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(54) **Titre : ELEMENT STRUCTURAL COMPOSITE GONFLABLE ET PROCEDE**
 (54) **Title: INFLATABLE COMPOSITE STRUCTURAL COMPONENT AND METHOD**

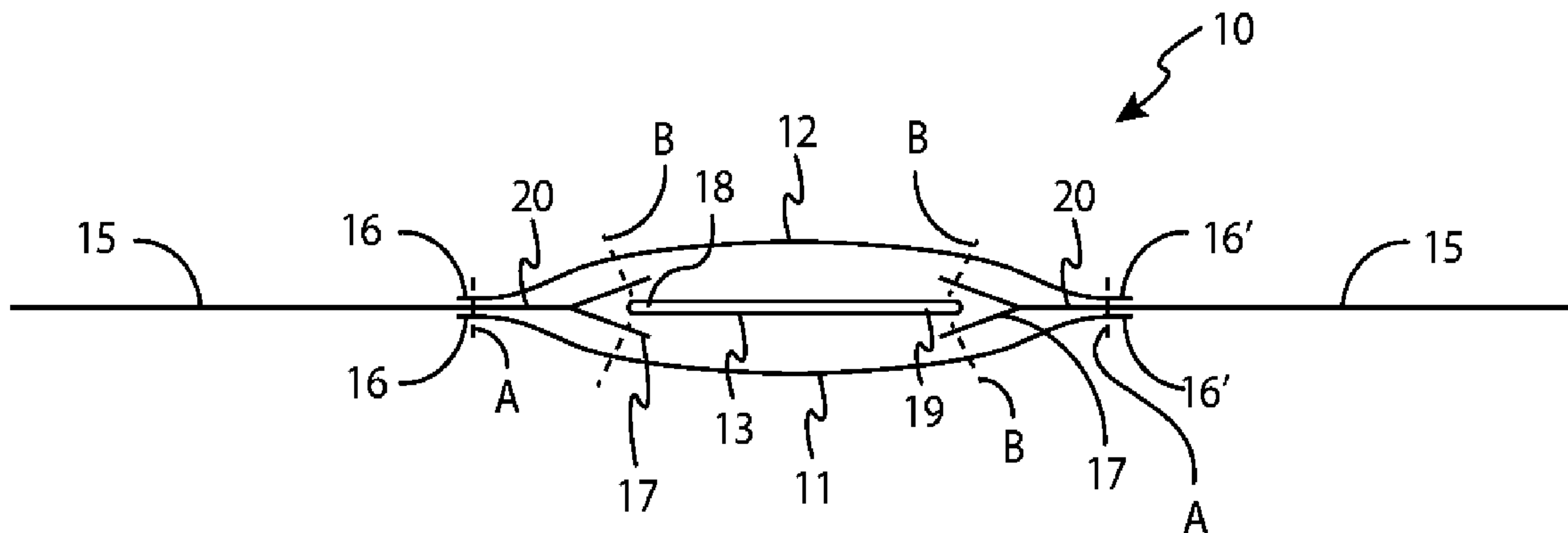


FIG. 1

(57) **Abrégé/Abstract:**

An inflatable structural component having a longitudinal first braided material layer and a longitudinal second braided material layer each forming a panel having a width-wise dimension transverse to a length-wise direction of the component bounded by first and second longitudinal edges along the length-wise direction of the component, the first and second braided material layers enveloping at least a portion of an inflatable longitudinal bladder, the first and second braided material layers arranged such that the first longitudinal edges of the first and second braided material layers are approximately aligned and connected together along a first side of the bladder and the second longitudinal edges of the first and second braided material layers are approximately aligned and connected together along a second side of the bladder.

