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(54) Title: GARMENT WITH AIR VENTILATING SYSTEM

(57) Abstract: A garment comprises an outer shell (10) and at least one air ventilating system (40). The air ventilating system (40) comprises an air ventilating chamber (50) disposed on the inner side of the outer shell and at least one external air access (30) to said air ventilating chamber (50) to allow external air to circulate within the chamber. An air permeable spacer arrangement (60) is located in the air ventilating chamber (50).

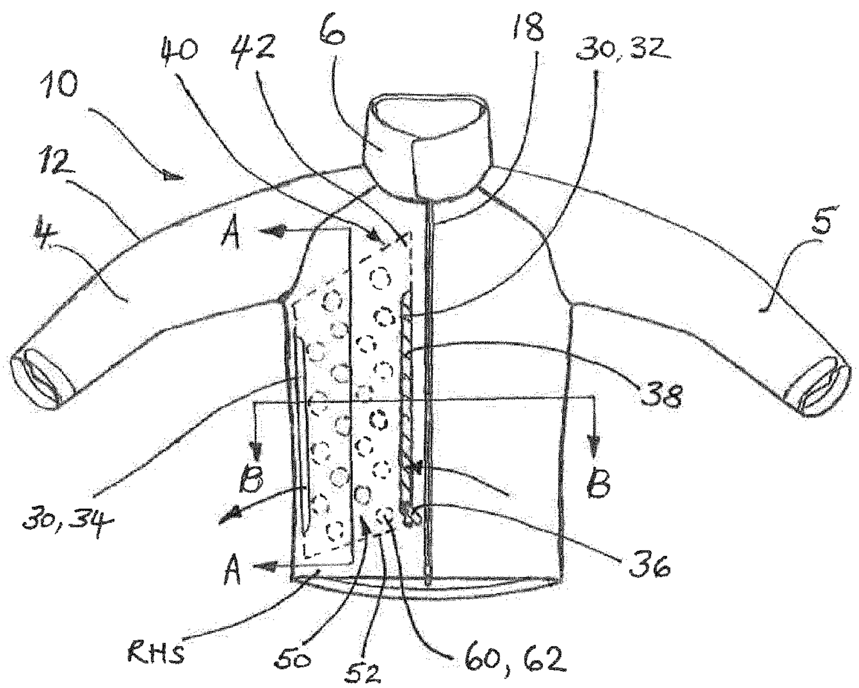

Fig. 2

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GARMENT WITH AIR VENTILATING SYSTEM

The present invention relates to a garment with an air ventilating system arranged to an outer shell of the garment. In one embodiment the garment comprises at least one pocket which is in arrangement with the air ventilating system.

BACKGROUND

Garments designed for waterproof and windproof outerwear protection are usually made with protective material that is not only waterproof or windproof but is also water vapour permeable or "breathable". In practice, use of these water vapour permeable outer materials allows the evaporation of sweat from the wearer's skin to pass through and escape from the outer material shell thereby enabling continued evaporative heat loss from the skin and reducing the level of sweat and moisture build up in the layers worn beneath. For this reason garments made with water vapour permeable materials provide a more comfortable experience for the wearer compared with garments made with impermeable materials.

Materials currently in use in waterproof or windproof garments vary considerably in the level of permeation performance and protection. The water vapour permeation characteristic of these materials when applied to garments is normally measured in terms of resistance to evaporative transport (Ret in m^2Pa/W), where materials with a lower resistance will generally be more desirable in terms of comfort.

For the very active user the level of sweat produced can be high and materials with high water vapour permeation performance must be used to reduce perspiration wetness in the under shell layers and to maximize comfort.

As well as using highly water vapour permeable materials, it is also necessary to consider the actual garment design, as features of a poorly designed garment can reduce the level of comfort and negate the benefits of using high permeability materials.

Difficulties arise when a garment is required to provide comfort in circumstances that involve both high levels of activity and levels of inactivity. In this situation the same garment is required to enable high levels of vapour and heat removal and then at a different time to provide increased levels of heat insulation. One solution is to carry multiple garments and adjust the layers of garments worn to meet the desired rate of heat loss. During high levels of activity another solution is to allow cooler external air to ventilate through the outer shell and enable further means of removal of heat and water from the under layers, although this has the significant disadvantage of also reducing the waterproof or windproof or other overall protection levels of the garment.

When pockets are incorporated in garments it is usually desirable to have the pockets made with similar protective material in order to provide some level of protection to the pocket contents. In this case it is necessary that the protective material also has sufficient water vapour permeation as using lower permeability material would impact the garment comfort performance particularly around the pocket area. For this reason the water vapour transmission performance of the pocket material is important when considering whole garment performance as the sweat vapour generated by the body in the regions covered by the pockets must pass through the pocket and pocket materials in order to exit the garment.

For functional reasons the pockets are often large and designed to carry maps, gloves or other items which themselves act to increase the pocket's thermal and water vapour resistance and hence the overall thermal and evaporative resistance of the garment.

The effect of sweat passing through water vapour permeable pockets is particularly noticeable in wear conditions where there is no rain but the wearer is perspiring. In this case the pockets are often surprisingly damp or wet depending on the total evaporative resistance of the different layers of material used, the level of exertion of the wearer and the external environment conditions. This situation can be made worse depending on the pocket contents. For example if the pocket contains an impermeable plastic coated map then particularly in cold conditions, the sweat vapour will condense as liquid on the inside of the pocket. The user will find the map covered in condensed sweat. Similarly other less permeable objects in the pocket such as mobile phones will also become covered in condensed sweat.

Some garments have been designed to allow ventilating air through the outer shell and into the inside of the garment to the base layers worn underneath the garment in an attempt to reduce the impact of pockets with high resistance to water vapour permeation.

There is a need in the outdoor garment market to provide a single garment in which the wearer is able to adjust the thermal performance in at least a portion of the garment to enhance comfort during different activity levels and environmental conditions without loss of windproof or waterproof protection.

There is also a need in the market to provide a protective garment which substantially prevents the problem of sweat condensation within the pockets while still maintaining performance comparable with the remainder of the protective garment.

SUMMARY

A garment comprises an outer shell and at least one air ventilating system. The air ventilating system comprises an air ventilating chamber constructed from at least one water vapour permeable and air –impermeable inner layer which is attached to an inner side of the outer shell by a circumferential seal. The circumferential seal creates the air ventilating chamber between the outer shell and the inner layer. The air ventilating system further comprises at least one external air access to the air ventilating chamber to allow external air to circulate within the chamber. An air permeable spacer arrangement is arranged in the air ventilating chamber.

The garment according to the present invention comprises any kinds of clothing like a jacket, trousers, a vest, shirts, coats, gloves, an overall as well as shoes and hats.

The garment described in this invention achieves variable heat loss performance by means of the above described combination of the outer shell and the air ventilating system attached to it. In one embodiment the water vapour permeable and air impermeable inner layer forms the innermost layer of the garment closest to the wearer and external air entering the air ventilating chamber via the at least one external air access, is directed over the chamber facing surface of the inner layer in order to remove the sweat permeating through said layer. In one embodiment the inner layer can also be waterproof.

The outer shell of the garment can comprise one material layer or several material layers and can also be formed from one or several material parts. The outer shell comprises an exterior facing outer side and an interior facing inner side. In one embodiment the outer shell comprises at least one water vapour permeable functional layer. In one embodiment the outer shell is formed from a laminate comprising the water vapour permeable functional layer adjacent to an outer textile layer. An inner lining layer may be arranged to the functional layer either forming a 3 layer laminate or as a separate lining layer. Additional thermal insulation layers or lining layers may be incorporated to the outer shell. In one embodiment the water vapour permeable functional layer is liquid impermeable, at least water impermeable (waterproof). In another embodiment the water vapour permeable functional layer is air impermeable. In another embodiment at least part of the outer shell in the area of the air ventilating chamber can be water vapour impermeable.

The water vapour permeable functional layer can comprise a membrane. In one embodiment the membrane comprises expanded polytetrafluororethylene (ePTFE).

The water vapour permeable and air impermeable inner layer can be in one embodiment water impermeable or waterproof. The inner layer can comprise at least one water vapour permeable and air impermeable functional layer. In one embodiment the inner layer is formed from a laminate comprising the water vapour permeable and air impermeable functional layer adjacent to a textile layer. In another embodiment the inner layer is made of a three layer laminate with the water vapour permeable and air impermeable functional layer embedded between two textile layers. In one embodiment the water vapour permeable functional layer is liquid impermeable, at least water impermeable (waterproof).

The air impermeable, water vapour permeable functional layer may comprise a membrane. In one embodiment the membrane comprises expanded polytetrafluororethylene (ePTFE).

The air ventilating chamber is an enclosed space inside the garment for the circulation of external air. The air ventilating chamber is formed between the inner side of the outer shell and the inner layer. The chamber has a circumferential seal which attaches the circumferential edge of the water vapour permeable and air impermeable inner layer to the inner side of the outer shell. The circumferential seal can be air impermeable. The air ventilating chamber is connected to the exterior environment by at least one external air access for the entry and exit of external air. The at least one air access is arranged in the outer shell within the area of the air ventilating chamber.

The air permeable spacer arrangement is provided inside the air ventilating chamber to maintain a distance between the outer shell and the inner layer and thereby enhance air circulation and efficient vapour removal.

The air permeable spacer arrangement is positioned adjacent or on the chamber facing surface of the inner layer to ensure that external air can circulate effectively over that inner layer. The air impermeable inner layer in combination with the air impermeable circumferential seal does not allow air to pass through to the interior of the garment and to the under layers worn by the user.

Such a garment construction allows external air to enter into the air ventilating chamber behind the outer shell but prevents the external air from passing completely through the garment to the under layers. The external air circulates within the chamber and takes up and removes sweat vapour that has been transmitted from the body through the inner layer.

By ensuring air circulation over the chamber facing surface of the inner layer, the permeation resistance and insulation resistance of the garment outer shell are now largely bypassed and in this air circulation area of the garment the overall water vapour removal and thermal performance are now more similar to that of the inner layer itself.

By choosing to reduce or increase the air flow over the chamber facing surface of the inner layer, the wearer can directly influence the amount of heat loss or sweat or moisture removal from of the garment.

External air flow over the chamber facing surface of the inner layer can be achieved by means of a single air access to the external environment or more preferably by means of multiple air exit and entry points. The at least one air access comprises means to control the air flow in the air ventilating chamber, for example, by means of opening or closing the at least one air access, preferentially by the use of closures or openers known to those familiar with current or state of the art closure technologies.

If the outer shell of the garment comprises particularly an insulating garment material designed for keeping the wearer warm, for instance for garments designed for use in snow sports, then opening the air access and allowing air circulation will alter the thermal insulation value of this particular part of the garment to insulation values that are similar to those of the inner layer. The insulative properties of the garment in this air circulation area will now have been reduced and the wearer will subsequently feel cooler.

In designs of the current invention there may also be multiple air access to the air chamber and the air permeable spacer arrangement should enable the air flow from one air access to the other with the objective of exposing the largest chamber facing surface area of the inner layer with sufficient air movement in order to maximize the reduction in thermal and water vapour resistance that occurs with the introduction of external circulating air.

The spacer arrangement is required in order to reliably maintain the air gaps in the air ventilating chamber that allow suitable low pressure air flow, for example in the case when the layers of the garment are subjected to forces of compression, tension, bending or shear that occur during wearing of the garment.

The spacer arrangement preferably has a three dimensional structure that is sufficiently free from obstruction as to allow the low pressure air flow that moves between the inner side of the outer shell and the water vapour permeable and air impermeable inner layer. The spacer arrangement should also preferably optimise the area of the inner layer that is exposed to sufficient levels of air circulation. Preferably, the spacer arrangement should enable the maximum level of air circulation and yet be light and soft to minimise wearer discomfort, excessive bulk or garment misshape.

The spacer arrangement comprises in one embodiment at least one air channel. The spacer arrangement can be skeletal in design, or made with 3D spacer materials, foam, textiles, reticulated mesh, shaped polymer materials or other combinations of continuous or discrete material arrangements known to those skilled in the art.

According to another embodiment the spacer arrangement comprises several air channels. The air channels are formed by the structural elements of the spacer arrangement. In one embodiment the structural elements can be one or more longitudinal spacer elements like tubes or bars which are arranged substantially in parallel to each other within the chamber. The space between the structural elements forms air channels for directing the external air.

In another embodiment the structural elements of the spacer arrangement are in the form of discrete elements like dots. In one embodiment the dots are made of polymeric materials. The dots are arranged on either the inner side of the outer shell or on the chamber facing surface of the inner layer in a discontinuous manner to maximize vapour transfer and air flow in the chamber. In another embodiment the dots are arranged on the inner side of the outer shell and the chamber facing surface of the inner layer in a discontinuous mixed manner.

In one embodiment the air ventilating system is arranged to the outer shell in the frontal area of the garment. In another embodiment the air ventilating system is arranged to the outer shell in the chest area of the frontal area of the garment.

In one embodiment there may be at least two external air access to the chamber, a first external air access and a second external air access, and the spacer arrangement should particularly enable the external air flow from one air access to the other with the objective of exposing the maximum chamber facing surface area of the inner layer with sufficient air movement.

In one embodiment the first external air access is in air flow connection to the second external air access.

In another embodiment the second external air access is arranged opposite of the first external air access.

The first external air access comprises a first opening and the second external air access comprises a second opening which are arranged in the outer shell and within the area of the air ventilating chamber and connect the air ventilating chamber to the outside such that external air can be transported between the first and the second opening.

In a further embodiment the at least one external air access comprises a first opening in the outer shell, for example in the frontal area of the outer shell. The first opening is arranged within the area of the air ventilating chamber. The first opening can be arranged next to the frontal closure of the garment. In one embodiment the second external air access comprises a second opening in the outer shell, for example in the frontal area of the outer shell. The second opening is arranged within the area of the air ventilating chamber but in the side area of the garment. The first opening and the second opening may be arranged on opposite sides of the air ventilating chamber such that air can flow between the two openings. With such an arrangement the external air circulates only in and out of the air ventilating chamber without passing through the garment to the base layers worn beneath.

In another embodiment the first opening and/or the second opening are arranged in the outer shell in a substantially vertical direction.

In another embodiment the at least one air channel of the spacer arrangement is in connection with the first opening and/or the second opening.

An additional benefit of this garment design feature occurs where the garment is fitted with either internal or external pockets and the air ventilating chamber with the air permeable spacer arrangement is arranged at least partially behind the pocket. The term "at least partially" means that the air ventilating chamber can be arranged completely or in parts behind the pocket.

In a further aspect of the present garment at least one pocket is arranged to the outer shell. In one embodiment the pocket is arranged to the frontal area of the outer shell. In another embodiment the pocket is arranged on the inner side of the outer shell within the air ventilating chamber. In a further embodiment the pocket is arranged on the outer side of the outer shell such that the air ventilating chamber is still at least partially behind the pocket.

In existing waterproof or windproof garments, pockets are also made with water vapour permeable protective material and sweat from the user perspiring passes through the pocket to evaporate from the outer shell surface. Sometimes these pockets are constructed internally and are then mostly invisible behind the outer garment shell or are constructed externally so that they are visible on the outside of the garment.

With a garment design of this invention the thermal and water vapour resistance of the pocket or pockets and the contents can be bypassed by the external air circulating behind.

The air permeable spacer arrangement with at least one air channel allows air from the surrounding environment to circulate in an area wholly or partially behind the pocket or pockets thereby assisting removal of sweat vapour from the garment and at the same time reducing sweat transport into the pocket.

The pocket contents then remain substantially dry and the overall water vapour removal performance and thermal insulation value of the garment in that air circulation area is similar to the performance of the air impermeable inner layer. The pockets can be added to a garment of this design without negatively impacting the overall thermal performance of the garment when compared to a similar garment without pockets.

Garments with such an air ventilating system at least partially behind the pocket create an air flow behind the pocket and restricts the entry of water vapour into the pocket.

The pocket can be loaded with bulky items such as gloves which would otherwise compress the area behind the pocket thereby reducing the air circulation gap or there may be folds that develop in the pocket area and act to shut off the air flow depending on the garment fit or there may be objects worn underneath the garment which impinge on the shape that the garment must conform to.

The garment with the air ventilating system at least partially behind the pocket allows the interior of the pocket to remain substantially free from sweat produced by the wearer while the garment area covered by the pocket can achieve a protection level and comfort performance similar to the material used in the air impermeable inner layer. The air ventilating system behind the pocket keeps the contents of the pocket dry.

The air permeable spacer arrangement with at least one air channel allows air from the surrounding environment to circulate in an area wholly or partially behind the pocket thereby assisting removal of sweat vapour from the garment and at the same time reducing sweat transport into the pocket.

In one embodiment the pocket is arranged on the inner side of the outer shell and is located in the air ventilating chamber. The pocket is formed of a pocket material incorporated to the inner side of the outer shell and therefore becomes an integrated part of the inner side. In this embodiment both, the pocket and the spacer arrangement behind the pocket are arranged in the air ventilating chamber.
In another embodiment the inner pocket can extend in its dimension over the dimensions of the air ventilating chamber, for example in the lower and upper edge areas. In that embodiment the air ventilating chamber is arranged only partially behind the pocket. The inner layer is attached to the inner side of the outer shell and in this embodiment the inner side of the outer shell also comprises at least part of the pocket material..

In another embodiment the pocket is arranged to the outer side of the outer shell in an area at least partially within the circumferential seal forming the circumferential edge of the air ventilating chamber. Such a configuration allows the spacer arrangement in the air ventilating chamber to be at least partially behind the pocket.

