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DRY SUIT

This invention relates to a comfortable, light and breathable dry suit for keeping persons having fallen into the water dry to delay their life-menacing hypothermia. Among experts one speaks of Immersion Protection Suits (IPS).

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An immersion suit or survival suit, is a special kind of waterproof dry suit. It is intended to protect people who have fallen into cold water as a result of an accident, usually after a sinking or capsized ship has been abandoned, or in the military sector after a crash into the water or an emergency landing of an aircraft on water. Such a dry suit should maintain the body heat within
10 the suit and keep the user dry until he or she is rescued from the cold water. These dry suits are tailored to the wearer's body and must be worn by a crew as a precautionary measure if there is the danger of falling into the water during a mission. It is therefore important that these suits are as light as possible, as well as quickly and easily put on and comfortable to wear. It is known that a person's chance of survival when he or she has fallen into the water can be
15 significantly increased essentially by staying dry and maintaining the body temperature, because then a hypothermia can be postponed.

Conventional dry suits are usually made of reinforced neoprene® and have a face seal and flap, finger gloves, waterproof zip fasteners, ankle cuffs, neoprene® pockets and reflective stripes,
20 and they are to limit the wearer's freedom of movement as little as possible. They must comply with the provisions of the *International Convention for the Safety of Life at Sea (SOLAS)* as to hypothermia, and their use is intended primarily for personnel on board military aircraft, military ships or military boats, ferries, offshore drilling rigs, lifeboats, fast-rescue boats and for general commercial use. US 2004/0261161 A1 shows a combination suit for hunters/fishermen. The
25 sleeves can be rolled up and turned inside out. A second pair of sleeves is closed at the front. There are inflatable bubbles to create buoyancy (middle section [0016]). The suit is made of a fabric, with front zipper. It is not shown how the turtleneck can be opened. US 3 925 839 shows a survival suit for arctic conditions made of foamed material and around the torso buoyancy means for 25 pounds. Weights ensure that the head always stays up. The suit is made of a
30 neoprene foam of approximately ¼ inch thickness, with a brightly colored nylon fabric (column 2, lines 60-64). Waterproof zippers at the front allow easy access to the suit (column 3, lines 1-3) and those at the transitions to the gloves allow hands to be kept out (column 3, lines 30-33). JP S60 173 103 A shows an equally thick suit with waterproof zips at the front (Figure 1) and at the sleeve openings (Figures 9 and 10). CA 2 690 574 A1 reveals a suit made of neoprene foam
35 material 4.5 to 5mm thick, with front zips 46, 48 as well as those 60 between the sleeve openings and the gloves. An inflatable life raft is carried on the back. US 2005/097652 shows a flame-

retardant velour fabric, with a woven outer layer containing spandex, aramid or basofil fibres (page 2, section [0017]) for high abrasion resistance, a thermally effective knitted layer, and an air-permeable intermediate layer of polyurethane, polyether ester, and stretchable polytetrafluoroethylene EPTFE (page 3, section [0023]). GB 2 357 235 A shows a survival suit
5 with an innermost layer of polyester fleece, a second layer of breathable fluorocarbon, for example polytetrafluoroethylene, and an outer layer of knitted synthetic material such as polyester or nylon (page 4, 2nd section from bottom). The suit can be designed as a combination (page 1, 2nd section from below) with waterproof zippers (page 6, 3rd section from below). The laminate layers can be sewn, welded or glued together. GB 2111 824 A shows a laminate dry
10 suit as a combination. It consists of a knitted substrate of modacrylic fibre, a polytetrafluoroethylene layer and an outer heat and flame resistant layer. There is a waterproof sliding closure at the front. CN 203 618 845 U shows a jacket with probably a waterproof zipper that reaches up to the hood, and DE 18 22 905 U shows a work suit that can be cooled by compressed air, as well as US 4738 119 A a jacket with cooling lines for this purpose. None of
15 these suits would be wearable under a street suit.