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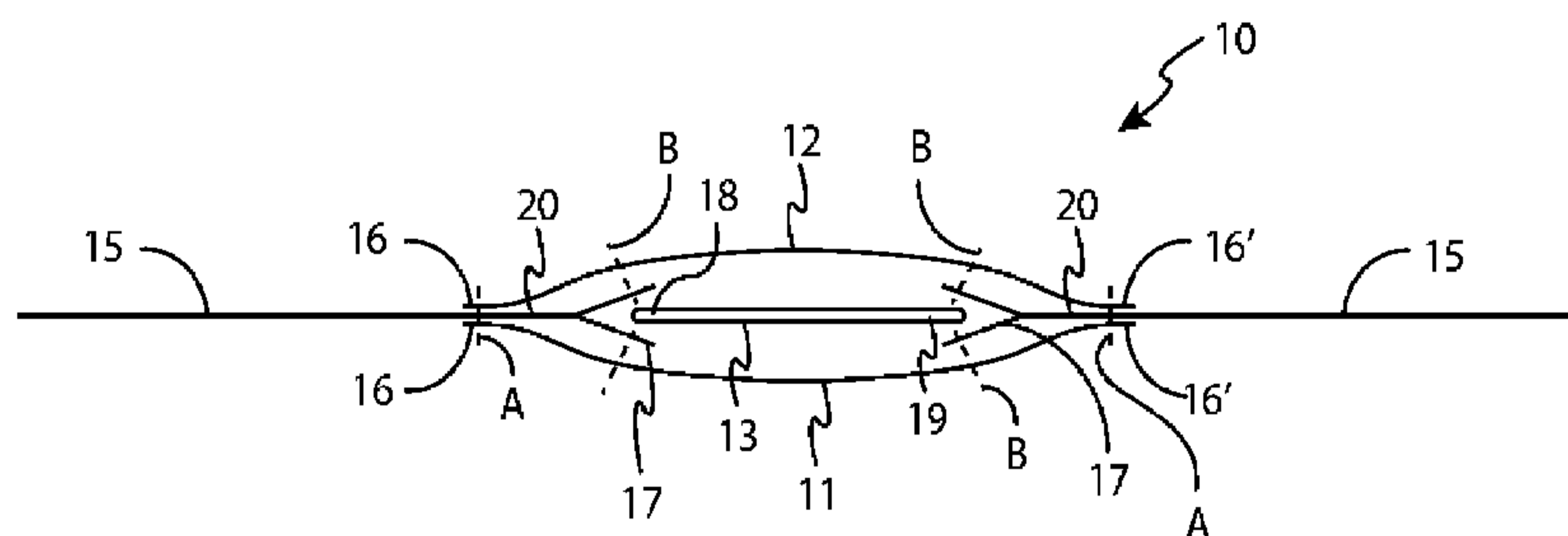


FIG. 1

(57) Abstract: An inflatable structural component having a longitudinal first braided material layer and a longitudinal second braided material layer each forming a panel having a width-wise dimension transverse to a length-wise direction of the component bounded by first and second longitudinal edges along the length-wise direction of the component, the first and second braided material layers enveloping at least a portion of an inflatable longitudinal bladder, the first and second braided material layers arranged such that the first longitudinal edges of the first and second braided material layers are approximately aligned and connected together along a first side of the bladder and the second longitudinal edges of the first and second braided material layers are approximately aligned and connected together along a second side of the bladder.

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INFLATABLE COMPOSITE STRUCTURAL COMPONENT AND METHOD

[0001] This international application claims the benefit of U.S. provisional patent application 61/834,298, filed June 12, 2013 and which is hereby incorporated herein by reference.

Background and Summary of the Disclosure

[0002] The present subject matter relates generally to a sub-component or component of an inflatable composite member in a structure.

[0003] Prior rapidly deployable structures with inflatable composite structural components have been used to erect temporary, semi-permanent or permanent structures in situ with a minimum of tools and support equipment. Representative structures of this type are generally stored and transported to an erection site in a compact form and deployed by unrolling, unfolding or other processes and inflating portions of the structure that take on a deployed shape and configuration on application of a rigidizing media such as compressed air. Exemplary applications of these structures have been deployed to support special events, commercial activities, military operations, and disaster relief operations.

[0004] Disclosed is an inflatable composite structural component comprising a first layer of braided material, at least one intermediate bladder and a second layer of braided material. The first and second layers of braided material include multiple adjacent regions of triaxial or biaxial tow architectures. In particular embodiments, for example, the layers may comprise a first triaxial region adjacent a second biaxial region adjacent a third triaxial region. The outer triaxial regions of the first and second layer of braided fabric are held together with adhesive, stitching, or other means. In certain prior curved air beams, curvature was applied to the braid at the time of braiding "locking" the shape into the structure at the time of braiding with varying length tows around the braid, which had disadvantages in wrinkling of the braid when the deflated structure was laid flat for rolling or folding for transport.

[0005] The first layer of braided fabric is manufactured with a first predetermined bias angle and the second layer of braided fabric is manufactured with a second predetermined bias angle. For structural components deployed as

generally straight structural components the first and second predetermined bias angles are generally equal and equal to a bias hose angle as discussed below. For structural components deployed as curvilinear structural components the layer of braided fabric situated inside the radius of curvature will have a predetermined bias angle less than the braid hose angle and the layer of braided fabric situated outside the radius of curvature will have a predetermined bias angle greater than the braid hose angle.