The at least one air channel of the spacer arrangement is in connection with the first opening and/or the second opening to direct the external air through the spacer arrangement and therefore at least partially behind the pocket. The at least one opening and/or the second opening is in addition to a pocket opening and may be covered by an air permeable protective cover.

BRIEF INTRODUCTION TO THE DRAWINGS

Figure 1 shows a front view of a person wearing a garment in the form of a jacket having an air ventilating system on either side of the a front closure respectively;

Figure 2 shows a front view of a jacket according to one embodiment with an air ventilating system arranged on an inner side of the outer shell in the frontal area of the jacket, where an air ventilating chamber is connected to the exterior by a first air access and a second air access;

Figure 2A shows a cross section of an embodiment of the outer shell material;

Figure 3A shows a cross section on section A-A from Figure 2;

Figure 3B shows a cross section on section B-B from Figure 2;

Figure 4 shows a trouser according to a further embodiment with an air ventilating system arranged on an inner side of the trouser outer shell in the frontal area of the trousers right leg;

Figure 5 shows a front view of a garment according to another embodiment with an interior pocket, an air ventilating system behind said pocket and one external air access to the air ventilating chamber;

Figure 6 shows a front view of a garment according to another embodiment with an interior pocket, an air ventilating system behind said pocket and two opposite arranged external air access;

Figure 7a shows a cross section on section C-C from Figure 6;

Figure 7b shows a cross section on section D-D from Figure 6;

Figure 8 shows a front view of a garment according to a further embodiment with an external pocket, the air ventilating system behind said pocket and two opposite arranged external air accesses;

Figure 9A shows a cross section on section E-E from Figure 8;

Figure 9B shows a cross section on section F-F from Figure 8;

Figure 10a to 10b show cross sections of different embodiments of the air permeable spacer arrangement;

Figure 11 shows a schematic view of another embodiment of the air permeable spacer arrangement;

Figure 12 shows a schematic view of a further embodiment of the air permeable spacer arrangement;

Figure 13 shows a front view of a test garment with a right hand side (RHS) having an internal pocket and the air ventilating system arranged behind the pocket, and a left hand side (LHS) having a standard internal pocket.

Figure 14 shows the results of the measurement of relative humidity and temperature inside the pocket of the RHS of the garment according to Figure 13;

Figure 15 shows the results of the measurement of relative humidity and temperature inside the pocket of the LHS of the garment according to Figure 13;

Figure 16 shows the photograph of plastic films placed respectively in the pockets of garment according to Figure 13;

Figure 17 shows the results of the measurement of relative humidity and temperature inside the pocket of the RHS of the garment according to Figure 13;

Figure 18 shows the results of the measurement of relative humidity and temperature inside the pocket of the LHS of the garment according to Figure 13;

Figure 19 shows the results of the measurement of relative humidity and temperature inside the pocket of the RHS of a garment with a pocket on the outer side of the outer shell and the air ventilating system behind the pocket and on the inside of the outer sell;

Figure 20 shows the results of the measurement of relative humidity and temperature inside the pocket of the LHS of a garment with a pocket on the outer side of the outer shell and the air ventilating system partially behind the pocket and on the inside of the outer sell;

Figure 21 shows the results of the measurement of relative humidity on the inside of the garment of Figure 13 on the RHS and the LHS respectively;

DETAILED DESCRIPTION OF THE INVENTION

Described, herein, is a garment with an outer shell and an air ventilating system arranged to the inside of the outer shell. The air ventilating system comprises an air ventilating chamber with an air permeable spacer arrangement. At least one air access through the outer shell into the air ventilating chamber allows external air to circulate only inside the chamber. The external air takes up water vapour that has permeated into the chamber and transports it away from the air chamber to the outside. Therefore, the wearer feels dry and more comfortable in a broader range of activities.

Exemplary embodiments will now describe in connection with the illustrative drawings appended hereto.

A first embodiment is exemplified in Figure 1, 2 and 3.

Figure 1 shows a schematic front view of a user 1 wearing a garment 10 in the form of a jacket having air ventilating system 40 arranged in the frontal area of the garment on either side of a front closure 18. The garment 10 comprises an outer shell 12 having an exterior facing outer side 16 with the front closure 18 and two sleeves 4, 5 with wrist cuffs. The frontal area of the garment 10 comprises four external air access 30, shown as first opening 32 and second opening 34 on the right hand side (RHS) and the left hand side (LHS) of the garment 10. In one embodiment the external air access 30 comprises an opening through the outer shell 12 into an air ventilating chamber (not shown). Each first opening 32 is closed by a zip. Each second opening 34 is permanently open without a zip. In one embodiment the first and the second opening can comprise an air permeable mesh. Each of the first and second openings provides external air access to the air ventilating chamber which is arranged on the inner side of the outer shell 12.

Figure 2 illustrates a schematic front view of the garment 10 as shown in Figure 1, and shows in more detail the outline of the air ventilating system 40 located on the garment right hand side (RHS). The garment 10 can have also an air ventilating system 40 on the left hand side (LHS) of the garment or in other garment locations. The outer shell 12 comprises an exterior facing outer side 16 and an interior facing inner side (not visible). The garment 10 comprises a front closure 18, sleeves 4, 5 with wrist cuffs and circumferential collars 6. The outer shell 12 can comprise a single layer or multiple layers depending on the end use. The outer shell can comprise at least one water vapour permeable and air impermeable functional layer. In a further example the outer shell can comprise at least one water vapour permeable and water impermeable functional layer. The multiple layers can be in the form of a laminate, like a two layer laminate or a three layer laminate. In one embodiment the outer shell 12 is formed of a three layer laminate 70 exemplified in the cross-sectional illustration of Figure 2a. The laminate 70 comprises a functional layer 76 embedded between two textile layers 72, 74. In one example the functional layer 76 is a porous membrane. The textile layers 72, 74, such as a woven, a knit or non-woven textile, are bonded to the porous membrane in a manner that maintains a desirably high level of water vapour transmission. The textile layers are attached to the porous membrane by discontinuous attachments, for example dot-laminated using polyurethane-based adhesive. The first textile layer 72 is forming the outer side 16 of the outer shell 12. The second textile layer 74 is forming the inner side 14 of the outer shell 12. The porous membrane 76 may be coated with an oleophobic composition that is also hydrophobic. In one embodiment the membrane is made of expanded polytetrafluoroethylene (PTFE). In another embodiment the membrane can comprise a bi-component expanded PTFE membrane. A bi-component expanded PTFE membrane is generally comprised of expanded PTFE membrane and monolithic coatings of water vapour permeable polymers, such as water vapour permeable polyurethanes. Such bi-component expanded PTFE membrane are also liquidproof. The first textile layer 72 can have a coating applied to repel water or oil or a combination thereof.

The right hand side (RHS) of the frontal area of the garment 10 has two air access 30, a first opening 32 and a second opening 34. The first opening 32 can be closed by a closure like a zip 36. The first and the second opening 32, 34 can comprise an air permeable protective material 38 like an air permeable mesh.

An air ventilating system 40 is disposed on the inner side of the garment and schematically shown with dotted lines in Figure 2. A water vapour permeable and air impermeable inner layer 42 is attached to the inner side (not visible) of the outer shell 12 by a circumferential seal 52. The water vapour permeable and air impermeable inner layer 42 is provided to form an air ventilating chamber 50 in which external air can circulate but can not enter the inside of the garment 10. The first and the second openings 32, 34 connect the air ventilating chamber 50 to the environment to enable an air flow and are arranged within the area of the chamber 50.

In one embodiment the inner layer 42 can comprise a bi-component expanded PTFE membrane as described above with respect to the outer shell 12.

The above described construction of the air ventilating system 40 prevents external air penetrating through the whole garment 10.

An air permeable spacer arrangement 60 in the form of multiple discrete structural elements 62 is located in the air ventilating chamber 50. In one embodiment the discrete structural elements 62 are in the form of suitable polymeric dots as shown with dotted lines in Figure 2. Such structural elements can be adhered in one example on the inner side of the outer shell 12 in a discontinuous pattern such that external air can circulate through the chamber 50. The pattern of the arrangement of the discrete structural elements 62 forms air channels which direct the external air to flow over the chamber-facing surface of the inner layer 42.

Figure 3A illustrates a cross section of the air ventilating system 40 according to section A-A in Figure 2. The outer shell 12 comprises an exterior facing outer side 16 and an interior facing inner side 14 and can comprise in one embodiment a laminate as described above with respect to Figure 2A. The water vapour permeable and air impermeable inner layer 42 is attached by the circumferential seal 52 to the inner side 14 of the outer shell 12 in forming the air ventilating chamber 50. In the embodiment of Figure 3A the circumferential edge of the inner layer 42 is adhesively attached to the inner side 14 of the outer shell 12 and that seam is sealed by a seam tape 54. The air permeable spacer arrangement 60 with its multiple discrete structural elements 62 is located inside the air ventilating chamber 50. In the embodiment of Figure 3A the elements 62 are adhesively attached to the inner side 14 of the outer shell 12. The elements 62 separate the inner layer 42 and outer shell 12 in forming a space. The space between the elements 62 forms air channels 64 through which the external air will be directed.

Figure 3B illustrates a cross section of the air ventilating system 40 according to section B-B in Figure 2. The air ventilating system 40 is arranged on the right hand side (RHS) of the front closure 18 of the garment. The outer shell 12 comprises in the area of the air ventilating system 40 a first opening 32 and a second opening 34 forming air access 30 to the air ventilating chamber 50 on the inside of the garment. The first opening 32 comprises an air permeable protective material 38, for example in the form of a mesh which allows the transport of external air through it but prevents the use of the chamber 50 as a pocket. The air ventilating chamber 50 is formed by the water vapour permeable and air-impermeable inner layer 42 which is adhered to the inner side 14 of the outer shell 12 by a circumferential seal 52. The air permeable spacer arrangement 60 with its multiple discrete structural elements 62 is located inside the air ventilating chamber 50 and separate the inner layer and the outer shell. External air, shown by the arrow, enters the air ventilating chamber 50 and circulates through the chamber 50 and over the chamber facing surface of the inner layer 42. Sweat vapour that has been transmitted from the body through the inner layer 42 can be taken up by the external air and transports out of the chamber 50 through the second opening 34 (see arrow).

Figure 4 illustrates an alternative embodiment wherein the garment 10 is a pair of trousers. This embodiment has the same basic structure as the embodiment of Figure 1 and 2, with outer shell 12 and an air ventilating system 40 on the inside of the garment 10. Each trouser leg 8 comprises a pocket 20 in the upper front area.

The air ventilating system 40, shown by the dotted lines in the Figure, is arranged on the inside of the right trouser leg 8 in the upper front area and behind the pocket 20. In another embodiment the air ventilating system is arranged on the right hand side and the left hand side of the trouser. The air ventilating chamber 50 is formed by the circumferential seal 52 between the inner side (not visible) of the outer shell 12 and the water vapour permeable and air impermeable inner layer 42. The air permeable spacer arrangement 60 within the air ventilating chamber 50 is in the form of discrete structural elements 62 which are arranged in a discontinuous manner in a line. In one embodiment the outer shell 12 material and the inner layer 42 material can be the same as for the jacket in Figure 2.

Figure 5 illustrates another alternative embodiment of a garment 10 in the form of a jacket. In this embodiment the jacket comprises a pocket 20 in the frontal area on the right hand side (RHS) of the front closure 18.
The outer shell 12 comprises an exterior facing outer side 16 and an interior facing inner side (not visible). The garment 10 comprises a front closure 18, sleeves 4, 5 with wrist cuffs and circumferential collars 6.
In this embodiment the right hand side (RHS) of the garment 10 comprises a pocket 20 incorporated to the outer shell 12 such that the pocket 20, shown in dotted lines in the Figure, is on the inner side of the outer shell 12 and only a pocket opening 26 is visible on the outer side 16 of the outer shell 12. The pocket opening 26 allows access to the pocket 20 through the outer shell 12. The pocket opening 26 can be open and close by a pocket zip 27. Furthermore an air ventilating system 40, also shown in dotted lines, is arranged on the inside of the garment 10 such that it is arranged behind the pocket 20. In this embodiment the water vapour permeable and air impermeable inner layer 42 completely covers the pocket 20 on the inner side of the outer shell 12. The circumferential seal 52 goes in a distance around the outer border 28 of the pocket 20 so that the pocket 20 is fully located within the air ventilating chamber 50.
In another embodiment the inner pocket of Figure 5 can have the size as shown in Figure 8. In that case the pocket material in the upper and lower border area go beyond the circumferential seal of the air ventilating chamber. In this embodiment

the inner side of the outer shell also comprises the pocket material and therefore the inner layer is partially attached to the pocket material as part of the outer shell material in that area

A separate external air access 30 to the air ventilating chamber 50 is arranged in the outer shell 12 adjacent to the front closure 18 and in an area between the circumferential seal 52 and the outer border 28 of the pocket 20. External air, shown by the arrows, enters via the air access 30 the air ventilating chamber 50 and circulates over the chamber facing surface of the inner layer 42 until it exits the chamber 50 via the same air access 30.

Figure 6 illustrates another embodiment of the jacket construction with pockets as generally illustrated in Figure 5. The construction of the jacket is similar to Figure 5 with the difference that a second air access 30 is provided on the side area of the right hand side (RHS) part of the garment 10. The second air access 30 comprises a second opening 34. The air permeable spacer arrangement 60 within the air ventilating chamber 50 is the form of multiple discrete structural elements 62. In this embodiment the discrete structural elements 62 are in the form of polymeric dots which are adhered on the inner side of the outer shell 12 in a discontinuous pattern such that external air can circulate through the chamber 50. The discrete structural elements 62 in dot form separate the inner layer 42 and the inner side of the outer shell 12. Furthermore the pattern of the arrangement of the dots forms air channels 64 which direct the external air to flow over the chamber-facing surface of the inner layer 42. The first and the second opening 32, 34 connect the air ventilating chamber 50 to the environment.

Figure 7A shows a cross section of section C-C of Figure 6. The outer shell 12 has an exterior facing outer side 16 and an interior facing inner side 14. On the inner side 14 of the outer shell 12 the water vapour permeable and air impermeable inner layer 42 is attached by a circumferential seal 52 forming the air ventilating chamber 50. The pocket 20 is arranged on the inner side 14 of the outer shell 12 and located adjacent to the chamber 50. The air permeable spacer arrangement 60 is therefore located between the inner layer 42 and the pocket material 25. In this embodiment the spacer elements 62 of the air permeable spacer arrangement 60 are attached to the chamber-facing surface of the inner layer 42. The inner layer 42 completely surrounds the pocket 20 in forming the air ventilating chamber 50. Due to the circumferential seal 52 and the air impermeable inner layer 42 the external air can only circulate within the chamber 50 between the first and the second opening. Air channels 64 direct the external air over the chamber facing surface of the inner layer 42.

Figure 7B illustrates a cross section of the air ventilating system 40 according to section D-D in Figure 6 but only in the front area of the right hand side (RHS) of the garment 10. The outer shell 12 comprises in the area of the air ventilating system 40 a first opening 32 and a second opening 34 forming air access 30 to the air ventilating chamber 50 on the inside of the garment. Furthermore an interior pocket 20 is formed to the inner side 14 of the outer shell 12 with a pocket opening 26 closed by a zip 27. The air ventilating chamber 50 is formed by the water vapour permeable and air-impermeable inner layer 42 which is adhered to the inner side 14 of the outer shell 12 by a circumferential seal 52. The inner layer 42 also fully surrounds the pocket 20 and the first opening 32 and the second opening 34 are located on opposite sides of the pocket edge. The air permeable spacer arrangement 60 with its multiple discrete structural elements 62 is located inside the air ventilating chamber 50 and separates the inner layer 42 and the pocket material 25. External air, shown by the arrow, enters the air ventilating chamber 50 and circulates through the chamber 50 and over the chamber facing surface of the inner layer 42. Sweat vapour that has been transmitted from the body through the inner layer 42 can be taken up by the external air and transported out of the chamber 50 through the second opening 34 (see arrow).

Figure 8 illustrates another embodiment of a garment 10 with a pocket 20. The construction of the garment 10 with the air ventilating system 40 is similar as described with respect to the Figures 2, 5 and 6. In this embodiment the pocket 20 is arranged on the outer side 16 of the outer shell 12 with a pocket zip 27 to open and close the pocket 20. The air ventilating system 40 is arranged on the inner side of the outer shell 12 partially behind the pocket 20 and has similar construction as explained with respect to the Figures 5 and 6. In this example the size of the pocket 20 in the upper and lower border area go beyond the area of the air ventilating chamber and therefore the air ventilating chamber is only partially behind the pocket 20. In this embodiment both the first and the second opening 32, 34 comprises a protective material 38.

Figure 9A shows a cross section of section E-E of Figure 8. The pocket 20 is formed by a pocket material 25 that is attached to the outer side 16 of the outer shell 12. The inner layer 42 is adhered and circumferential sealed by a sealing tape 54 to the inner side 14 of the outer shell 12 forming the air ventilating chamber 50 such that chamber 50 is arranged partially behind the pocket 20. The spacer elements 62 are adhered to the inner side 14 of the outer shell 12 and separating the outer shell 12 and the inner layer 42. Air channels 64 formed between the elements 62 will direct the external air over the chamber facing surface of the inner layer 42.

