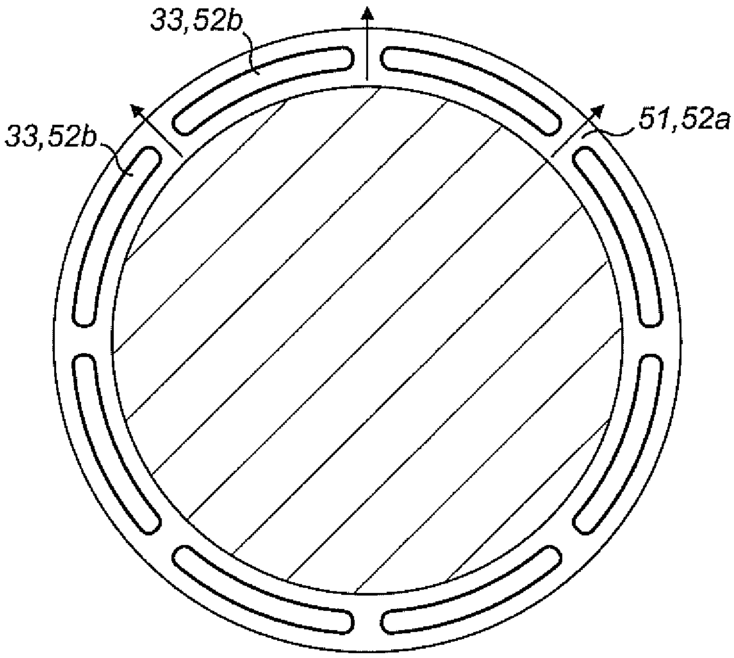

FIG. 13A

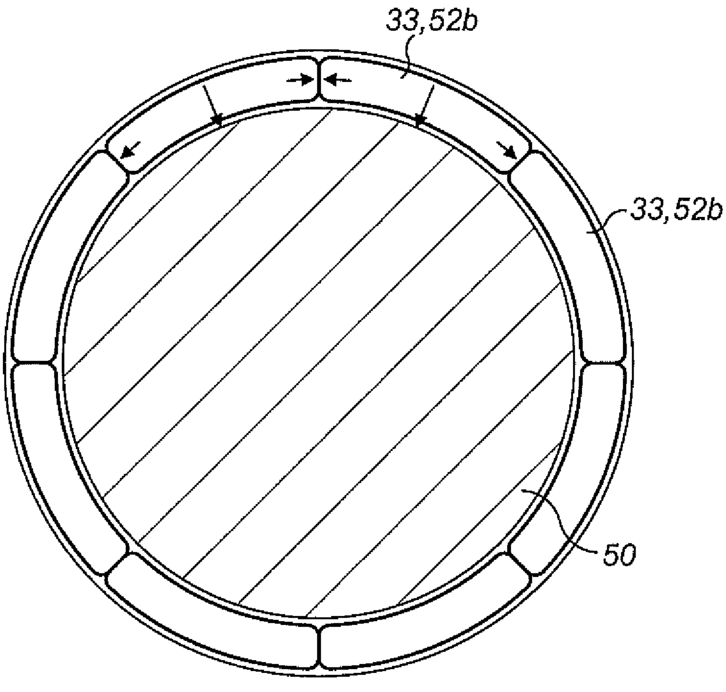

FIG. 13B

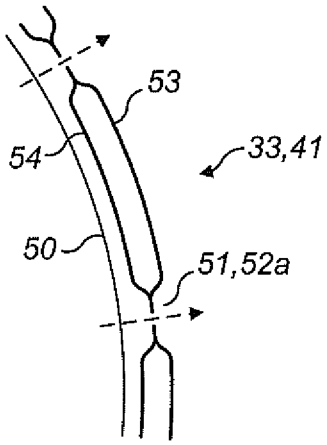

FIG. 14A

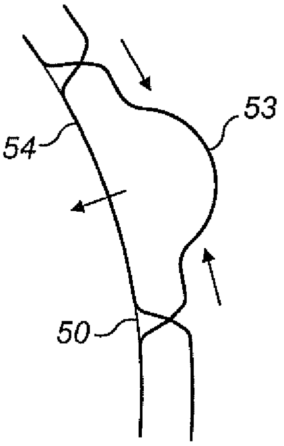

FIG. 14B

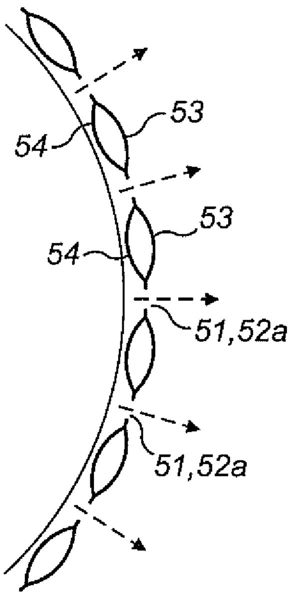

FIG. 14C

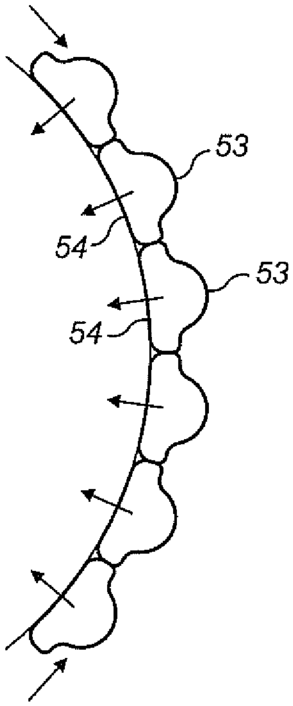

FIG. 14D

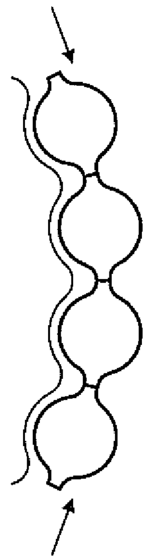

FIG. 14E

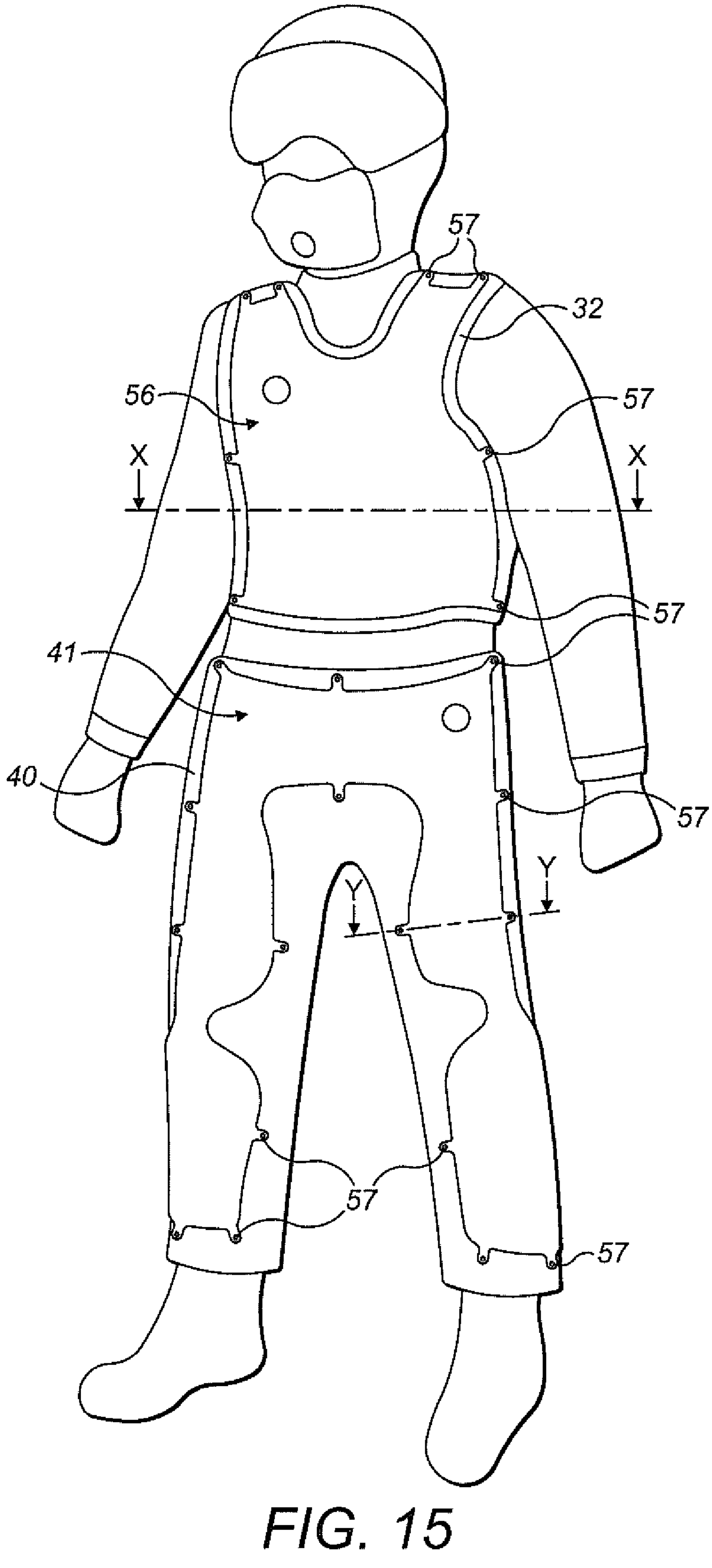

FIG. 15

