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DESCRIPTION

Description

BACKGROUND

1. Field of the disclosure

[0001] The disclosure relates to a three-dimensional woven preform having the form of a support beam. In particular, the disclosure includes intersecting support beams having continuous warp reinforcement along both lengths of the beams and a method of making thereof.

2. Related Art

[0002] The use of reinforced composite materials to produce structural components is now widespread, particularly in applications where their desirable characteristics are sought of being light in weight, strong, tough, thermally resistant, self-supporting, and adaptable to being formed and shaped. Such components are used, for example, in aeronautical, aerospace, satellite, recreational (as in racing boats and autos), and other applications.

[0003] Typically such structural components may be used in reinforcement components. The structural components can include reinforced composites having reinforcement preforms in the shape of I-Beams, H-Beams, or C-Beams, for example, made from reinforcement materials embedded in matrix materials. The support beam may be made from materials such as glass, carbon, ceramic, aramid, polyethylene, and/or other materials, which exhibit desired physical, thermal, chemical, and/or other properties, chief among which is great strength against stress failure. Through the use of such materials, which ultimately become a constituent element of the completed reinforcement component, the desired characteristics of the materials, such as very high strength, are imparted to the completed reinforcement component. The constituent reinforcement preforms typically may be woven, knitted, nonwoven or otherwise oriented into desired configurations and shapes. Usually particular attention is paid to ensure the optimum utilization of the properties for which the constituent reinforcing materials have been selected. Usually such reinforcement preforms are combined with matrix material to form desired finished reinforcement structural components or to produce working stock for the ultimate production of finished reinforcement components.

[0004] After the desired reinforcement preform has been constructed, matrix material may be introduced to and into the preform, so that typically the reinforcement preform becomes encased in the matrix material and matrix material fills the interstitial areas between the constituent elements of the reinforcement preform. The matrix material may be any of a wide variety of materials, such as epoxy, polyester, vinyl-ester, ceramic, carbon and/or other materials, which also exhibit desired physical, thermal, chemical, and/or other properties. The materials chosen for use as the matrix may or may not be the same as that of the reinforcement preform and may or may not have comparable physical, chemical, thermal, or other properties. Typically, however, they will not be of the same materials or have comparable physical, chemical, thermal, or other properties, since a usual objective sought in using composites in the first place is to achieve a combination of characteristics in the finished product that is not attainable through the use of one constituent material alone. So combined, the reinforcement preform and the matrix material may then be cured and stabilized in the same operation by thermosetting or other known methods, and then subjected to other operations toward producing the desired component. After being cured, the then solidified mass of the matrix material normally is very strongly adhered to the reinforcing material (e.g., the reinforcement preform). As a result, stress on the finished component, particularly via its matrix material acting as an adhesive between fibers or other constituent material, may be effectively transferred to and borne by the constituent material of the reinforcing preform.

[0005] A typical combination of preform reinforcement support beams is made by the preforms at an angle (typically a right-angle) with respect to each other. Usual purposes for such angular arrangements of joined reinforcement preforms are to create a desired shape to form a reinforcement preform to strengthen the resulting composite structure that it produces against deflection or failure upon being exposed to exterior forces, such as pressure or tension. In any case, a related consideration is to make each juncture between the reinforcement support beams as strong as possible. Given the often desired very high strength of the reinforcement preform constituents, weakness of the juncture becomes, effectively, a "weak link" in a structural "chain".

[0006] The support beams are attached at the juncture where they intersect. Most attachment schemes center on those acceptable for metals, e.g., using fasteners such as rivets, bolts, clips and the like. In particular, support beams in the shape of C-Beams intersecting one another have little area for attachment where they intersect. The standard construction method for beams in general includes one continuous primary beam to which the ends of secondary beams are attached. An improvement on this design incorporates continuous fiber across the intersection in the web of both the primary and secondary beams. However, in the case of C-Beam preforms, there are cuts in the flanges in at least one direction at the intersecting portion. The cut flanges could form a small lap shear joint with the continuous flange (See Figure 1), but there is a limited overlapping area available in the intersecting portion requiring reinforcement with brackets, fasteners, and/or an additional separate piece that acts as a sill across the joint.

[0007] Examples of known woven preform and method of forming thereof are disclosed in

US4922968 A, JPS6278235 A, US2013/099062 A1, US6283168 B1.

SUMMARY

[0008] The aforementioned aims are solved by a woven preform and a method of forming a woven preform and a composite structure as claimed in the appended set of claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The accompanying drawings, which are included to provide a further understanding of the invention, are incorporated in and constitute a part of this specification. The drawings presented herein illustrate different embodiments of the invention and together with the description serve to explain the principles of the invention. In the drawings:

Figure 1 illustrates a paper model of an as-formed cruciform with flanges.

Figure 2 illustrates a series of images illustrating movement of a line of intersection of weft fibers during forming a cruciform using a paper model.

Figure 3 illustrates a top view of a preform that allows warp sliding.

Figure 4 illustrates a top view of an as-formed flange intersection.

Figure 5 illustrates a cross-sectional view of an as-woven preform having one crossover portion.

Figure 6 illustrates a top view of a preform according to the present disclosure as-woven.

Figure 7 illustrates a bottom view of the preform of FIG. 6.

Figure 8 illustrates the preform of FIG. 7 formed into a cruciform.

Figure 9 illustrates a top view of a top edge folded into a flange on the cruciform of FIG. 8.

Figure 10 illustrates a bottom view of a bottom edge folded into a flange on the cruciform of FIG. 8.

Figure 11 illustrates a composite of a C-Beam cruciform according to the present disclosure.

Figure 12 illustrates a cutaway view of three different warp columns within the intersection.

Figure 13 illustrates an I-Beam cruciform woven and formed according to the present disclosure.

Figure 14 illustrates a cross-sectional view of an as-woven preform having a single crossover portion.

Figure 15 illustrates a cross-sectional view of an as-woven preform having four crossover portions.

Figure 16 illustrates a cross-sectional view of an as-woven preform having nine crossover portions.

Figure 17 illustrates a C-Beam cruciform formed from an as-woven preform having four crossover portions.

DETAILED DESCRIPTION

[0010] The terms "threads", "fibers", "tows", and "yarns" are used interchangeably in the following description. "Threads", "fibers", "tows", and "yarns" as used herein includes monofilaments, multifilament yarns, twisted yarns, multifilament tows, textured yarns, braided tows, coated yarns, bicomponent yarns, as well as yarns made from stretch broken fibers of any materials known to those ordinarily skilled in the art. Yarns can be made of carbon, nylon, rayon, fiberglass, cotton, ceramic, aramid, polyester, metal, polyethylene glass, and/or other materials that exhibit desired physical, thermal, chemical, or other properties.

[0011] As used herein, "fabric" means warp fibers interwoven with weft fibers and a fabric can be either a single layer fabric or a multilayer fabric. The term "multilayer fabric" is used herein for convenience and includes single layer fabrics as well.

[0012] The term "folded" is broadly used herein to mean "forming", which includes unfolding, bending, and other such terms for manipulating the shape of a woven fabric. The terms "C-flange" and "C-Beam" are used interchangeably to refer to a structure having a C-shaped cross-section. Similarly, the terms "H-Beam", "I-Beam", "T-Beam", "L-Beam", and " π -Beam" (Pi-Beam) are used to refer to structures having an H-, I-, T-, L-, or π -shaped (Pi-shaped) cross-section, respectively. However, this listing of cross-sectional shapes is not to be considered exhaustive. That is, all cross-sectional shapes are contemplated. The term "support beam" is used to include a beam having any cross-sectional shape.

[0013] In the following description, it is understood that such terms as "front", "back", "left", "right", "transverse", "longitudinal", "above", "below", "over", "under" and the like are words of relational convenience and are not to be construed as limiting terms.

[0014] For a better understanding of the invention, its advantages, and objects attained by its uses, reference is made to the accompanying descriptive matter in which non-limiting embodiments of the invention are illustrated in the accompanying drawings and in which corresponding components are identified by the same reference numerals.

[0015] The disclosure is directed to structural components with reinforcing preforms in the shape of a support beam. In one embodiment, disclosed is a three-dimensional (3D) woven cruciform preform having arms with a C-shaped cross-section (C-Beams) and fiber continuity across the length of the arms or fiber continuity over at least the crossover portion where the C-Beam arms of the cruciform intersect. Accordingly, the disclosure provides for a woven C-Beam support preform that avoids the need to cut the fibers in the C-beam arms or to use fasteners in order to attach the arms where they intersect.

[0016] FIG. 1 illustrates a model of a desired final shape of a 3D preform cruciform 100 having C-Beams 104, 106. As discussed below, the C-Beams are woven to have continuous warps along the intersecting flanges 102 of the C-Beams. This arrangement provides a cruciform with C-Beams or arms having continuous fiber in both directions X, Y of the cruciform. Where the X-direction is the direction of the warp fibers in a first arm and the Y-direction is the direction of the warp fibers in a second arm. That is, the flanges 102 of the C-beams have continuous warp tows across the length of the cruciform and, in particular, across crossover portion 108, which is the location where the C-Beams of the cruciform intersect.

[0017] The flanges of the C-Beam can provide an increase to the bending stiffness of the resultant cruciform reinforcing preform over C-Beam cruciform without fiber continuity across the crossover portion. The present disclosure provides for simultaneously achieving fabric continuity of fibers in both the X and Y direction of the cruciform. The simultaneous continuity is prevented in prior-art C-Beam cruciforms because the desired as-formed crossover location is different than the as-woven crossover location. That is, the weft fibers of the flanges prohibit the necessary sliding of the warp fibers in the crossover location to enable forming of the C-Beam flanges. FIG. 2C illustrates the change in position of this crossover location.