Figure 9B shows a cross section of section F-F of Figure 8 but only in the front area of the right hand side (RHS) of the garment 10. The outer shell 12 comprises on the right hand side of the front closure 18 in the area of the air ventilating system 40 a first opening 32 and a second opening 34 forming air access 30 to the air ventilating chamber 50 on the inside of the garment. Furthermore an exterior pocket 20 is formed to the outer side 16 of the outer shell 12 with a pocket opening 26 closed by a zip 27. The air ventilating chamber 50 is formed by the water vapour permeable and air-impermeable inner layer 42 which is adhered to the inner side 14 of the outer shell 12 by a circumferential seal 52. The chamber 50 is formed in an area that its covers the pocket along the inner side of the outer shell. The air permeable spacer arrangement 60 with its multiple discrete structural elements 62 is located inside the air ventilating chamber 50 and separates the inner layer 42 and the outer shell 12. External air, shown by the arrow, enters the air ventilating chamber 50 and circulates through the chamber 50 and over the chamber facing surface of the inner layer 42. Water vapour that has been transmitted from the body through the inner layer can be taken up by the external air and transports out of the chamber 50 through the second opening 34.

Figure 10, 11 and 12 show different embodiments of the air permeable spacer arrangement.

Figure 10A shows a cross section of a section of the air ventilating chamber 50 with the air permeable spacer arrangement 60. In that section the air permeable arrangement 60 comprises several discrete structural elements 62 in the form of polymeric dots which are arranged at a distance to each other between the inner layer 42 and the inner side 14 of the outer shell 12 or the pocket material. In this embodiment the elements 62 are attached in a discontinuous manner to the inner side 14 of the outer shell 12. The structural elements 62 keep the inner layer 42 and the outer shell 12 or pocket material in a distance to each other to allow external air to circulate within the chamber 50. The distance between the outer shell 12 or pocket material and the inner layer 42 can be at least 1mm, in another embodiment it can be 10mm, in a further embodiment the distance is between 15mm and 50mm. The spaces between the structural elements create air channels 64 through which the external air will be directed. In one embodiment the structural elements 62 can have a diameter of around 5mm and the distance between two adjacent structural elements 62 can be around 5mm. In one embodiment the inner side 14 of the outer shell 12 is covered with around 50mm diameter structural elements 62 and the distance between the structural elements 62 is around 100mm. The structural elements 62 can be made of polymeric material and can be printed or extruded or adhered or fixed in place in a repeating or random pattern by methods known to those skilled in the art.

Figure 10B shows a cross section of a section of the air ventilating chamber 50 with the air permeable spacer arrangement 60 in another embodiment. In that section the air permeable arrangement 60 comprises several discrete structural elements 62 in the form of rectangular shaped elongated spacers, e g. bars, which are arranged in a substantially parallel manner and in a distance to each other between the inner layer 42 and the inner side 14 of the outer shell 12 or pocket material. Also in this embodiment the elongated spacer elements 62 keep the inner layer 42 and the outer shell 12 or pocket material in a distance to each other to allow external air to circulate within the chamber 50. The spacer elements 62 can be adhered to either the inner side 14 of the outer shell 12/pocket material or to the chamber facing side of the inner layer 42 in a preferentially parallel and substantially horizontal arrangement. The space between two adjacent spacer elements forms an air channel 64 through which the external can circulate. The elongated spacer elements 62 can have a length to suit the air chamber length and can have a height of between 1mm to 50mm. The distance between the spacer elements can be between 2 to 200mm.

Figure 11 shows a perspective view of another embodiment of the air permeable spacer arrangement 60.

In this embodiment a three dimensional (3D) spacer shape is created by moulding protrusions into a sheet of suitable forming polymeric material. When this 3D spacer shape is then placed between two layers of material, air channels are created around the raised protrusions and in the gap that now exists between the two material layers and particularly between the layer resting on the protrusions and the base sheet layer.

In the embodiment shown in Figure 11 of a spacer structure 66 appropriate as an air-permeable spacer arrangement 60, roughly hemispherical protrusions or bulges 68 bulge upward from a lower flat structure 67 whose upper crests define an upper support surface. In one variant, this spacer structure 66 consists of an initially flat knit or solid material which, after it has been brought to the form shown, is moulded such that it retains this shape. In addition to a moulding process, other steps can be used, namely deformation by a thermoforming process or impregnation with a synthetic resin that cures to the desired form.

Figure 12 shows a perspective view of another embodiment of the air permeable spacer arrangement 60. This spacer is constructed by a process of three dimensional (3D) weaving in which the dimension of thickness is added to the more common 2D weaving product using additional multiple weft and warp yarns.

Advances in weaving machinery mean that even discrete channels and shapes may be woven in the thickness dimension.

The term "outer shell" as used herein comprises at least one layer or layered structure or multiple layers that forms the appearance of the garment. The outer shell of a garment is usually made of several material layers or layered structures which are attached to each other in assembling the garment. In one embodiment the outer shell comprises at least one laminate. The laminate may be incorporated into a fabric composite structure. The outer shell has an outer side and an inner side. The outer side is directed to the exterior and the inner side is directed to the interior or inside of the garment or faces towards the body of a wearer. The inner side can comprise additional features like seams or pocket materials which have been attached to the outer shell. The garment may comprise additional internal layers which form linings of the garment and which may or may not be attached to the outer shell. In one embodiment the outer shell comprises at least one water vapour permeable functional layer. In one embodiment the outer shell is formed from a laminate comprising the water vapour permeable functional layer adjacent to an outer textile layer. An inner lining layer may be arranged to the functional layer either forming a three layer laminate or as a separate lining layer. Additional thermal insulation layers, for example those used in a snow sports garment, or lining layers may be incorporated as part of the outer shell. In one embodiment the water vapour permeable functional layer is liquid impermeable, at least water impermeable. In another embodiment the water vapour permeable functional layer is air impermeable. In another embodiment the outer shell can comprise a water vapour impermeable material limited to the area of the air ventilating system.

The term "air ventilating chamber" as used herein is a means to circulate external air within a defined air space on the inside of the garment. The chamber comprises at least one water vapour permeable and air impermeable inner layer attached to the inner side of the outer shell by a circumferential seal.

The term "inner layer" as used herein comprises a water vapour permeable and air impermeable material layer or layers or layered structure arranged inside of the garment, and forms the part of the air ventilating chamber that is innermost towards the body. In one embodiment the inner layer comes in contact with the undergarment of the wearer. The inner layer comprises at least one functional layer. In one embodiment the inner layer can be in the form of a laminate comprising a functional layer and one or more textile layers. The inner layer can be arranged such that it is very close to the body so that water vapour can easily transport through it into the chamber. In one embodiment the inner layer has a Ret of $3m^2Pa/W$. The inner layer can also be water impermeable (waterproof).

The term "laminate" as used herein refers to at least two individual layers, which are bonded via an adhesive or otherwise.

The term "circumferential seal" as used herein refers to the attachment of the circumferential edge of the water vapour permeable and air impermeable inner layer to the inner side of the outer shell. The attachment can comprise any attachment means like for example welding, gluing, sewing and/or seam taping. The seal is air impermeable according to the definition further below. In one embodiment the seal can be water impermeable (waterproof) according to the definition further below.

The term "functional layer" as used herein is intended to include any layer which readily permits water vapour transmission through the layer, layered composite or laminate form. The layer might be a textile layer or a functional layer as described herein.
In one embodiment the term "functional layer" defines a film, membrane, coating or non-woven construction that provides a barrier to air penetration and/or to penetration to a range of other gases, for example gas chemical challenges. Hence, the functional layer is air impermeable and/or gas impermeable, yet still allows water transport from one side of the layer to the other. In another embodiment the functional layer serves as a liquid barrier but also allows water transport through the layer from one side to the other.

The functional layer may be a membrane, a film or a laminate comprising polytetrafluoroethylene (PTFE), expanded PTFE, polyurethanes, or other suitable substrates. The functional layer can be realized using suitable membranes, e.g. microporous membrane made from expanded polytetrafluoroethylene (PTFE).

Water vapour permeation as used herein is understood to be the characteristic of a functional layer or garment material in terms of ability to be able to transport water vapour from one side of the functional layer or material to the other side. In one embodiment the outer shell and /or the inner layer comprises said functional layer. In another embodiment the outer shell and / or the inner layer may be also waterproof in comprising at least one waterproof and water vapour permeable functional layer.

The water vapour transmission resistance or resistance to evaporative transport (R_{et}) is measured by the Skin model according to ISO 11092(2005) or by a suitable alternative instrument with results calibrated to the said Skin model. Values for the sample material are determined from the evaporation heat flux passing through a given area under a constant partial pressure gradient. A textile layer or functional layer or inner layer according to the invention is considered to be water vapour permeable if it is has a water vapour transmission resistance Ret of below 150 (m^2Pa)/W. The said layer has in one embodiment a Ret of below 30 (m^2Pa)/W and in another embodiment has a water vapour permeability resistance (Ret) of less than 5 m^2Pa/W.

The resistance to thermal conductivity (R_{ct} in m^2C/W) is measured according to ISO 11092 (2005) or suitable thermal resistance instrument with results calibrated to ISO 11092 (2005). Values for the sample material are determined from the heat flux rate between two opposing surfaces of the material, measured over a unit area and under a steady state temperature difference.

Any layer and seal is considered to be air impermeable if it has an air permeability of less than 40 l/m²/sec at 100Pa, in particular embodiments if it has an air permeability of less than 5 l/m²/sec at 100Pa. (EN ISO 9237, 1995).

EN342:2004/AC:2008 "Ensembles and garments for protection against cold" groups garments into three air permeability classifications, where garments that have an air permeability of less than 5 l/m²/sec (Class 3) are all considered as effectively air impermeable.

To measure the air permeability of a layer or a functional layer or a layer construction with a seam, a test machine which can measure the air flow through the layer is used. The samples are placed between two rings which results in a test area of 100 cm². Air is sucked through the sample at a constant pressure of 100 Pa. The amount of air coming through the sample is measure and calculated in l/m²/s. The test method is described in EN ISO 9237.

Liquidproof or water impermeable (also described as waterproof) as used herein is understood to be the characteristic of a layer, a functional layer, garment material or seal which provides a barrier to liquid water penetration, and ideally to a range of liquid chemical challenges. In some embodiments the layer, functional layer, garment material or seal is considered liquid impermeable if it prevents liquid water penetration at a pressure of at least 0.05 bar. The water penetration pressure is measured on a sample of the layer, functional layer, garment material or seal based on the same conditions described with respect to the ISO 811 (1981).

The water vapour permeable functional layer may comprise one or more layers. In one embodiment the functional layer is water vapour permeable and air impermeable to provide air impermeable but water vapour permeable characteristics. In another embodiment the functional layer is also liquid impermeable, at least water impermeable.

The water vapour permeable functional layer can be made, for example, from a porous membrane comprising polymeric materials such as fluoropolymers, polyolefins, polyurethanes, and polyesters. Suitable polymers may comprise resins that can be processed to form porous or microporous membrane structures. For example, polytetrafluoroethylene (PTFE) resins that can be processed to form stretched porous structures are suitable for use herein. For example, PTFE resins can be stretched to form microporous membrane structures characterized by nodes interconnected by fibrils when expanded according to the process taught in patents such as US Pat. Nos. 3,953,566; 50814,405; or 7,306,729.

The pocket material can comprise one layer or layered structure or multiple layers made of one or several materials. In one embodiment the pocket material comprises a two layer or three layer laminate as described with respect to the outer shell and Figure 2a.

Example 1

A waterproof breathable Mountain Equipment Changabang garment (commercially available from OSC Limited, Redfern house, Dawson, St. Hyde U.K. SK14 1RD) which has a double overlapping internal pocket arrangement on each side of the centre zip is used. The garment has the following construction:

The outer shell is made of a waterproof water vapour permeable 80g/m^2 three layer GORE-TEX® PRO laminate (Part no GRNL000500Y, W.L.Gore & Associates Ltd, Simpson Parkway, Livingston U.K. EH54 7BH) which comprises a microporous membrane made of expanded polytetrafluoroethylene (ePTFE) adhered with a water vapour permeable adhesive between outer and inner layers of 100% polyamide woven textile.

The double overlapping inner pocket arrangement is constructed in the chest area of the garment on the inside of the outer shell and on both sides of the central zip. The double overlapping inner pocket arrangement comprises two pockets arranged one on top of the other on the inside of the outer shell. The outermost inner pocket on the left hand side (LHS) or right hand side (RHS) is accessed by a water resistant second zip located in vertical orientation adjacent to the underarm zip. An additional innermost pocket, known as a map pocket or inner pocket, is formed behind the outermost pocket and is accessed from a water resistant first zip located adjacent to the central zip in a vertical orientation.

Each pocket is made with a waterproof and water vapour permeable GORE-TEX® GR 3 L PRO pocket liner material (Part no PKLN003003Y, W.L.Gore & Associates Ltd, Simpson Parkway, Livingston U.K. EH54 7BH). The pocket liner material is a 75g/m^2 three layer laminate where the mid layer is a microporous membrane made of expanded polytetrafluoroethylene (ePTFE) adhered between outer and inner layers of 100% polyamide woven textile.

The garment is altered as follows:

The left hand side (LHS) of the garment is modified by cutting and removing the innermost pocket layer so that the remaining outermost pocket with water resistant second zip access from the exterior side area (next to the underarm zip) remains fully functional. The first zip of the removed innermost pocket is now fully closed.

The right hand side (RHS) of the garment is modified in exactly the same way as the LHS described above by cutting and removing the innermost pocket so that the remaining outermost pocket with a single access (second zip) from the exterior side area remains fully functional. The single access of the outermost pocket can be closed by the water resistant second zip.

The external zip access (first zip) of the removed innermost pocket remains and is subsequently used to form the first opening of the later formed air ventilating chamber. That first opening can be closed or opened by this water resistant first zip as required.

A cut is made in the garment outer shell to create an additional air access for the later formed air ventilating chamber. The cut is approximately parallel to and has the same length (approximately 270mm) as the remaining second zip in the exterior side area. The cut is made in the area between the underarm zip and the remaining second zip and within the outer edge of the area originally covered by the removed innermost pocket. The cut forms the second opening of the air ventilating chamber.

Four spacer elements are attached onto the garment interior facing surface of the remaining outermost pocket material which is now visible from the inside of the garment thereby forming the air permeable spacer arrangement. The spacer elements are arranged substantially horizontally between the first opening and the second opening. The distance between the spacer elements is approximately 50 mm. The gap between two adjacent spacer elements forms an air channel through which external air can move from the first opening to the second opening or vice versa. Thus, three air channels have been created between the four spacer elements. Each spacer element is a rectangular prism shape with a length of approximately 200mm, a width of approximately 17mm and a depth of approximately 10mm. Each spacer element is made by cutting commercially available spacer material (Müller Textil, part no 5900, Muller GmbH, D-51674 Wiehl, Germany) into strips of 200 mm length and 20mm wide and inserting the strip into a sewn tube of water vapour permeable and waterproof laminate (commercially available as a three layer laminate under the name GORE-TEX® PRO laminate by W.L.Gore & Associates (UK) Limited, part no GRNL000500Y). The spacer elements are attached to the inner (wearer facing) surface of the remaining outermost pocket material by means of hot melt adhesive (Part no 4RPALE50PWHTUK, W.L.Gore & Associates Ltd, Simpson Parkway, Livingston U.K. EH54 7BH).

The first zip is opened and an air permeable three dimensional (3D) mesh (available from Heathcoat Ltd, Westexe, Devon, EX16 5LL, part No N02591-A01) is attached to either side of the second zip using sewing thread. The 3D mesh is cut to a piece with size of approximately 50mm x 250mm to fit over the zip area. This zip access will become the first opening to the air chamber that is about to be formed, thereby allowing external air to access the spacer arrangement and the additional cut (second opening). The use of this 3D mesh will allow air to pass through the openings into the spacer arrangement but will also prevent the wearer using the chamber as a pocket. This 3D mesh is attached to the openings without compromising the waterproofness of the garment or severely restricting air flow between the spacers in the arrangement.

The air ventilating chamber is formed on the inner side of the RHS of the outer shell and over the area of the removed innermost pocket material. The air ventilating chamber is formed by attaching a water vapour permeable and air impermeable inner layer to the inner side of the outer shell. A two layer $50 g/m^2$ laminate made of polyamide knit and a microporous membrane of expanded polytetrafluoroethylene (ePTFE) (GORE-TEX® lifestyle liner material, W.L.Gore and Associates (UK) Limited, Part number LNER000000), is cut to replace approximately the shape and size of the original removed innermost pocket liner. This inner layer laminate has an RET of $3 m^2Pa/W$, an air permeability of less than $1.0 l/m^2/s$ and is capable of containing hydrostatic pressure to >5 m (ISO811:1981).

The inner layer laminate is bonded to the inner side of the outer shell in a location that replaces the original removed pocket liner and therefore fully covers the spacer elements and the first and the second opening. The polyamide knit is oriented to face towards the wearer and the bonding is achieved by hot pressing Gore hot melt seam tape (W.L.Gore & Associates (UK) Limited, Part number 4GTAH013NKLHUK) around the circumferential edge of the inner layer laminate. This seals the inner layer laminate in a waterproof manner to the inner side of the outer shell.

The inner layer is arranged as the innermost layer of the garment and therefore in close contact to the wearer.

External air can flow along the channels of the air permeable spacer arrangement and therefore along the chamber facing surface of the inner layer taking up water or moisture which has permeated through it.

The modified right hand side (RHS) of the waterproof water vapour permeable garment now provides a first waterproof water vapour permeable pocket as before and behind this pocket there is the air ventilating chamber with the air permeable spacer arrangement spacer therein which allows external air to circulate but not to enter the inside of the garment. External air can move or circulate behind the pocket via the external air access, the first and the second openings and the spacer arrangement. Opening or closing at least the zip of the first opening can change the amount of air circulating behind the pocket.