The challenges in constructing a dry suit are the various conflicts of aims. The suit should provide optimum protection against heat loss and wetness. However, the better it fulfils these characteristics, the more uncomfortable it is to wear, as long as its actual function does not
20 matter. Because of the waterproofness, for example when using neoprene®, sweating or breathing of the body's skin is impossible. Correspondingly, the heat accumulates in the body, which is very unpleasant. The better the thermal insulation, the less comfortable the suit is to wear. Many dry suits with thick layers of thermal insulation materials are so stiff and cumbersome that they can hardly be put on by the users themselves. They need helpers to put
25 on the suit. If, for example in the case of aircraft crews, a dry suit has to be worn during the preparation phase or briefing for a flight as well as during debriefing, this is usually very uncomfortable for those affected. In the usual suits one sweats, although in principle one can't sweat effectively for the heat dissipation. As soon as one has put on a conventional dry suit, the neck and wrists are sealed waterproof in this suit and any air exchange between the inside and
30 outside, and thus with the body surface, is prevented. This leads to the fact that very soon one has a moist or wet body surface and has to suffer from a heat accumulation. Wearing such a dry suit is therefore very unpleasant in the long run and considerably impairs well-being and performance, a fact every naval pilot will immediately confirm.

35 The object of this invention is therefore to create a dry suit which, in addition to the function of keeping the wearer dry in water and insulating the heat in accordance with the existing regulations is now considerably lighter and much easier to put on and much more comfortable

to wear. Furthermore, the dry suit should be capable of being worn in combination with an acceleration protection suit as one is indicated in WO2012/066114 A1, and it should in any case be capable of being put on and taken off by the user without assistance, and have passive or optionally active cooling functions for the phases of non-functional use.

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This object is solved by a dry suit according to claim 1.

In the figures, this suit is pictured in two versions and described hereafter, and its function explained.

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There are shown:

Figure 1 The dry suit is designed as a one-piece combination suit, in donned state, as viewed from the front;

Figure 2 The dry suit is as a tow-piece suit, except for a textile material bridge, having

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jacket and trousers, in donned state, as viewed from the front.

As can be seen in Figure 1, the suit in this example is designed as a combination suit 1, i.e. it forms a one-piece suit. This suit consists of a three-layer, flame-resistant, waterproof, breathable and incident flow-proof fabric laminate with a weight per unit area of merely 220
20 grams/m². This fire-retardant fabric laminate consists of a tear- and flame-resistant fabric on the outside, followed by a glue layer, then a membrane with a microporous structure, based on polytetrafluoroethylene, with more than 10 million pores per mm² so that this membrane is waterproof but vapor-permeable. Then comes another glue layer, followed by a fabric with aramid fibers (Kevlar®), which is particularly light, about 40 gr./m² ± 10%, and serves as a
25 protective layer for the inner membrane. Hence the fabric laminate can withstand a pressure column of up to 10 meters and is therefore highly watertight or waterproof as well as incident flow-resistant. By using this fabric laminate, a low overall weight of the entire dry suit of less than 1.5 kg is achieved, which has hardly been thought possible so far. This in turn significantly increases the wearing comfort of this dry suit. Experiments have shown that it adds so little
30 bulkiness to the body that it can even be worn under an ordinary street suit without the viewer noticing it. The fabric of the dry suit has to be incident flow-resistant in order that the dry suit can withstand very high incident-flow speeds of up to 600 knots (kn) or 1111 km/h, as these occur in the event of an ejector seat ejection and act on the pilot. This incident flow-resistance is achieved by the mentioned high tear resistance which is offered by the flame-retardant thin
35 outer fabric.

To put on the dry suit, one slips one's legs and feet into the trouser joints 2, and this part

hereafter wraps the legs and feet of the wearer already waterproof so that the wearer could stand knee-deep to hip-deep in water because the trouser joints 2 made of waterproof three-layer fabric seamlessly merge into foot bindings 3. The suit is easy to put on because a waterproof zip fastener 4 extends from the area of the crotch to the top of collar 5. To put on the upper-body garment 6, one opens along with the front main zip fastener 4 also the two zip fasteners 7 on the cuffs 13 and front sleeves 8. Hereafter one can slip on the upper-body garment 6 and in the process slip one's arms into the sleeves 8. The suit offers at least one waterproof zip fastener chest pocket 15, which can be closed with a waterproof zip fastener 14, as well as another waterproof zip fastener 18, which allows access inside the suit in the chest area. This is in particular necessary if the dry suit is worn over another suit, especially over an acceleration suit. It has been shown that in this case the function of the acceleration protection suit is not impaired by this dry suit being worn over it. Furthermore, the dry suit can optionally have a waterproof trouser pocket 10 which can likewise be closed with a waterproof zip fastener 9.