[0018] FIG. 2 illustrates forming a C-Beam cruciform structure (from a top view) by rotating the arms (not visible) using a paper model for illustration. The added flanges (204, 206, and as in Figure 2) that form a C-Beam cruciform structure increases the stiffness over an un-flanged cruciform (that is, without flanges 102) when a force or load is applied along the line formed by the intersecting arms 204, 206. However, cutting the warp fibers in the flanges to facilitate intersection of the cruciform arms results in a discontinuity of fibers in one of the flange directions. The discontinuity of the warp fibers creates a weak spot that can degrade the performance of a structure to the limit of what a subsequently applied resin bond can transfer across the crossover portion.

[0019] Maintaining continuous fiber throughout the flanges in both directions of a C-Beam cruciform can increase the tensile and compressive stiffness along the length of each arm of the resultant preform. The present invention enables warp fiber continuity simultaneously along each of the flanges of the arms of a C-Beam cruciform.

[0020] In an embodiment, at least some of the warp fibers float - that is, are not interwoven with weft fibers - in the crossover portion of the flanges throughout the range of motion of the arms. That is, the warp fibers in a flange of a first arm of the cruciform are free to slide against

the warp fibers of a second arm of the cruciform in the crossover portion. This feature can enable the flat woven arms of a C-Beam to be rotated about the crossover portion into the as-formed geometry of the arms.

[0021] Figure 3 illustrates one arm 300 of a C-Beam as woven. The C-Beam is flat woven. Edges 302, 304 of the flat-woven C-Beam will later be formed into flanges of the C-Beam. Warp fibers in edge portions 306, 308 of edges 302, 304 are not interwoven with weft fibers. As such, warp fibers in portions 306, 308 float. The floating of the warp fibers in edges 306, 308 can enable the warp fibers in the arm 300 to slide over warp fibers in another intersecting arm to fold the edges of the arm into the C-Beam cross-sectional shape. The dimension of edge portions 302, 304 in which the warp fibers are floating across the width of the arm 300 can determine the length of the C-Beam flange when folded, which is typically in the range of 2,54 mm to 50,8 mm (0.1 inch to 2 inches), but greater and lesser lengths of flanges are contemplated. The dimension of edge portions 306, 308 along the length of arm 300 may be any width and length, but typically the width will match the width of edge portions 302, 304 and the length will accommodate the width of a crossing arm (not illustrated in FIG. 3).. However, the dimensional ranges of edge portions 306, 308 range is not a limiting factor in the disclosed structure.

[0022] Figure 4 illustrates a top view of the intersection of flanges after a flanged C-Beam cruciform has been formed. In Figure 4, the cross hatching on the horizontal arm represents a flange of a first arm 406 of the C-Beam cruciform that is visible from the top and the cross hatching on the vertical arm represents a flange of a second arm 404 of the C-Beam cruciform. Flanges 404, 406 may be formed perpendicular to one another or at any desired angle for the final cruciform structure.

[0023] The horizontal lines along the length of first arm 406 represent warp tows 408 of first arm 406. The lines perpendicular to the warp tows 408 represent the weft tows 412 of first arm 406. Similarly, the vertical lines 410 along the length of the second arm 404 represent warp tows 410 of second arm 404. And the lines perpendicular to the warp tows 410 represent the weft tows 414 of second arm 404.

[0024] The location where the first arm 406 and second arm 404 cross is the intersection - crossover portion 402 - of the cruciform. In Figure 4 the weft tows 412, 414 are not present in the flanges of the first and second arms in crossover portion 402 of the formed preform.

[0025] Figure 5 illustrates a cross-sectional view in the warp direction of as-woven fabric preform 500 as the fabric comes off a loom. The preform illustrated includes two multilayer fabrics 502, 504 that will form a cruciform structure having one crossover portion 518. Multilayer fabric 502 is woven under multilayer fabric 504 before the crossover portion. Multilayer fabric 502 is woven over multilayer fabric 504 after the crossover portion.

[0026] For identification in later figures, multilayer fabric 502 has surface 514A on one side of the fabric and 514B on the opposite side of the fabric before the crossover portion. Multilayer

fabric 502 has surface 512A on one side of the fabric and 512B on the opposite side of the fabric after the crossover portion. Similarly, multilayer fabric 504 has surface 510A on one side of the fabric and 510B on the opposite side of the fabric before the crossover portion. Multilayer fabric 504 has surface 516A on one side of the fabric and 516B on the opposite side of the fabric after the crossover portion.

[0027] The warp fibers of the first and second multilayer fabrics float in the crossover portion where they will be folded into flanges and the warp fibers in the first and second multilayer fabrics are continuous across the crossover portion. The first multilayer fabric can later be used to form a first arm of the C-Beam cruciform. Likewise, the second multilayer fabric can later be used to form a second arm of a C-Beam cruciform. The first and second multilayer fabrics are rotated about the crossover portion so that the fabrics are at a desired angle to one another. In a particular embodiment, the angle between the first and second multilayer fabrics is 90 degrees. However, other angles such as 45 degrees, etc. are contemplated. The edges of the first multilayer fabric are folded to form flanges so the first multilayer fabric has a C-shaped cross-section. Similarly, the edges of the second multilayer fabric are folded to form flanges so the second multilayer fabric has a C-shaped cross-section.

[0028] The preform is a two-dimensional (flat-woven) structure having a first multilayer fabric woven over a second multilayer fabric for a desired length of the preform. The first multilayer fabric intersects with the second multilayer fabric at a crossover portion of the preform so that after the crossover portion the first multilayer fabric is woven underneath the second multilayer fabric. That is, the first and second multilayer fabrics are interwoven with one another at the crossover portion and are elsewhere not interwoven with one another in the preform in a cruciform structure having one crossover portion according to the present disclosure.

[0029] Figures 6 through 11 show views in the forming of woven preform 500 having one crossover portion using the identification of surfaces in Figure 5. Figure 6 is a top view of the flat-woven fabric preform prior to forming into a C-Beam structure with one crossover portion 518. Warp fibers in portions 506, 508 on edges 620, 622 of the fabric are not interwoven with weft fibers. As such, warp fibers in portions 506, 508 float. Surfaces 510A, 512A identified in Figure 5 are seen in the top view of the woven fabric preform on respective sides of a midpoint 614.

[0030] Figure 7 is a bottom view of the fabric preform 500 of Figure 6 where areas 506, 508 interwoven in the top view are not interwoven in the bottom view. Surfaces 514A, 516A identified in Figure 5 are seen in the bottom view of the woven fabric preform on respective sides of midpoint 614.

[0031] Figure 8 shows forming the flat-woven fabric illustrated in Figure 5 into a C-Beam cruciform by rotating fabrics 502, 504 with respect to one another. For purposes of explanation, fabric surfaces 512A, 512B and 514A, 514B of multilayer fabric 502 are rotated in the direction of the arrows J and K shown in Figure 5.

[0032] Figure 9 is a top view showing the forming of the C-Beam cruciform of Figure 8 into a C-Beam cruciform. Edges 620, 622 are folded to form flanges 902, 904, respectively, resulting in the C-Beam cross-sectional shape. Warp fibers in crossover portion 518 are floating, which enables edges 620, 622 to be folded. The warp fibers in portion 506, for example, in the crossover portion 518 are not interwoven with weft fibers. As such, the warp fibers in multilayer fabric 502 in the crossover portion can slide over the floating warp fibers of multilayer fabric 504 in the crossover portion without being obstructed by weft fibers. Remaining edges are similarly folded to form C-Beam cross-sectional shapes on the other arms of the cruciform structure.

[0033] Figure 10 shows a bottom view of the C-Beam cruciform formed in Figure 9. Similar to Figure 9 described above, warp fibers in crossover portion 518 are floating, which enables edges 620, 622 to be folded. The warp fibers in portion 508, for example, in the crossover portion 518 are not interwoven with weft fibers. As such, the warp fibers in multilayer fabric 502 in the crossover portion can slide over the floating warp fibers of multilayer fabric 504 in the crossover portion without being obstructed by weft fibers.

[0034] After forming the C-Beam cruciform structure, the preform can be impregnated with a matrix material to form a composite. An example of the composite C-Beam cruciform is shown in Figure 11.

[0035] Figure 12 illustrates three warp columns A, B, and C in the flange crossover portion of a C-Beam cruciform (after forming). Warp tows 1804 of the flange of the first arm and warp tows 1806 of the flange of the second arm are not interwoven with weft fibers. As shown, warp tows of the first arm 1804 are interwoven with warp tows 1806 of the second arm across the crossover portion 1802. This feature enables the arms of the C-Beams to rotate about the crossover portion when being formed from the as-woven preform into the desired cruciform shape.

[0036] The subject invention can also be applied to make an I-Beam cruciform preform 1300, shown in Figure 13. The preform comprises a first arm 1306 and a second arm 1304. Each of first arm 1306 and second arm 1304 has two opposing flanges 1302. The first and second arms intersect at crossover portion 1308.

[0037] The present invention is not limited to woven preforms having only one crossover portion that may be formed into C-Beam cruciform structures. Cruciform structures having C-Beam cross-sectional forms that are flat-woven with multiple crossover portions may be formed. Figures 14 to 16 illustrate cross-sectional views of multilayer fabrics that may be used to form cruciform structures. Preforms with other cross-sectional forms including, but not limited to, "H-Beam", "I-Beam", "T-Beam", "L-Beam", and " π -Beam" are contemplated as well.

