



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
21.10.2009 Bulletin 2009/43

(51) Int Cl.:
B63H 9/06 (2006.01)

(21) Application number: **08154582.4**

(22) Date of filing: **15.04.2008**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MT NL NO PL PT RO SE SI SK TR
Designated Extension States:
AL BA MK RS

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(54) **Sailcloth of flexible composite laminate and method of making a sail thereof**

(57) The invention relates to sailcloth (20) comprising a flexible composite laminate (10) of at least two stacked unidirectional sheets (1,2) of parallelly arranged drawn polymeric tapes (11,12,21,22,23,24). The sheets are at least partly adhered to each other such that the sailcloth has a stable three- dimensional shape. The sailcloth may

be locally reinforced by additional unidirectional and/or woven sheets and/or tapes (611,612,...). The invention also relates to a method for producing the sailcloth, and to a sail comprising the sailcloth according to the invention. The sailcloth is extremely light weight, durable and shows excellent form consistency.

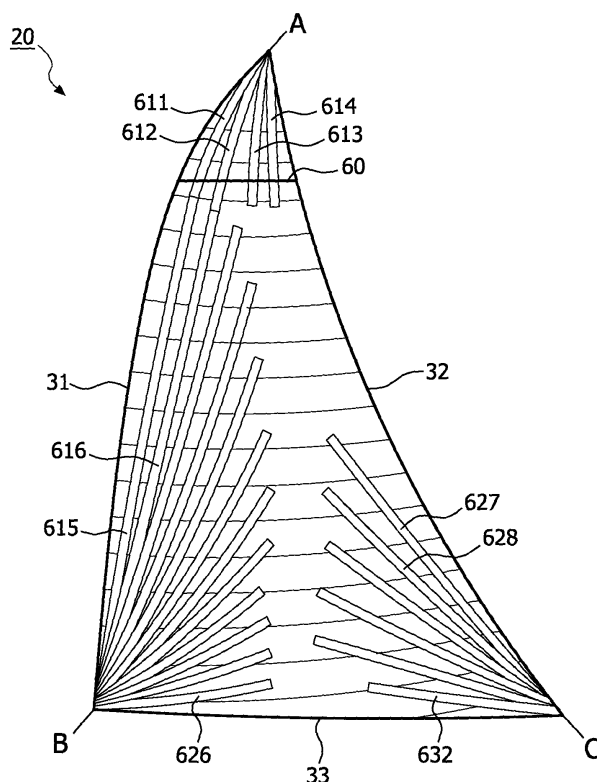


FIG. 4

Description

[0001] The present invention relates to sailcloth comprising a flexible composite laminate and to methods for making products thereof. The sailcloth is particularly useful for making a sail for sail craft or other pliant lifting structures, or for making cover sheets to protect against wind and/or rain.

[0002] Conventional sails are typically fabricated from a number of separate flat panels of woven cloth. The flat panels are first cut into the desired predetermined shape, and adjacent panels are joined together by sewing or broad seaming to provide a sail having a three-dimensional or airfoil shape. Rather than using woven cloth to make the panels, it has been proposed in US 4,708,080 for instance to use flat laminates of film and individual reinforcing threads to make the flat panels, which are later joined together in a conventional fashion. The resulting structure, however, will still have a number of seams between the adjacent panels, and these seams may contribute to excessive stretch or imperfect load transfer when the sail is placed under load.

[0003] US 5,097,784 discloses an improvement over the above-described sail by providing a sail in which the body of the sail is in the form of essentially a one piece or unitary three-dimensional laminated construction. The laminated construction comprises a plurality of pre-stretched yarns or threads disposed between two film layers. The yarns or threads extend in a continuous and uninterrupted fashion over the surface of the sail from edge to edge to provide the unitary construction. The disclosed sail minimizes the need for seams and the attendant problem of stretch between the seams. A disadvantage of the disclosed sail however is that it needs additional film layers to make the laminate impervious to wind. This adds to the weight of the sail. Moreover, the known sail is difficult to make, and provides limited design flexibility. Because the yarns are continuous, there is a fixed relationship between yarn trajectories and the yarn densities achieved. This makes it difficult to optimize yarn densities within the sail. Indeed, a compromise must be sought between the yarn density in a particular area of the sail, and yarn alignment across the complete length of a trajectory. Also, it has turned out that the known sail is relatively prone to fracture or wear.

[0004] One object of the present invention is to provide a sailcloth of a flexible composite laminate, particularly useful for making a sail or cover sheet, with which the above-mentioned disadvantages may at least partly be overcome.

[0005] The sailcloth according to the invention is therefore characterized in that it comprises a flexible composite laminate of at least two stacked unidirectional sheets of parallelly arranged drawn polymeric tapes, the sheets being at least partly adhered to each other such that the sailcloth has a stable three-dimensional shape. The sailcloth according to the invention is inherently substantially impervious to wind, and therefore does not need addi-

tional film layers. The unidirectional sheets of the flexible laminate provide for the stiffness and strength needed for good sailing performance, and are optimally arranged in discontinuous and/or continuous trajectories from one edge of the sail to another edge thereof, to substantially carry the load imposed on the sail. The use of unidirectional sheets of parallelly arranged drawn polymeric tapes instead of yarns or chords provides a more even stress distribution across the sail, which leads to strength and wear levels that are unexpectedly high, given the fact that the strength of tapes is generally lower than the strength of yarns or chords.

[0006] Another advantage of the three-dimensionally shaped sailcloth according to the invention is that it can be manufactured in its final dimensions, which typically are above 1 m², more preferably above 2 m², and most preferably above 5 m².

[0007] In an alternative embodiment a three-dimensionally shaped sailcloth is provided comprising a flexible composite laminate of at least two stacked woven sheets of drawn polymeric tapes, the sheets being at least partly adhered to each other such that the sailcloth has a stable three-dimensional shape. Such an embodiment has essentially the same advantages as described above.

[0008] Crimp or geometrical stretch in the known sail is usually considered to be due to a serpentine path taken by a yarn in the sailcloth. In a weave, for instance, the fill and warp yarns are going up and down around each other. This prevents them from being straight and thus from initially fully resisting stretching. When woven sailcloth is loaded, the yarns tend to straighten before they can begin resist stretching based on their tensile strength and resistance to elongation. Crimp therefore delays and reduces the stretch resistance of the yarns at the time of the loading of the sailcloth. The sail according to the present invention does not have this disadvantage.

[0009] In a preferred embodiment of the sailcloth according to the invention, the tapes of two subsequent sheets extend at an angle between 15 and 90 degrees to each other. In another preferred embodiment of the sailcloth according to the invention, the sailcloth is characterized in that the tapes of two subsequent sheets extend squarely to each other. Such an arrangement (also referred to as a 'cross-ply') improves the shear strength of the sailcloth.

[0010] In a further preferred embodiment of the sailcloth according to the invention, the sailcloth is characterized in that the tapes of two subsequent sheets extend in the same direction and are arranged in an orderly fashion, whereby tapes overlap either below or above, or both, over the total length with regard to a first sheet, or over part of the trajectory. This embodiment yields a substantially unidirectional assembly of two adjacent sheets. Such a sheet is useful when one wants to optimize the specific properties of the sail. With specific properties are meant properties divided by weight.