In rain conditions it is possible that water may enter the spacer arrangement via either air access. Drainage can be provided by various means, in this case it is provided by means of the sloping seam of the inner layer and the outer shell.

The modified left hand side (LHS) of the garment now provides a first waterproof water vapour permeable pocket as before. This LHS waterproof pocket is a common feature of waterproof garments where there is a single side zip access to a pocket made with waterproof vapour permeable materials that are assembled into the garment in a waterproof manner.

A picture of the altered garment according to example 1 is shown in Figure 13.

Example 2:

A waterproof breathable Mountain Equipment Changabang garment (commercially available from OSC Limited, Redfern house, Dawson St.Hyde U.K. SK14 1RD) which has a double overlapping internal pocket arrangement on each side of the centre zip is used. The double overlapping pocket arrangement is constructed in the chest area of the garment on the inside of the outer shell and on both sides of the central zip respectively. The garment has the same construction as the garment described in example 1 in the unchanged configuration.

The garment is altered as follows to incorporate another embodiment of this invention:

The right hand side (RHS) and the left hand side (LHS) of the garment are modified by cutting and removing all inside pockets from the garment, so that the internal overlapping pocket arrangement is removed. On the left hand side (LHS) the two pocket access in the form of the first zip and the second zip are closed.

On the right hand side (RHS) the outermost pocket access (second zip) is zipped closed. The external access (first zip) of the removed innermost pocket remains and is subsequently used to form the first opening of the later formed air ventilating chamber. That first opening can be closed or opened by the water resistant first zip as required.

A cut is made in the garment outer shell to create an additional air access for the later formed air ventilating chamber. The cut is approximately parallel to and has the same length (approximately 270mm) as the closed outermost pocket access (second zip) in the exterior side area. The cut is made in the area between the underarm zip and the closed outermost pocket access (second zip) and within the outer edge of the area originally covered by the removed innermost pocket. The cut forms the second opening of the later formed air ventilating chamber.

Four spacer elements are attached onto the inner surface of the outer shell which is now visible from the inside of the garment thereby forming the air permeable spacer arrangement. The spacer elements are arranged substantially horizontally between the accesses that form the first opening and the second opening. The distance between the spacer elements is approximately 50 mm. The gap between two adjacent spacer elements forms an air channel through which external air can move from the first opening to the second opening or vice versa. Thus, three air channels have been created between the four spacer elements. Each spacer element is a rectangular prism shape with a length of approximately 200mm, a width of approximately 17mm and a depth of approximately 10mm. Each spacer element is made by cutting commercially available spacer material (Müller Textil, part no 5900, Muller GmbH, D-51674 Wiehl, Germany) into strips of 200 mm length and 20mm wide and inserting the strip into a sewn tube of water vapour permeable and waterproof laminate (commercially available as a three layer laminate under the name GORE-TEX® PRO laminate by W.L.Gore & Associates (UK) Limited, part no GRNL000500Y). The spacer elements are attached to the wearer facing surface of outer shell material by means of hot melt adhesive (Part no 4RPALE50PWHTUK, W.L.Gore & Associates Ltd, Simpson Parkway, Livingston U.K. EH54 7BH).

The first zip is opened and an air permeable three dimensional (3D) mesh (available from Heathcoat Ltd, Westexe, Devon, EX16 5LL, part No N02591-A01) is attached to either side of the first zip using hot melt adhesive (Part no 4RPALE50PWHTUK, W.L.Gore & Associates Ltd, Simpson Parkway, Livingston U.K. EH54 7BH) and sewing thread. The 3D mesh is cut to a piece with size of approximately 50mm x 250mm to fit over the zip area. This zip access will become the first opening to the later formed air chamber that is about to be formed, thereby allowing external air to access the spacer arrangement and the additional cut (second opening). The use of this 3D mesh will allow air to pass through the openings into the spacer arrangement but will also prevent the wearer using the chamber as a pocket. This 3D mesh is attached to the openings without compromising the waterproofness of the garment or severely restricting air flow between the spacers in the arrangement.

The air ventilating chamber is formed on the inner side of the RHS of the outer shell and over the area of the removed innermost pocket material. The air ventilating chamber is formed by attaching a water vapour permeable and air impermeable inner layer to the inner side of the outer shell. The inner layer is a 2 layer 50g/m² laminate made of polyamide knit and a microporous membrane of expanded polytetrafluoroethylene (ePTFE). GORE-TEX® lifestyle liner material (W.L.Gore and Associates (UK) Limited, Part number LNER000000) is cut to replace the approximately shape and size of the removed innermost pocket liner. This inner layer laminate has a RET of 3 m^2Pa/W, an air permeability of less than 1 l/ m^{2}/s and is capable of containing hydrostatic pressure to >5 m (ISO811:1981).

The inner layer laminate is bonded to the inner side of the outer shell in a location that replaces the original removed pocket liner and that fully covers the spacer elements and the first and the second opening. The polyamide knit is oriented to face towards the wearer and the bonding is achieved by hot pressing Gore hot melt seam tape (W.L.Gore & Associates (UK) Limited, Part number 4GTAH013NKLHUK) around the circumferential edge of the inner layer laminate. This seals the inner layer laminate in a waterproof manner to the inner side of the outer shell.

The inner layer is arranged as the innermost layer of the garment and therefore in close contact to the wearer.

External air can flow along the channels of the air permeable spacer arrangement and therefore along the chamber facing surface of the inner layer taking up sweat vapour which has permeated through it.

The modified right hand side (RHS) of the waterproof water vapour permeable garment now provides an air ventilating chamber with the air permeable spacer arrangement spacer therein which allows external air to circulate but not to enter the inside of the garment. External air can move or circulate behind the outer shell via the external air accesses, the first and the second openings and the spacer arrangement. Opening or closing at least the zip of the first opening can change the amount of air circulating behind the pocket.

In rain conditions it is possible that water may enter the spacer arrangement via either air access. Drainage can be provided by various means, in this case it is provided by means of the sloping seam of the cavity layer and spacer arrangement.

On the RHS and LHS of the frontal area of the garment according to example 2 two outer pockets are formed on the outer side of the garment, on each side of the front zip. For the pockets two material pieces made with a waterproof and water vapour permeable laminate material (three layer laminate with a weight of $80g/m^2$, commercially available as GORE-TEX® PRO laminate by W.L. Gore & Associates (UK) Limited, Part no GRNL000500Y) are cut to a size of each of 130 x 300mm. Such a laminate comprises a microporous membrane of expanded polytetrafluoroethylene (ePTFE) adhered between two layers of 100% polyamide woven textile.

A three layer (3L) pocket laminate piece is placed on the chest area of the RHS of the garment on the exterior surface of the outer shell between the first and second openings of the air ventilating chamber such that the chamber is arranged behind the pocket. The pocket laminate is bonded to the outer surface of the outer shell by a hot melt sheet adhesive (W.L.Gore and Associates (UK) Limited, Part number 4RPALE50PWHTUK), hot pressed and adhered in place on vertical and bottom edges of the pocket laminate piece.
Another pocket laminate piece is placed on the chest area of the LHS of the garment on the exterior surface of the outer shell in a mirror image location to the first piece. The pocket laminate piece is bonded to the outer surface of the outer shell by a hot melt sheet adhesive (W.L.Gore and Associates (UK) Limited, Part number 4RPALE50PWHTUK), hot pressed and adhered in place on vertical and bottom edges of the pocket laminate piece.

The completed example garment now has two outer attached pockets in the chest area.
The air ventilating chamber containing the air spacer arrangement is located behind the RHS pocket on the inner surface of the outer shell. Such a construction allows

external air to circulate within the chamber only and prevents air or water passing through to the innermost side of the garment. External air can enter behind the outer pocket via the first and/or second opening. By opening or closing at least the zip of the first opening the amount of air circulating behind the outer pocket can be changed.

The modified left hand side (LHS) of the garment now provides a single externally fitted pocket with no external air circulation behind it.

A summary of key material properties are provided below:

	R_{et} (Pa m^2/W)	Air permeability (l/m^2/s @ 100Pa)	Water entry pressure (m) (ISO 811:2081)
Outer shell laminate	4.5	<1	>5
Inner layer laminate	3	<1	>5
Pocket material	5.5	<1	>5

Test Methods:

Method 1: Measurement of relative humidity in pockets of garment

A fitness treadmill is obtained and set to a walking rate of 6km/hr with an incline of 6 degrees.

A fan arrangement is created such that when a person is on the treadmill they are faced with a gentle wind of ~3m/s.

The garment under test is of split construction according to example 1 or example 2. Inside each pocket an MSR sensor (MSR Electronics GmbH, Mettlenstrasse 6, 8472 Seuzach, Switzerland: part no MSR145B4) is attached with adhesive tape in a central position on the external facing side of the pocket liner material. Each sensor is set to log temperature and humidity at 30 second intervals. The pockets on the RHS and the LHS are then zipped closed (second zips are closed) to prevent air access from the external environment. The first opening (first zip) and the second opening (cut) in the RHS of the outer shell remain open to access the air ventilating chamber behind the pocket and therefore to allow external air to flow behind the pocket.

The garment is worn by a user for 45 min walking on the treadmill. Room temperature T (°C) and Relative humidity RH (%) are recorded.

After approximately 45min (2700sec) the treadmill is stopped. Data from the sensors is plotted.

Method 2: Visual Observation of sweat or water vapour condensation in pockets of garment

As per method 1 but in addition two sections of impermeable thin plastic material (Office Depot B.V., Colimbusweg 33, 5928 La Vento, Holland, 75 micron plastic folder part no 3359344) of the same size are cut to shape to fit inside each of the LHS and RHS pockets of the garment according to example 1 or example 2. Each plastic section has rectangular dimensions of 90mm x 250mm. The pockets on the

RHS and the LHS are then closed with the provided zip or in the case of example 2 are sealed closed with a single strip of adhesive tape to prevent air access from the external environment. The first opening and the second opening in the RHS of the outer shell remain open to allow external air to flow behind the pocket by the air ventilating system with the connecting air chamber and air permeable spacer arrangement.

After approximately 45 min (2700sec) the treadmill is stopped and the plastic samples inside the garment pockets are removed from each pocket and a visual wetness comparison is made for water condensation on the two plastic films. A photograph is taken to record condensation on the plastic film. Alternatively the wetness may be measured by weighing the plastic sample when wet and then later when dry.

Method 3: Measurement of skin relative humidity.

A fitness treadmill is obtained and set to a walking rate of 6km/hr with an incline of 6 degrees.

A fan arrangement is created such that when a person is on the treadmill they are faced with a gentle wind of ~3m/s.

The garment under test is of split construction according to example 1. Two MSR sensors (MSR Electronics GmbH, Mettlenstrasse 6, 8472 Seuzach, Switzerland: part no MSR145B4) are attached with adhesive tape to the skin of the wearer. On the right hand side of the body the sensor is attached to the skin at a point that coincides with an approximate central position of the garment inner functional liner. The second sensor is attached on the left hand side of the body in a mirror image to the right hand sensor where the mirror axis is the central garment zip. Each sensor is set to log temperature and humidity at 30 second intervals. The pockets on the RHS and the LHS are then zipped closed (first zips are closed) to prevent air access from the external environment. The first opening (first zip) and the second opening (cut) in the RHS of the outer shell remain open to access the air ventilating chamber behind the pocket and therefore to allow external air to flow behind the pocket.

The user dons an underwear layer and then the outer garment is worn for 45 min walking on the treadmill. Room temperature T (°C) and Relative humidity RH (%) are recorded.

After approximately 45 min the treadmill is stopped. Data from the sensors is plotted.

Test 1:

The garment according to example 1 is tested per method 1. The room temperature is 22°C and the room relative humidity starts at 64% and finishes at 68%. The person on the treadmill had height of 1.80m and weight of 73kg. The underclothing worn consisted of a polyester fleece (Resistance to evaporative transport (R_{et}) ~ 6 m^2Pa/W and clothing insulation resistance (R_{ct}) of ~0.05 m^2C/W) over a polyester shirt (R_{et} ~ 4.2 m^2Pa/W and R_{ct} of ~0.027 m^2C/W)

The results of relative humidity RH (%) and temperature T (°C) inside the pockets versus test time duration for each side of the garment are shown in the figures 14 and 15, whereby Figure 14 shows the data of the sensor in the pocket of the RHS of the garment and Figure 15 shows the date of the sensor in the pocket of the LHS of the garment.

It is observed that for the RHS modified garment construction the relative humidity in the pocket starts at 57% and after 43min (2600sec) of the test it reaches a peak of 77% on test completion (Figure 14). For the LHS garment construction the relative humidity in the pocket starts at 59% and then rises quickly to reach over 90% after 25min of test duration and 95% on test completion.

The temperature in the pocket of the LHS garment construction is approximately 2 degrees Celsius higher than the temperature in the pocket of the RHS garment construction for the majority of the test.

The relative humidity and temperature in the wearer's RHS pocket are lower than the LHS demonstrating that sweat vapour is being removed from the garment by the air ventilating system incorporated behind the pocket on the garment RHS.

Test 2:

The garment according to example 1 is tested per method 1 and method 2.
Room temperature is 17°C and the room relative humidity is 50%. The person on the treadmill had height of 1.78m and weight of 84kg. The underclothing worn consisted of a polyester shirt (Resistance to evaporative transport (R_{et}) ~4.2 m^2Pa/W and clothing insulation resistance (R_{ct}) of ~0.027 m^2C/W).

The result of method 2 is shown in Figure 16 in the photograph comparing the two plastic films.
The plastic film from the pocket of the RHS garment construction is observed to be completely dry. The plastic film from the pocket of the LHS garment construction is observed to be wet with condensed sweat as seen in the photograph.

The results of relative humidity RH (%) and temperature T (°C) inside the pockets versus test time duration for each side of the garment are shown in the Figures 17 and 18, whereby Figure 17 shows the data of the sensor in the pocket of the RHS of the garment and Figure 18 shows the date of the sensor in the pocket of the LHS of the garment.

The data from the MSR loggers shows that the relative humidity in the pocket of the RHS garment construction reached 60% after 45min (2700sec) whereas the relative humidity in the pocket of the LHS garment construction reached 65% after just 5min (300sec) and >85% by 20min (1200sec) into the test.
The temperature in the pocket of the LHS garment is approximately 4 degrees Celsius higher than the temperature in the pocket of the RHS garment construction.
With a different wearer and different environmental conditions compared with Test 1, the relative humidity and temperature in the wearer's RHS pocket are again lower than the LHS demonstrating that sweat is being removed from the garment by the air ventilating system incorporated behind the pocket on the garment RHS. Visual representation of the difference is shown in the photograph of moisture or sweat build up on the plastic film (Figure 16).

Test 3:

The garment according to example 2 with external pockets is tested per method 1. The room temperature is 24°C and the room relative humidity starts at 38% and finishes at 44%. The person on the treadmill had height of 1.80m and weight of 73kg. The underclothing worn consisted of a polyester shirt (Resistance to evaporative transport (R_{et}) ~4.2 m^2Pa/W and clothing insulation resistance (R_{ct}) of ~0.027 m^2C/W).

The results of relative humidity RH (%) inside the pockets versus test time duration for each side of the garment are shown in the Figures 19 and 20 whereby Figure 19 shows the data of the sensor in the pocket of the RHS of the garment and Figure 20 shows the date of the sensor in the pocket of the LHS of the garment.

Test 3 shows that in the RHS garment construction the relative humidity (%) in the pocket is 45% at test start and reaches a peak of 55% on test completion. For the pocket in the LHS garment construction the relative humidity is 40% at test start and rises quickly to reach 85% after approximately 30 min (1800sec) of test duration. The pocket temperature for the RHS is generally lower than that of the LHS for the majority of the test.

The relative humidity and temperature in the wearer's RHS pocket are lower than the LHS demonstrating that sweat vapour is being removed from the garment by the air ventilating system incorporated behind the pocket on the garment RHS.

Test 4:

The garment according to example 1 is tested per method 3.

The room temperature is 24°C and the room relative humidity starts at 43% and finishes at 52%. The person on the treadmill had height of 1.80m and weight of 73kg. The underclothing worn consisted of a polyester fleece (Resistance to evaporative transport (R_{et}) ~ 6 m^2Pa/W and clothing insulation resistance (R_{ct}) of ~0.05 m^2C/W) over a polyester shirt (R_{et} ~4.2 m^2Pa/W and R_{ct} of ~0.027 m^2C/W)

The results of relative humidity on the skin versus test time duration for each side of the garment are shown in Figure 21.

Test 4 shows that the increase in relative humidity of the skin behind the RHS inner functional liner is less than the increase in relative humidity of the skin at a similar position on the LHS of the garment. The LHS of the garment reaches 85% after 18 minutes (1080sec) from test start whereas the RHS reaches this humidity after 35min (2100sec) from start. Skin temperatures on RHS and LHS are similar. This result demonstrates that the sweat vapour removal from the RHS of the garment which incorporates the air ventilation system is greater than that from the LHS of the garment which is of standard construction.

Claims

1. A garment (10) comprises:

- an outer shell (12) and
- at least one air ventilating system (40), said air ventilating system comprises
  - an air ventilating chamber (50) comprising at least one water vapor permeable and air-impermeable inner layer (42), said layer (42) being attached to an inner side (14) of the outer shell (12) by a circumferential seal (52);
  - at least one external air access (30) to said air ventilating chamber (50) to allow external air to circulate within the chamber; and
  - an air permeable spacer arrangement (60) located in the air ventilating chamber (50).