[0038] Figure 14 illustrates a cross-sectional view of a flat-woven preform having two multilayer fabrics 1402, 1404 and a single crossover portion 1400₁. Multilayer fabric 1402 is woven over multilayer fabric 1404 on one side of crossover portion 1400₁ and under multilayer

fabric 1404 on another side of the crossover portion. As discussed in detail above, the preform can be formed in a C-Beam structure having a "cross" or "X-shape".

[0039] Figure 15 illustrates a cross-sectional view of a flat-woven preform having four multilayer fabrics 1502, 1504, 1506, 1508 and four crossover portions 1500₁, 1500₂, 1500₃, 1500₄. Each multilayer fabric includes two crossover portions with each of two other multilayer fabrics. In each case, a first multilayer fabric is woven over a second multilayer woven fabric on one side of the crossover portion and under the second fabric on the other side of the crossover portion. For, example, multilayer fabric 1502 includes two crossover portions 1500₁, 1500₄ with multilayer fabrics 1506 and 1508, respectively. Fabric 1502 is woven over fabric 1506 on one side of crossover portion 1500₁ and under fabric 1506 on the other side of crossover portion 1500₁. Fabric 1502 is woven over fabric 1508 on one side of crossover portion 1500₄ and under fabric 1508 on the other side of crossover portion 1500₄. A similar weaving may be accomplished for each of remaining fabrics 1504, 1506, 1508. In this embodiment, the result is a cruciform structure having the form of a "hash" or "number" symbol shape that bounds an open area 1518.

[0040] Figure 17 is an illustration of the cruciform structure formed from the fabric illustrated in Figure 15. The cruciform structure shown in Figure 17 includes four arms 1502, 1504, 1506, 1508. Each arm intersects with two other arms at crossover portions. As such, each arm has two crossover portions. Arm 1502 includes crossover portions 1500₁, 1500₄ with multilayer fabrics 1506 and 1508, respectively; arm 1504 includes crossover portions 1500₂, 1500₃ with multilayer fabrics 1506 and 1508, respectively; arm 1506 includes crossover portions 1500₁, 1500₂ with multilayer fabrics 1502 and 1504, respectively; arm 1508 includes crossover portions 1500₃, 1500₄ with multilayer fabrics 1504 and 1502, respectively. As discussed above, the result is a structure having the form of a "hash" or "number" symbol that bounds an open area 1518.

[0041] Figure 16 illustrates a cross-sectional view of a flat-woven preform having six multilayer fabrics 1602, 1604, 1606, 1608, 1610, 1612 with nine crossover portions 1600₁, 1600₂, 1600₃, 1600₄, 1600₅, 1600₆, 1600₇, 1600₈, 1600₉. Each of the fabrics includes three crossover portions with three other fabrics. For example, fabric 1602 includes crossover portions 1600₁, 1600₂, 1600₃ with fabrics 1608, 1610, 1612, respectively. The preform woven in this manner results in the complex cruciform pattern illustrated.

[0042] Other implementations are contemplated that expand this structure or create other structures from the basic two-arm cruciform described herein. The pattern described in Figures 14-16 may be continued for the desired structure. Such structures include, but are not limited, to triangular, rhomboid, pentagonal, hexagonal, etc. shaped structures.

[0043] In any of the embodiments, the woven preform can be impregnated with a matrix material. The matrix material includes epoxy, bismaleimide, polyester, vinyl-ester, ceramic,

carbon, and other such materials.

[0044] Other embodiments are within the scope of the following claims.

REFERENCES CITED IN THE DESCRIPTION

Cited references

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US4922968A [0007]
- JPS6278235A [0007]
- US2013099062A1 [0007]
- US6283168B1 [0007]

Patentkrav**1. Fremgangsmåde til at danne en vævet præform, omfattende:**

at væve et første stof (502, 504, 1402, 1404) over et andet stof (502, 504, 1402, 1404) i en første del af den vævede præform, hvor det første og andet stof (502, 504, 1402, 1404) hver inkluderer kædefibre vævet sammen med islætfibre;

at sammenvæve kædefibre af det første stof (502, 504, 1402, 1404) med kædefibre af det andet stof (502, 504, 1402, 1404) ved en overgangsdelen (518, 1400₁) af den vævede præform således at efter overgangsdelen (518, 1400₁) det første stof (502, 504, 1402, 1404) væves under det andet stof (502, 504, 1402, 1404) i en anden del af den vævede præform;

hvor kædefibrene i det første og andet stof (502, 504, 1402, 1404) er kontinuerlige over overgangsdelen (518, 1400₁), **kendetegnet ved, at** kædefibrene på kanter af det første stof (502, 504, 1402, 1404) og kædefibrene på kanter af det andet stof (502, 504, 1402, 1404) flyder i overgangsdelen (518, 1400₁).

2. Fremgangsmåden til at danne en vævet præform ifølge krav 1, hvor det første stof (502, 504, 1402, 1404) er et enkeltlagsstof eller flerlagsstof; og hvor det andet stof (502, 504, 1402, 1404) er et enkeltlagsstof eller flerlagsstof.

3. Fremgangsmåden til at danne en vævet præform ifølge et hvilket som helst af kravene 1 til 2, omfattende:

at rotere det første stof (502, 504, 1402, 1404) omkring overgangsdelen (518, 1400₁) for at danne en vinkel i forhold til det andet stof (502, 504, 1402, 1404).

4. Fremgangsmåden til at danne en vævet præform ifølge krav 3, hvor vinklen er 90 grader.

5. Fremgangsmåden til at danne en vævet præform ifølge et hvilket som helst af kravene 3 eller 4, omfattende:

at folde kanter af det første og andet stof (502, 504, 1402, 1404), omkring en akse

parallel med kædetrådsretningen, for at få præformen til at have en tværsnitsform valgt fra gruppen bestående af H-bom, I-bom, T-bom, L-bom og Pi-bom.

6. Fremgangsmåden til at danne en vævet præform ifølge et hvilket som helst af

5 kravene 3 eller 4, omfattende:

at folde kanterne af det første stof (502, 504, 1402, 1404), omkring en akse parallel med kædetrådsretningen, til en C-bom; og

at folde kanterne af det andet stof (502, 504, 1402, 1404), omkring en akse parallel med kædetrådsretningen, til en C-bom.

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7. Fremgangsmåde til at danne en kompositstøttestruktur omfattende:

at danne den vævede præform ifølge krav 6; og

at imprægnere den vævede præform med et matricemateriale.

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8. Vævet præform, omfattende:

et første stof (502, 504, 1402, 1404) af kædefibre vævet sammen med islætfibre;

20 et andet stof (502, 504, 1402, 1404) af kædefibre vævet sammen med islætfibre,

hvor kædefibrene af det første stof (502, 504, 1402, 1404) er vævet sammen med kædefibrene af det andet stof (502, 504, 1402, 1404) ved en

overgangsdel (518, 1400₁) således at kædefibrene i det første stof (502, 504,

25 1402, 1404) og kædefibrene i det andet stof (502, 504, 1402, 1404) er

kontinuerlige over overgangsdelen (518, 1400₁),

hvor det første stof og det andet stof (502, 504, 1402, 1404) andre steder end overgangsdelen (518, 1400₁) ikke er vævet sammen med

hinanden, **kendetegnet ved, at**

30 kædefibrene på kanter af det første stof (502, 504, 1402, 1404) og

kædefibrene på kanter af det andet stof (502, 504, 1402, 1404) flyder i overgangsdelen (518, 1400₁).

9. Den vævede præform ifølge krav 8, hvor det første stof (502, 504, 1402, 1404) er et enkeltlagsstof eller flerlagsstof; og

5 hvor det andet stof (502, 504, 1402, 1404) er et enkeltlagsstof eller flerlagsstof.

10. Den vævede præform ifølge et hvilket som helst af kravene 8 og 9, omfattende:

et tredje stof af kædefibre vævet sammen med islætfibre, hvor det tredje stof er et enkelt- eller flerlagsstof,

10 hvor kædefibrene af det tredje stof er vævet sammen med kædefibrene af det andet stof (502, 504, 1402, 1404) ved en overgangsdelen således at

kædefibrene i det tredje stof og kædefibrene i det andet stof (502, 504, 1402, 1404) er kontinuerlige over overgangsdelen,

15 hvor det tredje stof og det andet stof (502, 504, 1402, 1404) andre steder end overgangsdelen ikke er vævet sammen med hinanden,

hvor det første, andet og tredje stof danner en vinkel med mindst et andet af de resterende stoffer.

20 **11.** Den vævede præform ifølge et hvilket som helst af kravene 8 og 9, hvor det første og andet stof (502, 504, 1402, 1404) er foldet, omkring en akse parallel med kædetrådsretningen, til at have en tværsnitsform valgt fra gruppen bestående af H-bom, I-bom, T-bom, L-bom og Pi-bom.

25 **12.** Den vævede præform ifølge et hvilket som helst af kravene 8 til 10, hvor det første og andet stof (502, 504, 1402, 1404) hver er foldet, omkring en akse parallel med kædetrådsretningen, til en C-bom.

13. Kompositstøttestruktur, omfattende:

30 den vævede præform ifølge et hvilket som helst af kravene 8 til 10; og et matricemateriale.