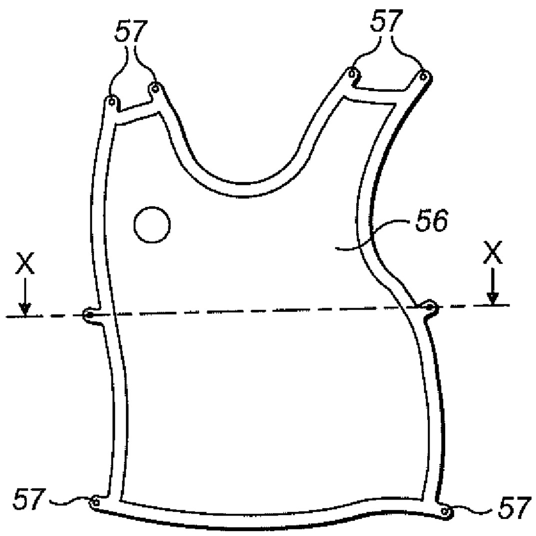

FIG. 16A

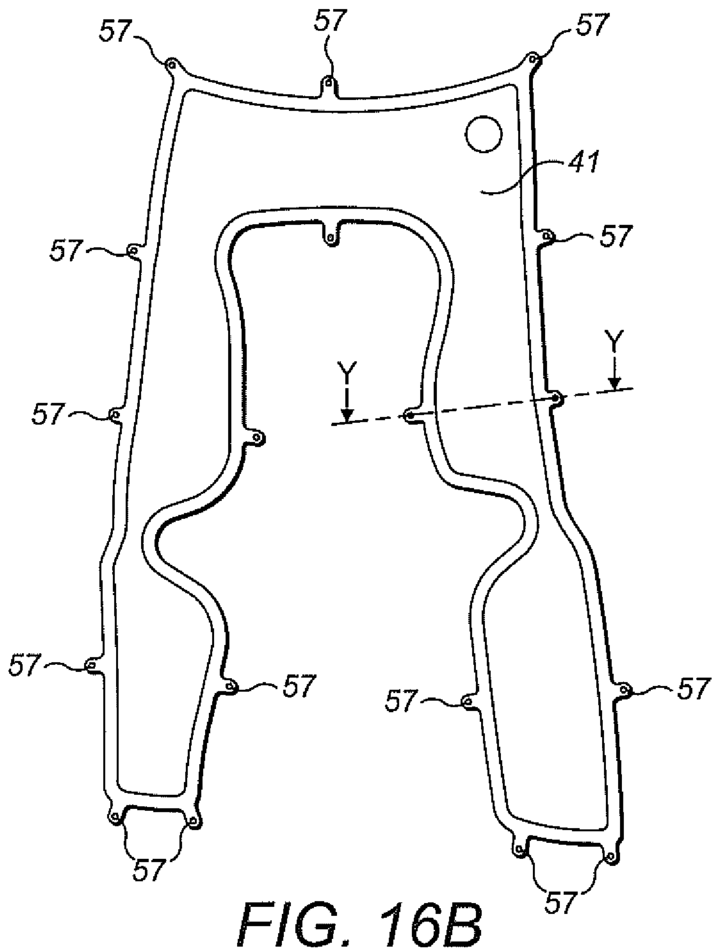

FIG. 16B

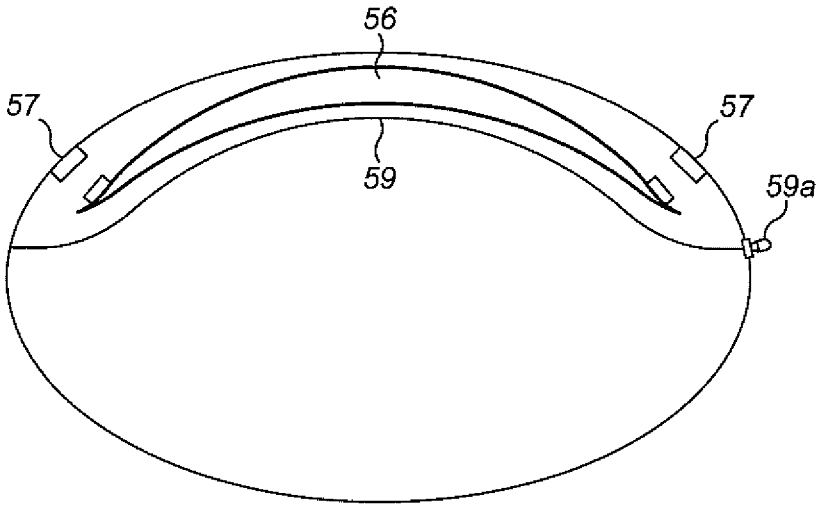

FIG. 16C

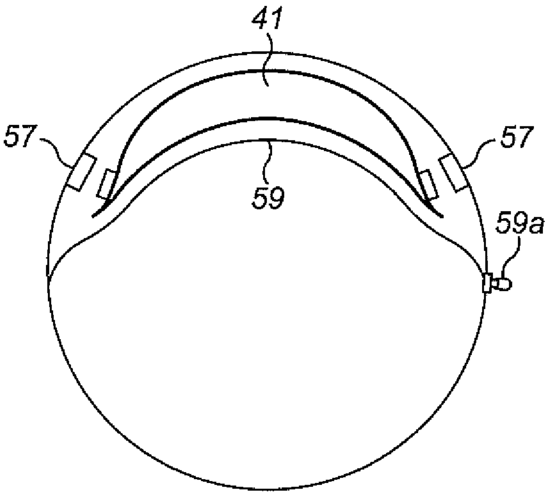

FIG. 16D

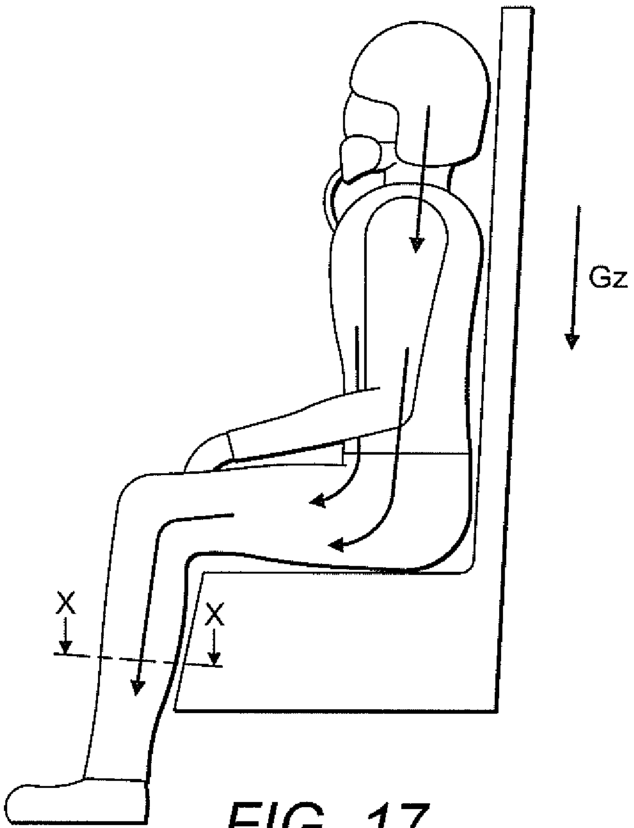

FIG. 17

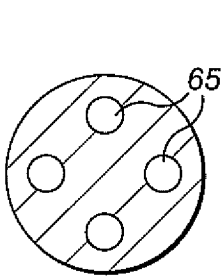

FIG. 18

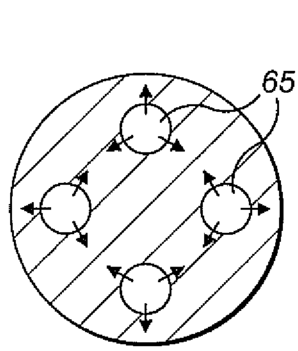

FIG. 19

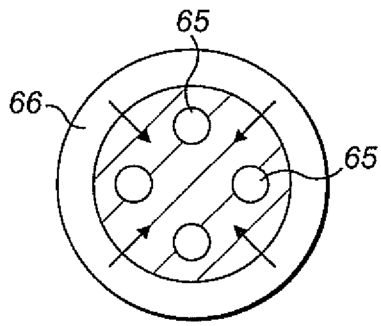

FIG. 20