[0011] Although not necessary to the invention, the sailcloth may be characterized in that it additionally com-

prises at least one polymeric film sheet in a stacked arrangement with the flexible composite laminate. The additional polymeric film sheet may be impervious to wind or other environmental action. Polymeric sheets are needed in the state of the art, such as disclosed in US 5,097,784, to hold the yarns. However, crimp in sailcloth made of laid-up yam can easily occur, for instance by lateral shrinkage of the polymeric films during conventional lamination processes. This is because the heated film shrinks laterally as it undergoes thermoforming, which considerably deforms the yarns and is catastrophic with regard to the stretch performance of the composite fabric in highly loaded applications. Since the sailcloth according to the invention does not need polymeric film sheets to hold the tapes, its shape is well controlled due to the absence of crimp, which generally occurs when using yarns. If any crimp occurs at all, this crimp is homogeneous. Even when using polymeric films in addition to unidirectional sheets of parallelly arranged tapes, possible film shrinkage is readily accommodated by the tapes, being adhesively bonded to the polymeric film sheets.

[0012] Preferably, the sailcloth according to the invention is characterized in that the flexible composite laminate is locally reinforced by additional unidirectional and/or woven sheets and/or tapes. This adds to the efficiency of reinforcement and therefore further reduces weight.

[0013] The sheets of the laminate may be laminated, bonded and/or consolidated using any adhesive means known in the art, and using any method for applying the adhesive means. A particularly preferred sailcloth is characterized in that the tapes of the unidirectional or woven sheets are coated with adhesive means for bonding the sheets together. Although the adhesive means may be any adhesive means known in the art, particularly preferred adhesive means comprise polyolefin (co)polymers, of which EVA or olefin block co-polymer is particularly preferred.

[0014] The sheets may comprise any polymer known in the art. Particularly preferred is a sailcloth of a flexible composite laminate, wherein the polymer of at least one sheet is selected from the group consisting of polyolefin's, polyesters, poly-acetals (POM), polyvinyl alcohols, polyacrylonitriles, and polyamides, especially poly(p-) phenylene terephthalamide. Most preferred is a sailcloth of a flexible composite laminate, wherein the polyolefin comprises high density or ultra high molecular weight polyethylene. The use of such a polymer provides strength at extremely low weight. Other preferred polymers are polyacetals.

[0015] The invention also relates to a method for producing a three-dimensional sailcloth using a convex or concave mold surface, said method comprising placing a plurality of drawn polymeric tapes of polymeric material on the mold surface in a parallel arrangement to form a first sheet, with the sheet defining the borders of the sailcloth and the three dimensional surface thereof, applying

at least a second plurality of drawn polymeric tapes of polymeric material over said first sheet on the mold surface in a parallel arrangement to form a second sheet, and consolidating said sheets together on said mold at elevated temperature and/or pressure.

[0016] The method of the invention provides an easy manufacturing process for a sailcloth using standard lamination procedures, known in the art. Moreover, a sail is provided with improved design flexibility. Indeed the unidirectional sheets of parallelly arranged polymeric tapes may be positioned in the sail according to the stress intensity distribution, whereby tape density and tape alignment are optimized with the engineering flexibility to adjust the tape intensity over the total or partial length of the trajectories from one edge of the sail to another edge. Alternatively, tapes as such can be arranged for optimization with engineering flexibility.

[0017] In an alternative embodiment a method for producing a three-dimensional sailcloth using a convex or concave mold surface is provided, said method comprising placing a woven fabric of drawn polymeric tapes of polymeric material on the mold surface to form a first sheet, with the sheet defining the borders of the sailcloth and the three dimensional surface thereof, applying at least a second unidirectional sheet of parallelly arranged drawn polymeric tapes over said first sheet on the mold surface to form a second sheet, and consolidating said sheets together on said mold at elevated temperature and/or pressure. In another preferred embodiment the second sheet comprises a woven fabric of drawn polymeric tapes of polymeric material.

[0018] To facilitate production of the sail, the method according to the invention is further characterized in that the tapes of the sheets are coated with an adhesive prior to application to said first sheet. Preferred adhesives include polyolefin (co)polymers, of which EVA and olefin block co-polymers are particularly preferred.

[0019] The sailcloth of the present invention comprises a three dimensional, molded flexible laminate, which already has the aerodynamical form, required. The laminate has at least two distinct layers of load bearing unidirectional tapes. The unidirectional tapes are disposed in discontinuous and/or continuous trajectories from one edge of the sailcloth to the other, or partially or locally, and substantially carry the entire load imposed on the sailcloth. The tapes and or sheets of unidirectional tape are placed according to the stress intensity distribution, optimizing tape density and tape alignment with the engineering flexibility to adjust the tape intensity over the total or partial length of the trajectories from one edge of the sail to the other. Under changing wind conditions (speed and/or angle) or sail trim, further unidirectional sheets are preferably added to engineer for different set of stress intensities by further tape density and tape alignment. Where the unidirectional sheets make crossover points with other sheets, this will add to the shear strength of the sail.

[0020] The sailcloth according to the present preferred

embodiment is molded onto a mold and after lamination consolidated into a unitary laminated structure. In this way, in addition to build a sailcloth which will resist deterioration from weather and mechanical abuses, a lightweight, flexible, three-dimensional air foil is created that will maintain its desired aerodynamic shape through a chosen wind range. A key factor in achieving such a favorable sail is stretch control of the airfoil. Stretch is to be avoided since it distorts the sail shape as the wind increases, making the sail deeper and thus creating undesired drag as well as excessive heeling of the boat. Moreover, sail stretch wastes precious wind energy that should be transferred to the sail craft through its rigging. The sailcloth of the present invention, which makes use of sheets of unidirectional tapes shows a low level of stretch, especially for an embodiment in which the unidirectional sheets run from edge to edge of the sail.

[0021] A unitary laminated construction moreover has the advantage that it does not contain a number of joined together sections or panels, the different panels shrinking at different rates and thereby affecting the smoothness of the sail along the joining seams of the different sections, especially over time.

[0022] Further features of the invention will emerge from the following schematic figures, without otherwise being restricted thereto.

Figure 1 shows a first embodiment of a three-dimensionally formed sailcloth according to the invention; Figure 1A shows a side-view of the sailcloth of figure 1 along the leech 23;

Figure 1B shows an exploded view of a flexible composite laminate of the sailcloth according to figure 1; Figure 2 shows an exploded view of another embodiment of a flexible composite laminate of the sailcloth according to the invention;

Figure 3 shows an exploded view of still another embodiment of a flexible composite laminate of the sailcloth according to the invention;

Figure 4 shows another embodiment of a three-dimensionally formed sailcloth according to the invention;

Figure 4A shows a cross-section along the line 60 of the sailcloth shown in figure 4;

Figure 5 shows another embodiment of a three-dimensionally formed sailcloth according to the invention;

Figure 5A shows a side-view of the sailcloth of figure 5 along the leech 42;

Figure 5B shows an exploded view of a flexible composite laminate of the sailcloth according to figure 5; Figure 6 shows another embodiment of a three-dimensionally formed sailcloth according to the invention;

Figure 6A shows a cross-section along the line 80 of the sailcloth shown in figure 6; and finally

Figure 7 shows still another embodiment of a three-dimensionally formed sailcloth according to the in-

vention.

[0023] Typical three-dimensional sailcloth 20 for sail craft made in accordance with the present invention is shown in figure 1 and another embodiments thereof in figures 4, 5, 6 and 7. Three-dimensionally formed sailcloth 20 is made from a flexible composite laminate 10 as will further be described below, which defines a luff 21, extending between the head A and tack B, a foot 22 between the tack B and clew C, and a leech 23 between the head A and clew C. Sailcloth 20 has a triangular shape when viewed in plan but also has a molded airfoil shape or draft, which will be explained further down. Sailcloth 20 of the present invention is applicable to the manufacture of any type of sail, including main sails, headsails, foresails and the like, comprising as well as related plant lifting structures.