14. Fremgangsmåde til at danne en vævet præform, omfattende:

at væve mindst tre vævede stoffer (1502, 1504, 1506, 1508, 1602, 1604, 1606, 1608, 1610, 1612) der inkluderer kædefibre vævet sammen med
 5 islætfibre, hvor hvert vævet stof har et første stof (1502, 1504, 1506, 1508, 1602, 1604, 1606, 1608, 1610, 1612) vævet over et andet stof (1502, 1504, 1506, 1508, 1602, 1604, 1606, 1608, 1610, 1612) i en første del af den vævede præform;

at sammenvæve hvert af de mindst tre stoffer (1502, 1504, 1506, 1508, 1602, 1604, 1606, 1608, 1610, 1612) med mindst et resterende vævet stof ved en
 10 respektiv overgangsdelt (1500₁, 1500₄, 1600₁, 1600₂, 1600₃, 1600₄, 1600₅, 1600₆, 1600₇, 1600₈, 1600₉), således at der er mindst to overgangsdele (1500₁, 1500₄, 1600₁, 1600₂, 1600₃, 1600₄, 1600₅, 1600₆, 1600₇, 1600₈, 1600₉) i hvert vævet stof (1502, 1504, 1506, 1508, 1602, 1604, 1606, 1608, 1610, 1612);

15 hvor efter hver overgangsdelt (1500₁, 1500₄, 1600₁, 1600₂, 1600₃, 1600₄, 1600₅, 1600₆, 1600₇, 1600₈, 1600₉) af de mindst tre vævede stoffer (1502, 1504, 1506, 1508, 1602, 1604, 1606, 1608, 1610, 1612), et krydsende stof (1502, 1504, 1506, 1508, 1602, 1604, 1606, 1608, 1610, 1612) vævet over et andet stof (1502, 1504, 1506, 1508, 1602, 1604, 1606, 1608, 1610, 1612)
 20 væves under det andet vævede stof (1502, 1504, 1506, 1508, 1602, 1604, 1606, 1608, 1610, 1612),

hvor kædefibrene i de krydsende stoffer (1502, 1504, 1506, 1508, 1602, 1604, 1606, 1608, 1610, 1612) er kontinuerlige over hver overgangsdelt (1500₁, 1500₄, 1600₁, 1600₂, 1600₃, 1600₄, 1600₅, 1600₆, 1600₇, 1600₈,
 25 1600₉), **kendetegnet ved, at**

kædefibrene på kanter af de mindst tre stoffer (1502, 1504, 1506, 1508, 1602, 1604, 1606, 1608, 1610, 1612) flyder i hver overgangsdelt (1500₁, 1500₄, 1600₁, 1600₂, 1600₃, 1600₄, 1600₅, 1600₆, 1600₇, 1600₈, 1600₉).

30

15. Fremgangsmåden til at danne en vævet præform ifølge krav 14, hvor hvert af de mindst tre stoffer (1502, 1504, 1506, 1508, 1602, 1604, 1606, 1608, 1610, 1612) er

et enkeltlagsstof eller flerlagsstof.

16. Fremgangsmåden til at danne en vævet præform ifølge et hvilket som helst af kravene 14 eller 15, omfattende:

- 5 at rotere de mindst tre stoffer (1502, 1504, 1506, 1508, 1602, 1604, 1606, 1608, 1610, 1612) omkring overgangsdelen (1500₁, 1500₄, 1600₁, 1600₂, 1600₃, 1600₄, 1600₅, 1600₆, 1600₇, 1600₈, 1600₉) således at de mindst tre stoffer (1502, 1504, 1506, 1508, 1602, 1604, 1606, 1608, 1610, 1612) danner en vinkel med mindst et andet af de mindst tre stoffer (1502, 1504, 1506, 10 1508, 1602, 1604, 1606, 1608, 1610, 1612), og eventuelt at folde kanter af hvert af de mindst tre stoffer (1502, 1504, 1506, 1508, 1602, 1604, 1606, 1608, 1610, 1612), omkring en akse parallel med kædetrådsretningen, til en C-bom.

- 15 **17.** Fremgangsmåden til at danne en vævet præform ifølge et hvilket som helst af kravene 14 eller 15 og 16, hvor der er fire stoffer (1502, 1504, 1506, 1508), hvor hvert stof (1502, 1504, 1506, 1508) krydser med præcis to andre stoffer (1502, 1504, 1506, 1508).

- 20 **18.** Fremgangsmåden til at danne en vævet præform ifølge krav 17, omfattende: at folde kanter af hvert af de fire stoffer (1502, 1504, 1506, 1508), omkring en akse parallel med kædetrådsretningen, til en C-bom.

- 25 **19.** Fremgangsmåden til at danne en vævet præform ifølge et hvilket som helst af kravene 14 eller 15 og 16, omfattende: at folde kanter af hvert af de mindst tre stoffer (1502, 1504, 1506, 1508, 1602, 1604, 1606, 1608, 1610, 1612), omkring en akse parallel med kædetrådsretningen, for at have en tværsnitsform valgt fra gruppen bestående af H-bom, I-bom, T-bom, L-bom 30 og Pi-bom.

- 20.** Fremgangsmåde til at danne en kompositstøttestruktur omfattende: at danne den vævede præform ifølge krav 18; og

at imprægnere den vævede præform med et matricemateriale.

21. Fremgangsmåde til at danne en kompositstøttestruktur omfattende:

- 5 at danne den vævede præform ifølge krav 16; og
 at imprægnere den vævede præform med et matricemateriale.

22. Vævet præform, omfattende:

- 10 mindst tre vævede stoffer (1502, 1504, 1506, 1508, 1602, 1604, 1606, 1608, 1610, 1612) der har kædefibre vævet sammen med islætfibre, hvor hvert vævet stof har et første stof (1502, 1504, 1506, 1508, 1602, 1604, 1606, 1608, 1610, 1612) vævet over et andet stof (1502, 1504, 1506, 1508, 1602, 1604, 1606, 1608, 1610, 1612) i en første del af den vævede præform;
- 15 hvor hvert af de mindst tre vævede stoffer (1502, 1504, 1506, 1508, 1602, 1604, 1606, 1608, 1610, 1612) er vævet sammen med mindst et resterende vævet stof (1502, 1504, 1506, 1508, 1602, 1604, 1606, 1608, 1610, 1612) ved en respektiv overgangsdel (1500₁, 1500₄, 1600₁, 1600₂, 1600₃, 1600₄, 1600₅, 1600₆, 1600₇, 1600₈, 1600₉), således at der er mindst to
- 20 overgangsdele (1500₁, 1500₄, 1600₁, 1600₂, 1600₃, 1600₄, 1600₅, 1600₆, 1600₇, 1600₈, 1600₉) i hvert vævet stof (1502, 1504, 1506, 1508, 1602, 1604, 1606, 1608, 1610, 1612);
- hvor efter hver overgangsdel (1500₁, 1500₄, 1600₁, 1600₂, 1600₃, 1600₄, 1600₅, 1600₆, 1600₇, 1600₈, 1600₉) af de mindst tre vævede stoffer (1502, 1504, 1506, 1508, 1602, 1604, 1606, 1608, 1610, 1612), et krydsende stof (1502, 1504, 1506, 1508, 1602, 1604, 1606, 1608, 1610, 1612) vævet over et andet stof (1502, 1504, 1506, 1508, 1602, 1604, 1606, 1608, 1610, 1612) væves under det andet vævede stof (1502, 1504, 1506, 1508, 1602, 1604, 1606, 1608, 1610, 1612),
- 25 hvor kædefibrene i de krydsende stoffer (1502, 1504, 1506, 1508, 1602, 1604, 1606, 1608, 1610, 1612) er kontinuerlige over hver overgangsdel (1500₁, 1500₄, 1600₁, 1600₂, 1600₃, 1600₄, 1600₅, 1600₆, 1600₇, 1600₈, 1600₉),
- 30 hvor kædefibrene i de krydsende stoffer (1502, 1504, 1506, 1508, 1602, 1604, 1606, 1608, 1610, 1612) er kontinuerlige over hver overgangsdel (1500₁, 1500₄, 1600₁, 1600₂, 1600₃, 1600₄, 1600₅, 1600₆, 1600₇, 1600₈, 1600₉),

kendetegnet ved, at

kædefibrene på kanter af de mindst tre stoffer (1502, 1504, 1506, 1508, 1602, 1604, 1606, 1608, 1610, 1612) flyder i hver overgangsdelt (1500₁, 1500₄, 1600₁, 1600₂, 1600₃, 1600₄, 1600₅, 1600₆, 1600₇, 1600₈, 1600₉).

5

23. Den vævede præform ifølge krav 22, hvor hvert af de mindst tre stoffer (1502, 1504, 1506, 1508, 1602, 1604, 1606, 1608, 1610, 1612) er et enkeltlagsstof eller flerlagsstof.

10

24. Den vævede præform ifølge et hvilket som helst af kravene 22 eller 23, hvor de mindst tre stoffer (1502, 1504, 1506, 1508, 1602, 1604, 1606, 1608, 1610, 1612) danner en vinkel med mindst et andet af de mindst tre stoffer (1502, 1504, 1506, 1508, 1602, 1604, 1606, 1608, 1610, 1612),

15 og eventuelt hvor hvert af de mindst tre stoffer (1502, 1504, 1506, 1508, 1602, 1604, 1606, 1608, 1610, 1612) er foldet, omkring en akse parallel med kædetrådsretningen, til en C-bom.