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During preparation and intermediate times, when the suit does not have to be in standby mode, i.e. during uncritical mission phases, this dry suit can be left open at the top of collar 5 and at the front sleeves 8 by not tightening the zip fasteners 7 there completely, but by leaving a section somewhat open as desired, and by leaving the main zip fastener 4 of collar 5 somewhat open at will. Hence an effective passive cooling function is achieved, which is not possible with any other dry suit to date and is probably the most important advantage of this dry suit. Conventional dry suits, once they are put on, namely enclose the neck and wrists in a waterproof manner so that air exchange with the body is no longer possible, which proves to be extremely unpleasant as long as no emergency occurs, which is true for most of the time when such a dry suit is worn. The cooling function of the dry suit presented here by opening collar 5 and cuffs 13 and front sleeve 8, however, offers the user an enormous and highly welcome relief in practice. Due to its cooling function and its special lightness, wearing this dry suit proves to be far more comfortable than closed dry suits of conventional design.

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The main zip fastener 4 is closed up to the upper collar edge only shortly before a standby phase. The collar 5 is equipped with an elastic rubber lip 11 at its upper edge, which attaches itself all-round waterproof to the neck of the wearer when the main zip fastener 4 is completely closed. The cuffs 13 at the front end of the sleeves are executed similarly. They terminate with a rubber lip 12 which runs around the zip fastener. When the zip fasteners 7 on the front sleeves 8 are completely closed toward the front, these rubber lips 12 close behind the wrist around the forearms in a waterproof manner.

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As Figure 2 shows, the dry suit can be produced in a variant as effectively a two-piece suit, with a jacket and trousers 17 attached to it by a textile material bridge. The trousers and the jacket are connectable in a waterproof manner by a waterproof zip fastener 16, which runs around the hip overlapping somewhat. This design offers a further cooling function in the hip area, because
5 when this zip fastener 16 is more or less opened, a very welcome cooling function is hence achieved in the area of the abdomen, hip and lower back. Especially in the area of the lower back one tends to sweat particularly heavily. Apart from that, this suit is constructed identically to the one corresponding to Figure 1, i.e. it also has at least one waterproof breast pocket 15, which can be closed with a waterproof zip fastener 14, and a waterproof zip fastener 18 in the
10 chest area, for reaching into the dry suit from outside. Further, as shown, this suit has a waterproof trouser pocket 10 which can be closed with a waterproof zip fastener.

Hence this dry suit, as presented, is the only known protection suit against cold and water for aircraft crews which, in the context of flight preparations and flight post-processing and
15 debriefings, can be worn with the collar open to the lower abdomen and with open cuffs 13 and front sleeves and nevertheless offers the wearer the necessary cold water-protection in an emergency by quickly closing the waterproof zip fasteners.

Furthermore, because this dry suit for the first time consists of a comparatively thin, three-layer
20 fabric laminate, it weighs less than 1.5kg and is therefore so light and hardly bulky that it can be worn over an acceleration protection suit, and the function of this G-suit is not impaired if it is constructed according to the design as disclosed in WO2012/066114. If it is furthermore combined with the features of a cooling suit, i.e. equipped with flat cooling channels on its inner side, which can be supplied for example at the hip area from a hose sleeve opening waterproof
25 outwardly via a hose from a portable pressurized gas cylinder with expanded and thus cool gas, preferably with cool air, it also offers, in addition to protection from cold and moisture, an active, highly effective cooling system for the periods in which it is worn as a protective suit merely as a precaution. The gas and air ducts are then led to all highly perspiring body parts and have outlet openings to transport heat away from there. These points are located especially at the
30 lower back, at the hips, in the hollows of the knees, at the neck and in the chest area, in the armpits, arm joints as well as at the front sleeves which face the inner sides of the wearer's forearms. The heat absorbed by this cooling gas or by the cooling air is then transported outward through the cuffs 13 kept open and the opened collar 5 as long as the dry suit is not used as such. Hence this offers a system which is even more comfortable and less heat-intensive for
35 intercontinental flights, as well as for operations in the tropics and in the polar regions.

