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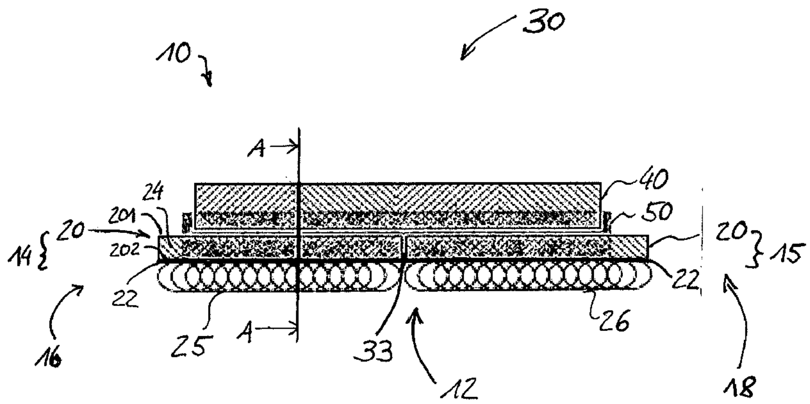
(54) Title: SEAM-JOINING STRUCTURE, TEXTILE ARTICLE WITH SUCH SEAM-JOINING STRUCTURE, METHOD AND APPARATUS FOR MANUFACTURING A SEAM-JOINING STRUCTURE

Fig. 2



(57) Abstract: A seam-joining structure (10) comprises at least a first composite layer (14) and a second composite layer (15), a seam area (30) comprising at least one seam (12) that joins the first and second composite layers (14, 15), at least one protective layer (40) which covers the at least one seam (12), and an adhesive material (50) which generates a liquidproof seal in the seam area (30) and which bonds the at least one protective layer (40) to the seam area (30). Each of the first and second composite layers (14, 15) comprises at least one porous membrane layer (20) with pores (24) and with a first side (201), and a barrier layer (22) joined to the at least one porous membrane layer (20) opposite the first side (201) and which is a barrier for the adhesive material (50), wherein at least in a portion of the seam area (30) the pores (24) of the respective porous membrane layers (20) between the first side (201) and the respective barrier layer (22) are completely filled with the adhesive material (50).

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Seam-joining structure, textile article with such seam-joining structure, method and apparatus for manufacturing a seam-joining structure

The present disclosure relates to a durable waterproof seam-joining structure with at least one seam that seals at least a first and second composite layer in a waterproof manner using adhesive material, wherein the first and second composite layers comprise membrane layers. The present disclosure further relates to a textile article, like a garment, with such seam-joining structure, and to a method and apparatus for manufacturing such seam-joining structure.

Textile articles, like clothing articles, can be made waterproof by arranging a waterproof water-vapor-permeable functional layer like a membrane, e.g. on the inside of the outer material of such article (which, in case of garments, are often called functional garments). A textile liner can be arranged on the side of the functional layer facing the body of the user of the clothing article.

Functional garments are often made of functional protective materials, such as membrane laminates, to provide the wearer with specific properties. In these garments, the membrane laminates have a function of protecting the wearer from the threat to his/her well-being, such as rain, snow, wind, temperatures, chemicals or blood pathogens. Examples of membrane laminates include porous polytetrafluoroethylene membranes, porous or monolithic polyurethane membranes, and polyetherpolyester.

Typically, garments are often sewn together from several pieces in order to achieve a specific fit, strength, durability, and/or optical appearance. When multilayer laminates of the above-mentioned type are used, individual cuts of the garment are cut out from laminate webs and then joined to form the garment. Generally, two laminate webs of the garment are thereby joined to each other by a sewing seam in a seam area. However, the functional layer of the laminate is perforated by such sewing, so that the waterproofness of the functional layer is adversely affected and undesired leaks can occur at the seam location. In order to make the seam location also waterproof, i.e., in order to retain the overall waterproofness of the garment, it is generally common to cover the seam with a waterproof seam seal. Such seam sealing can be made by a separately applied waterproof seam tape.

Ideally, a seam sealing provides a barrier function comparable to the membrane laminate. For example, such seams are covered by a thermoplastic seam tape. The tape is softened by hot air and applied over the seam by a specialized machine. Such tape most commonly includes at least two layers where one layer has a melting point higher than the other layer. This allows the hot air sealing machine to melt the lower melting sealing layer, leaving the higher melting layer intact as a carrier.

Moreover, thermoplastic adhesives are often used to seal fabric seams, such as adhesives made from polyurethanes, PVC, polyesters and polyamides. However, thermoplastic adhesives suffer from numerous disadvantages including temperature limitations, limited durability and resistance to hydrolysis, and susceptibility to some chemicals.

WO 01/26495 A describes the use of silicone for sealing seams. In particular, it is disclosed a seam seal that protects protective barrier fabrics by employing a sealing backer that seals the protective barrier fabrics over their seam joints with a silicone sealant layer. The silicone layer provides a seal between the sealing backer and the seamed protective barrier fabric panels and adheres the sealing backer to the seam. In one embodiment, the protective barrier in the sealing backer and the protective barrier in the fabric are selected such as to allow impregnation of liquid uncross-linked silicone into the pores of the sealing backer protective barrier and into the pores of the fabric protective barrier. However, such sealed seams still suffer from degradation of waterproofness over lifetime, particularly over a multitude of washing cycles of the fabric.

It would be beneficial to provide a seam-joining structure of the type as mentioned above that contributes to creating a durable and waterproof functional garment.

The present invention relates to a seam-joining structure with features according to claim 1. The invention also relates to a textile article, particularly a garment, with such seam-joining structure according to the features of claim 15. The invention also relates to a method of manufacturing a seam-joining structure according to the features of claim 17. The invention also relates to an apparatus for manufacturing a seam-joining structure according to the features of claim 26.

According to an aspect, there is disclosed a seam-joining structure comprising at least a first composite layer and a second composite layer, a seam area comprising at least one seam that joins the first and second composite layers, at least one protective layer which covers the at least one seam, and an adhesive material which generates a liquid proof seal in the seam area and which bonds the at least one protective layer to the seam area. Each of the first and second composite layers comprises at least one porous membrane layer with pores and with a first side, and a barrier layer joined to the at least one porous membrane layer opposite the first side and which is a barrier for the adhesive material, wherein at least in a portion of the seam area the pores of the respective porous membrane layers between the respective first side and the respective barrier layer are completely filled with the adhesive material.

For example, the composite layers may be waterproof and water vapor permeable composite layers. In particular, the adhesive material also acts as a sealing material in providing the liquid proof seal.

According to another aspect, there is disclosed a method of manufacturing a seam-joining structure, which comprises at least a first composite layer and a second composite layer and a seam area comprising at least one seam that joins the first and second composite layers, wherein each of the first and second composite layers comprises at least one porous membrane layer with pores and with a first side, and a barrier layer joined to the at least one porous membrane layer opposite the first side. The method is comprising the steps of applying an adhesive material to the at least one seam in the seam area which generates a liquidproof seal such that in at least a portion of the seam area the pores of the respective porous membrane layers between the respective first side and the respective barrier layer are completely penetrated with the adhesive material through to the respective barrier layer which is a barrier for the adhesive material, and bonding at least one protective layer to the seam area by the adhesive material, such that the at least one protective layer covers the at least one seam.

According to an embodiment, the adhesive material comprises silicone.

According to a further embodiment, the adhesive material comprises a two-component room temperature curing adhesive material. According to another embodiment the adhesive material comprises a two-component curing silicone.

The adhesive type used according to the invention provides a high hydrolysis resistance and temperature resistance compared to thermoplastic adhesives like PU based adhesive systems.

In one embodiment the adhesive material comprises a viscosity lower than 6000 mPa s for penetration of the pores of the porous membrane layers, in particular before applying to the seam area. According to another embodiment, the viscosity is lower than 4000 mPa s. In another embodiment, the viscosity is lower than 3000 mPa s. According to another embodiment, the viscosity is lower than 2000 mPa s.

In an embodiment, the adhesive material comprises a viscosity of 3500 mPa s for penetration of the pores of the porous membrane layers, in particular before applying to the seam area.

The viscosity may be measured according to test method as described in ISO 3219 at a temperature of 23°C.

Particularly, due to low viscosity and low surface tension, a two component curing silicone adhesive material provides prompt and full penetration capabilities into the porous membrane structures. Full penetration may be reached at least after a certain time period depending on, for example, the type of membrane and adhesive viscosity.

According to one embodiment, at least one or each of the composite layers comprises at least one porous membrane layer and a continuous non-porous layer. The continuous non-porous layer forms the barrier layer.

According to an embodiment, the at least one porous membrane layer is at least one first porous membrane layer, and each of the first and second composite layers further comprises at least one second porous membrane layer attached to the barrier layer opposite to the first porous membrane layer.

According to a further embodiment, at least one of the first porous membrane layer and the second porous membrane layer is water vapor permeable and waterproof.

According to another embodiment, the first porous membrane layer and/or the second porous membrane layer is water vapour permeable and air impermeable.

According to an embodiment, at least one of the first porous membrane layer and the second porous membrane layer comprises expanded polytetrafluororethylene (ePTFE).

The term “porous” membrane means any membranes with a permeable structure throughout the thickness of the membrane. In one example the permeable structure comprises a nodes and fibril structure forming pores as exemplary shown in Figure 9.

According to a further embodiment, the pore size of the pores of the at least one porous membrane layer is in a range between 0.05 µm to 10 µm, particularly from about 0.1 µm to about 1 µm, more particularly from about 0.15 µm to about 0.8 µm.

The barrier layer is a barrier for the adhesive material such that the adhesive material is hindered to penetrate through the barrier layer until the adhesive material has hardened. As such, the barrier layer does not need to be impermeable for the adhesive material as such. The barrier layer forms a border for the adhesive material such that in the manufacturing process the adhesive material cannot penetrate through the structure of the barrier layer and therefore is not visible on the side of the barrier layer opposite to the porous membrane layer. The barrier layer at least significantly slows down any penetration of the adhesive material into the barrier layer.

According to an embodiment, the barrier layer is impermeable for the adhesive material.

According to an embodiment, the barrier layer comprises a non-porous material. For example, the barrier layer comprises waterproof, water vapor permeable polyurethane. According to a further embodiment, the barrier layer comprises at least one of the following materials: polyurethane, polyester, silicone, paper, monolithic polymer layer or foil, material comprising polytetrafluororethylene (PTFE).

According to another embodiment, the barrier layer comprises a hydrophobic and/or oleophobic treated porous membrane. In one embodiment the barrier layer may comprise a porous membrane with a hydrophobic and/or oleophobic coating (e.g. with fluoropolymers or fluoroacylate).

According to an embodiment, each of the first and second composite layers further comprises at least one textile layer on the side of the barrier layer or on the side of the second porous membrane layer opposite to the first porous membrane layer. In one embodiment the at least one textile layer is the outer layer of a textile article like a garment.