25. Den vævede præform ifølge et hvilket som helst af kravene 22 eller 23 og 24, 20 hvor de mindst tre stoffer (1502, 1504, 1506, 1508, 1602, 1604, 1606, 1608, 1610, 1612) er foldet, omkring en akse parallel med kædetrådsretningen, til at have en tværsnitsform valgt fra gruppen bestående af H-bom, I-bom, T-bom, L-bom og Pi-bom.

25 **26.** Den vævede præform ifølge et hvilket som helst af kravene 22 eller 23 og 24, hvor der er fire stoffer (1502, 1504, 1506, 1508), hvor hvert stof (1502, 1504, 1506, 1508) krydser med præcis to andre stoffer (1502, 1504, 1506, 1508), og eventuelt hvor hvert af de fire stoffer (1502, 1504, 1506, 1508) er foldet, omkring en akse parallel med kædetrådsretningen, til en C-bom.

30

27. Kompositstøttestruktur omfattende:

den vævede præform ifølge krav 26; og
et matricemateriale.

28. Kompositstøttestruktur omfattende:

den vævede præform ifølge krav 24; og
et matricemateriale.

DRAWINGS

Drawing

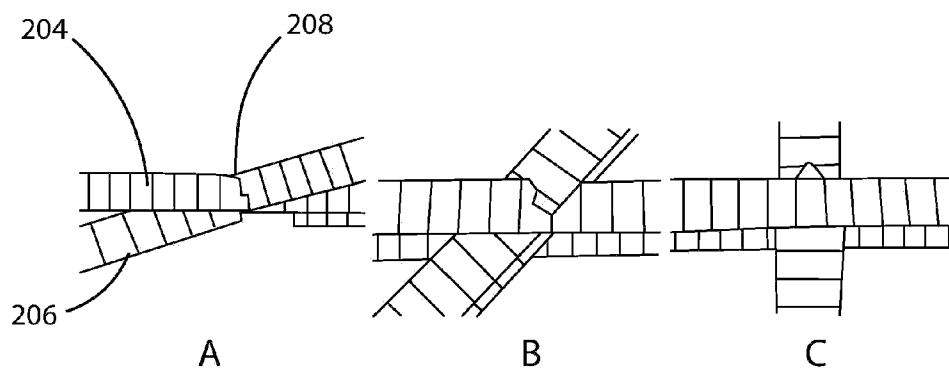
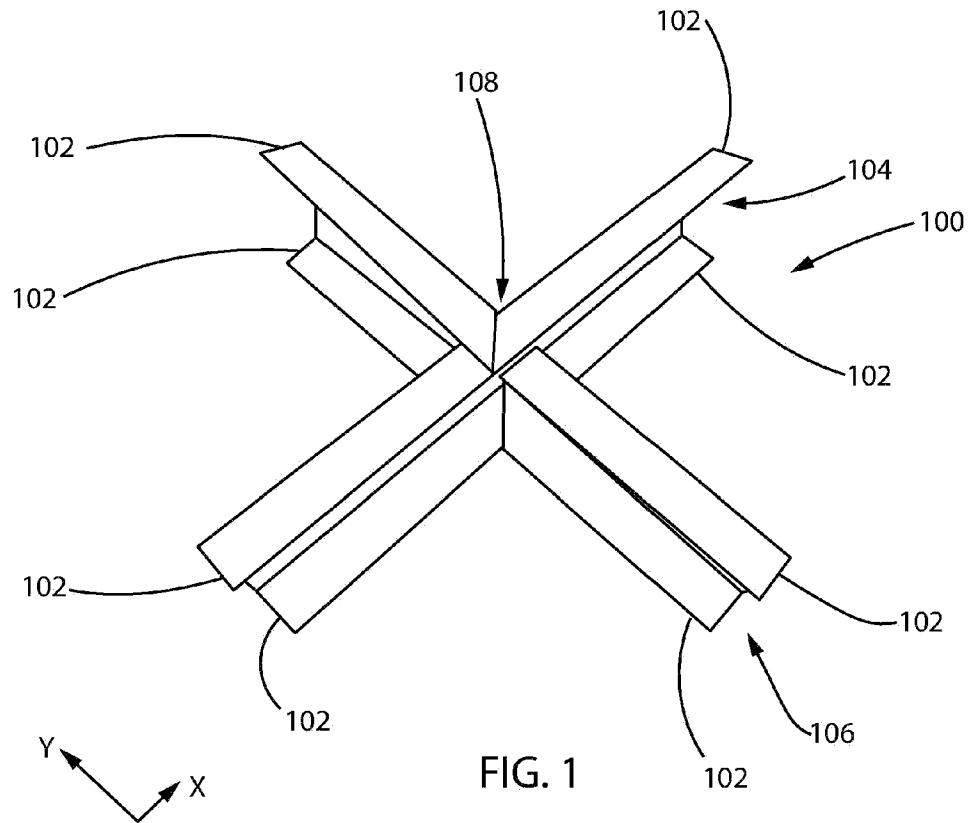