The pilot or other crew members do not need any help and can put on or take off the suit by

themselves. The very light and at the same time extremely heavy-duty 3-layer fabric laminate was developed especially for this dry suit. This innovative fabric laminate leads to a weight reduction and at the same time to high strength and durability. In addition to the waterproofness and a certain air permeability, the result is a weight of less than 1.5kg for the entire suit.

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This dry suit includes synthetic, waterproof zip fasteners, covered with fire-resistant fabric, which allow the suit to be worn opened at the neck and arms during the entire pre- and post-flight phase for maximum comfort. The openable sleeves 13 at the neck and the forearms offer significantly increased comfort and enable the longer-term wearing while preserving the performance of the wearer on account of low strain and correspondingly less tiredness of the wearer. The waterproof finish of collar 5 consists of an elastic rubber lip 11 made of neoprene®, silicone or a material with comparable properties laminated onto flame-resistant fabric, which is divided by main zip fastener 4, however, seals the neck area when the main zip fastener 4 is closed. Just like the collar 5, the cuffs 13 at the ends of the sleeves consist of such a structure, i.e. a rubber lip 12, which is divisible by the zip fasteners 7, laminated onto a flame-resistant fabric of the cuffs 13, the rubber lip 12 being made of neoprene®, silicone or a material with comparable properties.

In combination with the mentioned cooling system having gas or air ducts within the suit 1, prolonged operations are possible even under extreme environmental conditions with high ambient temperature and also in high relative humidity without significant fatigue of the user. Nevertheless, the user is always wrapped in a waterproof and heat-insulating way within seconds, which means that he or she merely needs to completely close the waterproof zip fasteners 4, 7, 9 and 16.

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The target groups for the use of such dry suits are mainly the following professions:

- Pilots/crew members of jet-propelled fighter aircraft.
- Pilots, crew members and passengers of helicopters, transport aircraft and special aircraft.
- 30 • Crews and passengers of seagoing vessels.
- Water sportsmen of all kinds (yachtsmen, canoeists, kayakers, surfers, stand-up paddlers etc.).

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List of numerals

- 1 Combination suit
 - 2 Trouser joints
 - 3 Foot bindings
 - 5 4 Main zip fastener
 - 5 Collar
 - 6 Upper-body garment
 - 7 Zip fastener 7 on the front sleeves
 - 8 Sleeve
 - 10 9 Zip fastener for closable trouser pocket
 - 10 Closable trouser pocket
 - 11 Elastic rubber lip on collar 5
 - 12 Elastic rubber lips on the cuffs
 - 13 Cuffs
 - 15 14 Waterproof zip fastener for breast pocket
 - 15 Breast pocket
 - 16 Zip fastener between jacket and trousers
 - 17 Fabric material bridge between jacket and trousers
 - 18 Waterproof zip fastener in the chest area for reaching inside the suit
- 20

Patentkrav

- 1.** Tørdragt til at holde personer, som er faldet i vandet, tørre for at udskyde deres livstruende hypotermi, hvilken dragt er fremstillet af et stofflaminat

5 bestående fra ydersiden til indersiden af et rive- og flammebestandigt stof, en vandtæt membran med en mikroporøs struktur på basis af polytetrafluorethylen og et indvendigt stof, og som har vandtætte lynlåse (4, 16) til at tage dragten på og af, idet en vandtæt lynlås (7) opdeler en krave (5) til åbning,

kendetegnet ved, at en vandtæt lynlås (7) strækker sig langs underarmen på

10 hvert af ærmerne (8), at de vandtætte lukninger ved halsen og håndleddene er udført via læber (11, 12), som hver kan opdeles af en vandtæt lynlås (4, 7), idet disse læber (11, 12) er lamineret på brandbestandigt stof, og når lynlåsene (4, 7) er lukket, er de beregnet til at være vandtætte ved halsen eller håndleddene, således at hele dragten under ikke-kritiske missionsfaser kan bæres åben ved

15 kraven (5) og de vandtætte manchetter (13) og således tillader en luftudveksling med kropsoverfladen, og at den fra denne tilstand ved lukning af alle vandtætte lynlåse (4, 7, 9, 16, 18) hurtigt kan bringes til den vandtætte tilstand, og at stofflaminatet er et trelags, flammebestandigt, vandtæt, luftgennemtrængeligt og således åndbart og oppusteligt stofflaminat, hvilket har en fladevægt på maks.