[0024] Referring to figure 1B, a flexible composite laminate 10 is provided that comprises a number of unidirectional sheets (1, 2) of drawn polymeric tapes. Preferred polymers are selected from the group consisting of polyolefin's, polyesters, polyacetals, polyvinyl alcohols, polyacrylonitriles, and polyamides, especially poly (p-) phenylene terephthalamide. Most preferred are tapes of ultra high molecular weight polyethylene and/or high density polyethylene.

[0025] A shown in figure 1B sheet 1 comprises any number of parallelly arranged drawn polymeric tapes (11, 12, 13, ...), the tapes all being aligned in the X-direction. In sheet 1, the tapes are arranged such that they partly overlap. Sheet 2 comprises any number of parallelly arranged drawn polymeric tapes (21, 22, 23, ...), the tapes all being aligned in the Y-direction. In sheet 2, the tapes are likewise arranged such that they partly overlap. The X- and Y- direction are mutually perpendicular. Figure 1B represents an exploded view of the sheets 1 and 2. According to the invention however the sheets 1 and 2 are at least partly adhered (consolidated) to each other by adhesive means, preferably an EVA or olefin block-copolymer. Preferably, the adhesive means is applied onto tapes (11, 12,...) and/or (21, 22, ...) during their production. A cross-section of the consolidated flexible composite laminate 10 according to this embodiment is shown in figure 1A, which also represents a side-view of the sailcloth of figure 1 along the leech 23.

[0026] Figure 2 shows an exploded view of another embodiment of a flexible composite laminate 10 according to the invention. In this embodiment composite laminate 10 comprises a number of unidirectional sheets (5, 6) of drawn polymeric tapes. Sheet 6 comprises any number of parallelly arranged drawn polymeric tapes (61, 62, 63, ...), the tapes all being aligned in the Y-direction. In sheet 6, the tapes are arranged in a staggered fashion. Staggering provides consistency to sheet 6. Sheet 5 comprises any number of parallelly arranged drawn polymeric tapes (51, 52, 53, ...), the tapes all being aligned at an angle to the X-direction. In sheet 5, the tapes are positioned adjacent to each other thereby forming a mon-

olayer. Figure 3 represents an exploded view of the sheets 3 and 4. According to the invention however the sheets 3 and 4 are at least partly adhered (consolidated) to each other by adhesive means, whereby the adhesive means are preferably applied onto tapes (31, 32,...) and/or (41, 42, ...) during their production.

[0027] Figure 3 shows an exploded view of another embodiment of a flexible composite laminate 10 according to the invention. In this embodiment composite laminate 10 comprises a number of unidirectional sheets (3, 4) of drawn polymeric tapes. Sheet 4 comprises any number of parallelly arranged drawn polymeric tapes (41, 42, 43, ...), the tapes all being aligned in the Y-direction. In sheet 4, the tapes are positioned adjacent to each other thereby forming a monolayer. Consistency to the composite laminate 10 is provided by sheet 3, which comprises any number of parallelly arranged drawn polymeric tapes (31, 32, 33, ...), whereby the tapes are all aligned at an angle to the X-direction. In sheet 3, the tapes are likewise positioned adjacent to each other thereby forming a monolayer. The embodiment shown in figure 3 and consisting of only two sheets (3, 4) provides an extremely low weight sailcloth, especially when using tapes of ultra high molecular weight polyethylene and/or high density polyethylene.

[0028] The term "tape" as used herein shall denote a continuous band of polymer with a thickness: width ratio of 1:3 or more, preferably of 1:100 or more, or even better of 1: 5000 or more over its' full length, and is selected from materials having good tensile strength and stretch resistance. Various polymers may be available and include ones composed of polyesters, polyacetals, polyethylenes (incl. HDPE and UHMWPE) and its copolymers, polypropylene and its copolymers, para-aramid, carbon fiber, polyamide, and the like, as well as blends, mixtures thereof or composites. In general the preferred range of the width of the tapes is in the order of from 3 mm up to 300 mm, more preferably between 1 mm and 100 mm, and most preferably between 1.5 mm and 10 mm. The accepted thickness of the tapes is generally between 1 micron and 1 mm, more preferably between 10 micron and 500 micron, and most preferably between 20 micron and 100 micron. The desired tensile strength of the tapes lies between 100 MPa and 6000 MPa, more preferably between 500 MPa and 5000 MPa. The tapes can be mono layers or multilayers of different or similar polymers (e.g. A B A structured, A B structured, A B C structured, etc) where the outer layers could act as adhesives. The desired elongation at break of the polymer tapes should lie between 0,3 % and 30 %, more preferably between 1,0 % and 15 %.

[0029] Particularly preferred are tapes having a modulus of elasticity below 100 GPa, even more preferably ranging between 15 and 90 GPa, and even more preferably between 50 and 60 GPa. The thickness of the unidirectional or woven sheets in the flexible composite laminates may be varied within a large range. Preferably, the thickness of the sheets ranges between 10 and 300

micron, more preferably between 20 and 150 micron, still more preferably between 25 and 100 micron. The unidirectional or woven sheets comprise tapes. Other desirable properties include high strength, lightweight, heat resistance, ultraviolet light resistance and non-porosity. In case the sailcloth is used for headsails and mainsails, the elongation at break or 'elasticity' of the tapes is preferably lower than 15%, more preferably lower than 10%, most preferably lower than 5%. For spinakers, an 'elasticity' range of between 10 to 20% would be more appropriate. If additional polymeric films are used, the thickness of the film employed will range in the order from about 2 micron to 2 mm, more preferably between 5 micron and 500 micron.

[0030] Suitable film materials may include, but are not limited to polyacetal, polyethylene and its copolymers, polypropylene and its copolymers, VLLDPE plastomers, polyamides, polyesters, polyacetals and polyurethane. The tapes are preferably provided with an adhesive. Very suitable tapes are the polymeric tapes of core-cladding type, as disclosed in WO 2006/107197, hereby incorporated by reference in its entirety. The amount of adhesive on the tapes can amount from 0,5% by weight up to 99 % of weight, more preferably between 5% and 60% by weight, most preferably between 20% and 40% by weight, as non-load bearing material. The thickness or weight of the sheets and the dimensions of the tapes are selected among variety available and depend on the size, type and usage of sail and wind range of sail being constructed.

[0031] Another embodiment of the three-dimensionally formed sailcloth 20 according to the invention is shown in figure 4. In this embodiment, sailcloth 20 is made from a flexible composite laminate 10 as has been described above in the context of figures 1A, 1B, 2 and 3. Again a luff 31, extending between the head A and tack B, a foot 33 between the tack B and clew C, and a leech 32 between the head A and clew C are defined. As in the embodiment of figure 1, sailcloth 20 has a triangular shape when viewed in plan but also has a molded airfoil shape or draft, which is form stable due to the fact that the sheets are mutually consolidated, i.e. adhesively bonded to each other. In the embodiment of figure 3, sailcloth 20 is provided with additional tapes (611, 612, ...) which extend from the corners (A, B, C) along lines of high stress. Tapes (611, 612, ...) act as local reinforcements to sailcloth 20 and extend over part of the sails surface only. The regions of high stress in the sail are caused by a variety of factors such as wind force and sail tensioning forces imposed, for example, by the halyard and trimming sheet attached to the clew, and also by the angle of the sail to the wind. As a result of aforementioned different lines or regions of stress, it is also possible and preferred to vary tape alignment and tape density in the sheets to accommodate the more highly loaded areas or to provide desired physical characteristics and performance. The flexible composite laminate according to this embodiment comprises a number of sheets that differs depend-

ing on the stress intensity in the sail. This is illustrated in figure 4A, which shows a cross-section along the line 60. A flexible composite laminate 10 is shown having a total of 4 layers, to which additional layers (611, ..., 614) have been added locally. The laminate comprises a first sheet 1 and a second sheet 2, sheet 1 being built from tapes (11, 12, ...) as shown in figure 1A, and second sheet 2 being built from tapes (21, 22, ...) as also shown in figure 1A.