2. The garment (10) according to claim 1, wherein the garment comprises at least one pocket (20) arranged to the outer shell (12) and where the air ventilating chamber (50) with said air permeable spacer arrangement (60) is arranged at least partially behind said pocket (20).

3. The garment (10) according to claim 1 and 2, wherein the air permeable spacer arrangement (60) comprises at least one air channel (64).

4. The garment (10) according to any of the preceding claims, wherein the at least one external air access (30) comprises a first opening (32) which is arranged in the outer shell (12) and within the area of the air ventilating chamber (50).

5. The garment (10) according to any of the preceding claims, wherein the

pocket (20) is arranged on an inner side (14) of the outer shell (12) and inside of the air ventilating chamber (50).

6. The garment (10) according to any of the preceding claims, wherein the pocket (20) is arranged to an outer side (16) of the outer shell (12).

7. The garment (10) according to any of the preceding claims, wherein the inner layer (42) is arranged innermost in the garment to be the closest layer to the wearer.

8. The garment (10) according to any of the preceding claims, wherein the at least one external air access comprises a first external air access (30) and a second external air access (30) to the air ventilating chamber (50), said first external air access (30) is in air flow connection to the second external air access (30).

9. The garment (10) according to claim 8, wherein the first external air access (30) comprises a first opening (32) and the second external air access (30) comprises a second opening (34) which are arranged in the outer shell (12) and within the area of the air ventilating chamber (50) and connect the air ventilating chamber (50) to the outside such that external air can be transported between the first and the second opening (32, 34).

10. The garment (10) according to any of the preceding claims, wherein the at least one air access (30) comprises means to control the air flow in the air ventilating chamber.

11. The garment (10) according to any of the preceding claims, wherein the outer shell (12) comprises at least one water vapor permeable and air impermeable functional layer.

12. The garment (10) according to any of the preceding claims, wherein the outer shell (12) comprises at least one water vapor permeable and water impermeable functional layer.

13. The garment (10) according to any of the preceding claims, wherein at least part of the outer shell (12) in the area of the air ventilating chamber (50) is water vapour impermeable.

14. The garment (10) according to any of the preceding claims, wherein the inner layer (42) comprises at least one water vapor permeable and air impermeable functional layer.

15. The garment (10) according to any of the preceding claims, wherein the inner layer (42) is water impermeable.

16. The garment (10) of claims 11, 12 and 14 wherein the functional layer comprises a membrane comprising expanded polytetrafluoroethylene (ePTFE).

17. The garment (10) according to any of the preceding claims, wherein the air permeable spacer arrangement (60) has a three dimensional structure.