The protective layer may comprise a porous material with pores which are at least partially filled with the adhesive material.

In one example the protective layer comprises expanded polytetrafluoroethylene. For example, the protective layer may comprise a one- or a multi-layer structure with at least one porous membrane as one of the layers. In principle, the protective layer can have the same or a similar structure as one of the first and second composite layers.

In an embodiment, the protective layer may comprise a textile material.

Another aspect of the invention is related to a textile article, particularly a garment, comprising a seam-joining structure as described above and in the following.

According to one embodiment the garment is configured such that it withstands 30 to 50 industrial washing cycles according to ISO 15797, method 8 at 60°C, drying method B (tunnel 150-155°C).

According to an embodiment, the adhesive material is formed from at least two components supplied to the seam area and which chemically react with each other forming a two-component curing silicone adhesive material, wherein the two-component curing silicone adhesive material is heated for accelerating the chemical reaction. Said adhesive material cures with room temperatures.

According to an embodiment, the method further comprises the step of applying a heated air flow to at least a portion of the seam area. Particularly, at a particular throughput speed of the first and second composite layers the adhesive material is treated with the heated air flow within a length in the range of 20 to 100 mm, more particularly within a length of 75 mm ± 5 mm along a transportation direction of the first and second composite layers. In this way it can be achieved that the adhesive material is hardened within a certain distance from a location where the liquid adhesive material is applied to the composite layers.

Preferably, the heated air flow generates a temperature of approximately 150°C at a surface of the protective layer facing the heated air flow. According to an embodiment, this results in a temperature in the adhesive material of approximately 70°C ± 5°C.

In a preferred implementation, the adhesive material is applied to the at least one seam at a throughput speed of 2.5 ± 0.5 m/min of the first and second composite layers.

The protective layer is preferably applied to the at least one seam separately from the adhesive material.

According to another aspect, there is disclosed an apparatus for manufacturing a seam-joining structure, which comprises at least a first composite layer and a second composite layer and a seam area comprising at least one seam that joins the first and second composite layers, wherein each of the first and second composite layers comprises at least one porous membrane layer with pores and with a first side, and a barrier layer joined to the at least one porous membrane layer opposite the first side. The apparatus comprises a first supply device for continuously applying a liquid adhesive material to the at least one seam in the seam area for generating a liquid proof seal, such that in at least a portion of the seam area the applied adhesive material completely penetrates the pores of the respective porous membrane layers between the respective first side and the respective barrier layer through to the respective barrier layer which is a barrier for the adhesive material. An air flow generating device is provided for generating and applying a heated air flow to the seam area applied with the adhesive material, wherein at a particular throughput speed of the first and second composite layers the air flow is applied to the adhesive material at a particular throughput speed of the first and second composite layers within a length in the range of 20 to 100 mm along a transportation direction of the first and second composite layers. A second supply device is provided for continuously supplying at least one protective layer to the seam area such that the at least one protective layer covers the at least one seam and bonds to the seam area by the adhesive material.

According to an embodiment, the air flow is applied to the adhesive material at a particular throughput speed of the first and second composite layers within a length of 75 mm ± 5 mm along a transportation direction of the first and second composite layers.

According to an embodiment, the apparatus further comprises a heating device for pre-heating the first and second composite layers in the seam area before the second supply device supplies the at least one protective layer to the seam area.

The invention will now be explained further below with reference to the Figures, in which

Fig. 1 shows a schematic view of two composite layers joined together to form a seam-joining structure according to an embodiment of the invention,

Fig. 2 shows a schematic view of two composite layers joined together to form a seam-joining structure according to another embodiment of the invention,

Fig. 3 shows a SEM picture of a cross-section through a seam-joining structure along line A-A according to the embodiments as shown in Figures 1 and 2,

Fig. 4 shows an example of a garment article with one or more seam-joining structures according to an embodiment of the invention,

Fig. 5 shows a schematic view of apparatus for manufacturing a seam-joining structure according to an embodiment of the invention,

Fig. 6 shows a schematic depiction of dimensions applied in the apparatus 60 according to Fig. 5 according to an embodiment of the invention,

Fig. 7 schematically shows a test apparatus for applying a peeling force to the protective layer for determining whether the adhesive material has hardened to a desired degree after application to the seam area,

Fig. 8 shows a table of exemplary manufacturing parameters used to determine the grade of curing of the adhesive material,

Fig. 9 shows a SEM of the surface of the first side of a porous membrane in one embodiment.

The accompanying drawings are included to provide a further understanding of the disclosure and are incorporated in and constitute a part of this specification, illustrate embodiments, and together with the description serve to explain the principles of the disclosure.

Persons skilled in the art will readily appreciate that various aspects of the present disclosure can be realized by any number of methods and apparatus configured to perform the intended functions. It should also be noted that the accompanying drawing figures referred to herein are not necessarily drawn to scale, but may be exaggerated to illustrate various aspects of the present disclosure, and in that regard, the drawing figures should not be construed as limiting.

A seam-joining structure according to embodiments of the present invention will be further explained below with reference to Figures 1 to 3. For this purpose, the composite layers which are joined together in a seam area are only depicted schematically in Figures 1 and 2, in order to better show the seam-joining structure.

A seam area is an area comprising at least one seam, e.g. an area covering a seam and/or surrounding a seam.

A seam area particularly is an area of a joint region comprising the seam and the adjacent membrane composites. The membrane composites are arranged such that the first porous membrane on each side of the seam is forming the "outer" side of the seam area where the adhesive material is applied to.

At least in a portion of the seam area the pores of the respective porous membranes are completely filled by the adhesive material. In an embodiment the filled pores in at least a portion of the seam area form a continuous adhesive line between the first side of the respective porous membrane and the barrier layer. The continuous adhesive line can be formed substantially vertical between the first side of the porous membrane and the barrier layer. In another embodiment the continuous adhesive line can be formed more irregular between the first side of the porous membrane and the barrier layer. In another embodiment the pores in the seam area are completely filled between the first side of the porous membrane and the barrier layer. Based on the process, air inclusions may be possible within the filled porous membrane areas.

The barrier layer is underneath the first porous membranes and stops the flow of adhesive material.

A composite layer has at least two components (or two different functional parts), each of them has a different function with respect to the adhesive material. One of the layers is a porous membrane layer which is permeable for the adhesive material. Another layer is a barrier layer which is a barrier for the adhesive material, preferably impermeable for the adhesive material. The composite layer is preferably at least water vapor permeable. In one embodiment the composite layer is water vapor permeable and waterproof.

The barrier layer is a layer forming a barrier for the adhesive material, particularly the silicone adhesive material. The silicone adhesive material completely fills the pores of the first porous membrane layers in the seam area, but substantially cannot penetrate and fill into the structure of the barrier layer. The barrier layer may have a structure that prevents any penetration of the adhesive material, particularly the silicone adhesive material. In one embodiment, the barrier layer comprises a continuous non-porous structure. In another embodiment the barrier layer comprises pores of a size that prevents the adhesive material, particularly the silicone adhesive material, from penetrating into the pores or significantly slows down the penetration.

Fig. 1 shows a first embodiment of a seam-joining structure 10, in which a first composite layer 14 and a second composite layer 15 are joined with a seam 12 which comprises a first stitch 121 and a second stitch 122 (so-called top stitch), both comprised in a seam area 30.

Fig. 2 on the other hand, shows a second embodiment of a seam-joining structure 10, in which respectively a first composite layer 14 and a second composite layer 15 are joined with a seam 12 which comprises a stitch (not shown) joining the composite layers 14 and 15 side-by-side (i.e. with their end faces or front faces abutting to one another) in a seam area 30.

In this context, it is to be noted that, in principle, any kind of seam joining at least two composite layers to one another can be employed in connection with the present invention. The term seam-joining structure shall encompass in principle any structure in which respective layers are joined by a seam. For example, a seam may be a stitched seam, a welded seam, or a glued seam, or any combination thereof. A seam may join at least two composite layers, but may, in principle, join more than two layers, wherein at least two of them are composite layers.

A variety of materials and layer configurations can be used for the composite layers being joined such as, for example, membrane composites comprising multiple membrane layers. In one embodiment a composite layer or the composite layers can be part of multilayer laminates, such as a two-layer laminate where the respective composite layer is combined with a textile layer. In another embodiment a composite layer or the composite layers can be part of a three-layer laminate in being embedded between two textile layers, for example, forming a layer structure with an outer material layer, a composite layer and a textile layer. However, in principle, many types of composite layers are suitable for producing a waterproof textile article like a garment that can be used to produce a barrier with respect to penetrating water.

A laminate as used herein is a layered structure with a composite layer. In one embodiment, a laminate comprises at least a two-layer laminate comprising a membrane composite and a textile layer.

A membrane or membrane layer is a sheet or film that is thin and has a functional property, such as water-vapor permeability and waterproofness. A membrane composite may comprise at least a first porous membrane layer and a barrier layer. A textile layer may be attached by discontinuous attachments (such as a discontinuous adhesive layer) to the side of the membrane composite opposite to the porous membrane side. The first porous membrane layer and/or second porous membrane layer comprises a microstructure with pores.

The first porous membrane layer preferably has a pore size of about 0.05 µm to about 10 µm, particularly of about 0.1 µm to about 1 µm, particularly of about 0.15 µm to about 0.8 µm.

For example, a two-layer laminate according to Fig. 2 may be used incorporating the respective first and second composite layers 14, 15, which are suitable for forming a waterproof, water-vapor-permeable and therefore breathable garment article. A first two-layer laminate 16, as shown in Fig. 2, may have a textile layer 25, like an outer material, which is water-vapor-permeable and not waterproof. A first waterproof, water-vapor-permeable composite layer 14 is arranged on a side of the textile layer 25. Likewise, a second two-layer laminate 18 may have a textile layer 26, like an outer material, which is water-vapor-permeable and also not waterproof. A second waterproof, water-vapor-permeable composite layer 15 is arranged on a side of the textile layer 26. The composite layers 14, 15 and the textile layers 25, 26 are preferably attached in a water vapor permeable manner, for example by using a discontinuous applied adhesive layer.

The first and second waterproof, water-vapor-permeable composite layers 14, 15 comprise each at least one waterproof, water-vapor-permeable porous membrane 20.

According to an embodiment, as shown in Fig. 2, each of the first and second composite layers 14, 15 comprises at least one porous membrane layer 20 and a barrier layer 22. Each of the porous membrane layers 20 has a first side 201 and a second side 202 opposite the first side 201. Pores 24 are arranged between the respective first side 201 and second side 202. For example, the respective porous membrane layer 20 can be made of expanded polytetrafluoroethylene (ePTFE). Such ePTFE layer 20 may be provided with a non-porous polyurethane layer as barrier layer 22. Such a composite layer is waterproof and water vapor permeable. Such composites are described for example in US 4 194 041 A.