Brief Description of the Drawings

[0006] FIG. 1 is a partially exploded diagrammatical view of a cross-section through the inflatable composite structural component in a deflated, pre-deployment form,

[0007] FIG. 2 is a diagrammatical plan view of a hybrid braided layer in its lay-flat configuration,

[0008] FIG. 3 is a diagrammatical plan view of a first hybrid braided layer,

[0009] FIG. 4 is a diagrammatical plan view of a second hybrid braided layer,

[0010] FIG. 5 is a partially exploded diagrammatical view of a cross-section through the inflatable composite structural component in an inflated, deployed form,

[0011] FIG. 6 is a partially exploded diagrammatical view of a cross-section through an alternative embodiment of the inflatable composite structural component,

[0012] FIG. 7 is a partially exploded perspective diagrammatical view showing one embodiment integrating the structural component of FIG. 6 into a structural application,

[0013] FIG. 8 is a partial diagrammatical view showing an apparatus used to manufacture one example of the structural component in the alternative embodiment of FIG. 6,

[0014] FIG. 9 is a partially exploded diagrammatical view of a cross-section through a second alternative embodiment of the inflatable composite structural component,

[0015] FIG. 10 shows a diagrammatical view of a rectilinear structure of structural panels utilizing the inflatable composite structural component of FIG. 9,

[0016] FIG. 11 shows a diagrammatical view of a geodesic dome structure of a

variation of the structural panels utilized in the structure of FIG. 10,

[0017] FIG. 12 is a partially exploded diagrammatical view of a cross-section through a third alternative embodiment of the inflatable composite structural component,

[0018] FIG. 13 shows a diagrammatical view of a Quonset-like structure of an embodiment of the structural components manufactured for deployment in curvilinear form,

[0019] FIG. 14 shows a diagrammatical view of the structure of FIG. 13 in a deflated, pre-deployed configuration,

[0020] FIG. 15 shows a diagrammatical view of a Quonset-like structure of an embodiment with a combination of low and high pressure versions of the structural component of the present invention,

[0021] FIG. 16 is a partial perspective diagrammatical view showing a structure combining a plurality of straight and curvilinear structural components of the present invention,

[0022] FIG. 17 is a partial perspective diagrammatical view showing another embodiment of a structure combining a plurality of straight and curvilinear structural components of the present invention, and

[0023] FIG. 18 shows a partially exploded diagrammatical view of a cross-section through yet another alternative inflatable composite structural component.

Detailed Description

[0024] Referring now to FIG. 1, a partially exploded diagrammatical view of a composite structural component 10 is shown in a cross-section transverse to a longitudinal axis of the structural component in the deflated, pre-deployed form, which may be in an as-manufactured configuration. As used in the present description and appended claims, the term “pre-deployed” means the state of the structure and any of its components before application of a rigidizing media. Rigidizing media is defined as a material or means for causing the pre-deployed structure or portions of the pre-deployed structure, for example, one or more of its components, to change shape or configuration facilitating the erection of the structure into an intended as-deployed state or configuration. Examples of rigidizing media include, but are not limited to, compressed gas such as compressed air,

nitrogen, helium, or other gas, pressurized or non-pressurized liquids for example water, glycol, or other liquid, or liquefied or flowable solids for example granular solids and powders and flowable, uncured concrete, and various combinations thereof.

[0025] An inflatable composite structural component is shown in FIG. 1 having a longitudinal first braided material layer 11 and a longitudinal second braided material layer 12 each forming a panel having a width-wise dimension transverse to a length-wise direction of the component bounded by first and second longitudinal edges along the length-wise direction of the component. The first and second braided material layers 11, 12 envelop at least a portion of an inflatable longitudinal bladder 13. The first braided material layer 11 and the second braided material layer 12 each comprise a selected braided material of a predetermined braid architecture. In the embodiment of FIG. 1, the first and second braided material layers 11, 12 are positioned to together surround the intermediate bladder 13 when the bladder is inflated, such as shown in FIG. 5.

[0026] Shown in the cross section in FIG. 1, the first braided material layer 11 is positioned on an inner side of the component on one side of the bladder 13, and the second braided material layer 12 is positioned on an outer side of the component on an opposite side of the bladder 13. The first and second braided material layers 11, 12 are arranged such that the first longitudinal edges 16 of the first and second braided material layers are approximately aligned along a first side 18 of the bladder and the second longitudinal edges 16' of the first and second braided material layers are approximately aligned along a second side 19 of the bladder. As used in the present disclosure and appended claims, the terms align and aligned are not intended to mean perfect alignment, but are used to mean positioned relative to one another within typical manufacturing and assembly variation. The outer longitudinal edges 16 of the first braided material layer 11 and second braided material layer 12 on one side of the component, for example, along the first side 18 of the bladder, are affixed to a joining edge 20 of a first structural panel 15, and the outer longitudinal edges 16' of the first braided material layer 11 and second braided material layer 12 on the opposite side of the component, for example, along the second side 19 of the bladder, are affixed to a joining edge 20 of a second structural panel 15, the connected braided material layers 11, 12 forming an enclosure around the bladder 13. In the partially

exploded view of FIG. 1, in particular embodiments, the layers are affixed together generally where dashed line "A" is shown. The structural panels 15 may be made of textile materials, elastomeric materials, polymeric sheets, materials having a plurality of interlocked solid shapes, and/or combinations thereof.