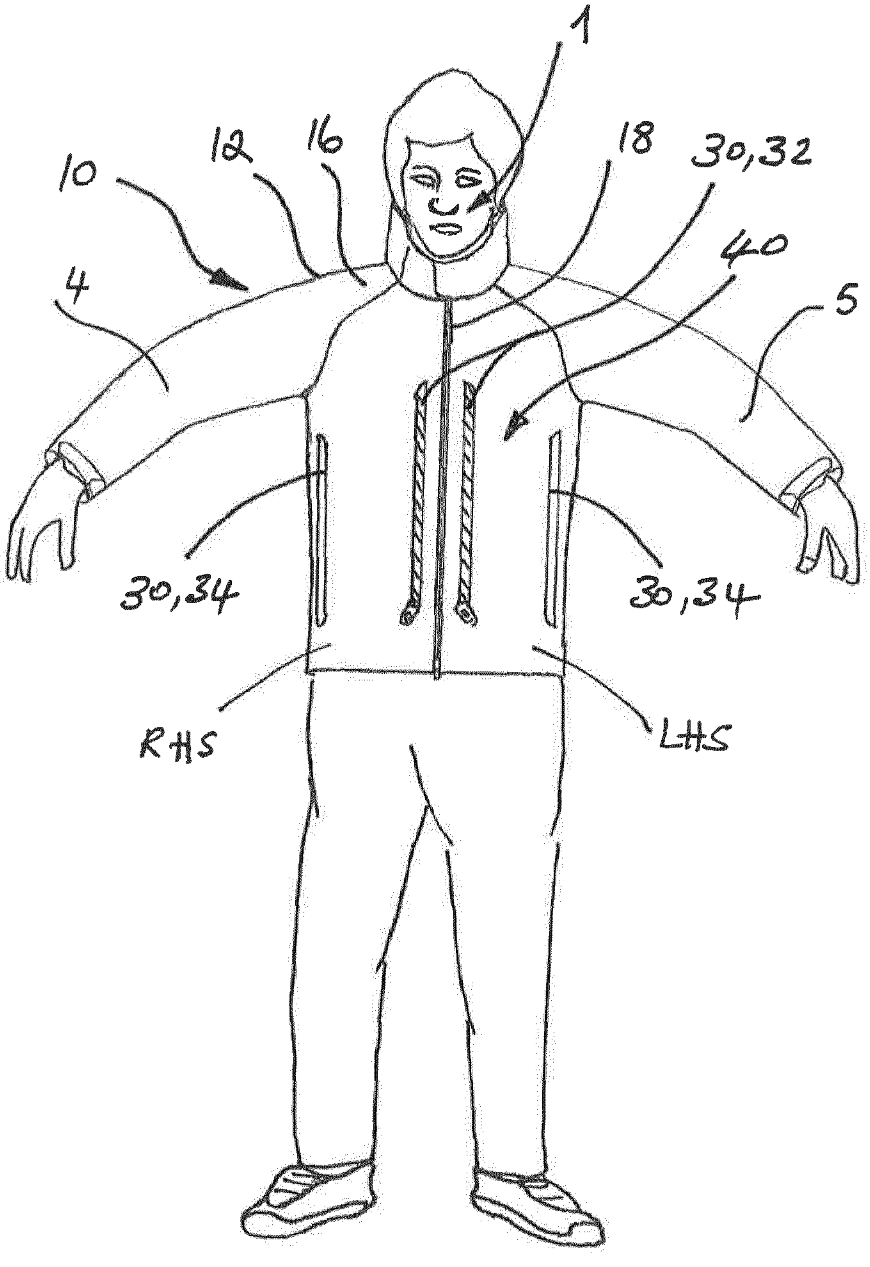


Fig. 1

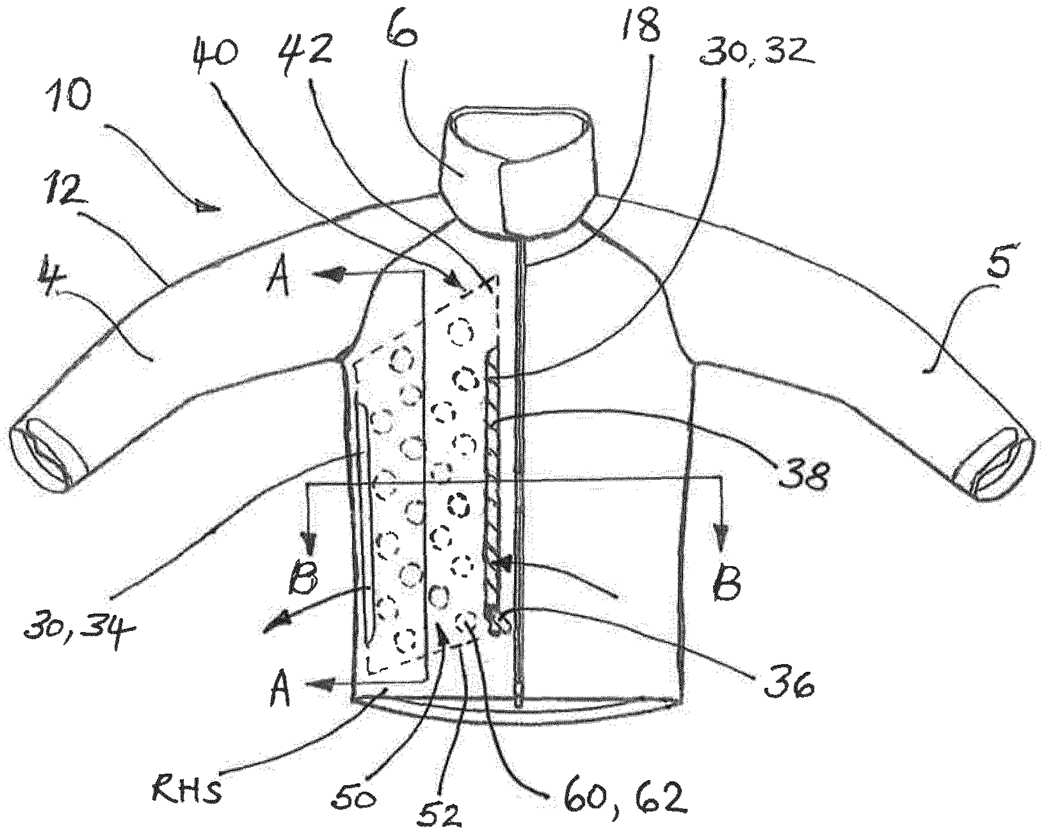


Fig. 2

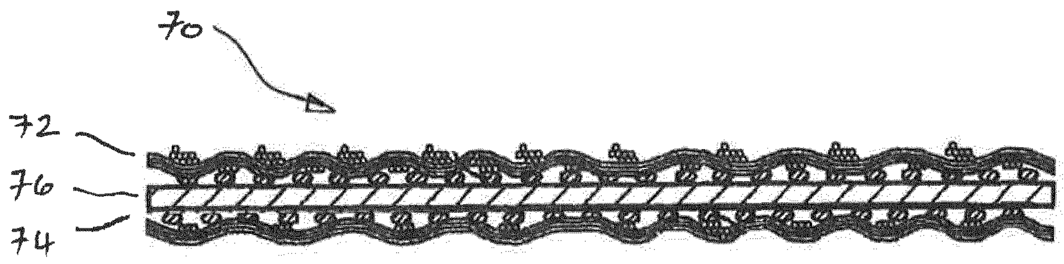


Fig. 2A

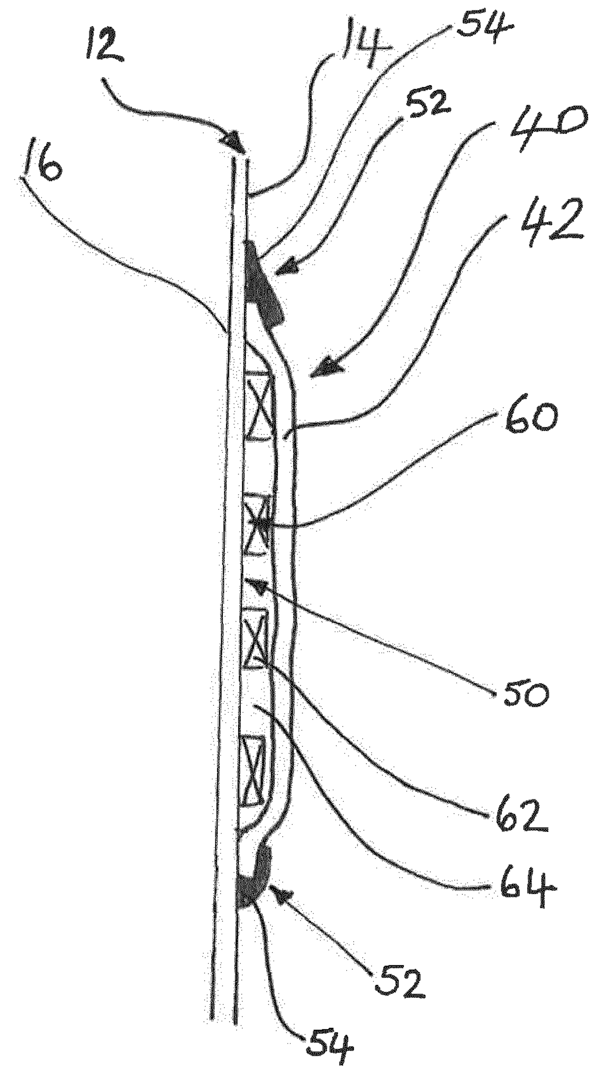


Fig. 3A

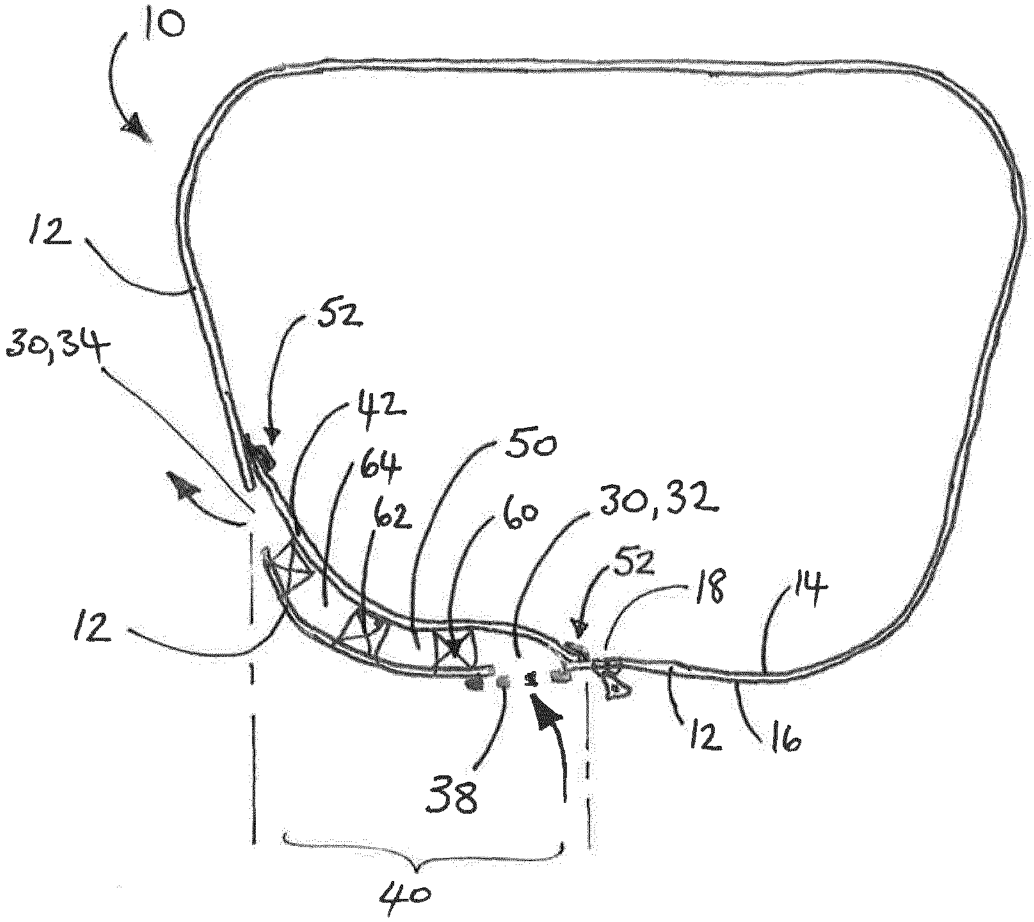


Fig. 3B

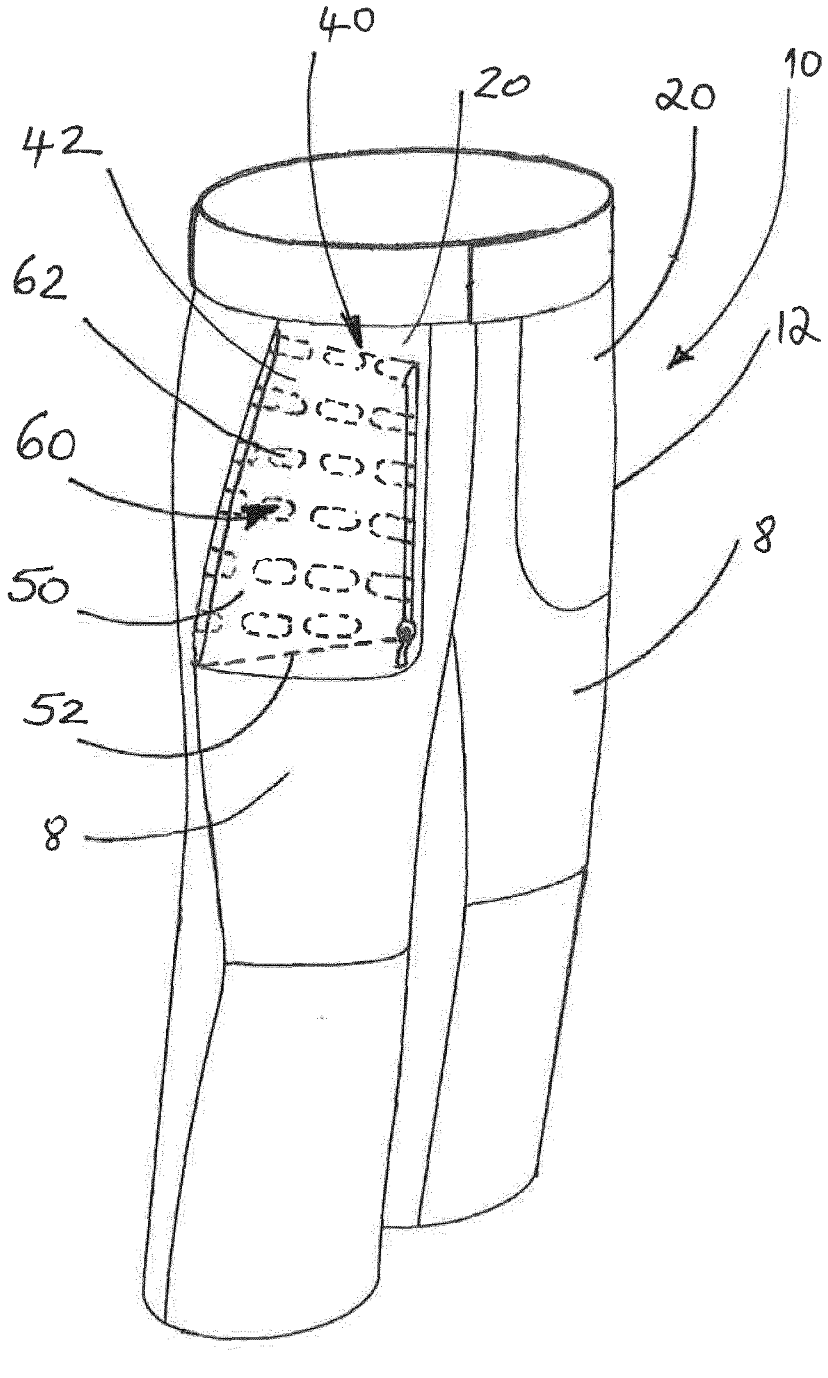


Fig. 4

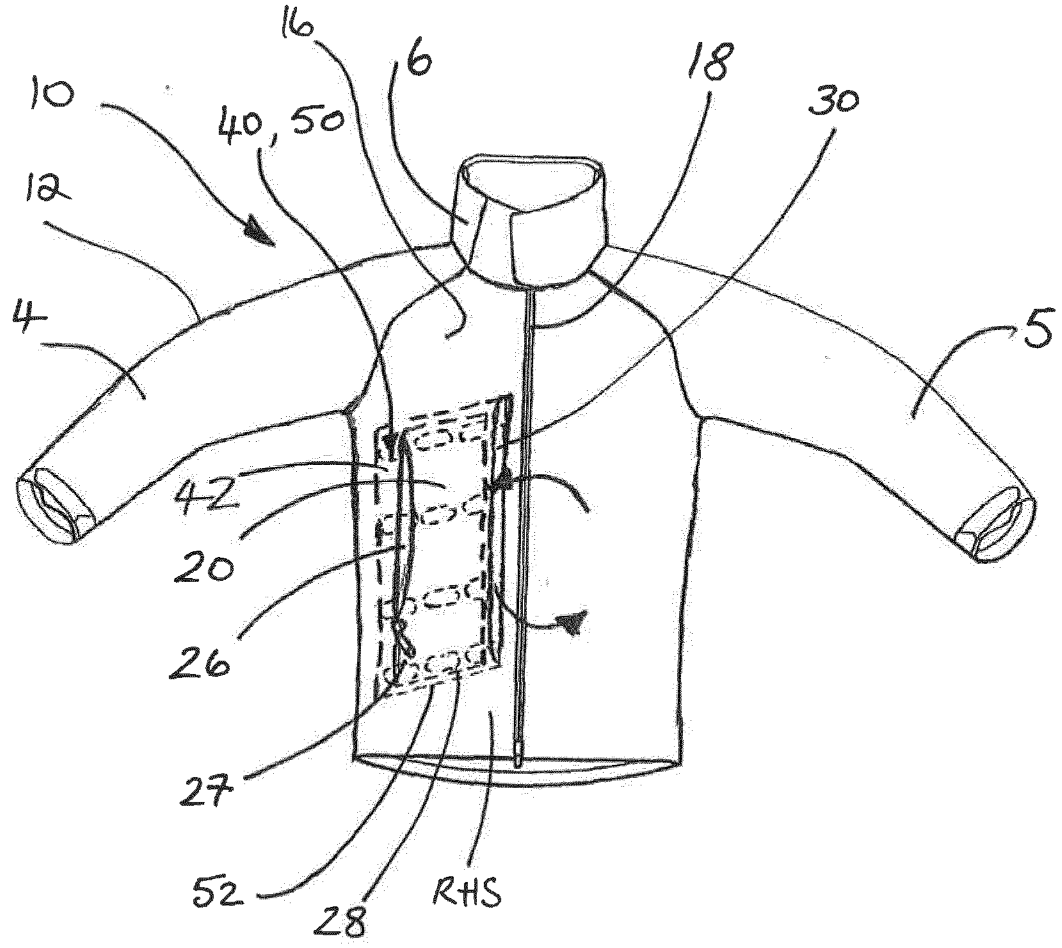


Fig. 5

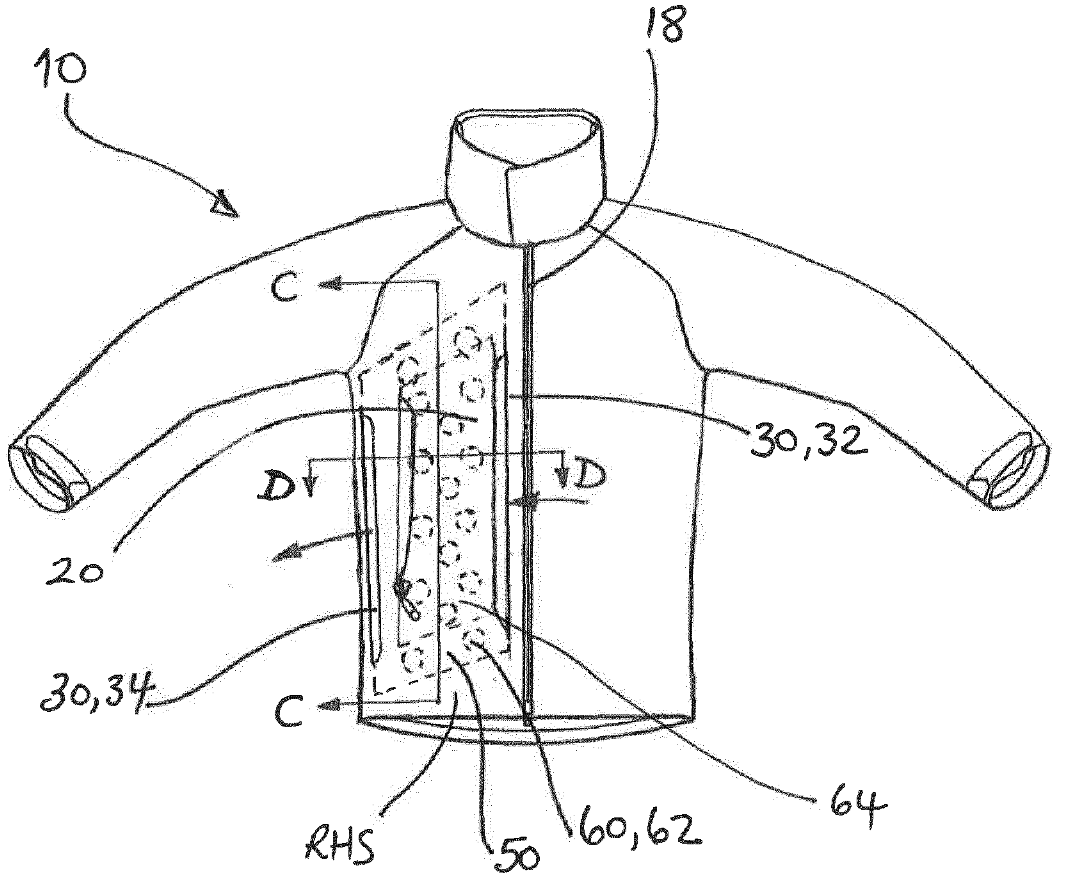


Fig. 6

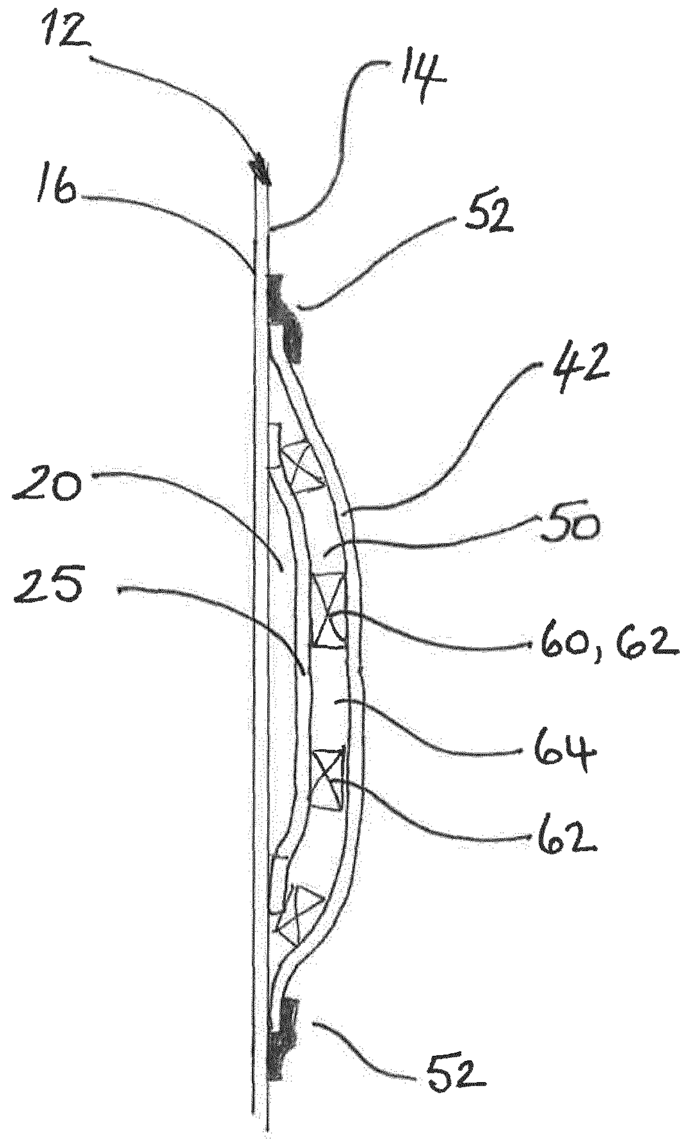


Fig.7A

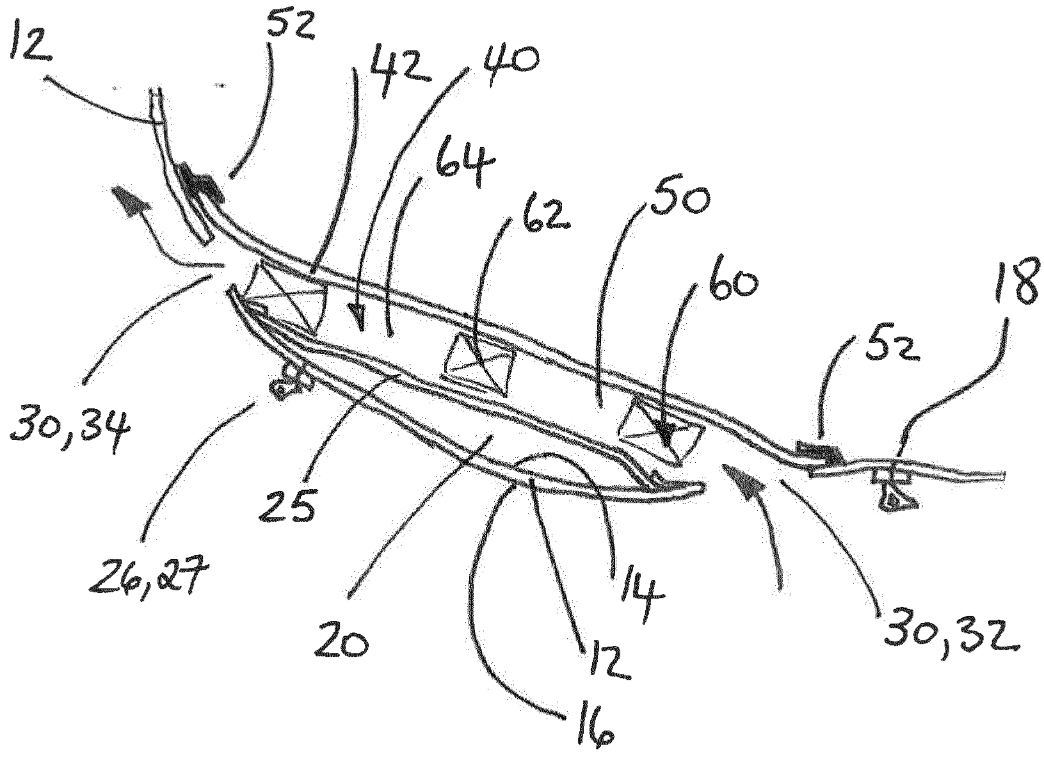


Fig 7B

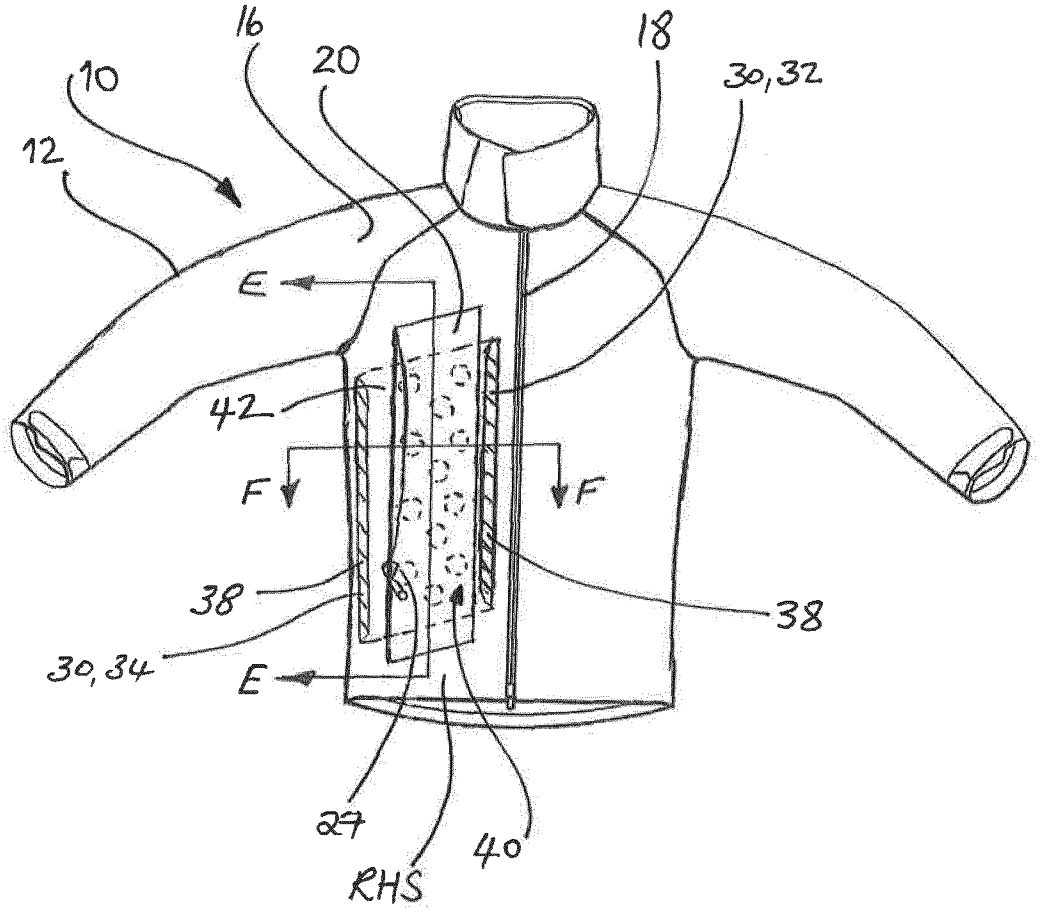


Fig.8

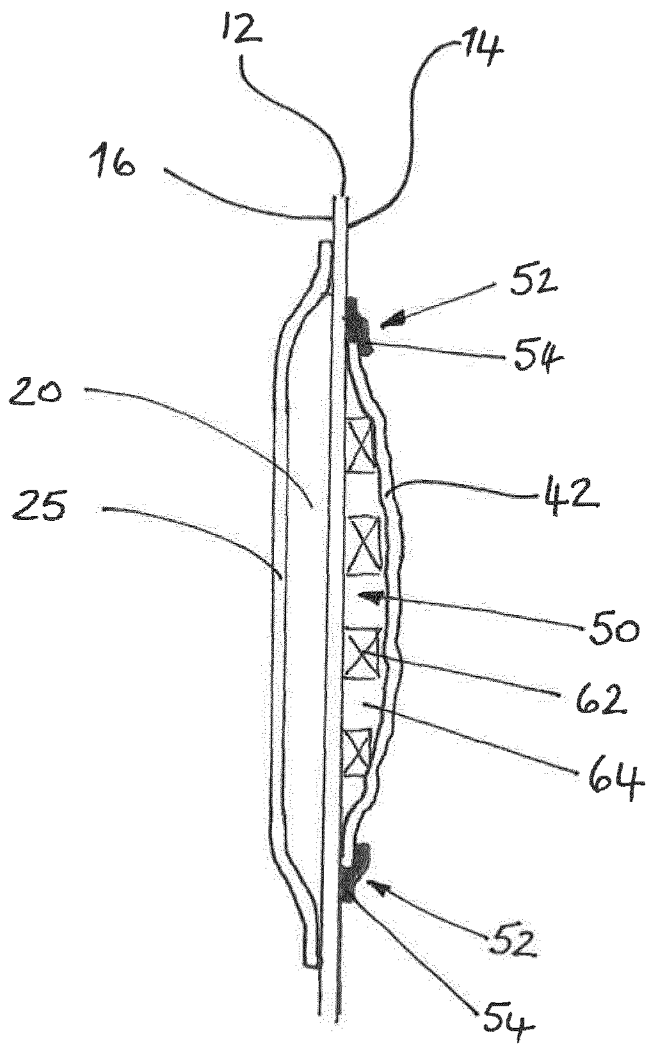