In each composite layer 14, 15, the barrier layer 22 is joined to the porous membrane layer 20 opposite the first side 201. Particularly, the barrier layer 22 is joined to the porous membrane layer 20 on the second side 202 of the porous membrane layer 20.

It should be noted that particularly the second side 202 of the porous membrane layer 20 may have various forms or structures and, in some embodiments, may not be unambiguously identifiable. For example, in some embodiments the barrier layer 22 may penetrate somewhat into the porous membrane layer 20 and is mechanically anchored there, such that there is no unambiguous identifiable second side 202, or the second side 202 is somewhat irregular and may have the form of a corrugated and/or interrupted side or surface.

In an embodiment as shown in Fig. 2, the first and second composite layers 14, 15 are each two-component composite layers having a porous membrane layer 20 and a barrier layer 22. The respective textile layers 25, 26 may be arranged on the side of the barrier layer 22 which is opposite to the porous membrane layer 20 in forming respective two layer laminates 16, 18. As in Fig. 2, the barrier layer 22 is joined to the porous membrane layer 20 opposite its first side 201.

A textile liner (not shown in Fig. 2) may be arranged on the side of the first porous membrane layer 20, e.g. facing the body of a user of the garment article. The textile layers 25, 26 as well as such textile liner can comprise materials chosen from the group of woven materials, knitted materials, and/or non-woven materials.

The layer structure according to Fig. 1 may be, in principle, the same or similar as the layer structure according to Fig. 2, wherein details regarding composition of the composite layers 14, 15 are not shown. Further, the textile layers 25, 26 are omitted in the structure according to Fig. 1.

With reference to Fig. 1, two material webs comprising at least the composite layers 14, 15 are initially prepared for joining to each other by a seam.

The composite layers 14, 15 are placed in a way that their respective barrier layers 22 are lying against each other, and are then stitched to each other with a first stitch 121 leaving a seam allowance of a particular length. The seam allowance of both composite layers 14, 15 is then bent towards the composite layer 15 and stitched to the composite layer 15 with a top stitch 122. The composite layers 14, 15 are thus joined to each other by means of the seam 12 (comprising in this example the stitches 121 and 122) comprised in the seam area 30. In this example, the seam area 30 covers both stitches 121, 122 of the seam 12, and may cover only one of the stitches 121, 122.

In the example of Fig. 2, the composite layers 14, 15 are joined to each other, with their side edges facing each other (shown at 33), by means of the seam 12. Thus, a seam area 30 is formed comprising the seam 12. For example, the seam 12 may comprise a different stitch as in Figure 1. For instance, the seam 12 may be sewn (e.g. by a zig-zag stitch, not shown), connecting the composite layers 14, 15.

In order to make the respective seam liquid proof, an adhesive material 50 is applied to the at least one seam 12 in the seam area 30 which generates a liquid proof seal at least in a portion thereof. Particularly, the adhesive material 50 is configured and applied in a manner such that in at least a portion of the seam area 30 (particularly in the seal joining area) the pores 24 of the porous membrane layers 20 of the composite layers 14, 15 are completely penetrated with the adhesive material 50 through to the respective barrier layer 22. The adhesive material 50 is applied directly onto the respective composite layers, particularly directly to the first side 201 of the respective porous membrane layers 20 at least in the seal joining area. In the seam area 30, at least a portion of the pores 24 of the respective porous membrane layer 20 between the respective first side 201 and the respective barrier layer 22 are completely filled with the adhesive material 50 to form a continuous adhesive line. More particularly, the pores 24 of the respective porous membrane layers 20 between the respective first side 201 and the respective second side 202 are completely filled with the adhesive material 50. The barrier layer 22 is a barrier for the adhesive material 50 and helps to prevent that the adhesive material 50 is penetrated through to the opposite side of the seam. This is shown in Figs. 2, where the adhesive material 50 completely fills the pores 24 of the porous membrane layers 20 in the seam area 30.

According to an embodiment, the seam area 30 may comprise, e.g., two portions on the left and right hand side of the stitches 121, 122, respectively, as shown in Fig. 1 at 31 and 32, respectively, or may comprise at least the centre region of the seam 12, as shown in Figs. 2 at 33 where the composite layers 14, 15 abut against each other. Depending on the type of seam and/or number of stitches used, the seam area 30 may comprise one or multiple portions arranged appropriately with respect to the seam.

The adhesive material 50 completely fills the pores 24 of the porous membrane layers 20 at least in a portion of the seam area 30. Particularly, the pores 24 are completely penetrated by the adhesive material 50 to build a continuous adhesive line within the porous structure of the respective porous membrane from the first side to the barrier layer. In one embodiment, in the seam area 30, all of the pores 24 in the cross-section of the respective porous membrane layers 20 of the first and second composite layers 14, 15 are filled with the adhesive material 50. It is possible that within the filled pores isolated air inclusions might be visible.

In order to protect the seam 12 against, e.g., abrasion or degrading over lifetime, and in some embodiments to further improve the sealing, at least one protective layer 40 is bonded to the seam area 30 by the adhesive material 50, such that the at least one protective layer 40 covers the at least one seam 12.

A protective layer as used herein in the context of this invention is a layer that covers the at least one seam the seam area of the seam-joining structure in order to give protection against the surrounding and any environmental influences. The protective layer protects among other things against damages by abrasion, puncture and friction. It also protects the rollers of the process against adhesive contamination. The protective layer also supports and improves waterproofness in the seam area. Furthermore, the protective layer improves the aesthetic appearance.

Preferably, the adhesive material 50 comprises a viscosity as described above, preferably a viscosity of 3500 mPa s (particularly measured at 23°C, according to test method described in ISO 3219) before applying to the seam area 30. This permits the adhesive material 50 to completely fill the pores 24 of the porous membrane layers 20 in their cross-section through to the barrier layer 22 which is a barrier for the adhesive material 50.

Preferably, the adhesive material 50 is formed from at least two components supplied separately from different reservoirs and mixed just before being applied to the seam area 30. These at least two components chemically react with each other at room temperature forming a room temperature curing adhesive material 50. Compared to, e.g., liquid rubber high temperature curing adhesives, the curing process and time can be considerably shortened, and flexibility in making three-dimensional designs and narrow seam curves can be considerably increased. The adhesive material 50 is preferably heated for accelerating the chemical reaction.

Fig. 3 shows a SEM picture of a cross-section through the seam-joining structure 10 according to one of Figures 1 or 2 taken along line A-A according to an embodiment of a seam-joining structure. As shown in Fig. 3, the adhesive material 50 extends into the porous membrane 20 of the composite layer 14 and partially into the protective layer 40. The porous membrane 20 (particularly all of its pores along its cross-section in the seam area) is completely filled with adhesive material (region 43) through to the barrier layer 22. The protective layer 40 may be porous and may be filled at least in part with the adhesive material 50, shown in region 41 in which the adhesive 50 is located in the pores of the protective layer 40. In one embodiment there may be a region 42 where only adhesive material 50 is located. SEM cross section analysis may be used to detect the penetration rate of the adhesive material in porous membranes according to this invention.

Fig. 5 shows a schematic view of an apparatus for manufacturing a seam-joining structure according to an embodiment of the invention.

The apparatus 60 comprises a first supply device 61 (schematically shown here as an adhesive applicator) for continuously applying a liquid adhesive material 50 (e.g., two components thereof mixed with each other) to the at least one seam in the seam area 30. The adhesive material 50, or its respective components, is supplied and applied, and has a composition in such a way that the applied adhesive material 50 completely penetrates the pores of the porous membrane layers in at least a portion of the seam area 30 through to the respective barrier layer. In a particular embodiment, two adhesive components are supplied simultaneously from a respective reservoir separately in a respective duct (two-part delivery system) and mixed before applying to the seam area 30. For example, a static mixer may be used for mixing the components before applying to the seam area 30. From such static mixer (shown here forming a part of supply device 61), an adhesive applicator (shown here as a duct at 61) may be arranged to supply the mixed adhesive compound 50, which is still liquid and has a preferred viscosity as described herein, to the seam area 30. According to various embodiments, the adhesive components may be premixed or mixed in the process. In either case, the supply system provides a stream of liquid adhesive material 50 to the applicator

61, mixed and ready to use and with sufficient pressure to flow through the applicator 61. Where the adhesive components 50 are premixed, the supply system handles only a single component.

Before supplying to the apparatus 60, the first and second composite layers 14, 15 are already joined by means of a seam 12 (like in Figures 1, 2) and supplied at a particular throughput speed to the first supply device 61 such that the adhesive material 50 is continuously applied to the joined and forward moving first and second composite layers 14, 15 at the seam area 30. The first and second composite layers 14, 15 are moved forward at a certain throughput speed in direction D which designates the transportation direction or throughput direction of the seam-joining structure. The moving forward can be performed manually by an operator or automatically by a guiding device (such as a roller) or a combination of both. Further, the particular throughput speed can vary over time during manufacturing, i.e. need not be constant during the manufacturing process.

The apparatus 60 further comprises a second supply device 62, which is separate from the first supply device 61, for continuously supplying at least one protective layer 40 to the seam area 30 in a way that the protective layer 40 covers the at least one seam and, at the end of the application process, bonds to the seam area 30 by the adhesive material 50. For example, the second supply device 62 comprises a cutting device for tailoring the protective layer 40. For example, the protective layer 40 is supplied from a process direction to the supplying direction of the composite layers 14, 15 such that the protective layer 40 is applied from a direction towards the upper side of the composite layers 14, 15 similar to the adhesive compound 50. By applying the protective layer 40, the separate liquid adhesive material 50 penetrates into the porous membrane layers of the composite layers 14, 15. A respective supplying or guiding device, such as a respective roller 65, may be provided for supplying and/or guiding the protective layer and composite layers, respectively. As a result of the low viscosity and the capillary effect, the adhesive material 50 immediately wets or moistens into the porous membrane layers. Moreover, the porous protective layer 40 is likewise penetrated by the adhesive compound 50 up to certain height, as shown in Fig. 2.

The apparatus 60 further comprises an air flow generating device 66 arranged after the supply device 61 for generating and applying a heated air flow 68 to the seam area 30 applied with the adhesive material 50. For example, the air flow generating device 66 comprises a heater for heating air to a particular temperature controlled by a heater control circuit and an air fan for blowing the heated air towards the seam area 30. Advantageously, the air flow 68 is heated to a temperature such that the adhesive material 50 is sufficiently hardened within a certain distance from its application location in liquid form. Particularly, the heated air flow 68 is applied to the seam area 30 such that the adhesive material 50 is treated with the heated air flow 68 within a length of 75 mm ± 5 mm along the transportation direction D of the first and second composite layers 14, 15, as shown schematically in Figs. 5 and 6. After such treatment, particularly at a throughput speed of 2.5 ± 0.5 m/min, the adhesive material 50 is considered hardened.