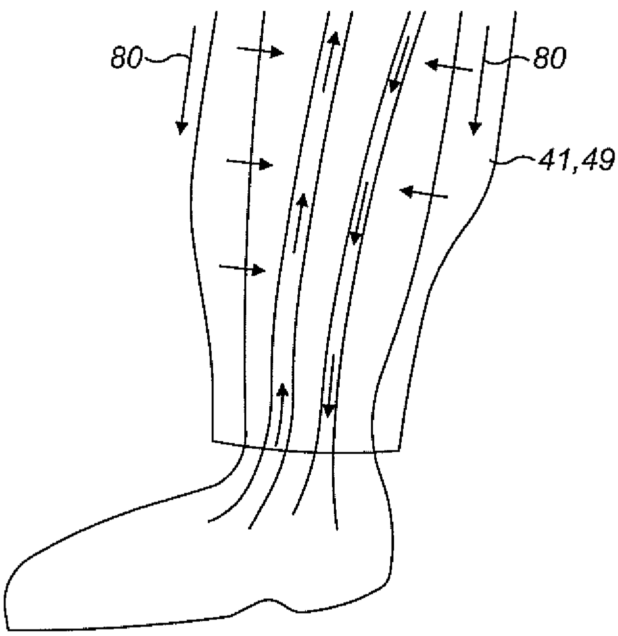

FIG. 21

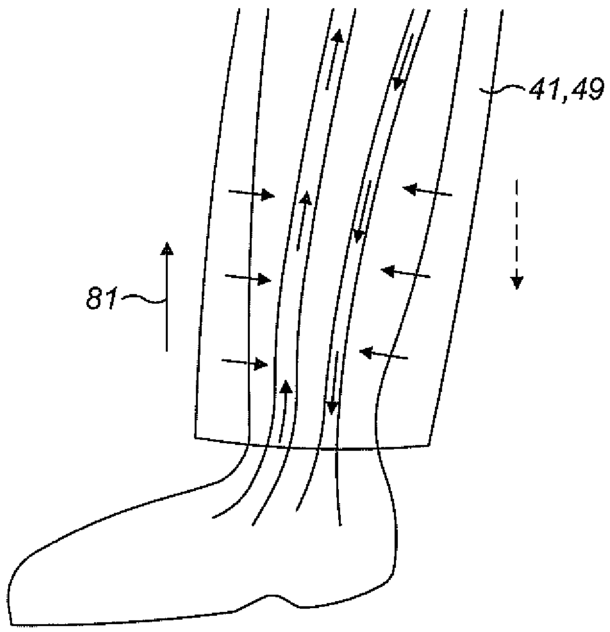

FIG. 22

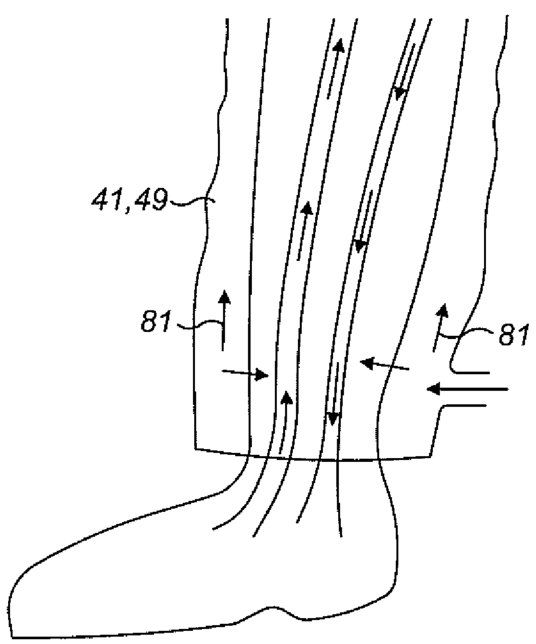

FIG. 23

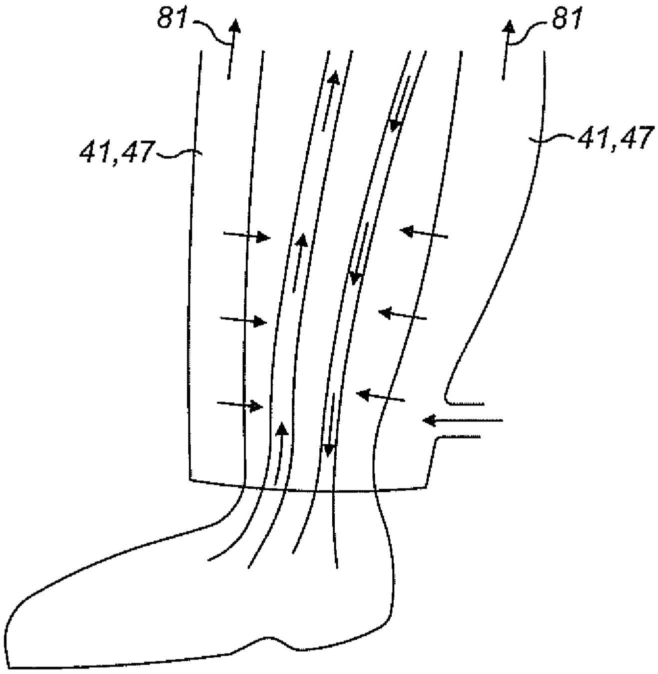

FIG. 24

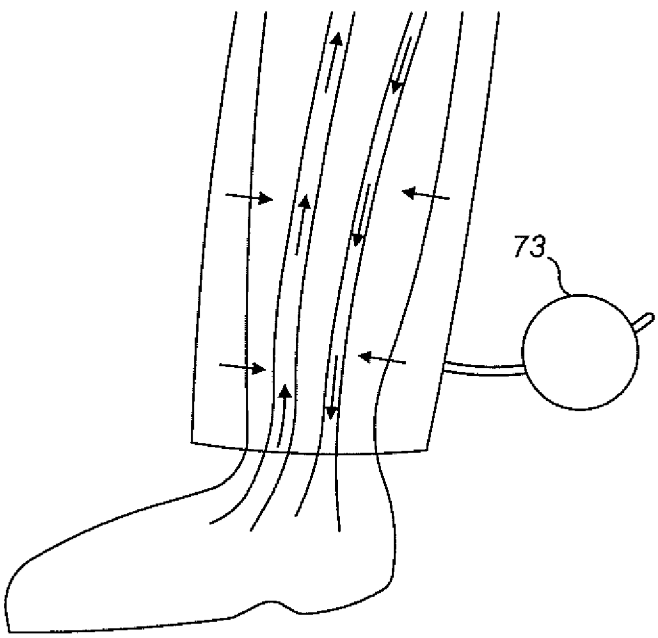

FIG. 25

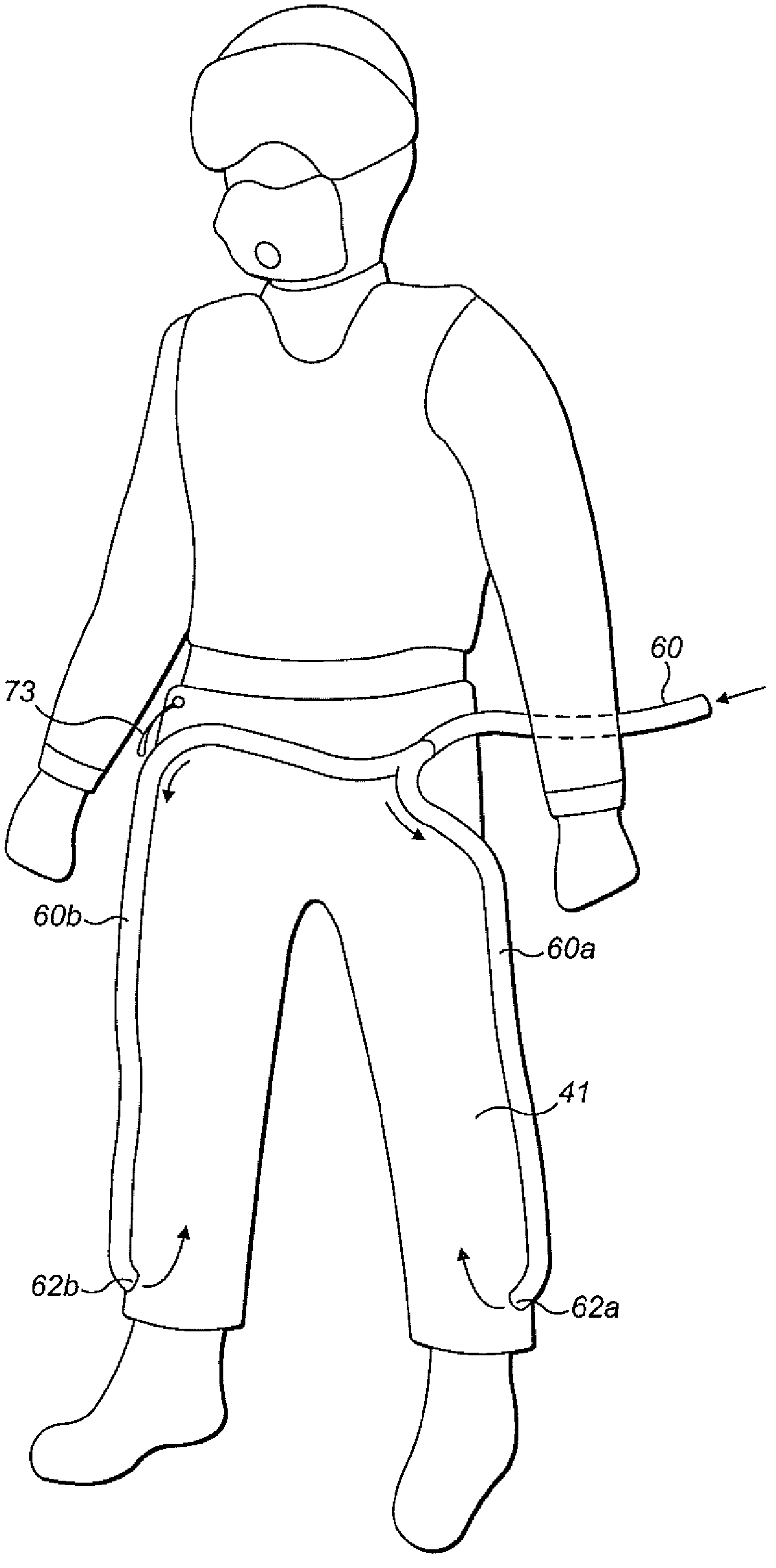

FIG. 26

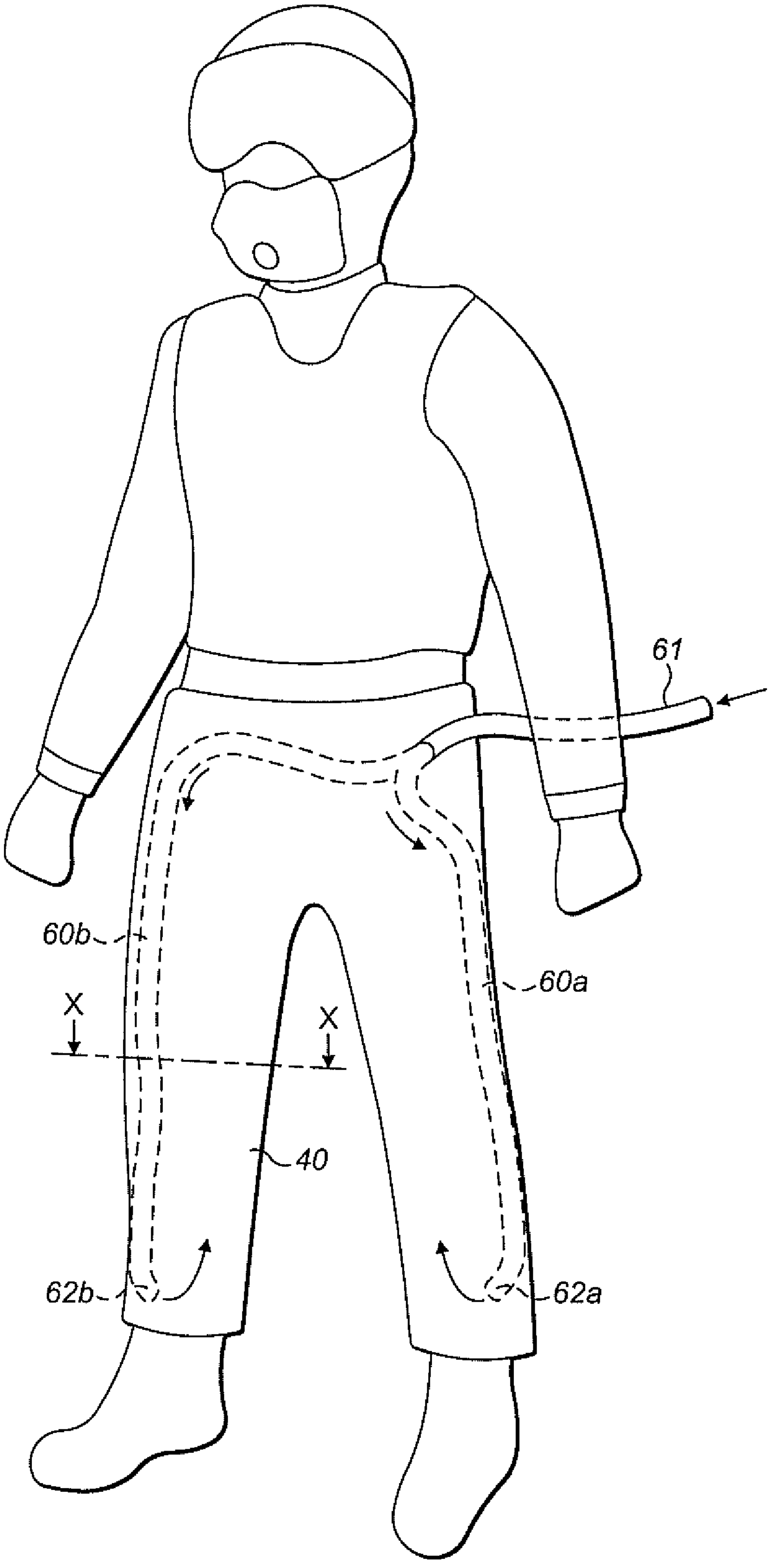

FIG. 27A

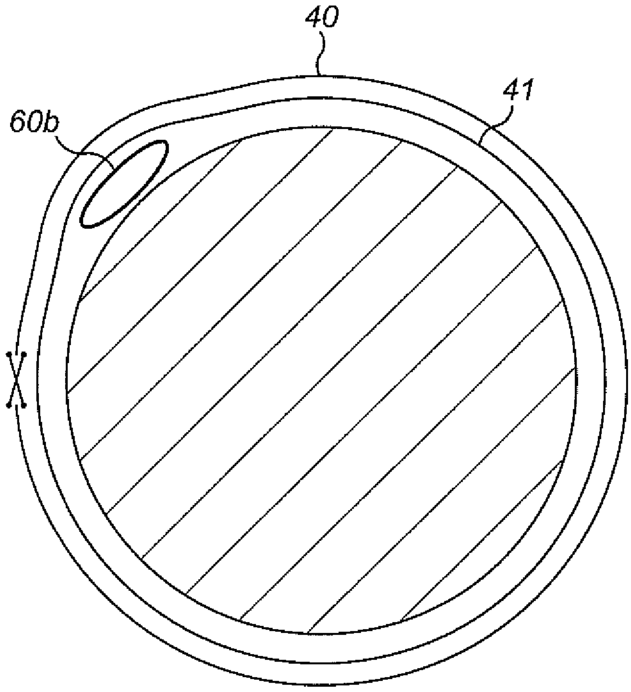

FIG. 27B

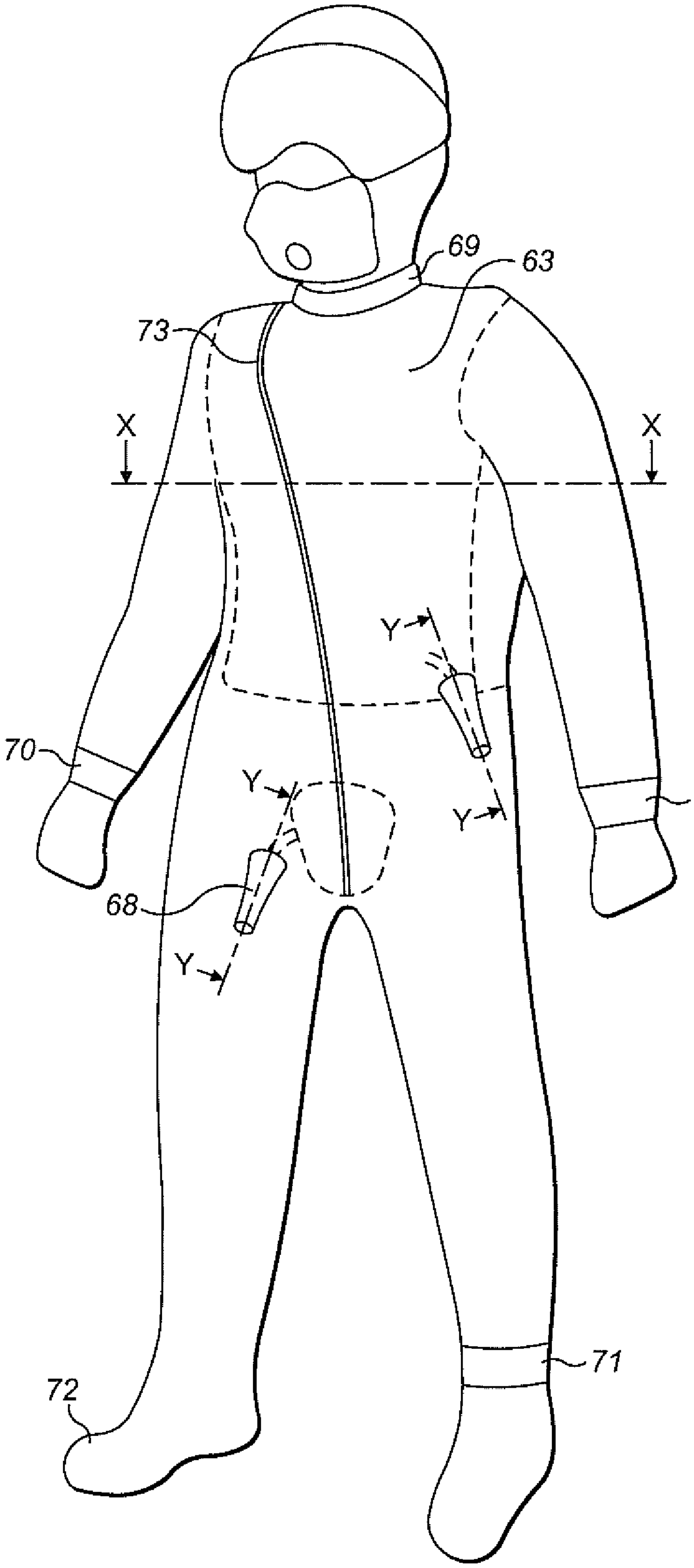