[0032] Another preferred embodiment of the three-dimensional sailcloth 20 for sail craft made in accordance with the present invention is shown in figure 5. Three-dimensionally formed sailcloth 20 has a luff 41, extending between the head A and tack B, a foot 43 between the tack B and clew C, and a leech 42 between the head A and clew C. Referring to figure 5A, sailcloth 20 comprises a flexible composite laminate 10 in the form of a consolidated woven fabric of a number of drawn polymeric tapes (71, 72, 73, ...), running in the weft direction, and a number of tapes 90 (or alternatively a polymeric film) running in the warp direction (the weft and warp direction being interchangeable). Figure 5B shows an exploded view of this embodiment.

[0033] Still another embodiment of the three-dimensionally formed sailcloth 20 according to the invention is shown in figure 6. In this embodiment, sailcloth 20 is made from a flexible composite laminate 10 as has been described above in the context of figures 5A and 5B. Sailcloth 20 is provided with additional tapes (101, 102, ...) which extend from the corners (A, B, C) along lines of high stress. Tapes (101, 102, ...) act as local reinforcements to sailcloth 20, as already described above, and extend over part of the sails surface only. A flexible composite laminate 10 is shown having a total of 3 layers, to which additional layers (101, ..., 104) have been added locally. The laminate 10 comprises a first sheet having a number of drawn polymeric tapes (71, 73, ...), running in the weft direction, a second sheet having a number of tapes 90 (or alternatively a polymeric film) running in the warp direction and a third sheet having a number of drawn polymeric tapes (72, ... 78, running in the weft direction.

[0034] Still another embodiment of the three-dimensionally formed sailcloth 20 according to the invention is shown in figure 7. In this embodiment, sailcloth 20 is made from a flexible composite laminate 10 as has been described above in the context of figures 1A, 1B, 2 and 3. Again a luff 31, extending between the head A and tack B, a foot 33 between the tack B and clew C, and a leech 32 between the head A and clew C are defined. As in the embodiment of figure 1, sailcloth 20 has a triangular shape when viewed in plan but also has a molded airfoil shape or draft, which is form stable due to the fact that the sheets are mutually consolidated, i.e. adhesively bonded to each other.

[0035] In the embodiment of figure 7, sailcloth 20 is provided with additional tapes (711, 712, ...), which extend continuously from a corner (in the embodiment shown, corners A and C) along lines of high stress across

the sail to the opposite edge thereof. Tapes (711, 712, ...) run from corner A to the opposite side 33 of the sail, while tapes (727, 728, ...) run from corner C to the opposite side 31 of the sail 20. The tapes (711, 712, ..., 727, 728, ...) run essentially in a straight line across the curved surface of the sailcloth.

[0036] One preferred embodiment of the method of manufacturing a one piece, three-dimensional sail 20 will now be described. According to the invention a convex or concave mold surface is provided first. The mold surface corresponds to the desired three-dimensional surface of the sail. and consolidating said sheets together on said mold at elevated temperature and/or pressure.

[0037] A first sheet of a plurality of drawn polymeric tapes of polymeric material is positioned on the mold surface, preferably in a parallel arrangement with the sheet defining the borders of the sail and the three-dimensional surface thereof. The tapes are preferably positioned such that a 'closed' surface is obtained, which is already substantially impervious to wind. If desired it is possible to position polymeric sheets in the form of layers of film on the mold surface, but this is not necessary. After the first sheet surface has been established, a second plurality of drawn polymeric tapes of polymeric material is positioned over said first sheet on the mold surface in a parallel arrangement to form a second sheet, preferably from one border to the other. Additional third sheets may then be applied in the desired pattern, i.e. covering the whole surface or covering only part of the surface. Positioning of the tapes to form the sheets may be performed manually, or mechanically, such as by a tape laying robot, known in the art. The tapes to form the sheets are preferably applied under uniform tension to minimize distortions in the final laminate. The adhesive means to join the sheets together can be applied separately on each surface, after it has been positioned on the mold surface. Preferably however, the adhesive is applied onto the sheets and/or unidirectional drawn polymer tapes as a surface coating, preferably on both sides of the third sheets and/or unidirectional drawn polymer tapes. Lamination is completed by curing or melting and consolidating the adhesive using heat or light and/or pressure, depending on the adhesive and materials employed. The preferred adhesive depends on the used tape-polymers, but is preferably selected from EAA (Ethylene Acrylic Acid), EMA (Ethylene Methacrylic Acid), EVA (Ethylene Vinyl Acetate), Polyurethanes, Acrylics, and/or combinations thereof, as long as they adhere well to the tapes and film sheets and remain flexible and durable. A particularly preferred adhesive is the olefin block copolymer, as disclosed in WO 2005/090425A1, hereby incorporated by reference in its entirety. Finally, all the sheets are consolidating together on said mold at elevated temperature and/or pressure, preferably by applying heated rollers. A preferred method for applying pressure comprises placing a non-adherent cover sheet over the formed flexible composite laminate assembly, and create a partial vacuum between the cover sheet and the assembly to

apply uniform pressure. If heat is required to cure the adhesive, this may be provided with heat lamps, heated blankets, or heated rolls. After the adhesive has cured or set, the molded sailcloth 20 may be removed from the mold and any finishing operations completed, such as installation of a bolt rope, adding grommets, defining the luff line and the like, in order to obtain a sail there from. In addition, reinforcing elements may be added to the corners if desired.

[0038] The sailcloth according to the invention is extremely light weight, durable and shows excellent form consistency. It should be understood that within the scope of the invention, various changes can be incorporated, which extend beyond the examples given above.

Claims

1. Sailcloth comprising a flexible composite laminate of at least two stacked unidirectional sheets of parallelly arranged drawn polymeric tapes, the sheets being at least partly adhered to each other such that the sailcloth has a stable three-dimensional shape.
2. Sailcloth comprising a flexible composite laminate of at least two stacked sheets of drawn polymeric tapes, the first sheet being a woven sheet of drawn polymeric tapes, and the second sheet being a unidirectional sheet of parallelly arranged drawn polymeric tapes, whereby the sheets are at least partly adhered to each other such that the sailcloth has a stable three-dimensional shape.
3. Sailcloth according to claim 1 or 2, **characterized in that** the tapes of two subsequent sheets extend at an angle between 15 and 90 degrees to each other.
4. Sailcloth according to claim 1, **characterized in that** the tapes of two subsequent sheets extend squarely to each other.
5. Sailcloth according to claim 1, **characterized in that** the tapes of two subsequent sheets extend in the same direction and are arranged in an orderly fashion, whereby tapes overlap either below or above, or both, over the total length with regard to a first sheet, or over part of the trajectory.
6. Sailcloth according to any one of the preceding claims, **characterized in that** it additionally comprises at least one polymeric film sheet in a stacked arrangement with the flexible composite laminate.
7. Sailcloth according to claim 6, **characterized in that** the additional polymeric film sheet is impervious.
8. Sailcloth according to any one of the preceding

claims, wherein the tapes of the unidirectional or woven sheets are coated with adhesive means for bonding the sheets together.