[0027] In particular embodiments, edger strips 17 are provided affixed to the first braided material layer 11 and the second braided material layer 12 adjacent the joining edges of the structural panels 15 between the first and second braided material layers, each edger strip 17 wrapping partially around the sides 18, 19 of the bladder 13. The edger strips may be used to reinforce the connections between the first and second braided material layers 11, 12 by carrying a portion of the hoop stress in the enclosure around the bladder when the bladder is inflated and applying pressure against the enclosure. In the partially exploded view of FIG. 1, in particular embodiments, the edger strips 17 are affixed to the first and second braided material layers 11, 12 generally where dashed line "B" is shown. The edger strips 17 are affixed to the first braided material layer 11 and the second braided material layer 12 along the mating faces between the braided material layers 11, 12 and the edger strips 17 and/or along the edges of the edger strips 17. The edger strips 17 may be attached to the joining edges of the structural panels 15 before assembly or during assembly to the first and/or second braided material layer for ease of handling and assembly. The edger strips 17 are generally folded in the pre-deployed configuration enclosing the outer sides 18, 19 of the bladder 13.

[0028] The bladder 13 is typically an elongated balloon-like container providing a gas barrier configured for inflating and deflating in the structural component. More generally, the bladder is a container configured for filling and retaining rigidizing media in the structural component, and for certain rigidizing media, the bladder may be configured to be emptied of its contents for deflating or breaking-down the structure. The bladder may be made from a material such as natural or synthetic rubber, thermoplastic elastomers, thermoset polymers, or other material as desired for the application.

[0029] A braided material typically includes three or more strands of material, commonly called tows, such that each tow is intertwined with other tows in a repeating pattern. Two-dimensional braided materials are those wherein the repeating pattern is largely characterized by two or more principal directions in a

plane, typically a longitudinal or axial direction of the braided fabric, and one or more oblique directions, commonly called bias directions, bias directions being a predetermined angle to the longitudinal direction. Three-dimensional braided materials are those wherein additional principal directions, typically being perpendicular to the longitudinal and oblique directions, are used to define the structure and the patterns thereof. For simplicity of description these additional directions are generically referred to as radial directions, whether the structure is generally tubular in form, laid out as a flattened tubular form or in a fabric, or generally planar, form.

[0030] Two-dimensional braided materials may be manufactured as generally cylindrical materials, commonly called sleeves, with the axial direction corresponding to the longitudinal axis of the cylinder and the bias directions oblique to and measured from the longitudinal axis. Braided materials manufactured in cylindrical form may then be laid flat to form a two-dimensional fabric having two layers joined along the longitudinal edges. The longitudinal edges may be cut to form two separate and distinct layers, commonly called a double-slit two layer fabric. Alternatively, one edge may be cut and the cylindrical fabric unfolded to form a singly-slit single layer fabric. Instead of a cylindrical form, two-dimensional braided materials may also be manufactured in a single layer flat form, commonly called a tape.

[0031] In this disclosure reference to braided fabric is generally directed to two-dimensional fabric forms but one skilled in the art recognizes that three-dimensional braided materials may be used in particular embodiments of the present invention as desired to satisfy requirements of particular applications.

[0032] The terms "strand", "tow", "yarn", "yarn bundle", "fiber" and "fiber bundle" are generally meant to describe what is laid into or intertwined in each of the principal directions of a braided fabric. In this disclosure the term "tow" will generally be used to describe what is laid into or intertwined in each of the principal directions of a braided fabric. A tow is an amalgamation of all material that runs together in a principal direction. A tow can comprise monofilaments, multiple filaments or comprise staple, or spun, material. Tow material can have a variety of cross-sectional shapes, including but not limited to, generally circular, ellipsoidal, triangular and flat tape shapes. Tow material may be subject to intermediate or pre-

processing prior to braiding operations. Examples of intermediate or pre-processing may include, but are not limited to, twisting, braiding small numbers of filaments into braided tow materials, pre-impregnation with resins and specialty coating to facilitate braiding and/or subsequent processing. A tow can comprise any combination of these materials and material forms. A tow may comprise one or more than one filament or staple materials. As non-limiting examples, a tow may include carbon materials, basalt, glass materials, thermoplastic polymeric materials, thermoset polymeric materials, a combination of carbon and polymeric materials or a combination of polymeric and glass materials, or some combination thereof. Tows that lay in one of the bias directions of the fabric are commonly called bias tows, identified in FIG. 2 as bias tows 24. Tows that lay in the axial direction of the fabric are commonly called axial or longitudinal tows, identified in FIG. 2 as axial tows 25.

[0033] Biaxial braid typically includes only bias tows. Triaxial braid typically includes both bias and axial tows. Hybrid braided fabrics are contiguous materials having regions of biaxial braid and regions of triaxial braid, the regions typically in a desired arrangement.