FIG. 28

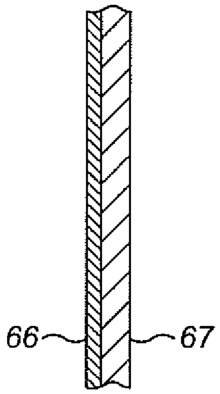

FIG. 29

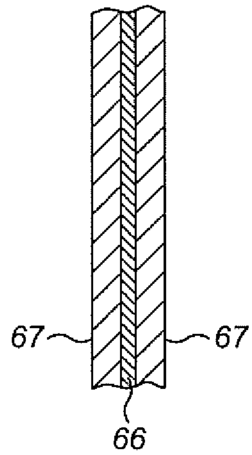

FIG. 30

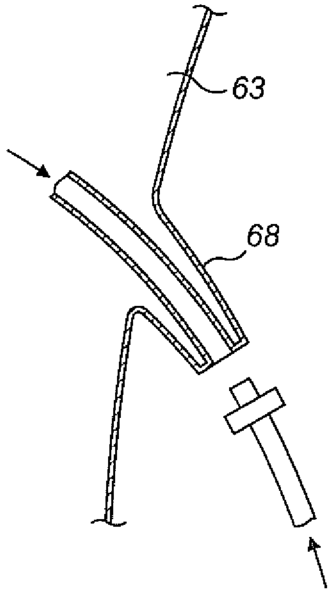

FIG. 31

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2011/067002

A. CLASSIFICATION OF SUBJECT MATTER
INV. B64D10/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B64D B64G A62B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 5 003 630 A (BASSICK