9. Sailcloth according to claim 8, wherein the adhesive means comprise an olefin block co-polymer.
10. Sailcloth according to any one of the preceding claims, wherein the polymer of at least one sheet is selected from the group consisting of polyolefin's, polyesters, polyacetals, polyvinyl alcohols, polyacrylonitriles, and polyamides, especially poly(p-)phenylene terephthalamide.
11. Sailcloth according to claim 10, wherein the polyolefin comprises ultra high molecular weight polyethylene and/or high density polyethylene.
12. Sailcloth according to any one of the preceding claims, wherein the flexible composite laminate is locally reinforced by additional unidirectional and/or woven sheets and/or tapes.
13. A method for producing a three-dimensional sailcloth using a convex or concave mold surface, said method comprising placing a plurality of drawn polymeric tapes of polymeric material on the mold surface in a parallel arrangement to form a first sheet, with the sheet defining the borders of the sailcloth and the three dimensional surface thereof, applying at least a second plurality of drawn polymeric tapes of polymeric material over said first sheet on the mold surface in a parallel arrangement to form a second sheet, and consolidating said sheets together on said mold at elevated temperature and/or pressure.
14. A method for producing a three-dimensional sailcloth using a convex or concave mold surface, said method comprising placing a woven fabric of drawn polymeric tapes of polymeric material on the mold surface to form a first sheet, with the sheet defining the borders of the sailcloth and the three dimensional surface thereof, applying at least a second (either woven or parallelly arranged tapes (UD / cross ply)) fabric of drawn polymeric tapes of polymeric material over said first sheet on the mold surface to form a second sheet, and consolidating said sheets together on said mold at elevated temperature and/or pressure.
15. Method according to claim 13 or 14, wherein the tapes of the sheets are coated with an adhesive prior to consolidating.
16. Sail of a sail craft, comprising the sailcloth according to any one of claims 1-15.