[0034] In particular embodiments, the first braided material layer 11 and second braided material layer 12 are made of a hybrid braided fabric of contiguous material having a plurality of adjacent regions of triaxial and biaxial tow architectures. FIG. 2 shows an embodiment of the present invention in which the first and second braided material layers 11, 12 have a first triaxial region 21 adjacent to a biaxial region 22 which is adjacent to a triaxial region 23.

[0035] The triaxial region 21 and triaxial region 23 of the braided material layer of FIG. 2 provide stable regions adjacent the longitudinal edges 16 for connecting the layers to the structural panels 15. Means for affixing the braided material layers 11, 12 to the structural panels include, but are not limited to, adhesives applied to the material layers and /or structural panels, adhesive materials and/or coatings incorporated with the axial tows in triaxial regions, polymeric welding, stitching, ties, knots, mechanical fasteners, for example snaps, rivets, studs, grommets, bolt-and-nut fasteners, and/or any other fastening system for connecting the braided material layers to the structural panels.

[0036] The first layer of braided material is manufactured with a first predetermined bias angle and the second layer of braided material is manufactured

with a second predetermined bias angle. For structural components deployed as straight structural components the first and second predetermined bias angles are generally equal and equal to the bias hose angle, as defined below. For structural components deployed as curvilinear structural components the layer of braided material situated inside the radius of curvature will generally have a predetermined bias angle less than the braid hose angle and the layer of braided material situated outside the radius of curvature will have a predetermined bias angle greater than the braid hose angle. Referring now to FIG. 3, a braid hose angle is the angle between the longitudinal direction of the braid 33 and a resultant force vector 34 obtained from the hoop and tensile forces applied to the braided material. The hose angle, also called the neutral angle, is the angle where the fibers are loaded only by tensile forces. When the bias angle is greater or less than the hose angle, unrestrained fibers under load tend to relocate such that the braided bias angle increases or decreases until the fibers are along the hose angle. The hoop and tensile forces applied to the braided material may be determined empirically or may be a design load that the system is expected to support. Additionally, biaxial braided materials may move under application of external forces and such movement can affect an increase or decrease in the bias angle. In general applications of braided materials subject to pressures exerted within an enveloped interior region, biaxial braids increase or decrease in diameter while inversely decreasing or increasing in longitudinal length. As such, the bias angles of the braid as manufactured prior to loading may be greater than or less than the bias angle desired when the component is under load as desired for the application. In particular embodiments, the bias angle is a function of the braid hose angle.

[0037] FIG. 3 is a schematic of the braid architecture of braided material layer 11. The first braided material layer 11 is manufactured bias tows 35 having a first bias angle 31. The first bias angle 31 has a predetermined relationship to the first braid hose angle 32.

[0038] Triaxial regions 21, 23 include axial tows 25 tending to inhibit the motion of the bias tows 24 thereby maintaining an approximately constant diameter and length under application of external forces.

[0039] To provide straight structural elements when the structural components are deployed, the first bias angle 31 is predetermined to be approximately the same

as the first braid hose angle 32 when the deployed structural component is under its design load.

[0040] To provide curved structural elements when the structural components are deployed, the first bias angle 31 is predetermined to be either less than or greater than first braid hose angle 32 when the deployed structural component is under its design load. The relationship between first bias angle 31 and first braid hose angle 32 is predetermined based on the relative position of braided material layer in the as-deployed structure. When the first braided material layer 11 in the as-deployed structure has a radius of curvature generally less than the radius of curvature of the neutral axis of the structural component, the first bias angle 31 will be a predetermined angle less than the braid hose angle 32. Under application of pressure exerted by the bladder in the as-deployed state, biaxial regions of the braided material layer will tend to decrease in length. When the first braided material layer 11 in the as-deployed structure has a radius of curvature generally greater than the radius of curvature of the neutral axis of the structural component, the first bias angle 31 will be a predetermined angle greater than the braid hose angle 32. Under application of pressure exerted by the bladder in the as-deployed state, biaxial regions of the braided layer will tend to increase in length. More particularly, as an example, the braid hose angle is determined to be about 55 degrees. In that example, the layer positioned with a radius of curvature greater than the radius of curvature of the neutral axis of the structural component had a bias angle of 65 degrees, and the layer positioned with a radius of curvature less than the radius of the neutral axis had a bias angle of 45 degrees. Braids of various cross-sectional shapes may have a braid hose angle that is greater or less than 55 degrees, such as between about 52 and 57 degrees. For various applications, the difference between the higher-radius bias angle and the braid hose angle may be the same as the difference between the lower-radius bias angle and the braid hose angle, such as 10 degrees in the particular exemplary embodiment. However, in other embodiments, the difference between the higher-radius bias angle and the braid hose angle may be different than the difference between the lower-radius bias angle and the braid hose angle. In one embodiment having a sleeve with a generally circular cross-section, the braid hose angle is 54.7 degrees. In this example, the layer positioned with a radius of curvature greater than the radius of the neutral axis has a bias angle of 65 degrees, and the

layer positioned with a radius of curvature less than the radius of the neutral axis has a bias angle of 40 degrees.