Fig. 6 shows a schematic depiction of dimensions applied in the apparatus 60 according to Fig. 5 according to an embodiment of the invention. In the present embodiment, the air flow generating device 66 applies the heated air flow 68 to the adhesive material 50 applied to the seam area 30 within a length of 75 mm ± 5 mm along the transportation direction D while the first and second composite layers 14, 15 are moving forward at a certain throughput speed in the transportation direction D. In the present case, the length d1 of the air outlet 69 of the air flow generating device 66 along the transportation direction D corresponds to the length of 75 ± 5 mm. This embodiment may be applied in cases in which the air flow 68 is blown out of the air flow generating device 66 approximately straight onto the seam area 30 (i.e perpendicular to the transportation direction D, as shown in Fig. 5). In other cases in which the heated air flow 68 has a different spatial distribution or blowing-out angles, the length d1 of the air outlet 69 of the air flow generating device 66 may deviate from the length of 75 ± 5 mm, for example the length may be in the range of 20 to 100 mm. According to an embodiment, there may be a distance d2 of approximately 5 mm in transportation direction D between the air flow generating device 66 and the rollers 65.

For example, the apparatus 60 comprises a plane 67 for guiding the joined first and second composite layers 14, 15 and the seam, respectively. This provides the advantage that the applied adhesive 50 is sufficiently hardened within the predetermined distance so that any shifting or slipping of the protective layer 40 on the seam 12 is substantially prevented. This facilitates an accurate application of the protective layer 40 on the seam 12.

According to an embodiment, the adhesive material 50 is applied to the seam 12 at a throughput speed of 2.5 ± 0.5 m/min of the first and second composite layers 14, 15. The apparatus 60 is capable to employ speed ranges between 0.5 and 3 m/min. For example, the rollers 65 of the apparatus 60 may be driven by a respective motor at a particular throughput speed for conveying the joined composite layers 14, 15 with the seam by the particular throughput speed. The rollers 65 may also be provided for guiding and, if appropriate, pressing the protective layer 40 onto the seam area 30 and distributing the liquid adhesive material 50 over a certain range in the seam area. Preferably, various mixing ranges of the adhesive material 50 are possible and may be adjusted, e.g. in a mixer (static or dynamic) and/or by the respective supply system of the respective adhesive component. In case that the throughput speed is increased, the heated energy applied to the seam area through the heated air flow 68 may then be increased correspondingly, in order to ensure that the adhesive material 50 is hardened within a certain distance as set out above. For example, if the throughput speed is increased, the temperature of the heated air flow 68 and/or the amount of air is increased as well.

According to an embodiment, the heated air flow 68 generates a temperature of approximately 150°C at a surface of the protective layer 40 facing the heated air flow 68. This contributes to hardening of the adhesive material 50 within a certain distance as set out above. In the present case, the temperature measured at the upper surface of the protective layer 40 may be between 80°C and 150°C. To this end, the air flow generating device 66 may generate a temperature of approximately 320°C ± 10°C in its heating chamber before blowing the heated air 68 towards the seam area 30. At a throughput speed of 2.5 ± 0.5 m/min the heated air flow 68 may be approximately 60 l/min.

Preferably, the process of hardening the adhesive material (e.g. by adjusting the throughput speed and/or the heated air flow 68) is adjusted such that at the end of the hardening process of the adhesive material, substantially no adhesive material has penetrated through the barrier layer 22 (in case that the barrier layer 22 is not completely impermeable to the adhesive material).

The apparatus 60 further comprises a heating device 63 for pre-heating the first and second composite layers 14, 15 in the seam area 30 (e.g. by heated air) before the first supply device 61 supplies the adhesive material to the seam area 30. This provides the advantage that the adhesive material 50 applied after the heating device 63 is sufficiently tacky (through the heat from the composite layers 14, 15) for preventing the protective layer 40 from spooling up with one of the rollers 65.

An apparatus, as described above according to an embodiment, is particularly capable to continuously dose a two component liquid phase silicone adhesive material in a ratio of 9:1 (between the two components) and a dosing range of 1 g/m min ± 0.5 g/m to 6 g/m ± 0.5 g/m. Particularly, a dosing of 1.2 g/m ± 0,5 g/m may be used. Adhesive penetration and curing can be controlled by the apparatus at a speed range from 1 – 3 m/min. Three-dimensional components of a garment can be seam sealed, and curves with a minimum 2.75 " (70 mm) radius can advantageously be processed. Further benefits are improved seam aesthetics, soft and durable sealed seams resulting in more flexible garments and/or reduced noise. Further, a suitable technology for stretchable and durable seams is provided.

The quality of the curing of the adhesive material in the seam can be determined by the curing measurement using a spring gauge test equipment, as explained below. The test determines the grade of curing by measuring the peel strength of the protective layer.

The spring gauge measurements refer to a test method as shown in Fig. 7 and further explained below. The results of the test method are summarized in Figure 8. The width refers to the width of the protective layer. The air flow temperatures refer to the air flow 68 as shown in Fig. 5. and the process speed refers to the throughput speed of the composite layers. In the comments column, the result of the respective applied manufacturing process parameters according to the respective row is described.

According to an embodiment, the adhesive material 50 comprises silicone. For example, at least one of the components of the adhesive material comprises a silicone material. According to another embodiment, the adhesive material 50 comprises a two-component room temperature curing adhesive material.

Further possible / alternative two component adhesive materials that can be applied according to the invention may be as follows:

- RTV2 silicone adhesives RT604 A/B; RT625 A/B; RT620 A/B and

LR6200 A/B by the company Wacker Chemie AG, Munich, Germany

- RTV Silbione 4410 A/B by the company Bluestar Silicones GmbH, Leverkusen, Germany
- RTV and HTV fluoro-silicones SIFEL8570 A/B; SIFEL8070 A/B by the company Shin-Etsu Silicones Europe B.V, Wiesbaden, Germany.

The two component curing silicone adhesive by the company Wacker may also use in alternative formulations:

- RT601 A/B in 8:1; 7:1; 10:1; 12:1 mix ratios
- RT601 A/B with silica reinforcing additive
- RT601 A/B with 'tack' additive
- RT601 A/B with Platinum additive
- RT601 A/B with adhesion promoters GF80 / GF82

In one embodiment the first porous membrane layer 20 and/or the second porous membrane layer 23 of the first and second composite layers 14, 15 is at least water vapor permeable. In another embodiment the first porous membrane layer 20 and/or the second porous membrane layer 23 is water vapour permeable and waterproof.

Suitable fluoropolymer materials include expandable fluoropolymers such as but not limited to expanded PTFE, expanded products made with polymers as described in U.S. Pat. No. 5,708,044 (Branca, 1988), U.S. Pat. No. 6,541,589 (Baille, 2003), U.S. Pat. No. 7,531,611 (Sabol et al., 2009), U.S. Pat. Application No. 11/906,877 (Ford), and the like.

The porous membrane may be a fluoropolymer membrane such as expanded polytetrafluoroethylene (ePTFE), expanded modified polytetrafluoroethylene, polytetrafluoroethylene (PTFE), ePTFE films or PTFE films coated with protective coatings such as polyurethanes, polyolefin films, polyurethane films, silicone and silicone containing films, as well as other fluoropolymer containing films such as skived PTFE and fluorinated ethylene propylene (FEP), and composites having polytetrafluoroethylene membranes.

In at least one exemplary embodiment, the composite layer is ePTFE at least partially coated with polyurethane.

In at least another exemplary embodiment, the composite layer may be comprised of:

a) a layer of a microporous polymer film that is water vapor permeable and liquid water resistant, said film is adhered to
b) an air –impermeable polymer layer that is water vapor permeable, wherein said layer (b) has adhered on the side opposite layer (a),
c) a layer of microporous polymer film that is water vapor permeable.

The layer (a) of said composite may form the porous membrane and layer (b) may form the barrier layer of the invention.

There are different variations of the said composite which are described for example in WO 97/49553 A, WO 97/49552 A, WO 94/21453 A, and the like.

In at least another exemplary embodiment the composite layer may have a structure as disclosed in WO 2011/140494 A.

The pore size of the pores of at least one of the first porous membrane layer 20 is in a range between 0.05 μm to 10 μm, preferably from about 0.1 μm to about 1 μm, more preferably from about 0.15 μm to about 0.8 μm.

The pore size of porous membrane layers can be measured with the Coulter Porometer™, produced by Coulter Electronics, Inc., Hialeah, Florida, USA.

Figure 9 shows a SEM picture of the surface of the first side of a porous membrane according to one embodiment. The picture shows a nodes and fibril structure into which the adhesive material will penetrate and fill up the spaces within the nodes and fibril structure.

According to an embodiment, the barrier layer 22 is impermeable for the adhesive material 50. For example, the barrier layer 22 comprises a non-porous material, such as a continuous polyurethane layer. With such constitution, the adhesive material 50 cannot penetrate through the barrier layer 22.

According to another embodiment, the barrier layer 22 comprises at least one of the following materials: polyurethane, polyester, silicone, paper, monolithic polymer layer or foil, cellulosic sheet like paper, material comprising PTFE. Moreover, embodiments of the barrier layer 22 may comprise a porous material with a pore size which does not allow the permeation of the adhesive material.

Further, the barrier layer 22 may comprise a porous membrane, as described in WO 2011/140494 A1 called there “interface”, e.g. as shown in Fig. 4 and Figs. 8a and 8b at reference numeral 17 between a first (14) and second (15) porous region. Regarding composition, configuration and potential materials of such interface layer, which may be used as a barrier layer 22 according to the present invention, the skilled person will find various embodiments of such interface layer for use in embodiments of the present invention in WO 2011/140494 A1, the disclosure of which in this regard is incorporated herein by reference.

In one embodiment the protective layer 40 comprises a porous material with pores which are at least partially filled with the adhesive material 50, as shown in Fig. 2. For example, the protective layer 40 may comprise a barrier layer, e.g. a layer of continuous non-porous polyurethane. This provides the additional advantage that the protective layer serves as an additional liquid barrier to penetration of liquids, but is still water vapor permeable, e.g. in regions outside of the adhesive material 50.

A seam-joining structure formed according to the invention can be used advantageously in a garment, preferably in a clothing article. Fig. 4 shows an example of a garment, particularly a jacket 100 in a front view and in a back view. All seams of the jacket 100 have been seam sealed according to the invention. The nine circled areas (1 to 9) demonstrate selected seam areas which have been tested for waterproofness according to the Suter Test. Since the seam-joining structures are designed to be waterproof, a clothing article with such a seam-joining structure can be used in wide areas under harsh conditions. Thanks to the improved seam-joining structure, the seams are capable to withstand a high number of washing cycles, even at increased temperatures which may applied for drying the garment.

A textile article, particularly a garment, of the general type, as described above, which is waterproof, but water-vapor-permeable, can be produced with a multilayer laminate structure, as explained above, whereby wearing comfort is increased by the water-vapor permeability.