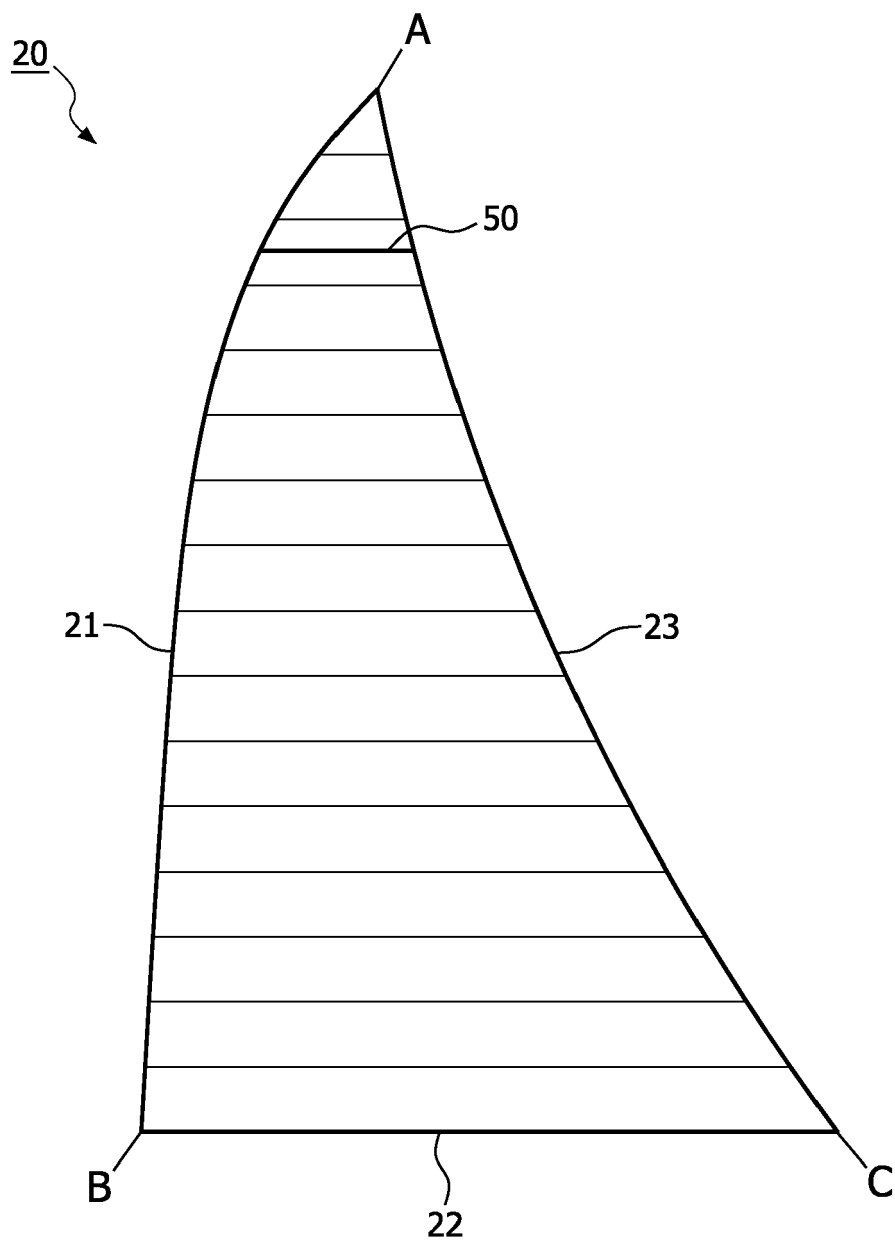


FIG. 1

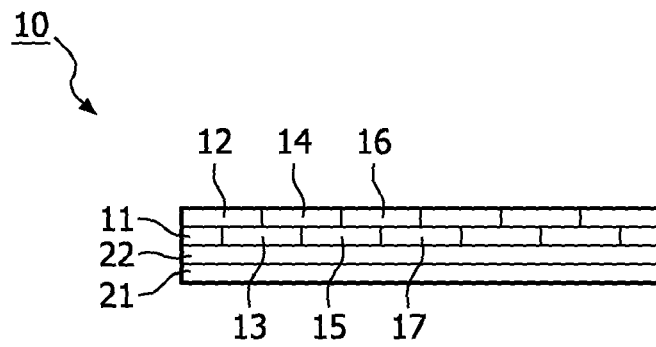


FIG. 1A

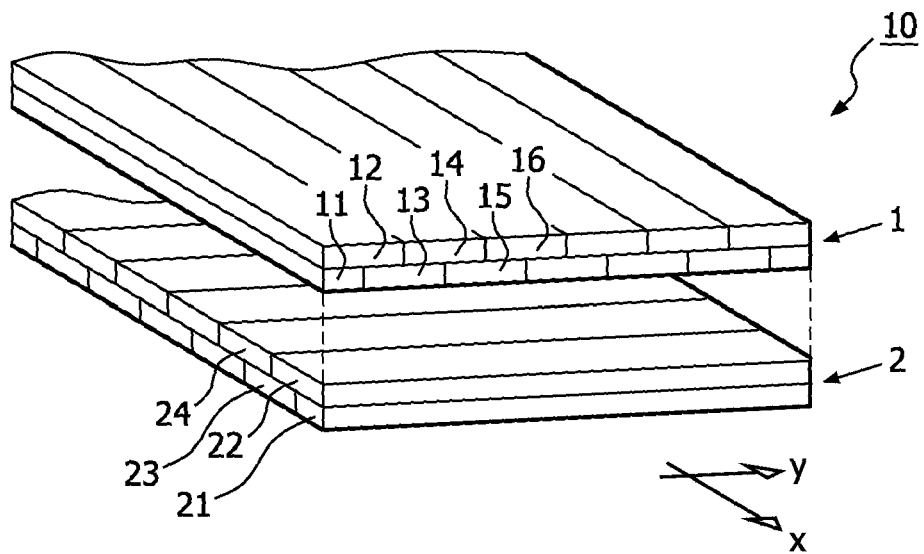
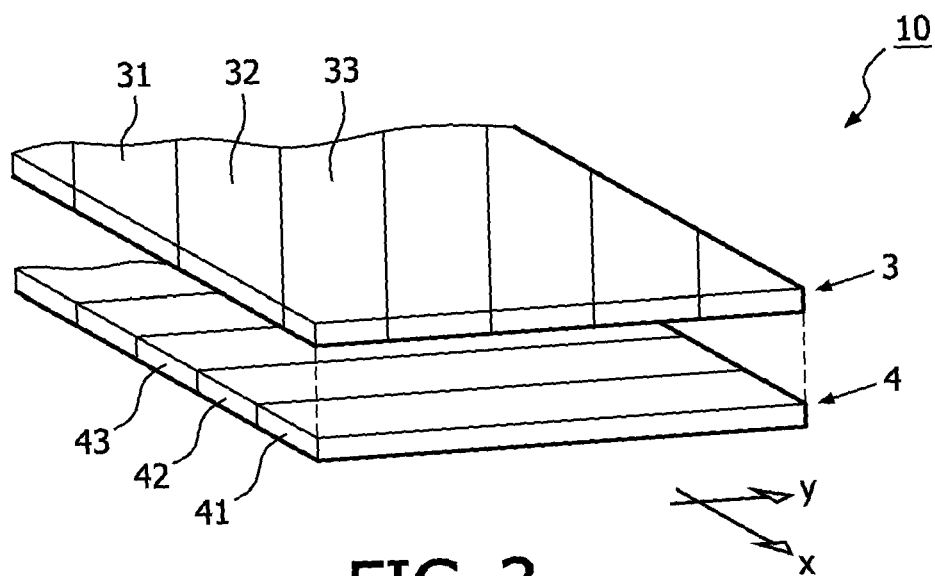
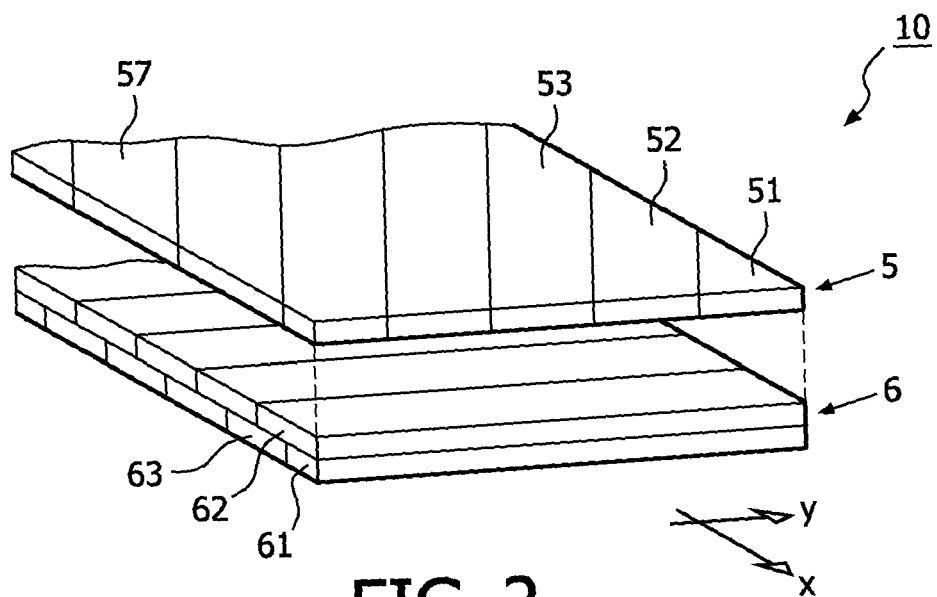