[0041] Similarly, as shown in schematic form in FIG. 4, second braided material layer 12 is manufactured with a second bias angle 41 with a predetermined relationship to second braid hose angle 42. Generally, for as-deployed structures in which the structural component is deployed in curvilinear form, when the second braided material layer 12 in the as-deployed structure has a radius of curvature generally less than the radius of curvature of the neutral axis of the structural component, the second bias angle 41 will be a predetermined angle less than the second braid hose angle 42. And, when the second braided material layer 12 in the as-deployed structure has a radius of curvature generally greater than the radius of curvature of the neutral axis of the structural component, the second bias angle 41 will be a predetermined angle greater than the second braid hose angle 42.

[0042] In FIG. 5, the structural component 10 is shown in transverse cross-section in the as-deployed state as affected by application of rigidizing media in the interior 51 of the enclosure formed by the connected first and second braided material layers 11, 12 around the bladder 13. In an embodiment of the present invention, the circumference of bladder 13 is greater than the perimeter of the enclosure around the interior 51 thereby limiting internal stresses within the walls of the bladder. Additionally, the pressure applied by the rigidizing media to the materials is predetermined to be low to reduce forces on the affixation of the edge strips 17 to the structural panels 15 and the affixation of the first and second braid materials to the structural panels 15. Additionally, the separate affixations of first braided material layer 11 and second braided material layer 12 to structural panels 15 provide an alternate load path for pressure-induced forces that guide those forces around the affixation of edge strips 17 to the structural panels 15 and into structural panels 15.

[0043] FIG. 6 is an embodiment of the present invention in which the composite structural component 10a is manufactured as an integral component which can be supplied and deployed independently of other elements of the intended structure, being affixed to some of those elements in situ. In this embodiment, the first braided material layer 11 and second braided material layer 12 are affixed to one another along their longitudinal edges to form attachment ridges 61. The first braided material layer 11 and the second braided material layer 12 form an enclosure around

the bladder 13 similar to the embodiment in FIG. 1. The composite structural component 10a may include reinforcement strips 62 as shown in FIG. 6 to reduce shear forces on the affixation of the first braided material layer 11 to the second braided material layer 12, as discussed above with reference to edger strips 17 in FIG. 1. In particular embodiments, the reinforcement strips 62 are affixed to the first braided material layer 11 and the second braided material layer 12 along the mating faces between the braided material layers 11, 12 and the reinforcement strips 61 and/or along the edges of the reinforcement strips 62. In particular embodiments, the reinforcement strip 62 are affixed to the first and second braided material layers 11, 12 generally where dashed line "B" is shown in FIG. 6.

[0044] FIG. 7 shows one example of affixing the as-deployed composite structural component 10a of FIG. 6 into its structure. Snaps 71 affixed to attachment ridges 61 or embedded within attachment ridges 61 are juxtaposed with mating features in structural panels 15. Other means for affixing the structural component to the structure may be used. Means for affixing the braided material layers 11, 12 to the structure include, but are not limited to, adhesives applied to the material layers and/or attaching structure, adhesive materials and/or coatings incorporated with the axial tows in triaxial regions, polymeric welding, stitching, ties, knots, mechanical fasteners, for example snaps, rivets, studs, grommets, bolt-and-nut fasteners, and/or any other fastening system for connecting the braided material layers to the structural panels.

[0045] The embodiment of FIG. 6 may be manufactured by a similar process to that of FIG. 1. For structural components 10a to be deployed as straight structural elements the relationship between first bias angle and first braid hose angle is equivalent to the relationship between second bias angle and second braid hose angle as discussed above with reference to FIGS. 3 and 4, thereby enabling simplified manufacture of structural components 10a. Structural components 10a may be manufactured with the apparatus shown in FIG. 8 wherein a hybrid sleeve 81 with largely biaxial regions and diametrically opposed triaxial regions 82 is formed over a shaped mandrel 83, the mandrel shaped to form the sleeve to partial lay-flat in the triaxial regions, affecting affixation of the inner surfaces of the triaxial regions to one another with affixation means such as a heater 84 to heat an adhesive in the braid while feeding the bladder 13 into the interior space of the sleeve as the sleeve is

further guided into a lay-flat configuration 85 encompassing the intermediate bladder. Means for affixing the braided material layers to the structure are applied for integration of the structural components into the intended structures. In other embodiments, the means for affixing the braided material layers could any other fastening system as discussed above, and the apparatus for implementing said attachment means provided accordingly as known to those skilled in the art. For example, in particular embodiments the means for affixing the braided material layers to the structure is by stitching, and the apparatus such as shown in FIG. 8 would use a sewing apparatus instead of a heating apparatus (84). In various embodiments, as the formed component is guided to the lay-flat configuration 85, a guide (not shown) may be provided to smoothly transition the component to its lay-flat shape.