Any membrane layer and/or barrier layer of such structure used herein can be water-vapor-permeable and gas-impermeable (air-impermeable), or water-vapor-permeable and liquid-proof (waterproof), or water-vapor-permeable, gas-imperneable, and liquid-proof.

A textile article in connection with the present invention can be any garment including jackets, trousers, hats, bands, shoes, boots, socks, gloves, mitten, coats, skirts, pants, and the like. A textile article can also be any of hoods, gators, bivi bags and tents.

A composite layer is considered “liquidproof or waterproof”, if it guarantees a water entry pressure of at least 1×10^4 Pa. The composite layer material preferably guarantees a water entry pressure of more than 1×10^5 Pa. The water-entry pressure may be measured, e.g., according to a test method in which distilled water, at 20 ± 2 °C, is applied to a sample of 100 cm^2 of the composite layer with increasing pressure. The pressure increase of the water is 60 ± 3 cm H_2O per minute. The water-entry pressure then corresponds to the pressure at which water first appears on the other side of the sample. Details of the procedure are stipulated in ISO standard 0811 from the year 1981.

A composite layer is considered “water-vapor-permeable”, if it has a water-vapor permeability Ret of less than 150 $m^2 \times Pa \times W^{-1}$. The water-vapor permeability is tested according to the Hohenstein skin model. This test method is described in DIN EN 31092 (02/94) or ISO 11092 (1993).

The term “air-impermeable (wind-tight)” means that the composite layer has an air permeability of less than 25 $l/m^2/s$, in some embodiments less than 5 $l/m^2/s$.

In order to measure the air permeability of a material web a test device is used that can measure the air flow through the material web. The test specimens are positioned between two rings, which results in a test area of 100 cm^2. Air is drawn through the test specimen at a constant pressure of 100 Pa. The amount of air that passes through the test specimen is then measured and calculated in $l/m^2/s$. The test method is described in EN ISO 9237.

A sealed seam is considered to be liquid proof or waterproof if it passes the Suter test as described further below.

Examples:

Example 1:

A two layer laminate, commercially available under the name “Flameliner A 2 layer” and with the article number FLMR000000A by W.L.Gore & Associates GmbH, Germany was provided. Said laminate has a two component membrane composite with porous ePTFE membrane and non-porous polyurethane layer. The porous membrane layer has a pore size of 0.2 to 0.25 µm.The textile layer is a plain weave L1/1 made of 50% Aramid and 50% Viscose FR. The laminate has a textile weight of 190 ± 7 g/m². The resistance to water penetration is ≥ 100 kPa according to EN20811/ ISO 811. The Ret is ≤ 8 m²Pa/W according to EN 31092 / ISO 11092.

Two pieces of the laminates are sewn together with the textile side facing outside and with a stitch length of 2-3 mm and a seam allowance of 2.5 mm ± 0.5 mm. The seam allowance is fixed by a top stitched seam (like in Fig. 1).
The same membrane composite layer was slitted in a 22 mm ± 1 mm wide covering tape to form the protective layer.
The adhesive material is a Wacker Silicone RTV 601 A+B ordered by the company Drawin Vertriebs GmbH in Ottobrunn Germany. The two components A and B of the RTV 601 adhesive mean
A: Poly(vinylidene dimethoxysiloxane), contains platinum catalyst, viscosity measured at 5000 mPa s and
B: Poly(hydrogen dimethoxysiloxane), crosslinker component, viscosity measured at 40 mPa s.
Both components are mixed according the supplier description.
About 2 g/m ± 0.5 g/m of the mixed silicone adhesive material at a given throughput speed of 2.5 m/min was applied on the membrane side of the laminate with the seam allowance such that is covers the seam area, and in a subsequent step the covering tape is laid over the seam allowance for bonding by the adhesive material and for protecting the seam. The curing process can be accelerated by applying additional heat by a heat press, e.g. according to the principles as described above.
The sealed seam structure has been tested for waterproofness according to the Suter Test (2min at 0.2 bar) and passed the test.

Example 2:

A two layer laminate, commercially available under the name "Fireblocker N 2 layer" and with the article number FIRB000000N by W.L.Gore & Associates GmbH, Germany was provided. Said laminate has a two component membrane composite with porous ePTFE membrane and non-porous polyurethane layer. The porous membrane layer has a pore size of 0.2 - 0.25 µm. The textile layer is a nonwoven made of 100% Aramid. The laminate has a textile weight of 140 ± 25 g/m². The resistance to water penetration is ≥ 100 kPa according to EN20811/ ISO 811. The Ret is ≤ 8 m²Pa/W according to EN 31092 / ISO 11092.

Two pieces of laminate are sewn together, face outside with a stitch length of 2-3 mm and a seam allowance of 2.5 mm ± 0.5 mm. The seam allowance is fixed by a top stitched seam (like in Fig. 1).

The same membrane composite layer was slitted in 22 mm ± 1 mm wide covering tape to form the protective layer.

The adhesive material is a Wacker Silicone RTV 601 A+B ordered the company Drawin Vertriebs GmbH in Ottobrunn Germany. The two components A and B of the RTV 601 adhesive mean

A: Poly(vinylidene dimethoxysiloxane), contains platinum catalyst, viscosity measured at 5000 mPa s and

B: Poly(hydrogen dimethoxysiloxane), crosslinker component, viscosity measured at 40 mPa s.

Both components are mixed according the supplier description.

About 2 g/m ± 0.5 g/m of the mixed silicone adhesive material at a given throughput speed of 2.5 m/min was continuously applied on the membrane side of the laminate with the seam allowance, and in a subsequent step the covering tape is laid over the seam allowance and bonded thereto protecting the seam. The composite is pressed together by two rotating rollers. The curing process is accelerated by applying additional heat through a hot air nozzle, e.g. according to the principles as described above.

The sealed seam structure has been tested for waterproofness according to the Suter Test (2min at 0.2 bar) and passed the test.

Comparative Example 3:

A two layer laminate, commercially available under the name "Flameliner A 2 layer" and with the article number FLMR000000A by W.L.Gore & Associates GmbH, Germany was provided. Said laminate has a two component membrane composite with porous ePTFE membrane and non-porous polyurethane layer. The porous membrane layer has a pore size of 0.2 to 0.25 µm. The textile layer is a plain weave L1/1 made of 50% Aramid and 50% Viscose FR. The laminate has a textile weight of 190 ± 7 g/m². The resistance to water penetration is ≥ 100 kPa according to EN20811/ ISO 811. The Ret is ≤ 8 m²Pa/W according to EN 31092 / ISO 11092.

Two pieces of the laminates are sewn together with the textile side facing outside and with a stitch length of 2-3 mm and a seam allowance of 2.5 – 4 mm ± 0.5 mm. The seam allowance is fixed by a top stitched seam (like in Fig. 1).
The seam has been seam sealed using a commercial available seam tape under the particle number 6GNAL022NATUK by W.L.Gore & Associates GmbH. Said seam tape comprises waterproof tape material with a thermoplastic polyurethane adhesive layer. The seam is applied to the seam by using a conventional seam tape machine.
The sealed seam structure has been tested for waterproofness according to the Suter Test (2min at 0.2 bar) and passed the test.

Example 1 and the comparative example 3 has been tested for heat stability using the oven test.
For that test a weight of approximately 2.8 g has been attached to an end of the protective layer in example 1 and to an end of the sealing tape in the comparative example 1.
Example 1 was hang into a heated oven (Type 6120 by Heraeus Instruments GmbH) such that the weight is causing tension on the protective layer and exposed to heat of 180°C for 5 min. During and after the heat exposure no peeling effect can be observed.
The comparative example 3 was hang into a heated oven (Type 6120 by Heraeus Instruments GmbH) such that the weight is causing tension on the protective layer and exposed to heat of 180°C for 5 min. During the heat exposure the weight has peeled off the seam tape for a length of 1.0 to 3.5 cm showing the low heat stability of the PU adhesive.

Example 4:
A jacket was made of the 2 layer laminate of example 1. The design of such a jacket is shown in Figure 4 in front and back view. All seams are waterproof sealed according to this invention and as explained in example 1. As protective

layer a porous layer made of ePTFE has been attached to the seams with a width of 22 mm ± 1 mm. Such a protective layer is exemplary shown in Figure 3.
The nine circled marked seam areas (shown in Figure 4) were tested for waterproofness according to the Suter test. All nine seam sealed areas passed the test.

Comparative example 5:
A jacket was made using a 2 layer laminate commercially available under the name “Burano 2 layer” and with the article number BURA000000 by W.L.Gore & Associates GmbH, Germany. Said laminate has a two component membrane composite with porous ePTFE membrane and non-porous polyurethane layer. The porous membrane layer has a pore size of 0.2 to 0.25 µm. The textile layer is a plain woven 1/1 made of 100% Polyester. The laminate has a textile weight of 220 ± 10 g/m². The resistance to water penetration is ≥ 100 kPa according to EN20811/ ISO 811. The Ret is ≤ 6 m²Pa/W according to EN 31092 / ISO 11092. The design of such a jacket is shown in Figure 4 in front and back view. All seams are waterproof sealed by using a commercial available seam tape under the particle number 6GNAL022NATUK by W.L.Gore & Associates GmbH. Said seam tape comprises waterproof tape material with a thermoplastic polyurethane adhesive layer. The seam is applied to the seam by using a conventional seam tape machine. The nine circled marked seam areas (shown in Figure 4) were tested for waterproofness according to the Suter test. All nine seam sealed areas passed the test.

Both jackets were tested for wash durability according to ISO 15797 at the Hohenstein Test Institute. The jackets according to example 4 and 5 run through 50 industrial wash cycles (IWC) at 60°C (method 8) and the drying method B (tunnel 150 to 155°C. No bleaching process was applied.

After the washing test the nine circled marked seam areas (shown in Figure 4) of each jacket were tested for waterproofness according to the Suter test.

The jacket of example 4 shows an 89% pass rate of the nine selected seam sealed areas according Figure 4.

The jacket of example 5 shows a 50% pass rate of the nine selected seam sealed areas according Figure 4.

Test methods:

It should be understood that although certain methods and equipment are described below, other methods or equipment determined suitable by one of ordinary skill in the art may be alternatively utilized.

Suter Test:

To determine whether a protective barrier fabric or a protective barrier layer or membrane or polymer is waterproof, the Suter test procedure is used. This procedure provides a low pressure challenge to the sample being tested by forcing water against one side of the test sample and observing the other side for indication that water has penetrated through the sample.

The test specimen is clamped and sealed between rubber gaskets in a fixture that holds the specimen so that water can be applied to an area of the specimen 4.72 inches in diameter (120±5 mm). The water is applied under air pressure of 3 PSI (0.2 bar) to one side of the specimen. In testing a fabric laminate, the water is applied to the face or exterior side. In testing a sealed seam, water is applied to the face side and the sealing backer is observed for leaks.