FIG. 1B



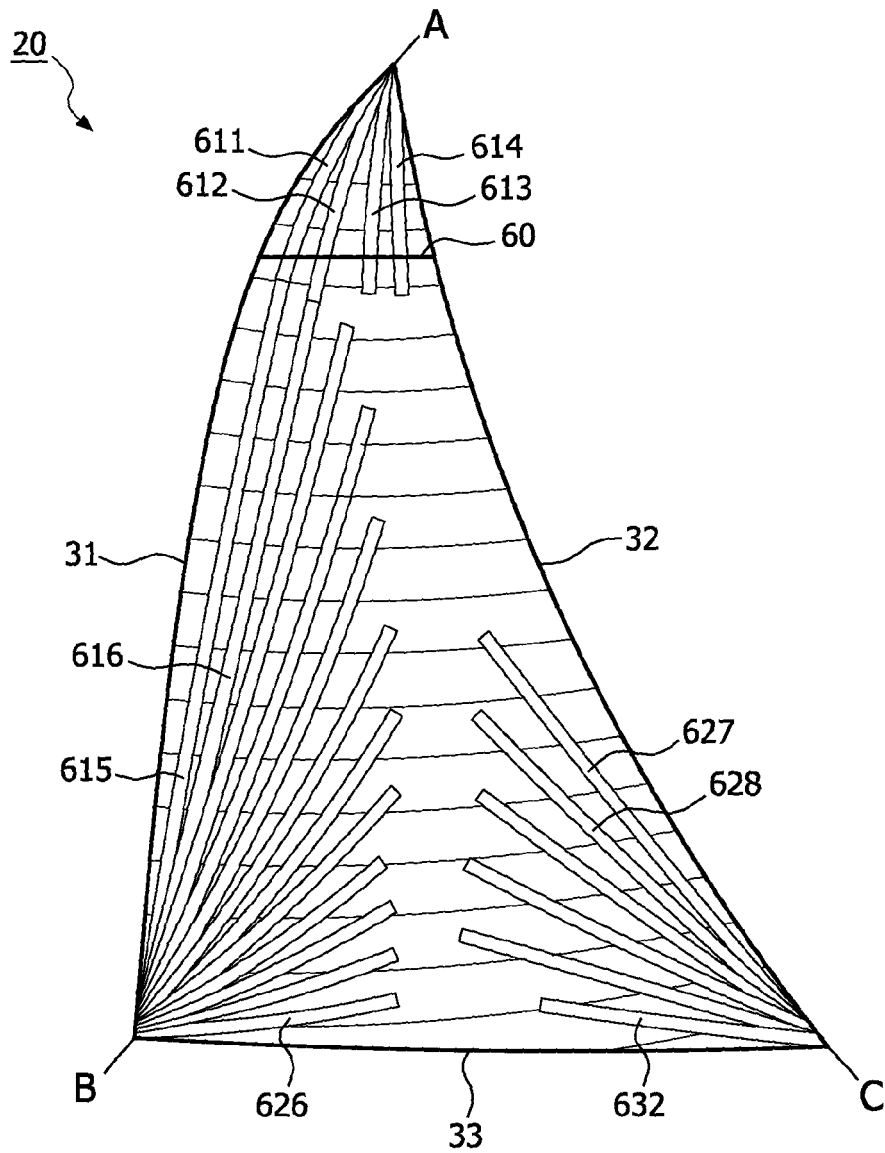


FIG. 4

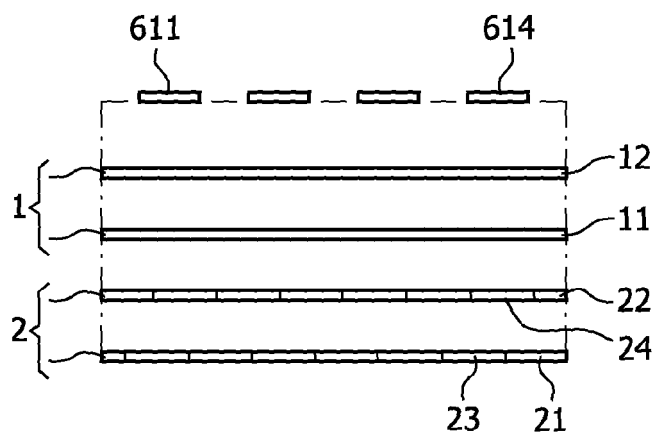


FIG. 4A

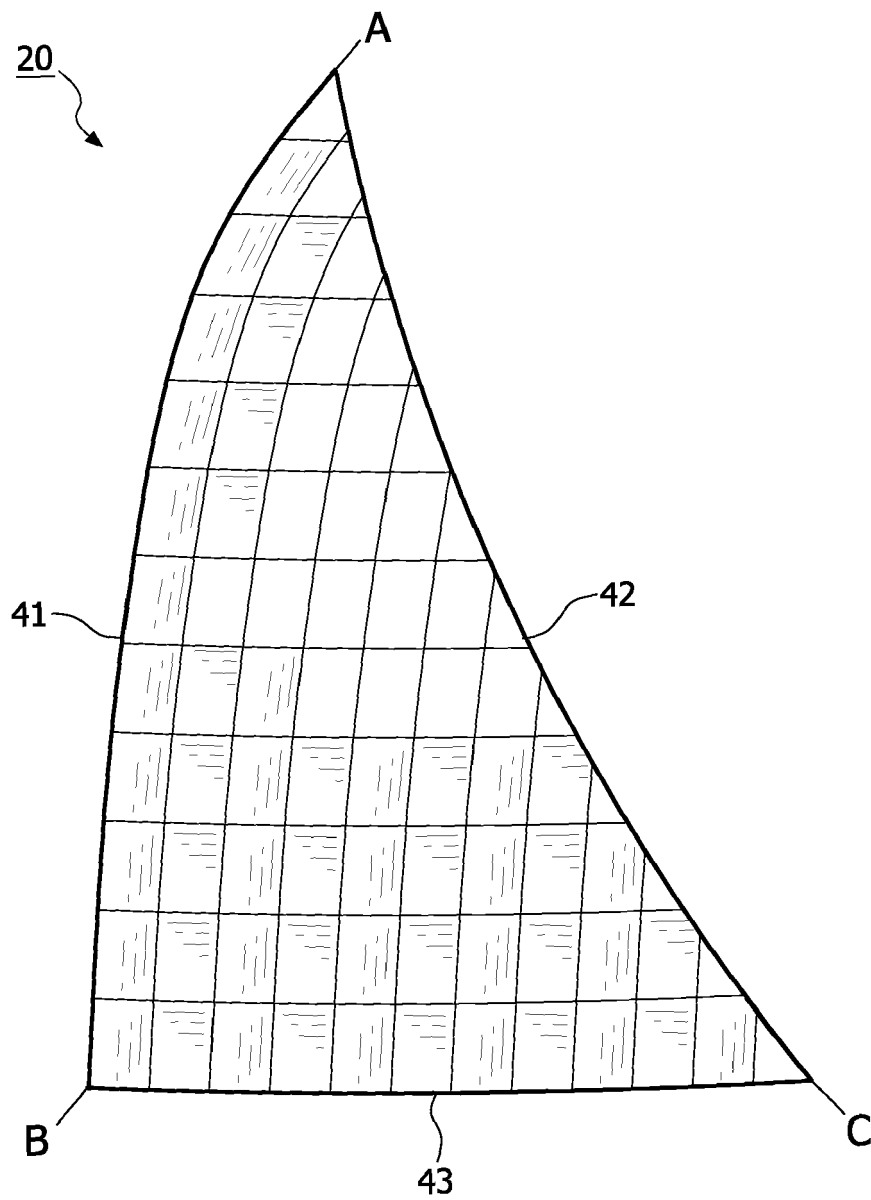


FIG. 5

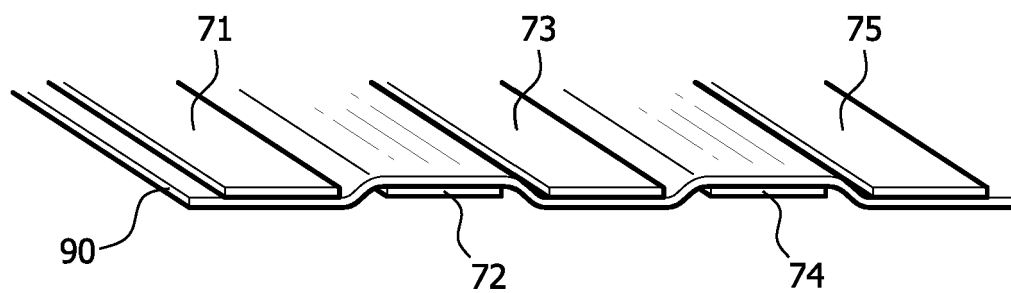


FIG. 5A

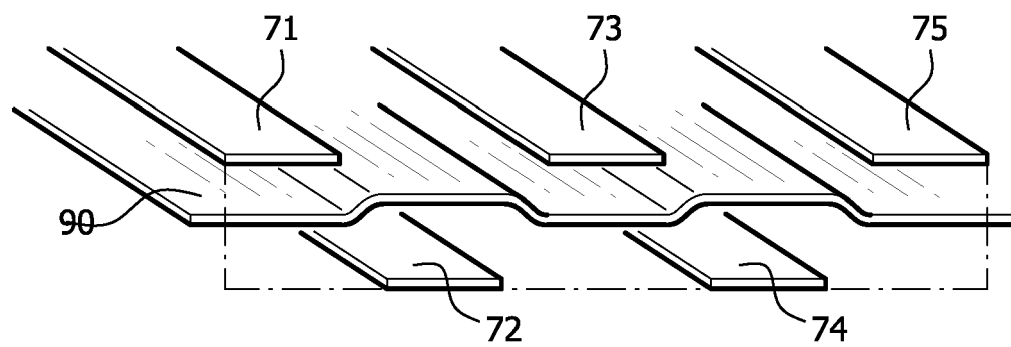


FIG. 5B