Fig. 9A

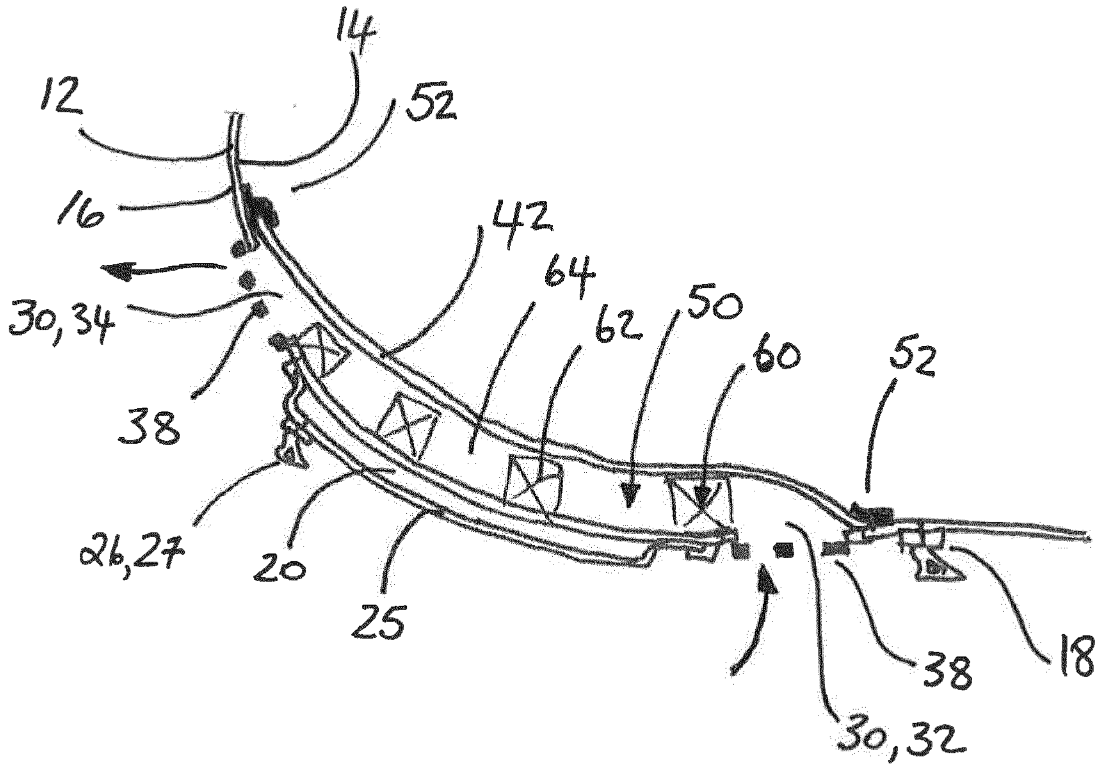


Fig. 9B

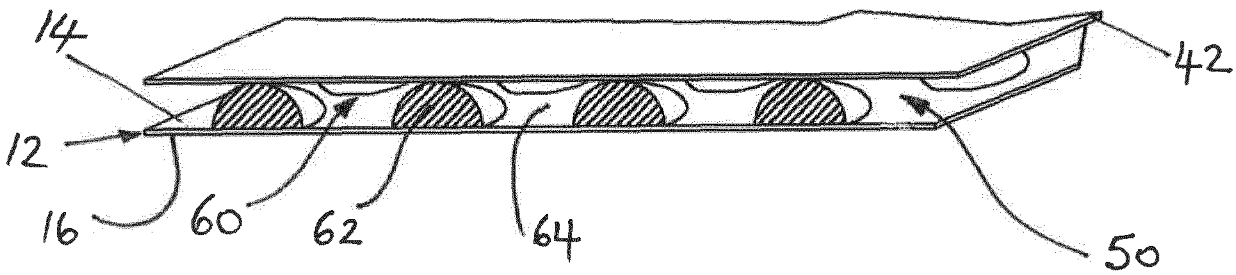


Fig. 10A

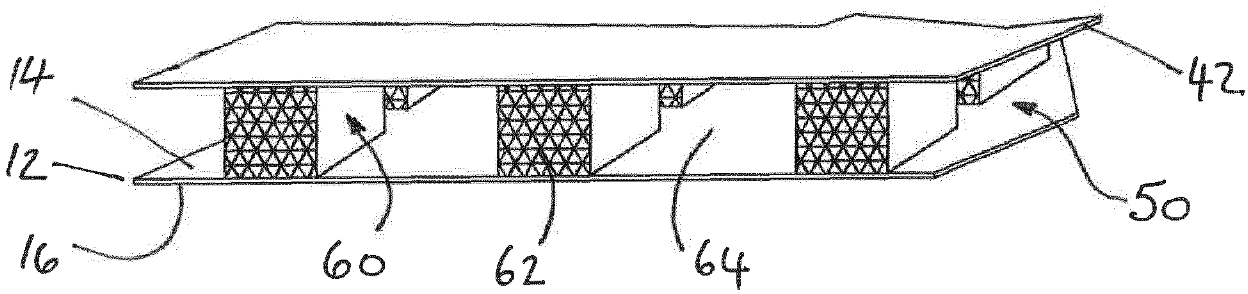


Fig. 10B

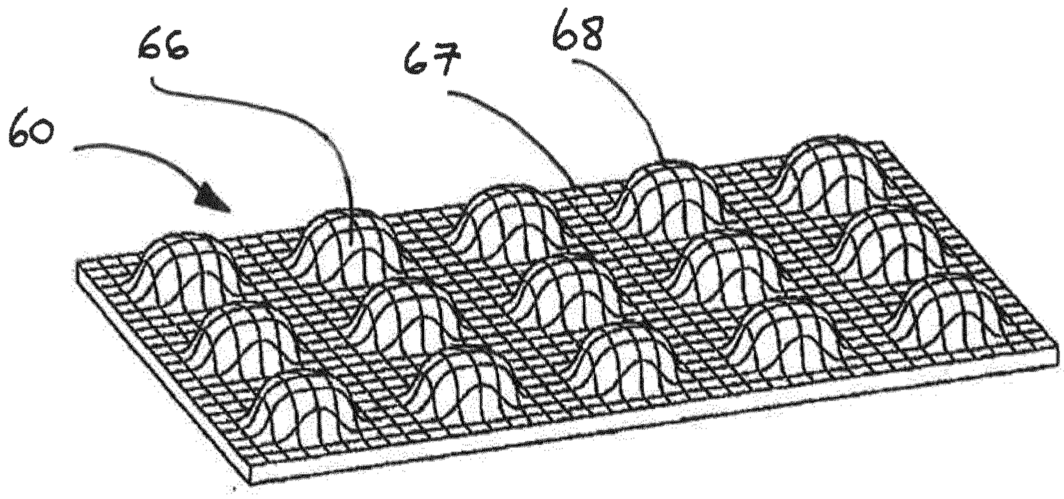


Fig. 11

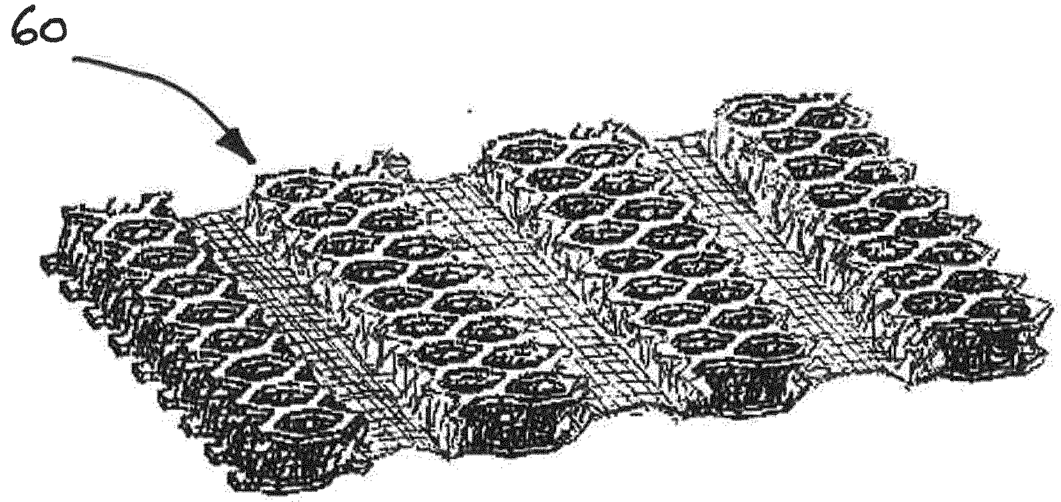


Fig. 12

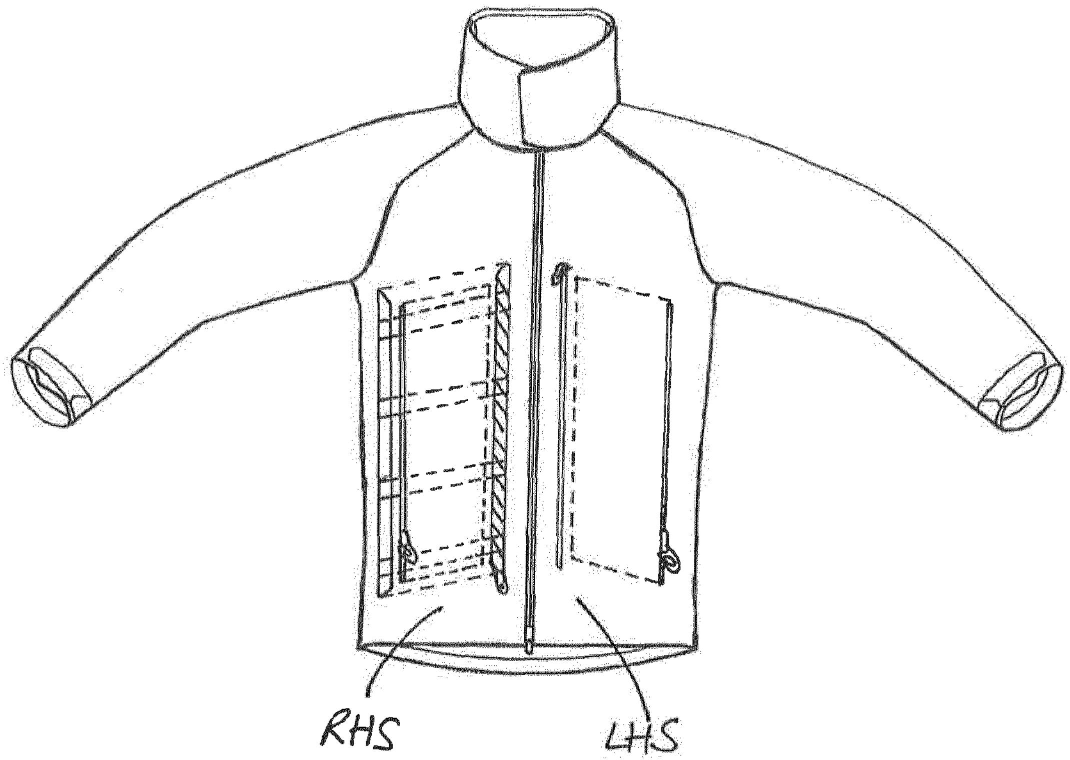


Fig.13

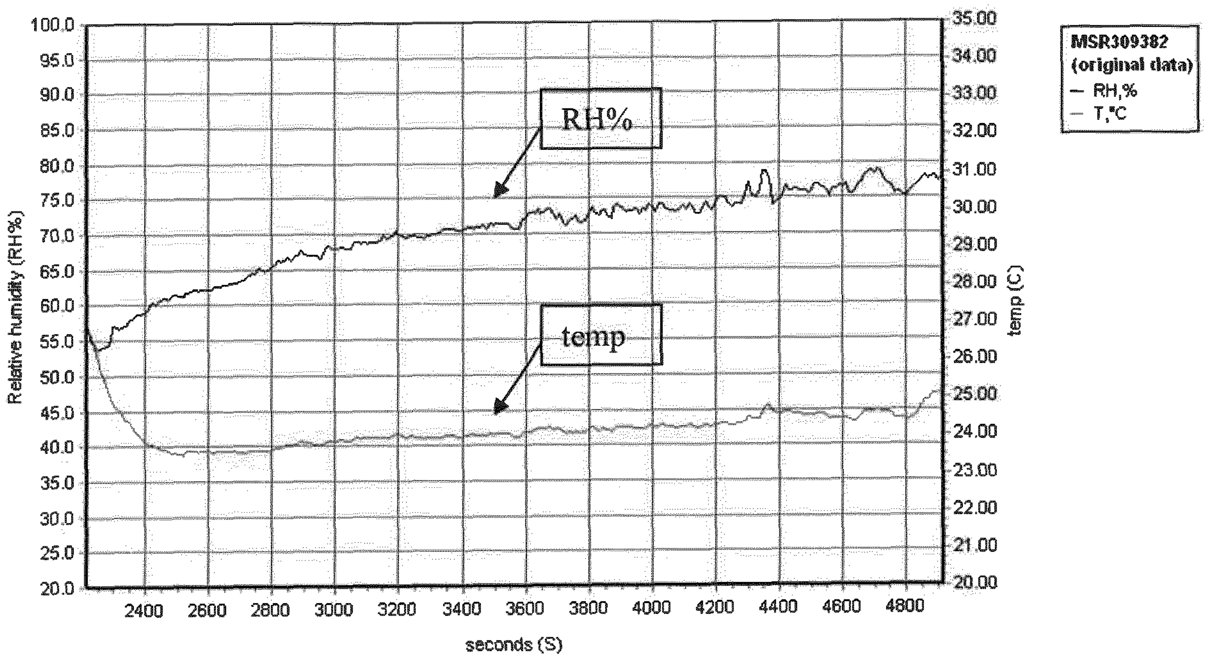

MSR309382
(original data)
RH,%
T,°C
RH%
temp
Relative humidity (RH%)
temp (C)
seconds (S)

FIG 14

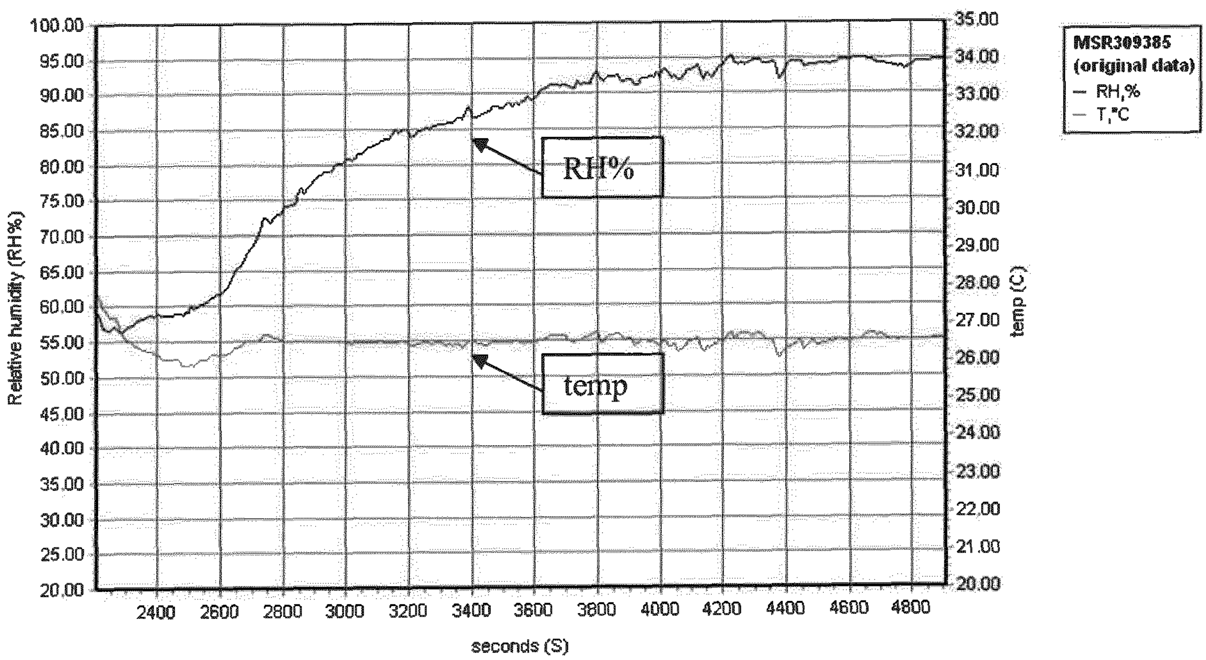

MSR309385
(original data)
RH,%
T,°C
RH%
temp
Relative humidity (RH%)
temp (C)
seconds (S)