The other side of the sample is observed visually for any sign of water appearing on the side for 2 minutes. If no water is observed, the sample has passed the test and the sample considered waterproof.

Curing Measurement by spring gauge measurement:

Figure 7 schematically shows a test apparatus for applying a peeling force to the protective layer for determining whether the adhesive material has hardened to a desired degree after application to the seam area. Particularly, Figure 7 shows a spring 70 applying a peeling force of approximately 3 N to the protective layer 40 in a peeling direction, which is approximately perpendicular to the longitudinal direction of the composite layers 14, 15 and the seam area 30, peeling it off again from the seam area 30 after the adhesive material 50 has been applied and has passed through the apparatus. If the peeling force is lower than the above value, then the adhesive material is still somewhat liquid and not considered hardened, so that lower forces suffice for peeling off the protective layer.

A hardened adhesive material shall mean that the adhesive material is cross-linked to at least 80%. A hardened adhesive material can also imply that a force for removing (peeling off) the protective layer from the seam area is at least 1.3 ± 0.2 N at a width of the protective layer of 100 mm and a peeling speed of about 10 mm/sec.

Aspects of the invention have been described herein both generically and with regard to various embodiments. It will be apparent to those skilled in the art that various modifications and variations can be made without departing from the scope of the claims.

Claims

1. Seam-joining structure (10) comprising:
- at least a first composite layer (14) and a second composite layer (15),
- a seam area (30) comprising at least one seam (12) that joins the first and second composite layers (14, 15),
- at least one protective layer (40) which covers the at least one seam (12), and
- an adhesive material (50) which generates a liquid proof seal in the seam area (30) and which bonds the at least one protective layer (40) to the seam area (30),
- wherein each of the first and second composite layers (14, 15) comprises at least one porous membrane layer (20) with pores (24) and with a first side (201), and a barrier layer (22) joined to the at least one porous membrane layer (20) opposite the first side (201) and which is a barrier for the adhesive material (50),
- wherein at least in a portion of the seam area (30) the pores (24) of the respective porous membrane layers (20) between the respective first side (201) and the respective barrier layer (22) are completely filled with the adhesive material (50).

2. The seam-joining structure according claim 1, wherein the adhesive material (50) comprises silicone.

3. The seam-joining structure according to one of claims 1 or 2, wherein the adhesive material (50) comprises a two-component room temperature curing adhesive material.

4. The seam-joining structure according to one of claims 1-3, wherein the adhesive material (50) comprises a viscosity lower than 6000 mPa s, particularly lower than 4000 mPa s, more particularly lower than 3000 mPa s, more particularly lower than 2000 mPa s, for penetration of the pores (24) of the porous membrane layers (20).

5. The seam-joining structure according to one of claims 1-4, wherein the adhesive material (50) comprises a viscosity of 3500 mPa s for penetration of the pores (24) of the porous membrane layers (20).

6. Seam-joining structure according to one of claims 1-5, wherein the at least one porous membrane layer (20) comprises expanded polytetrafluororethylene (PTFE).

7. Seam-joining structure according to one of claims 1-6, wherein the pore size of the pores of the at least one porous membrane layer (20) is in a range between 0.05 µm to 10 µm, particularly from about 0.1 µm to about 1 µm, more particularly from about 0.15 µm to about 0.8 µm.

8. The seam-joining structure according to one of claims 1-7, wherein the barrier layer (22) is impermeable for the adhesive material (50).

9. The seam-joining structure according to one of claims 1-8, wherein the barrier layer (22) comprises a non-porous material.

10. The seam-joining structure according to one of claims 1-9, wherein the barrier layer (22) comprises a hydrophobic and /or oleophobic treated porous membrane.

11. The seam-joining structure according to one of claims 1-10, wherein the barrier layer (22) comprises at least one of the following materials: polyurethane, polyester, silicone, paper, monolithic polymer layer or foil, cellulosic sheet like paper, material comprising polytetrafluoroethylene (ePTFE).

12. The seam-joining structure according to claim 11, wherein the barrier layer (22) comprises polyurethane.

13. The seam-joining structure according to one of claims 1-12, wherein each of the first and second composite layers (14, 15) further comprises at least one textile layer (24) on the side of the barrier layer (22) or a second porous membrane layer opposite to the first porous membrane layer (20).

14. The seam-joining structure according to one of claims 1-13, wherein the protective layer (40) comprises a porous material with pores which are at least partially filled with the adhesive material (50).

15. A textile article, particularly garment (100), comprising a seam-joining structure (10) according to one of the preceding claims.

16. The textile article according to claim 15, wherein the garment (100) is configured to withstand at least 30 to 50 industrial washing cycles according to ISO 15797, method 8 at 60°C, drying method B (tunnel 150-155°C).

17. A method of manufacturing a seam-joining structure (10), which comprises at least a first composite layer (14) and a second composite layer (15) and a seam area (30) comprising at least one seam (12) that joins the first and second composite layers (14, 15), wherein each of the first and second composite layers (14, 15) comprises at least one porous membrane layer (20) with pores (24) and with a first side (201), and a barrier layer (22) joined to the at least one porous membrane layer (20) opposite the first side (201),
the method comprising the steps of:
- applying an adhesive material to the at least one seam (12) in the seam area (30) which generates a liquidproof seal such that in at least a portion of the seam area (30) the pores (24) of the respective porous membrane layers (20) between the respective first side (201) and the respective barrier layer (22) are completely penetrated with the adhesive material (50) through to the respective barrier layer (22) which is a barrier for the adhesive material (50), and
- bonding at least one protective layer (40) to the seam area (30) by the adhesive material (50), such that the at least one protective layer (40) covers the at least one seam (12).

18. The method according to claim 17, wherein the adhesive material (50) comprises a viscosity lower than 6000 mPa s, particularly lower than 4000 mPa s, more particularly lower than 3000 mPa s, more particularly lower than 2000 mPa s, before applying to the seam area (30).

19. The method according to claim 17 or 18, wherein the adhesive material (50) comprises a viscosity of 3500 mPa s before applying to the seam area (30).

20. The method according to one of claims 17-19, wherein the adhesive material (50) is formed from at least two components applied to the seam area (30) and which chemically react with each other forming a two-component room tempera-

ture curing adhesive material (50), wherein the two-component room temperature curing adhesive material (50) is heated for accelerating the chemical reaction.

21. The method according to one of claims 17 to 20, further comprising the step of applying a heated air flow (68) to at least a portion of the seam area (30), wherein at a particular throughput speed of the first and second composite layers (14, 15) the adhesive material (50) is treated with the heated air flow (68) within a length (d1) in the range of 20 to 100 mm along a transportation direction (D) of the first and second composite layers (14, 15).

22. The method according to claim 21, wherein at a particular throughput speed of the first and second composite layers (14, 15) the adhesive material (50) is treated with the heated air flow (68) within a length (d1) of 75 mm ± 5 mm along a transportation direction (D) of the first and second composite layers (14, 15).

23. The method according to one of claims 21 to 22, wherein the heated air flow (68) generates a temperature of approximately 150°C at a surface of the protective layer (50) facing the heated air flow (68).

24. The method according to one of claims 17 to 23, wherein the adhesive material (50) is applied to the at least one seam (12) at a throughput speed of 2.5 ± 0.5 m/min of the first and second composite layers (14, 15).

25. The method according to one of claims 17 to 24, wherein the protective layer (40) is applied to the at least one seam (12) separately from the adhesive material (50).

26. An apparatus (60) for manufacturing a seam-joining structure (10), which comprises at least a first composite layer (14) and a second composite layer (15) and a seam area (30) comprising at least one seam (12) that joins the first and second composite layers (14, 15), wherein each of the first and second composite layers (14, 15) comprises at least one porous membrane layer (20) with pores (24) and with a first side (201), and a barrier layer (22) joined to the at least one porous membrane layer (20) opposite the first side (201), the apparatus comprising:
- a first supply device (61) for continuously applying a liquid adhesive material (50) to the at least one seam (12) in the seam area (30) for generating a liquid proof seal, such that in at least a portion of the seam area (30) the applied adhesive ma-

terial (50) completely penetrates the pores (24) of the respective porous membrane layers (20) between the respective first side (201) and the respective barrier layer (22) through to the respective barrier layer (22) which is a barrier for the adhesive material (50),
- an air flow generating device (66) for generating and applying a heated air flow (68) to the seam area (30) applied with the adhesive material (50), wherein at a particular throughput speed of the first and second composite layers (14, 15) the air flow (68) is applied to the adhesive material (50) within a length (d1) in the range of 20 to 100 mm along a transportation direction (D) of the first and second composite layers (14, 15),
- a second supply device (62) for continuously supplying at least one protective layer (40) to the seam area (30) such that the at least one protective layer (40) covers the at least one seam (12) and bonds to the seam area (30) by the adhesive material (50).

27. The apparatus according to claim 26, wherein at a particular throughput speed of the first and second composite layers (14, 15) the adhesive material (50) is treated with the heated air flow (68) within a length (d1) of 75 mm ± 5 mm along a transportation direction (D) of the first and second composite layers (14, 15).

28. The apparatus according to one of the claims 26 to 27, further comprising a heating device (63) for pre-heating the first and second composite layers (14, 15) in the seam area (30), said heating device (63) is arranged in the apparatus before the first supply device (61) supplies the adhesive material to the seam area (30).