FIG. 2

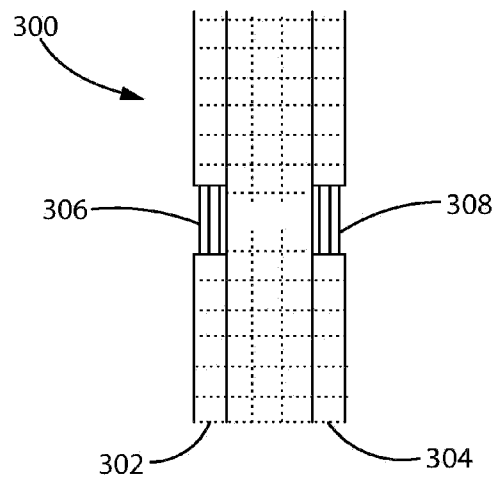


FIG. 3

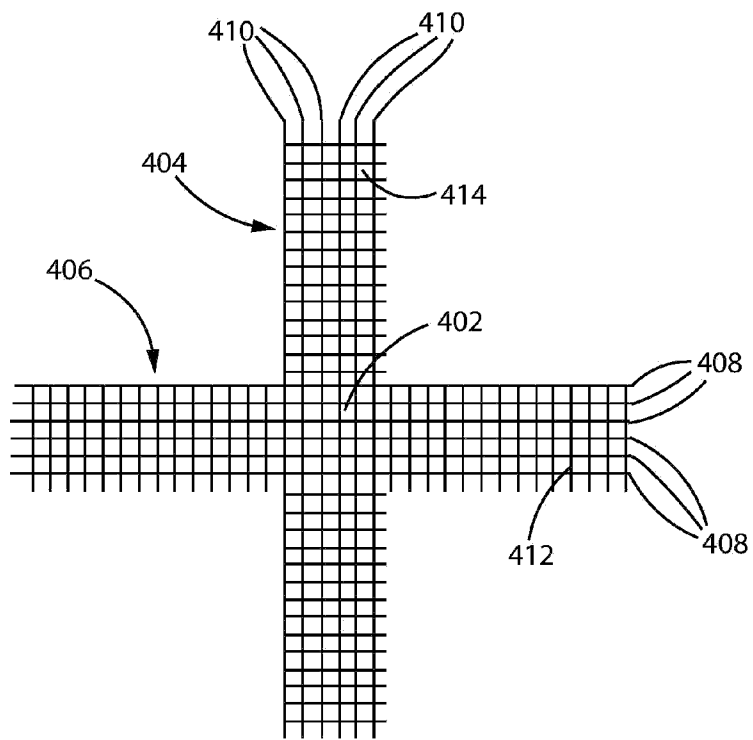


FIG. 4

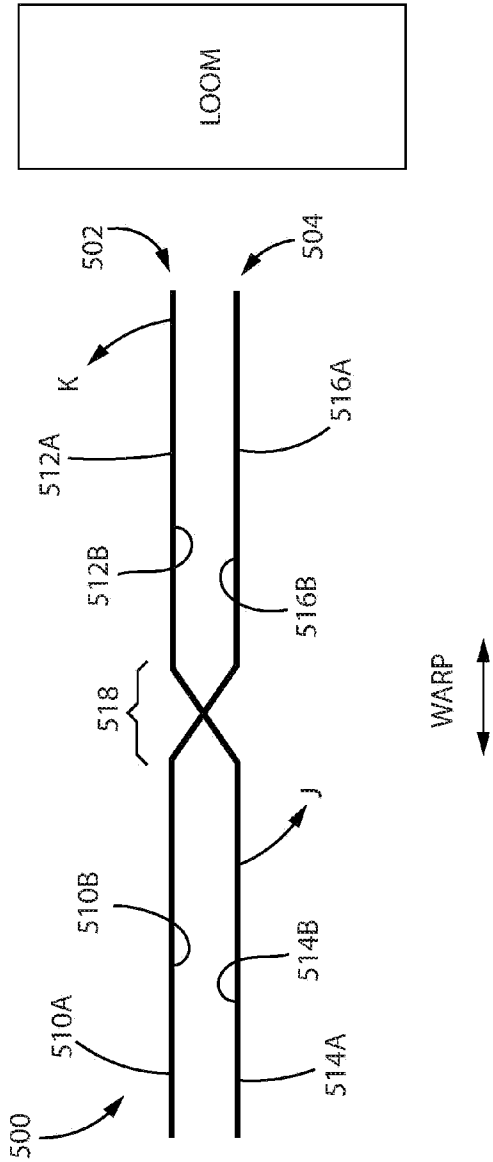


FIG. 5

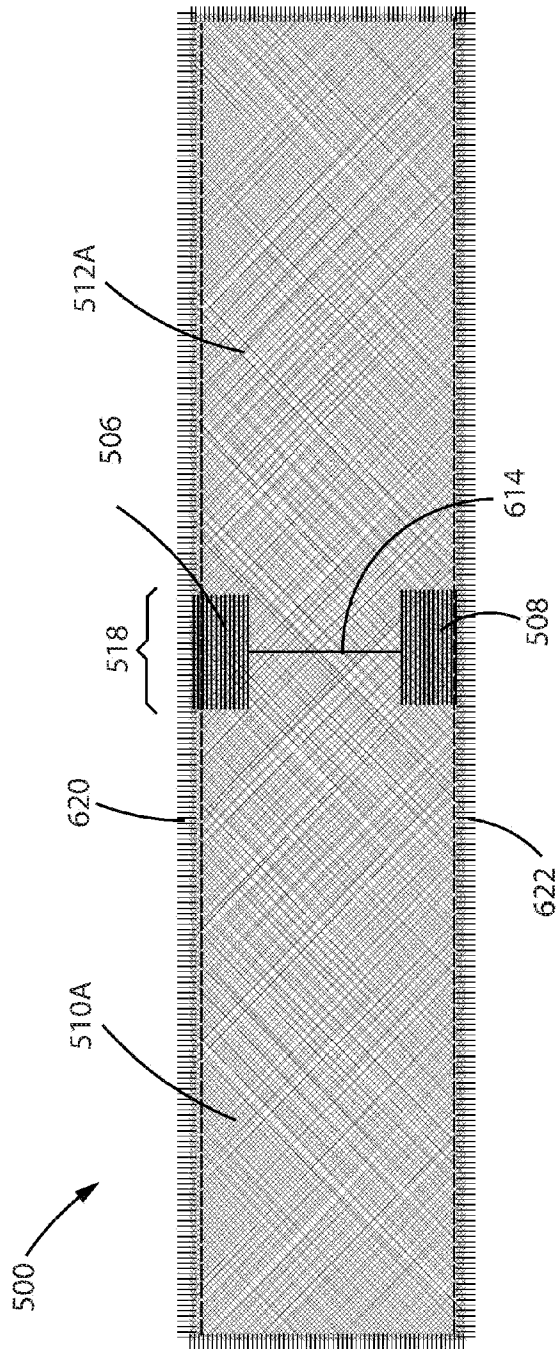


FIG. 6

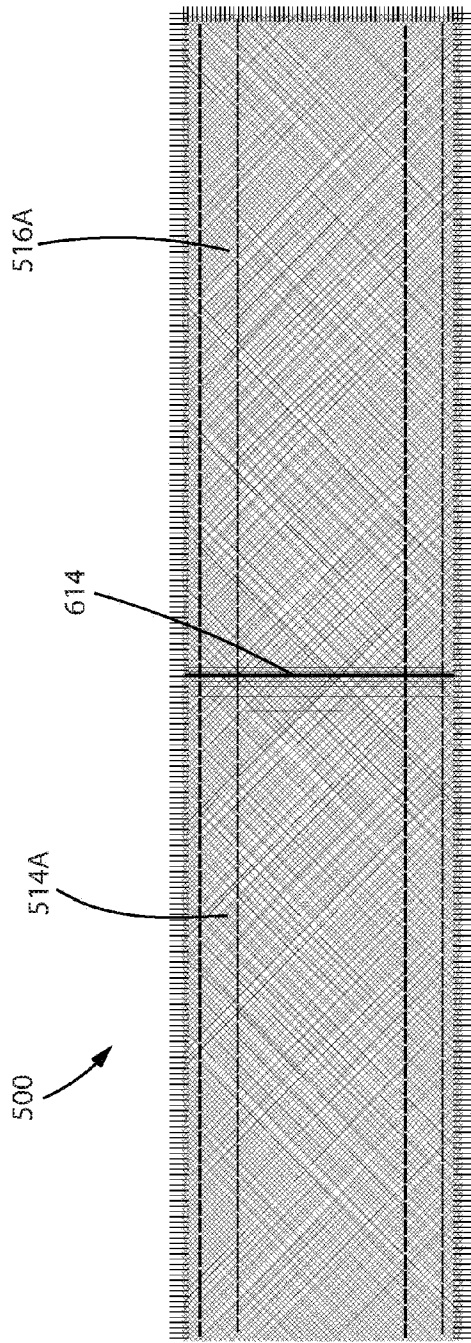