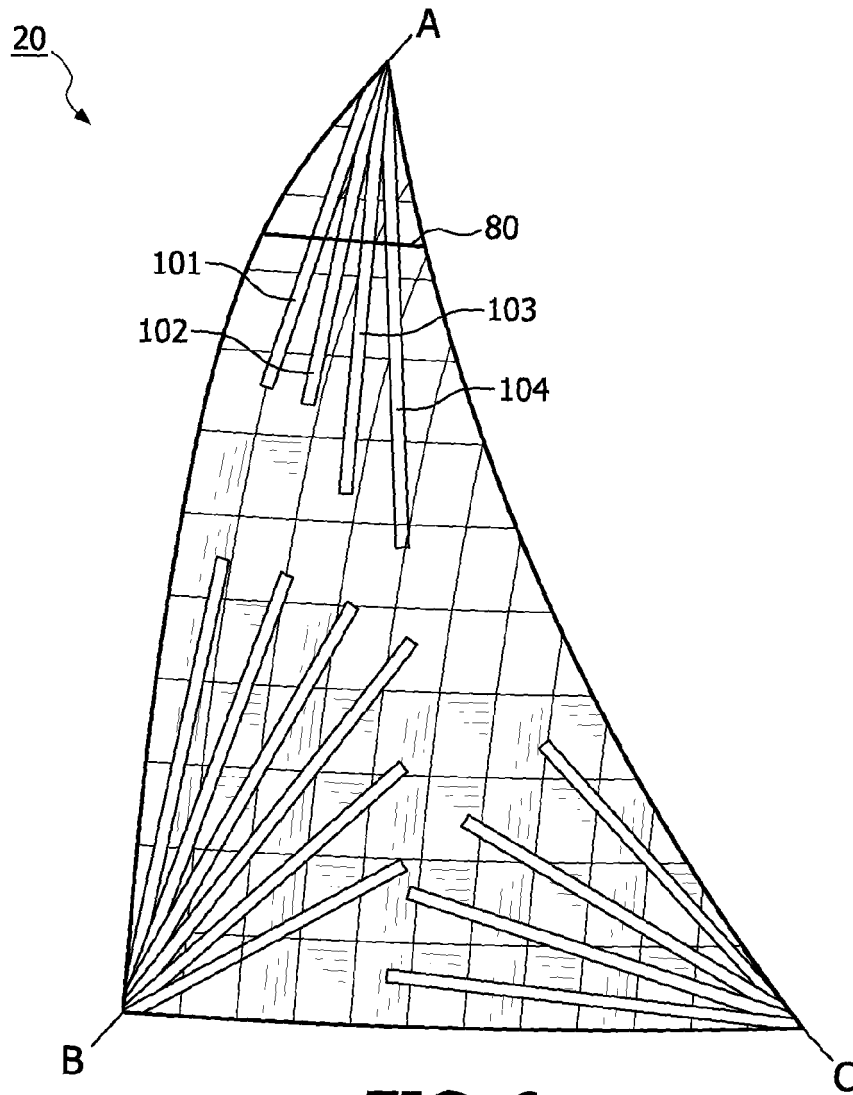


FIG. 6

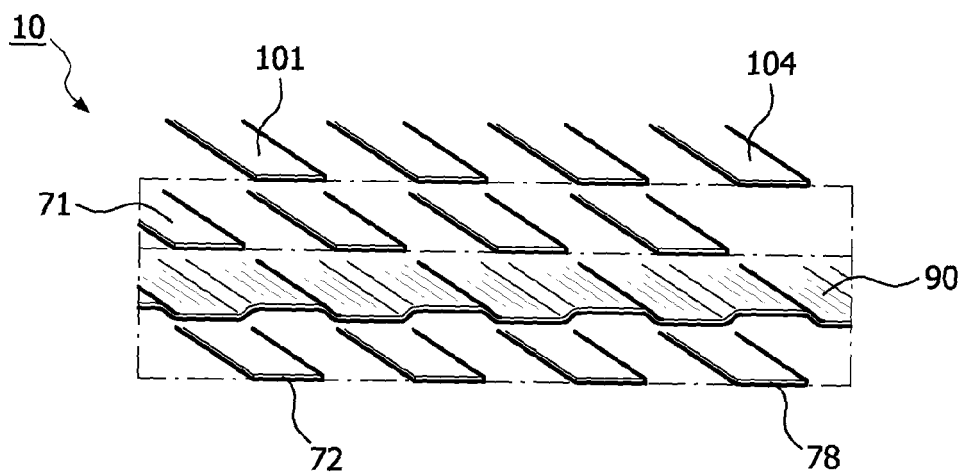


FIG. 6A

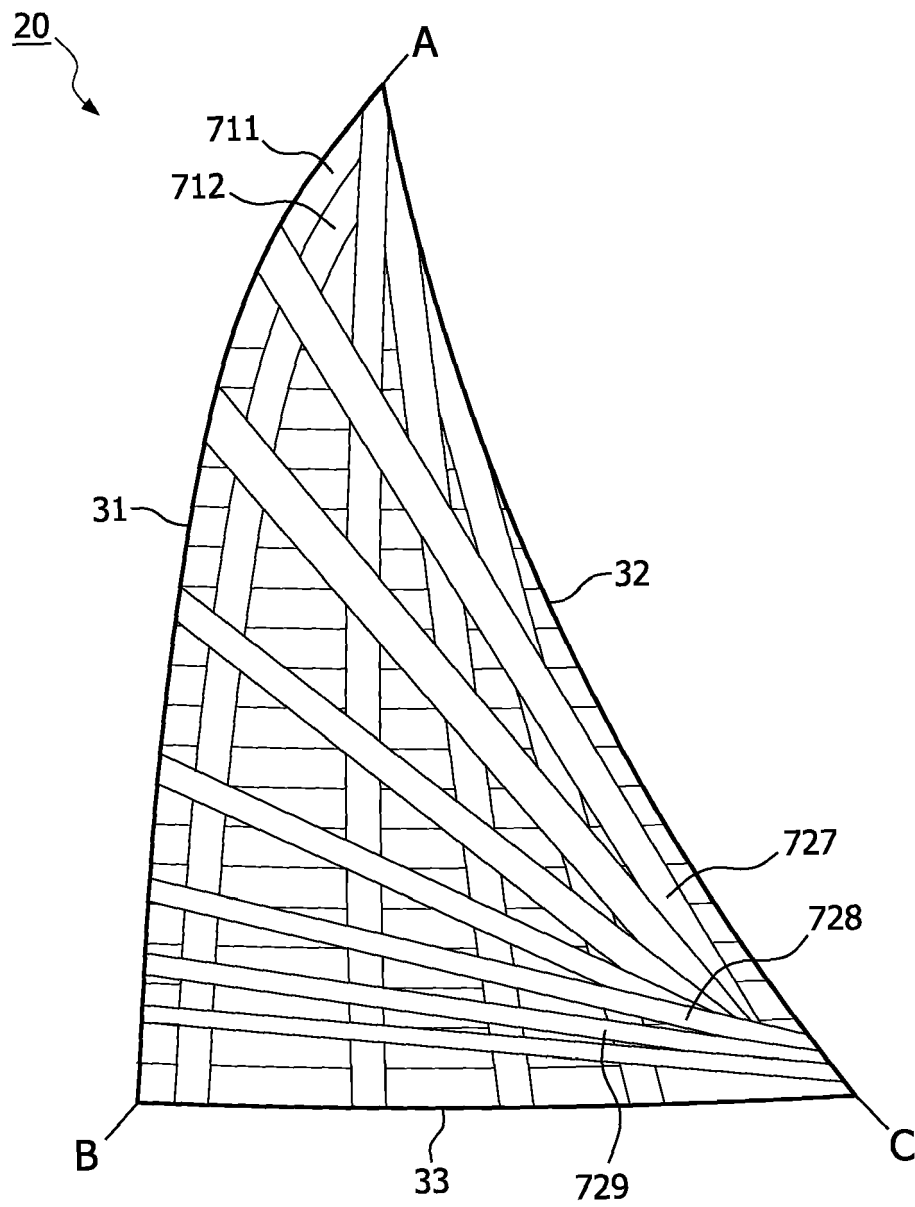


FIG. 7



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Application Number
EP 08 15 4582

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