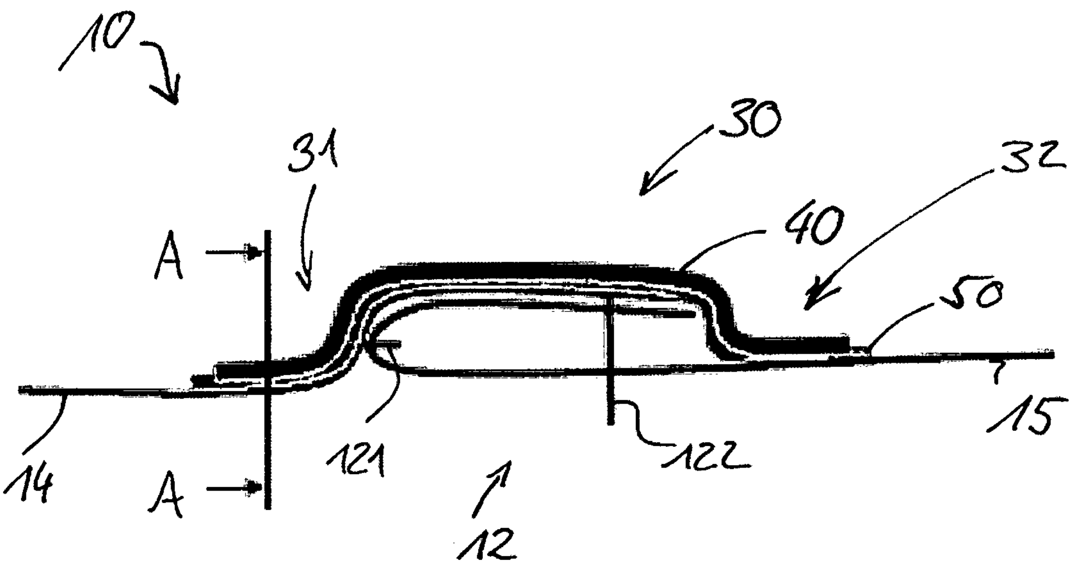
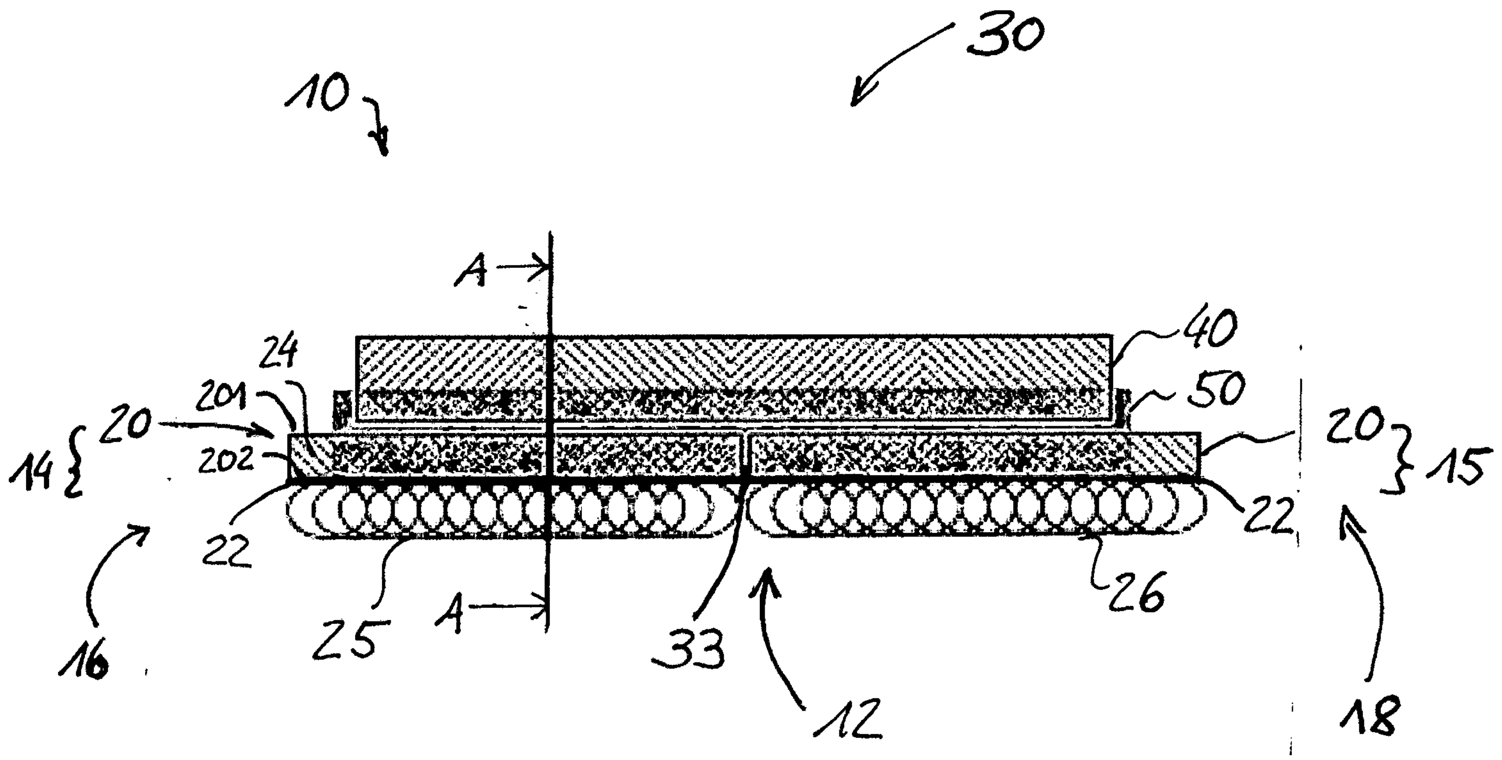