JOHN W [US] ET AL) 2 April 1991 (1991-04-02) column 1, lines 7-11 column 1, line 46 - column 2, line 12 column 2, line 28 - column 4, line 12 figures 1-4 -----	1-11 12-16
X	WO 2007/111981 A2 (TIAX LLC [US]; NOCENTE ANNA MARIE [US]; DEVINE MARLENE A [US]; STOKES) 4 October 2007 (2007-10-04) pages 1,2,4,5 pages 16,17 figures 1,4,6 -----	1,3-8

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
1 December 2011	09/12/2011

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Fernández Plaza, P

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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2011/067002

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	GB 2 409 150 A (RFD BEAUFORT LTD [GB]; SURVITEC GROUP LTD [GB]) 22 June 2005 (2005-06-22) pages 1,4-10 page 1-; figures 1-21 -----	12-16 1
A	US 2008/275291 A1 (REINHARD ANDREAS [CH]) 6 November 2008 (2008-11-06) paragraphs [0002], [0007], [0009], [0020], [0021] - [0032] figures 1-10 -----	1,12
A	WO 99/54201 A1 (LSS LIFE SUPPORT SYSTEMS AG [CH]; REINHARD ANDREAS [CH]) 28 October 1999 (1999-10-28) page 1, lines 3-6 page 4, line 15 - page 11, line 35 figures 1-15 -----	1,12
A	US 6 325 754 B1 (REINHARD ANDREAS [CH] ET AL) 4 December 2001 (2001-12-04) column 1, lines 2-6 column 2, line 38 - column 3, line 28 column 3, line 43 - column 4, line 50 column 5, lines 26-31 column 6, line 14 - column 8, line 17 figures 1-9 -----	1,12

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2011/067002

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
US 5003630	A	02-04-1991	NONE			
WO 2007111981	A2	04-10-2007	CA	2647183	A1	04-10-2007
			EP	2001314	A2	17-12-2008
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