FIG. 7

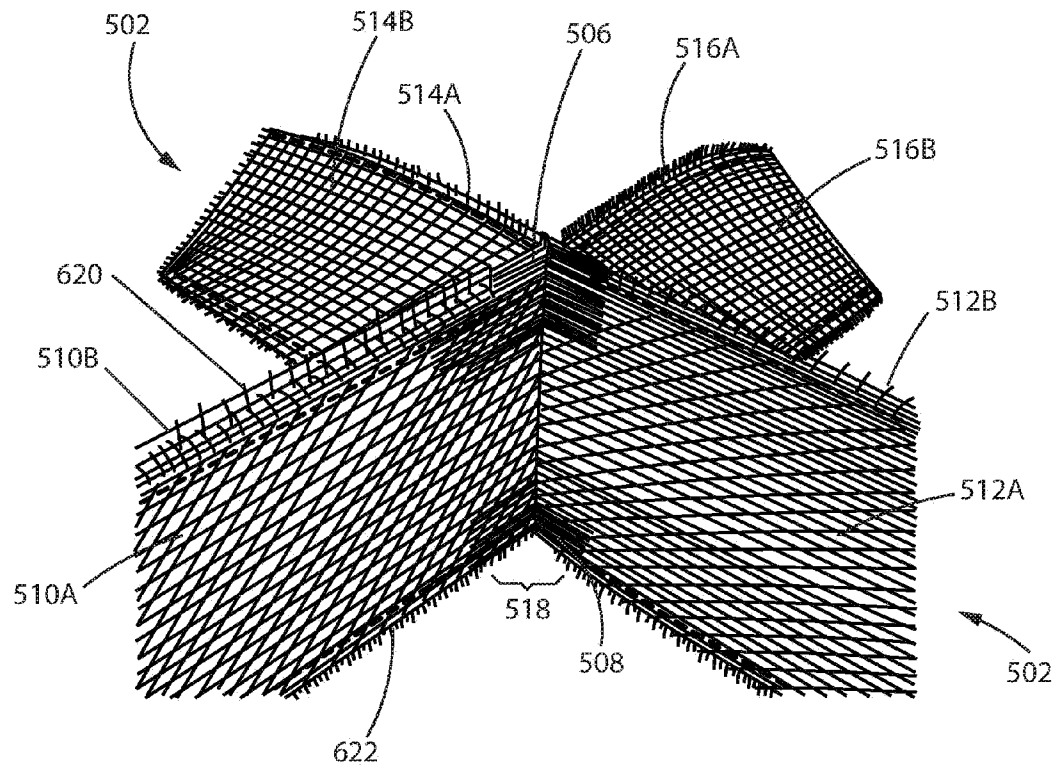


FIG. 8

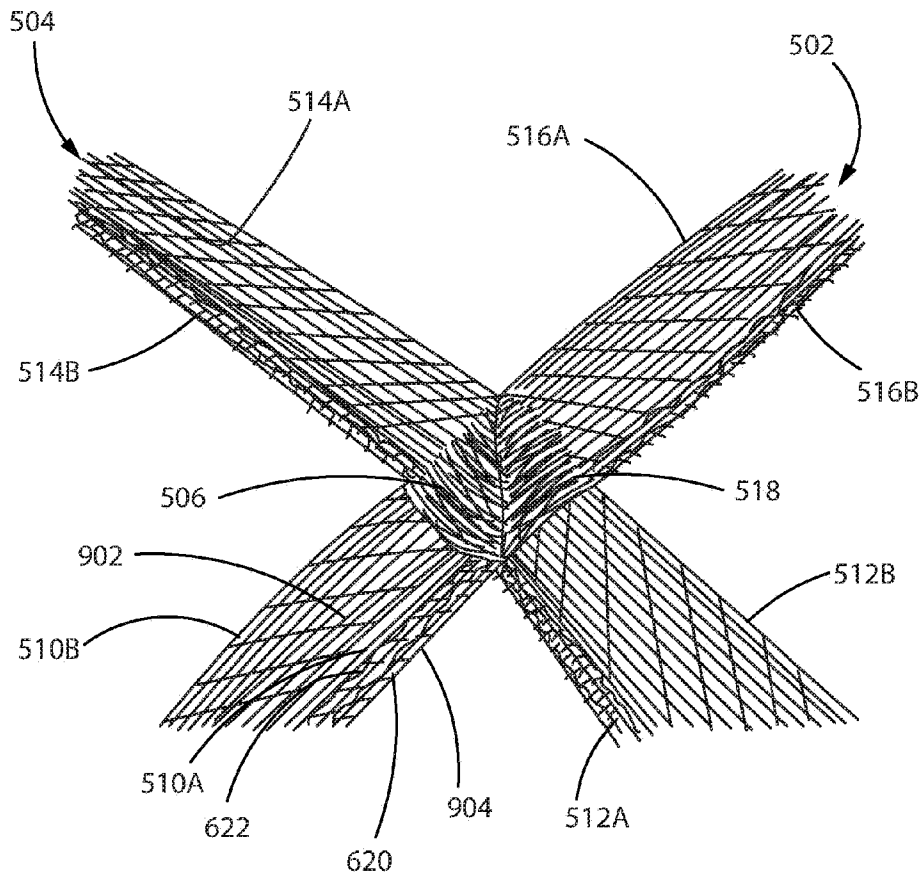


FIG. 9

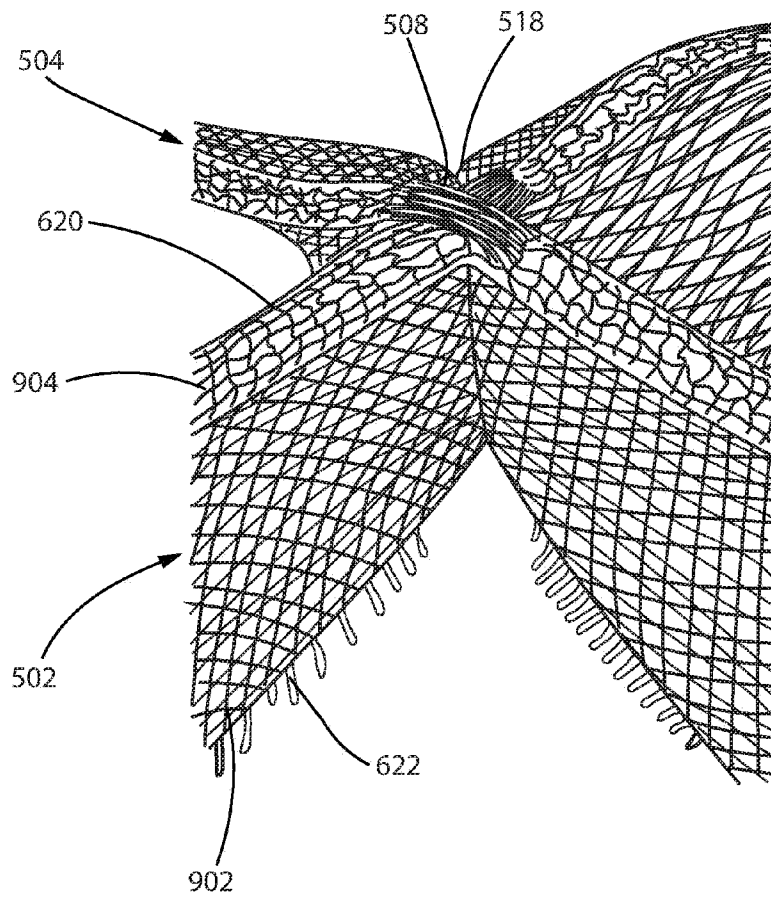


FIG. 10

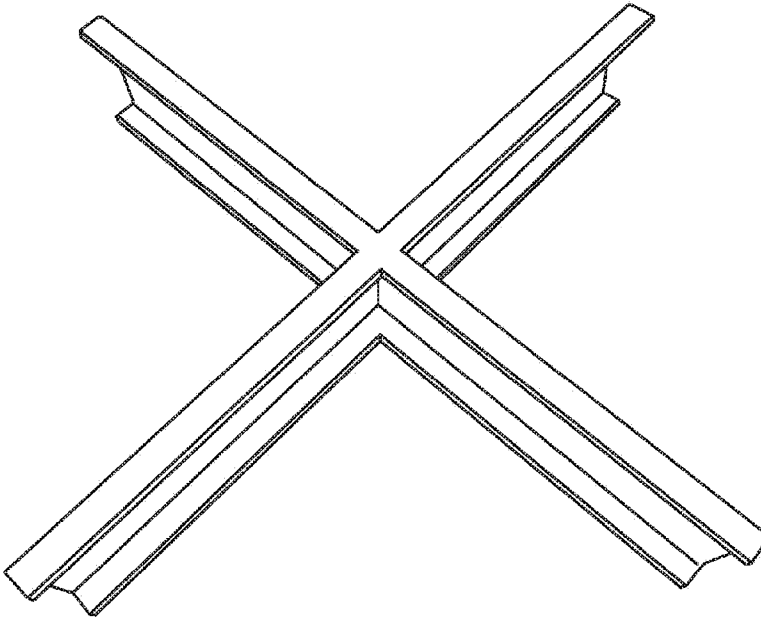
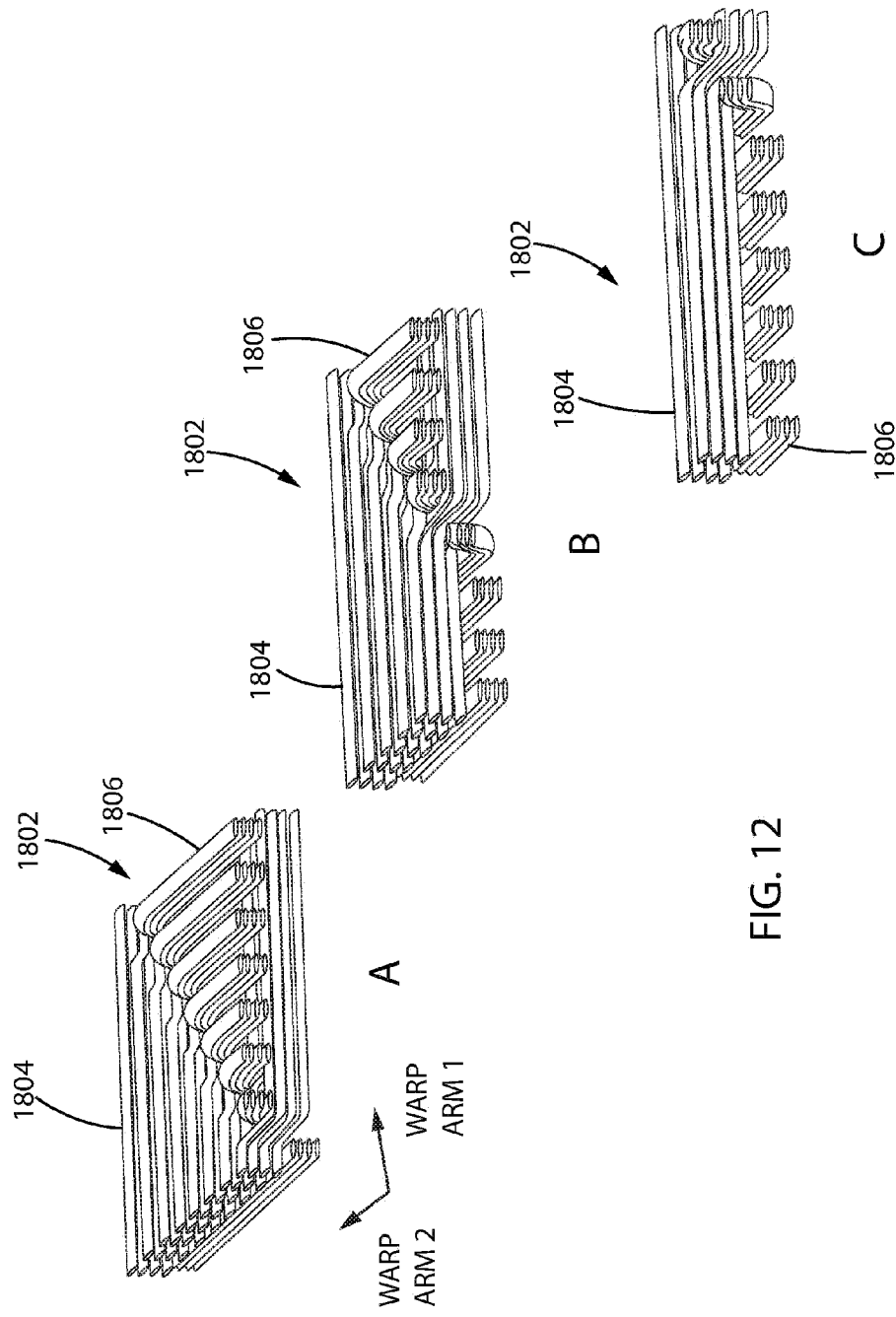