[0046] FIG. 9 is an alternate embodiment of the present invention encompassing features of the embodiments of FIG. 1 and FIG. 6. In this embodiment, the structural component 10b includes one edge of the first braided material layer 11 and the corresponding edge of the second braided material layer 12 affixed to the joining edge 20 of the structural panel 15 as discussed with reference to the embodiment of FIG. 1. In particular embodiments, the layers being affixed together generally where dashed line "A" is shown in FIG. 9. The diametrically opposed edges of the first braided layer 11 and the second braided layer 12 are affixed to one another as discussed with reference to the embodiment of FIG. 6 to form the attachment ridge 61. A reinforcement strip 62 may be affixed to the first braided material layer 11 and the second braided material layer 12 adjacent the attachment ridge 61 along the mating faces between the braided material layers 11, 12 and the reinforcement strip 62 and/or along the edges of the reinforcement strips 62. In particular embodiments, the reinforcement strip 62 are affixed to the first and second braided material layers 11, 12 generally where dashed line "B" is shown in FIG. 9. This embodiment provides edge-reinforced panels that can be deployed as panels and attached to a structure in situ.

[0047] FIG. 10 shows an example structure 101 comprising a frame 102 onto which panel components 103 are to be affixed. Panel components 103 include structural components 10b connected to structural panels 15 as depicted in FIG. 9.

[0048] FIG. 11 shows a geodesic dome structure 111 comprised of an alternate

embodiment of the panel component 103 depicted in FIG. 10 wherein the panel component construction is modified to form geodesic dome panel components 113. The geodesic dome panel components can be affixed to a rigid frame as in the structure of FIG. 10 or can include the alternate embodiment of the present invention depicted in FIG. 12. In the embodiment of FIG. 12, a structural component 10c is provided as described with reference to FIG. 6 or FIG. 9, with the additional feature that one longitudinal edge 121 of the structural component is shaped to allow insertion of one or a plurality of reinforcement rods into a sleeve 123 along the length of the structural component 10c. In one embodiment, not shown, the sleeve 123 is provided along two longitudinal edges 121 of the structural component. The sleeve 123 may be formed by connecting the edges of the first and second braided material layers making a loop forming the sleeve 123. The first and second braided material layers may include a longitudinal seam adjacent the loop reinforcing the sleeve. Alternatively, the first and second braided material layers may be integral, folded over making a loop forming the sleeve, which may further include a longitudinal seam adjacent the loop reinforcing the sleeve. Alternatively, a separate sleeve 123 may be affixed to the first and/or second braided material layers.

[0049] By varying the relationship of bias angle to braid hose angle in the first braided material layer 11 relative to that in second braided layer 12 the embodiments of FIG. 1, FIG. 6 and FIG 9 and other embodiments disclosed herein can be manufactured to deploy in a curvilinear form when provided with a rigidizing media. As such the configuration of the structure of FIG. 10 and other structures constructed utilizing the present invention is not limited to rectilinear shapes.

[0050] For structures utilizing a separate support frame, structural components of the present invention can be deployed utilizing low pressure rigidizing media, *e.g.* about 0.5 to 2 psi. For higher pressure applications, it may be desired to reinforce the bladder with a braided sleeve. In particular embodiments, the bladder may comprise a braided sleeve surrounding the bladder or embedded into the bladder. In one example, the braid-reinforced bladder comprises a biaxial braided sleeve embedded in an elastomeric matrix. In an alternative embodiment, a braided sleeve is impregnated with an elastomeric solution that is cured to form the bladder. By utilizing a braid-reinforced bladder, the pressure of the rigidizing media can be increased substantially thereby enabling structures to be constructed without

separate support frames. In particular embodiments, the braid-reinforced bladder enables pressure in the component between about 2 and 10 psi.

[0051] FIG. 13 shows a Quonset-like structure 131 with a curvilinear form of the structural component. The structure 131 of FIG. 13 includes components 10 as shown in FIG. 1 along central spans and components 10b as shown in FIG. 9 for edge spans. For particular applications, the Quonset-like structure 131 may benefit from utilizing a braid-reinforced sleeve with higher inflation pressure, for example, between 4 and 6 psi. The curvilinear form of the present structural component has an advantage that the curvature is an affect of deployment due to the varying relationships between the bias angle and braid hose angles of multiple braider material layers. As such the deflated structural components can be laid flat and rolled for transport without significant distortion of the braided tows, and deployed into curvilinear form.

[0052] A further advantage of the present invention is that the radius of curvature of a specific structural component can be varied in situ by varying the pressure of the rigidizing media to control the amount of scissoring within the biaxial regions of the braided material layers thereby controlling the relative differences in changes in length of the bias regions.