Fig. 1

Fig. 2



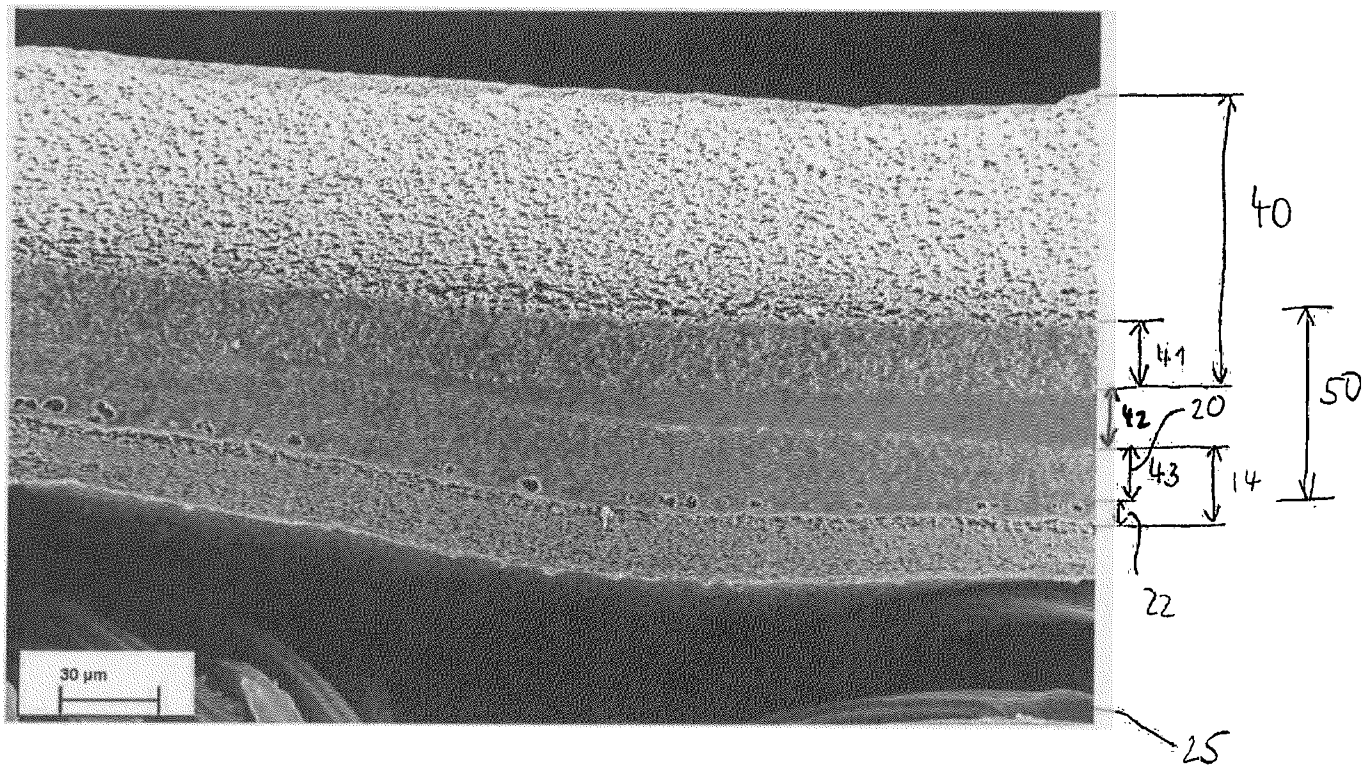


Fig. 3

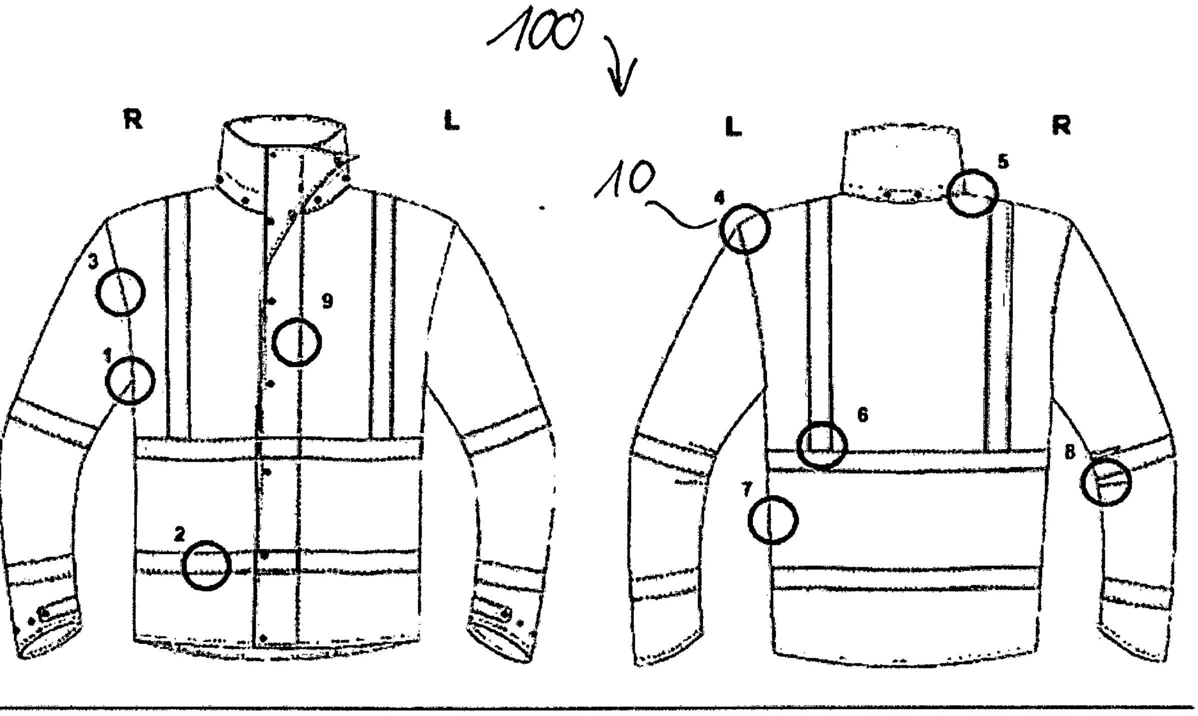


Fig. 4

Fig. 5

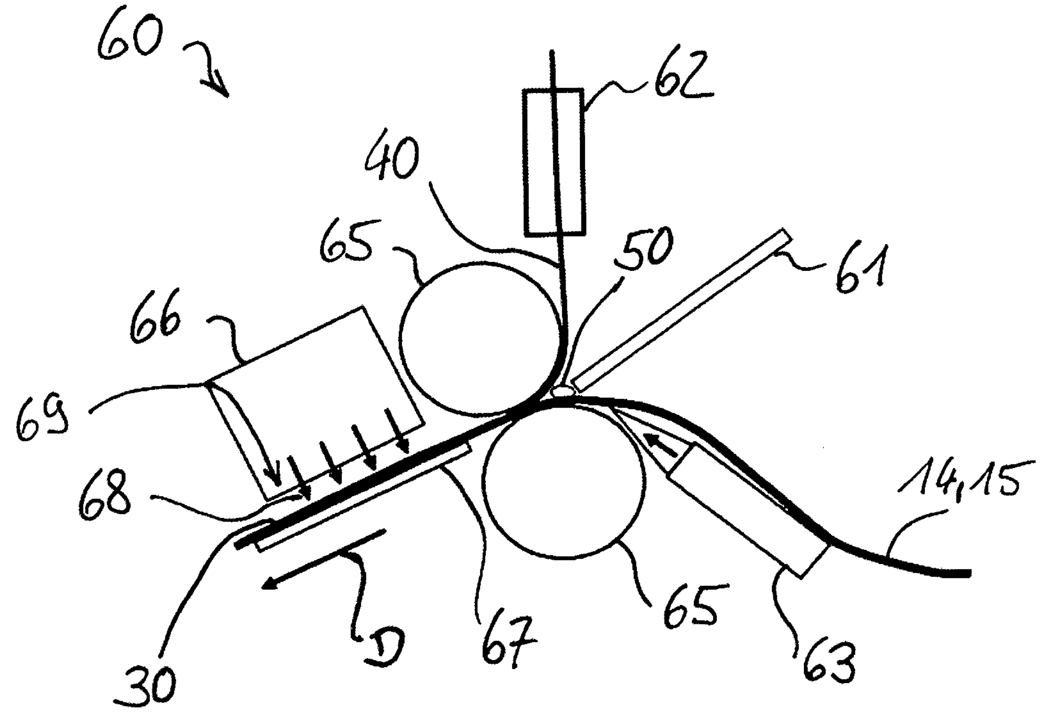


Fig. 6

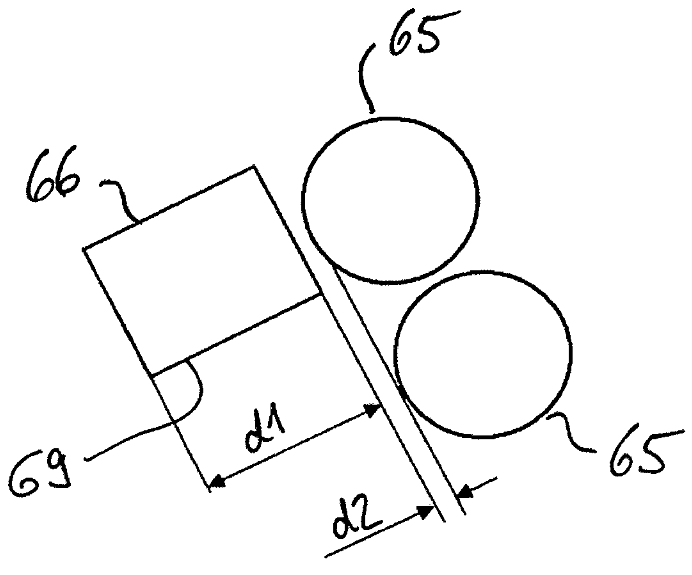
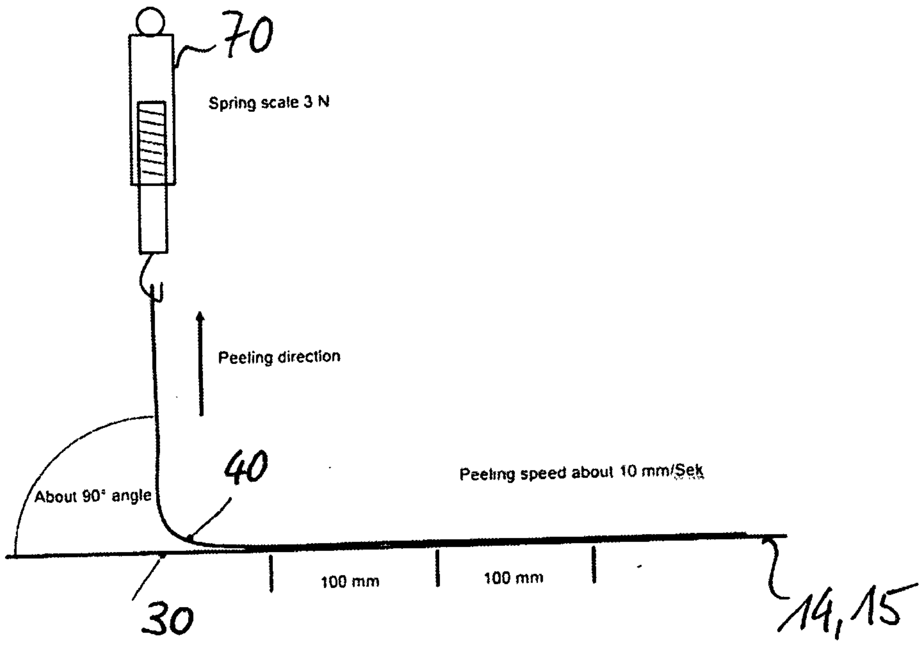


Fig. 7


70
Spring scale 3 N
Peeling direction
40
Peeling speed about 10 mm/Sek
About 90° angle
100 mm
100 mm
30
14,15

Airflow Temp	*Process Speed*	*Spring gauge measurement (N/22mm width)*	*Comments*
320 °C	1,5 m/min	1,5-2,2 N	100% cured
290 °C	1,5 m/min	1,0-1,5 N	almost' fully cured
250 °C	1,5 m/min	0,5-1,4 N	higher % of uncured adhesive than cured
200 °C	1,5 m/min	0,1-0,3 N	100% wet

Fig. 8

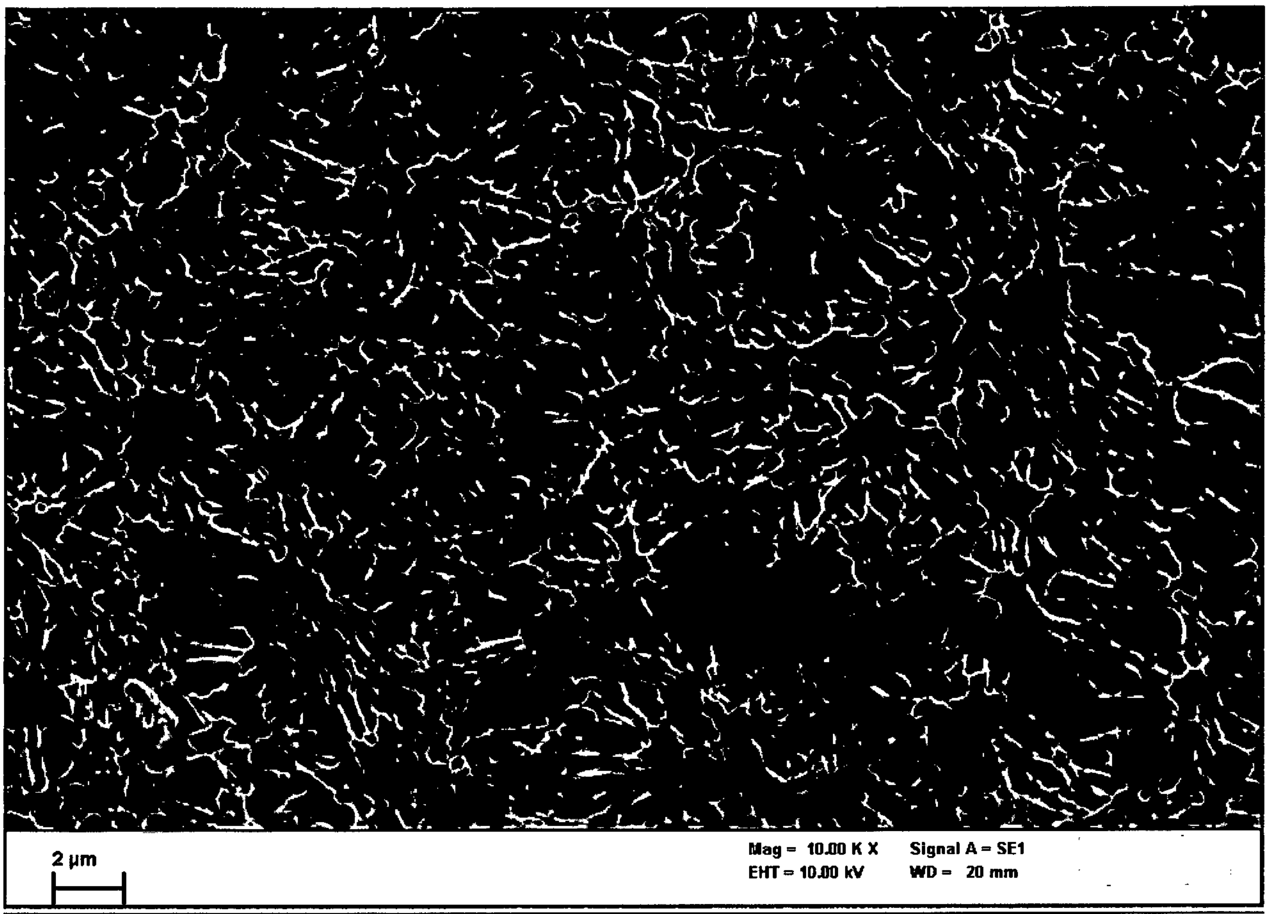


Fig. 9

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2015/000058

A. CLASSIFICATION OF SUBJECT MATTER
INV. A41D27/24 B29C65/48 A41H43/04 B29C65/52
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 B29C A41H

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.
X	US 8 402 566 B2 (STUBIGER WERNER [DE]) 26 March 2013 (2013-03-26) column 4, line 25 - column 7, line 33	1-20,25
X	WO 01/26495 A1 (GORE ENTERPRISE HOLDINGS INC [US]) 19 April 2001 (2001-04-19) cited in the application	1-3,6-15
A	page 8, line 18 - page 17, line 19; figure 1b	17,26
A	US 2012/328824 A1 (CARTABBIA GIOVANNI [IT]) 27 December 2012 (2012-12-27) paragraphs [0061] - [0077]; figures 2-4	1,17,26
A	US 2003/010439 A1 (FENTON JAY THOMAS [US]) 16 January 2003 (2003-01-16) paragraphs [0041] - [0046], [0057]; figures 1,2	17,26

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
31 August 2015	07/09/2015

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

Information on patent family members

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