20 220 gram/m² og består på ydersiden af det rive- og flammebestandige stof, efterfulgt af et limlag, derefter har membranen en mikroporøs struktur på basis af polytetrafluorethylen med mere end 10 millioner porer pr. mm², således at denne membran er vandtæt men dampgennemtrængelig, og derefter et yderligere limlag, efterfulgt af stoffet med aramidfibre med 40 gram/m² ± 10% som et

25 beskyttelseslag for den indvendige membran, således at hele tørdragten vejer mindre end 1,5 kg.

- 2.** Tørdragt ifølge krav 1, **kendetegnet ved, at** trelagsstofflaminatet giver så god en vandbestandighed og -tæthed, at det kan modstå en en tryksøjle på op til

30 10 meter.

- 3.** Tørdragt ifølge et af de foregående krav, **kendetegnet ved, at** den er udformet som en kombinationsdragt (1) i ét stykke med en vandtæt lynlås (4),

der strækker sig fra skridtområdet til den øvre kant af kraven (5).

4. Tørdragt ifølge kravene 1 til 2, **kendetegnet ved, at** den er udformet som en todelt dragt med bukser og jakke, bortset fra en tekstilmaterialebro (17) mellem 5 bukser og jakke, og at bukser og jakke i hofteområdet kan forbindes til en vandtæt lynlås (16) omsluttende hoften, med en side af lynlåsen i den nederste kant af jakken og en side af lynlåsen (16) på bukselinningen, idet lynlåsens (16) endeområder overlapper lateralt forskudt, inklusiv tekstilmaterialebroen (17) mellem jakke og bukser.

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5. Tørdragt ifølge et af de foregående krav, **kendetegnet ved, at** den kan bæres over en accelerationsbeskyttelsesdragt af typen beskrevet i WO2012/066114 uden at forringe funktionen af accelerationsbeskyttelsesdragten.

15 6. Tørdragt ifølge et af de foregående krav, **kendetegnet ved, at** den i brystområdet har mindst en indad forsænket brystlomme (15), der kan lukkes med en vandtæt lynlås (14), og i brystområdet en vandtæt lynlås (18) til at være i indgreb under den bårne tørdragt, når den bæres over en anden dragt eller accelerationsbeskyttelsesdragt.

20

7. Tørdragt ifølge et af de foregående krav, **kendetegnet ved, at** den omfatter mindst en bukselomme (10), der kan lukkes med en vandtæt lynlås (9).