FIG 15

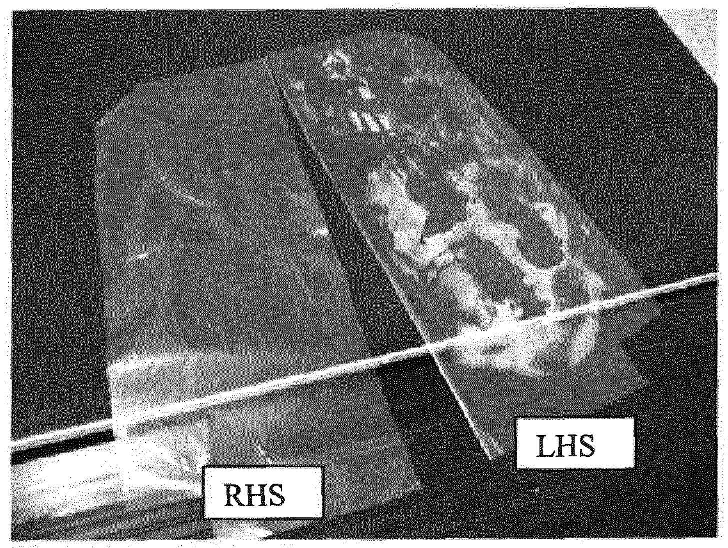
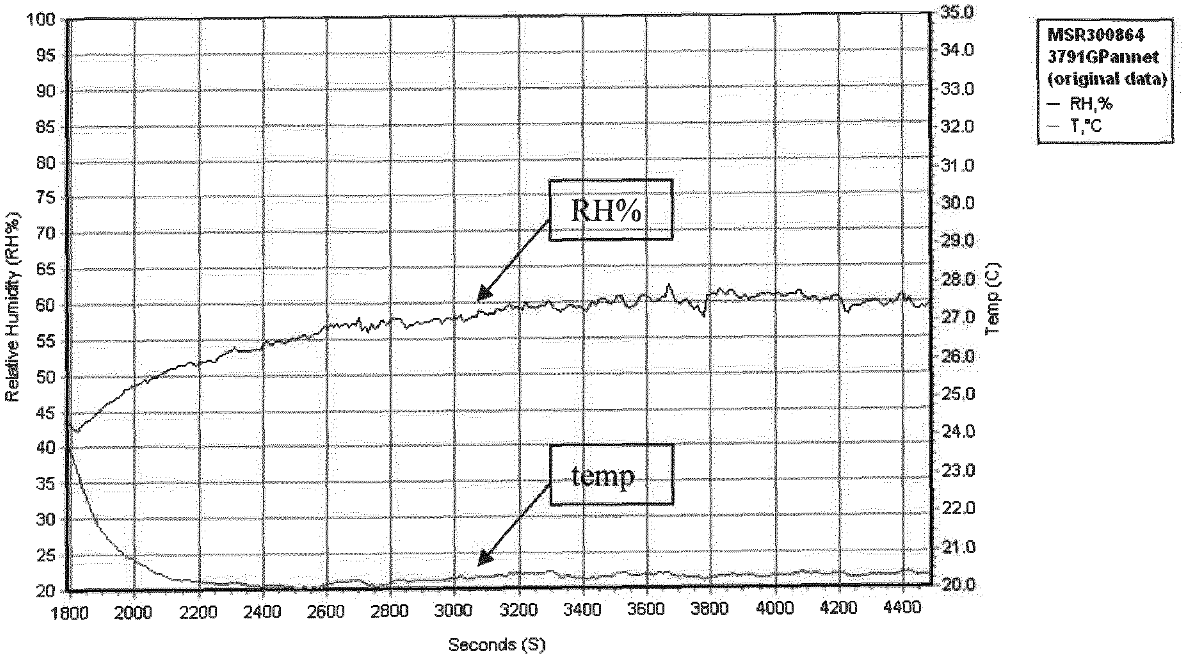


FIG 16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3791GPannet
(original data)
RH,%
T,°C
RH%
temp
Relative Humidity (RH%)
Temp (C)
Seconds (S)
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95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
35.0
34.0
33.0
32.0
31.0
30.0
29.0
28.0
27.0
26.0
25.0
24.0
23.0
22.0
21.0
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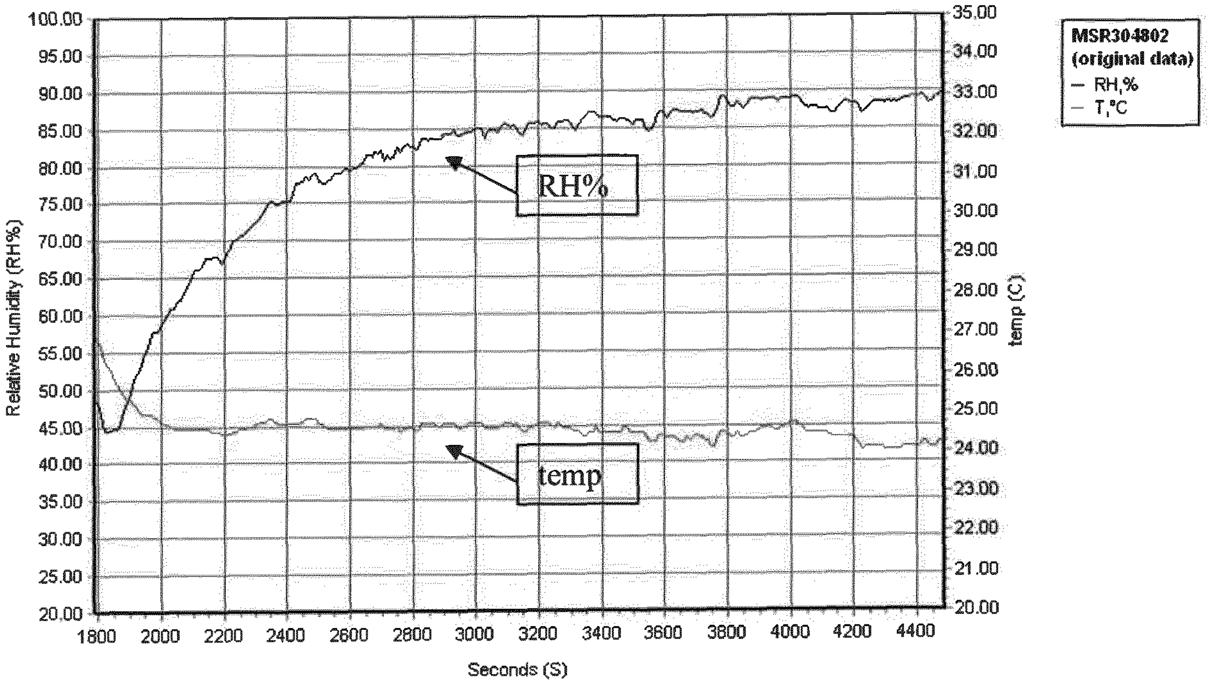
4000
4200
4400

FIG 17


MSR304802
(original data)
RH,%
T,°C
RH%
temp
Relative Humidity (RH%)
temp (C)
Seconds (S)
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85.00
80.00
75.00
70.00
65.00
60.00
55.00
50.00
45.00
40.00
35.00
30.00
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20.00
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34.00
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30.00
29.00
28.00
27.00
26.00
25.00
24.00
23.00
22.00
21.00
20.00
1800
2000
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3400
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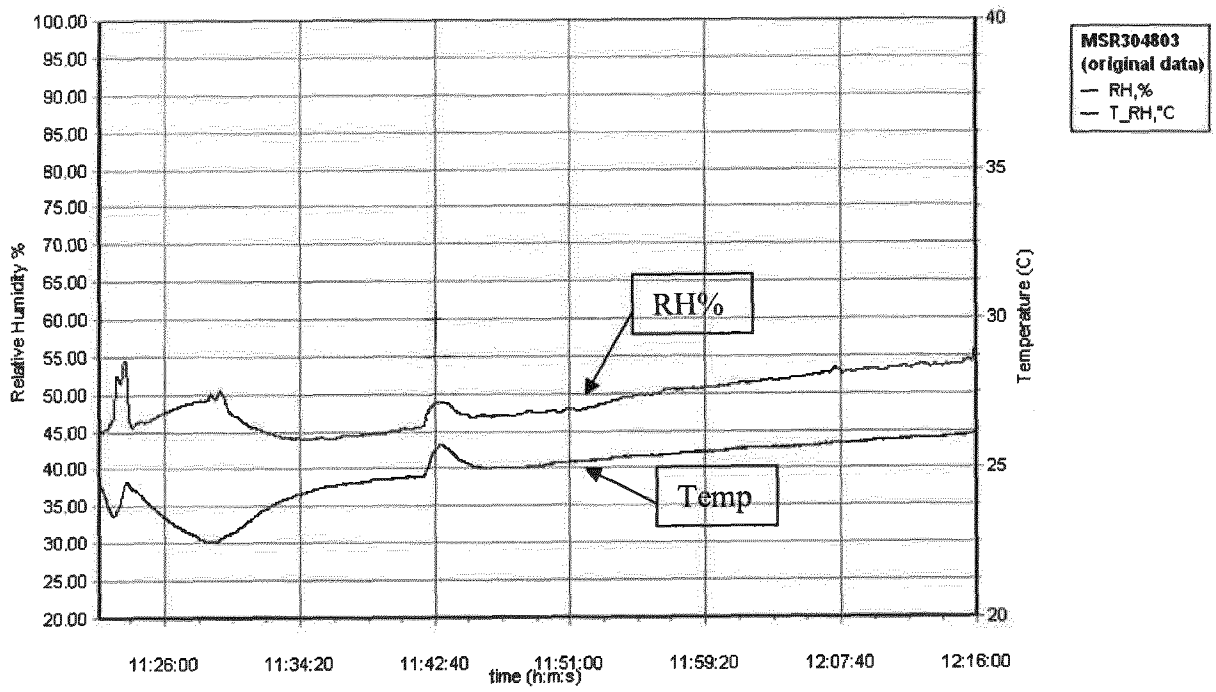
3800
4000
4200
4400

FIG 18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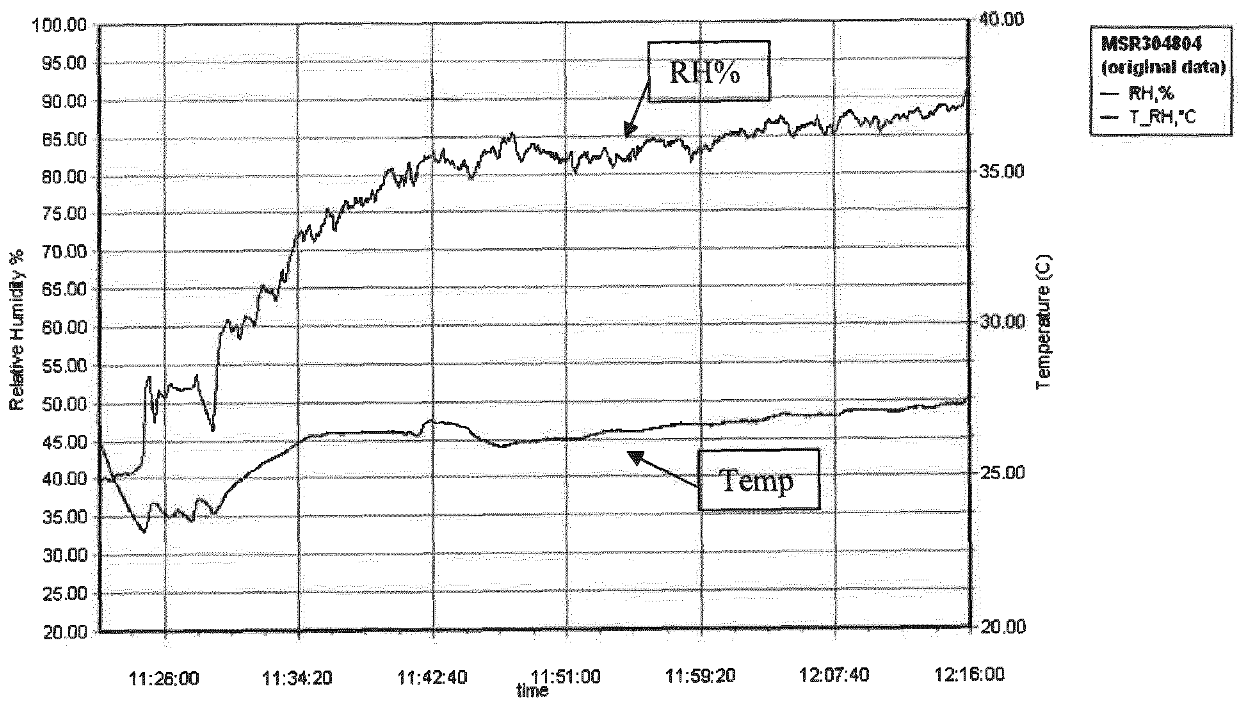
95.00
90.00
85.00
80.00
75.00
70.00
65.00
60.00
55.00
50.00
45.00
40.00
35.00
30.00
25.00
20.00
Relative Humidity %
40
35
30
25
20
Temperature (C)
MSR304803
(original data)
RH,%
T_RH,°C
RH%
Temp
11:26:00
11:34:20
11:42:40
11:51:00
11:59:20
12:07:40
12:16:00
time (h:m:s)

FIG 19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95.00
90.00
85.00
80.00
75.00
70.00
65.00
60.00
55.00
50.00
45.00
40.00
35.00
30.00
25.00
20.00
Relative Humidity %
40.00
35.00
30.00
25.00
20.00
Temperature (C)
MSR304804
(original data)
RH,%
T_RH,°C
RH%
Temp
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11:51:00
11:59:20
12:07:40
12:16:00
time

FIG 20

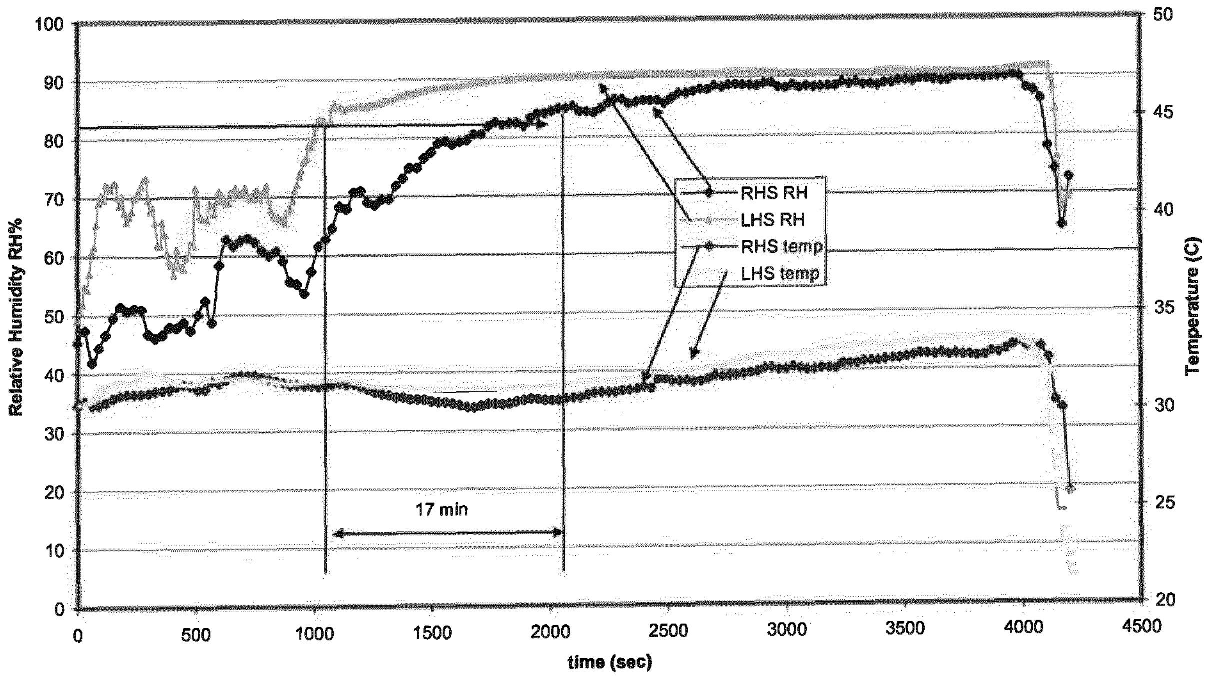
Relative Humidity RH%
Temperature (C)
time (sec)
17 min
RHS RH
LHS RH
RHS temp
LHS temp
100
90
80
70
60
50
40
30
20
10
0
50
45
40
35
30
25
20
0
500
1000
1500
2000
2500
3000
3500
4000
4500

FIG 21

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2015/025021

A. CLASSIFICATION OF SUBJECT MATTER
INV. A41D27/28
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)
A41D

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 practicable, 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.
A	US 2010/242149 A1 (MICKLE WILLIAM K [US] ET AL) 30 September 2010 (2010-09-30) paragraphs [0023] - [0031]; figures 2,5	1-17
A	US 2003/033656 A1 (JAEGER KNUT [DE]) 20 February 2003 (2003-02-20) paragraphs [0031] - [0033]; figures 3,4	1-17
A	WO 99/34972 A1 (IND FILMS LIMITED [GB]; SUGDEN KURT DAVID [GB]) 15 July 1999 (1999-07-15) page 9, lines 9-28; figure 2	1-17
A	US 2009/220760 A1 (CHEN SHI-CHUAN [TW]) 3 September 2009 (2009-09-03) paragraph [0022]; figure 1	1-17

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

[X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 95/22262 A1 (MICRO THERMAL SYSTEMS LTD [GB]; MIDDLETON NIGEL JOHN [GB]) 24 August 1995 (1995-08-24) page 10, line 5 - page 16, line 16; figures 1-4	1-7

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2015/025021

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