FIG.11



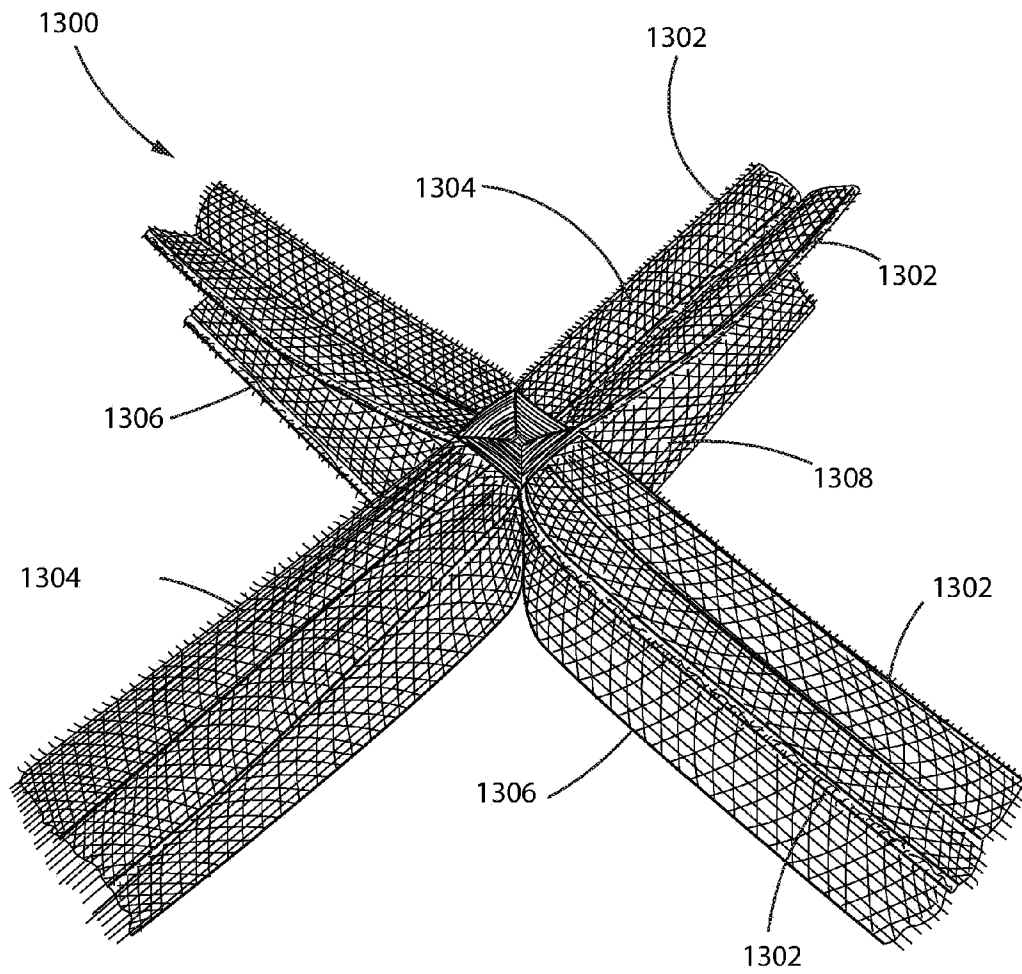


FIG. 13

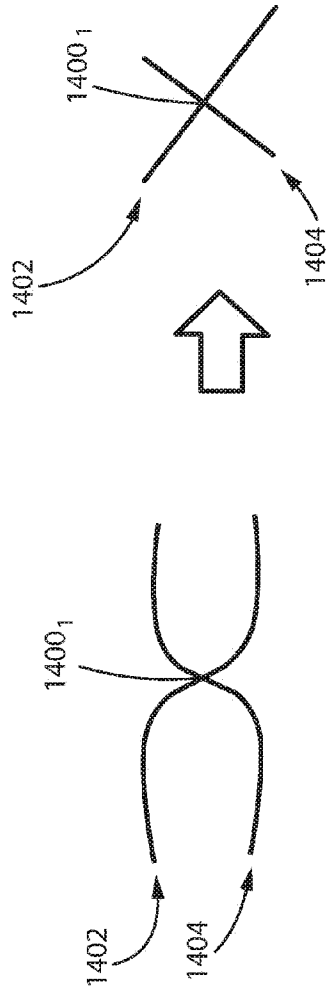


FIG. 14

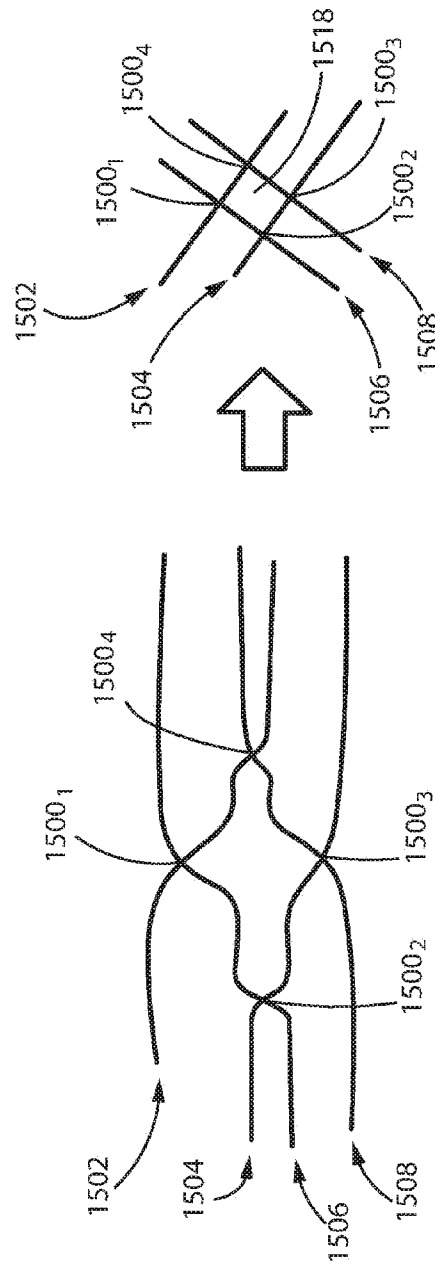


FIG. 15

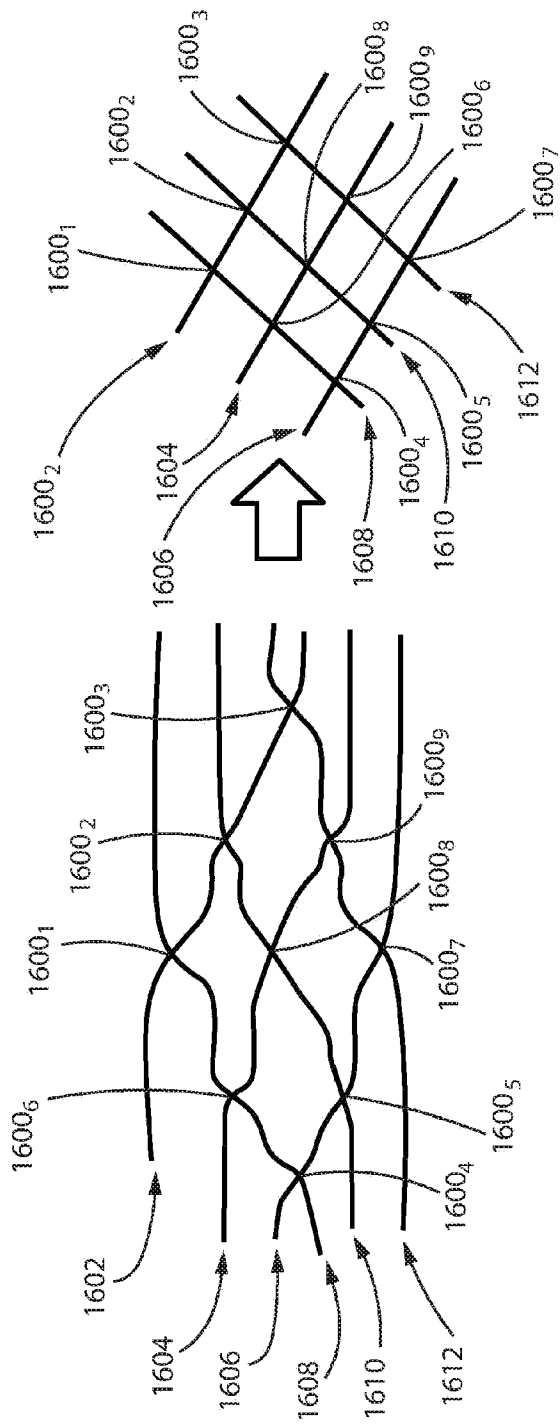


FIG. 16

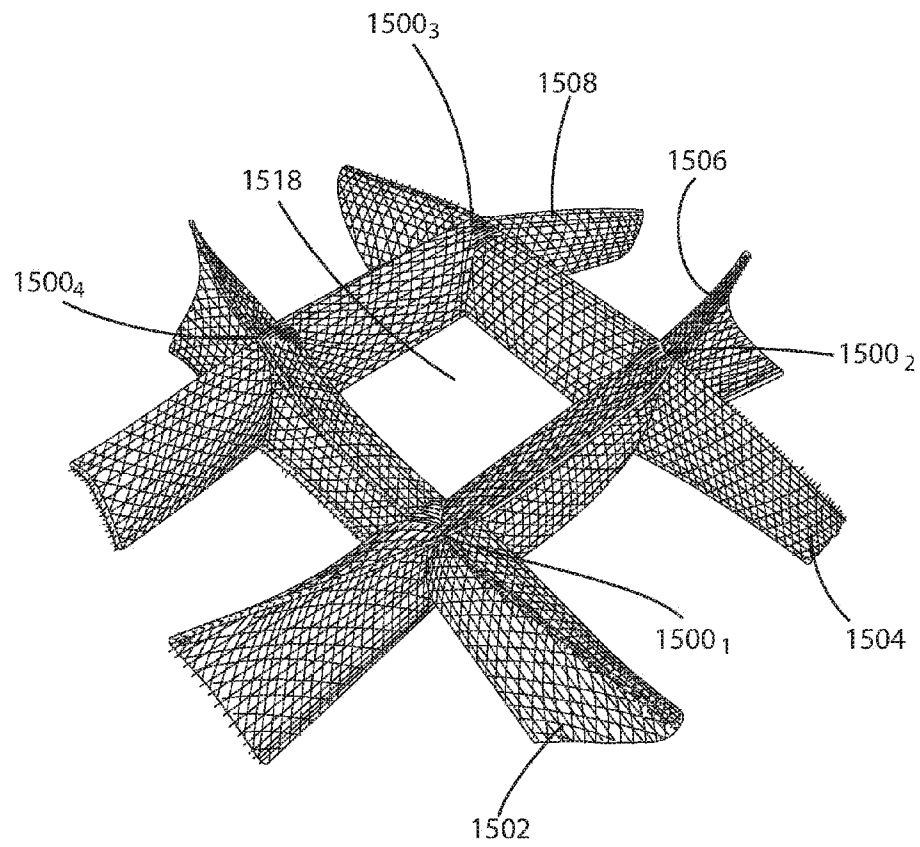


FIG. 17