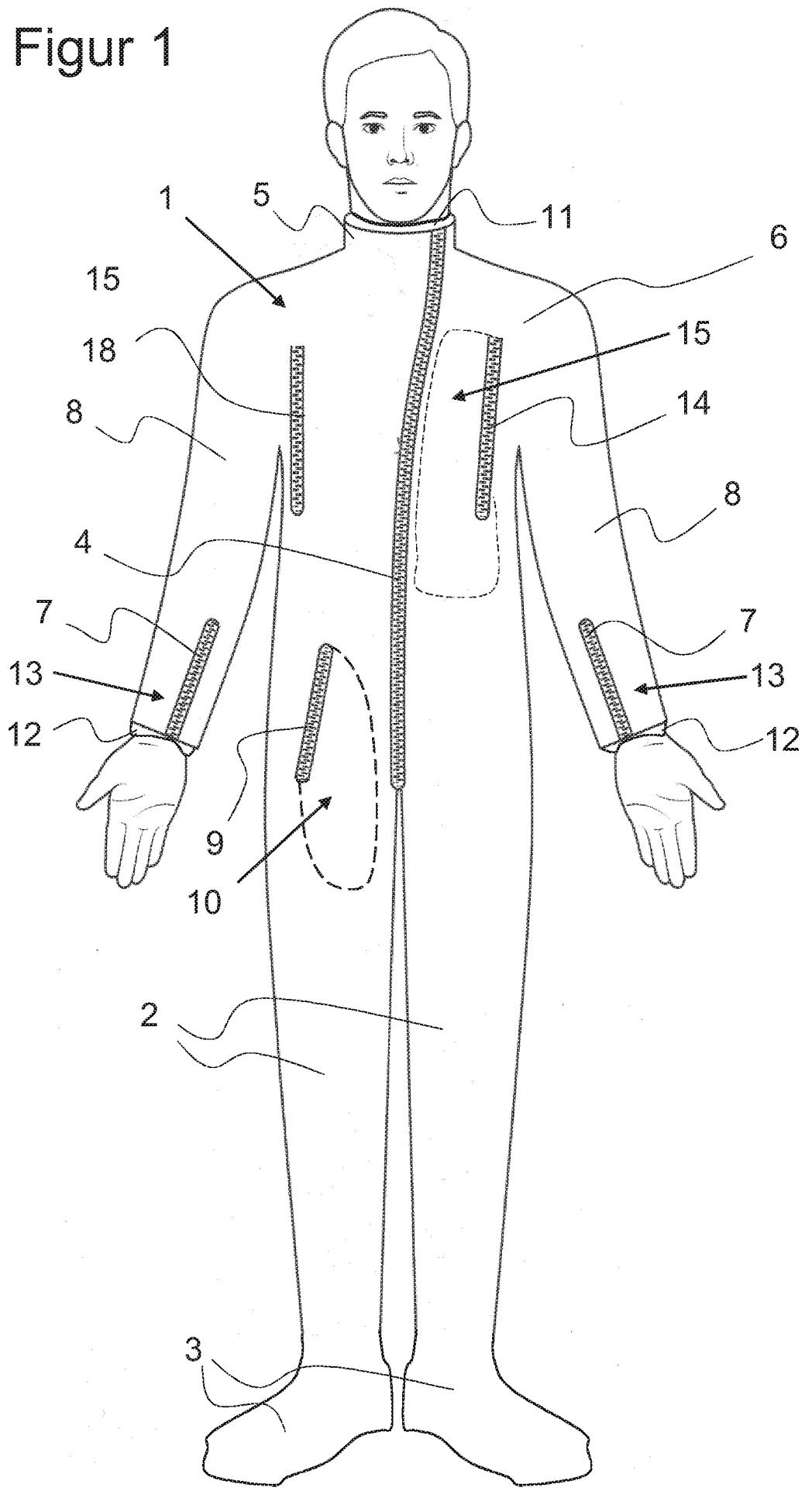
25 8. Tørdragt ifølge et af de foregående krav, **kendetegnet ved, at** trelagsstoffet er udført blæsesikkert, dvs. kan modstå luftstrømme på op til ca. 1111,2 km/t ubeskadiget, idet yderstoffet er vævet af rivebestandige syntetiske og aramidfibre.

30 9. Tørdragt ifølge et af de foregående krav, **kendetegnet ved, at** dens inderside yderligere er udstyret med flade gaskanaler, som fra en vandtæt udad åbnende slangemuffe via en slange fra en bærbar flaske med komprimeret gas kan forsynes med derfra ekspanderet og således afkølet gas, idet gaskanalerne på indersiden af tørdragten føres til de stærkt transpirerende kropsdele og der har udgangsåbninger til at fjerne varme derfra.

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10. Tørdragt ifølge krav 9, **kendetegnet ved, at** udgangsåbningerne af gaskanalerne navnlig er indrettet i området ved krydset, ved hofterne, i knæhaserne, i nakken og brystområdet, i armhulerne, ved armleddene og ved forærmerne, som ligger modsat indersiderne af bærerens underarme, således at 5 varmen absorberet af kølegassen kan transporteres ud gennem de åbne manchetter (13) og kraven (5), så længe tørdragten anvendes i ikke-kritiske missionsfaser.

Figur 1



Figur 2