[0053] FIG. 14 shows the structure of FIG. 13 in its pre-deployed state 141. The structure can be rolled on completion of manufacture, transported to the deployment site, un-rolled into the pre-deployed state of FIG. 14 and formed into the structure of FIG. 13 by application of the rigidizing media.

[0054] A method of constructing an inflatable structure, for example as depicted in FIGS. 13-14, may include forming components 10 as discussed above with reference to FIG. 1 for inflatable components along central spans and components 10b as discussed above with reference to FIG. 9 for inflatable components along the edges of the structure. The method may include steps of applying regularly spaced longitudinal strips of first braided material layer (reference 11 in FIGS. 1 and 9) to a fabrication surface, each first braided material layer having a width-wise dimension transverse to a length-wise direction of the layer bounded by first and second longitudinal edges along the length-wise direction of the layer. Longitudinal structural panels 15 having a joining edge on each longitudinal side are then positioned between the strips of first braided material layer with the joining edges

overlapping with adjoining first braided material layer. The structural panels may include edger strips (reference 17 in FIGS. 1 and 9) pre-affixed along the longitudinal sides of the structural panels as discussed above with reference to FIG. 1. Structural panels 15 may be affixed to the first braided material layers at this time by, for example, but not being limited to, rolling application of adhesive, adhesive tapes, application of heat to melt adhesive incorporated into the triaxial regions of first braided material layers or by polymeric welding. Bladders (reference 13 in FIGS. 1 and 9) are then laid along the first braided material layers with the edges of the bladders situated such that the edger strips, if present, wrap around the edges of the bladder. Strips of second braided material layer (reference 12 in FIGS. 1 and 9) corresponding to each first braided material layer are then laid over the bladders arranged such that longitudinal edges of the second braided material layer overlap with adjoining joining edges of the structural panels. The strips of second braided material layer may then be bonded to the structural panels 15. Alternatively, the affixation of first braided material layers and second braided material layers to the structural panels 15 may be accomplished at the same time, and may be performed in a single operation. This construction method may be utilized to produce structures with straight structural components, curvilinear structural components, and combinations thereof.

[0055] The construction method may be semi-automated or fully automated utilizing using conventional composite tape layup methods.

[0056] FIG. 15 shows a structure 151 constructed with a combination of curvilinear structural components 152 and a plurality of connecting structural components 153 arrayed as purlins. In particular embodiments, the curvilinear components 152 may be high-pressure components as discussed above. In various embodiments, the connecting components 153 are high-pressure or low-pressure as desired for the application.

[0057] FIGS 16-17 show straight and curvilinear structural components combined in a structure. In FIG 16, straight structural component 161 is affixed end-to-end to curvilinear structural component 162 which is affixed at its opposing end to curvilinear structural component 163. The relationships between first and second bias angles and braid hose angles in structural component 162 and structural component 163 are predetermined to affect varying degrees of curvature at different

positions in the as-deployed structure. Alternately, the two curvilinear structural components 172 in FIG. 17 utilize the same relationship between first and second bias and braid hose angles but small differences in as-deployed curvature are affected by variations in rigidizing media or variations in the pressure applied by rigidizing media.

[0058] FIG. 18 shows a partially exploded diagrammatical view of another alternative embodiment of an as-deployed structural component of the present invention in which either the first braided material layer 11 or the second braided material layer 12, or both, is replaced by two or more braided material layer segments 181. In the embodiment shown in FIG. 18, the first braided material layer 11 is replaced by two braided material layer segments 181 each affixed to a structural panel 15 along one longitudinal edge and affixed to the second braided material layer 12 along the opposite longitudinal edge. In the partially exploded view of FIG. 18, in particular embodiments, the segments 181 are affixed to the panel 15 generally where dashed line "A" is shown. The affixation of the braided material layer segments 181 to second braided material layer 12 forms attachment ridges 182, similar to the attachment ridges 61 described with reference to FIG. 6, which provide attachment means along the inside of the structure. In various applications, the attachment means 182 provide additional attachment points for additional structural elements, such as, for example, panels of acoustic or insulating foam. In particular embodiments, the reinforcement strip 62 may be provided affixed to the second braided material layer 12 and braided material layer segments 181 generally where dashed line "B" is shown in FIG. 18.

[0059] In yet another alternative embodiment of the present invention, a plurality of bladders run adjacent to one another through the structural component along the full length of the component. Another alternate embodiment includes a plurality of bladders running adjacent to one another through the structural component along less than the full length, or alternatively, a plurality of bladders that run end to end through the structural component. A third alternative embodiment includes combinations of the two configurations of bladders. In each embodiment, varying pressures of rigidizing media may be applied to affect the shape and structural rigidity of the structure.

[0060] An alternate embodiment of the present invention comprises the first

braided material layer and the second braided material layer each incorporating an additional triaxial region in the center of the biaxial region. The triaxial region in the first braided material layer is affixed to the triaxial region of second braided material layer such that two interior spaces are formed thereby creating a figure-eight as-deployed transverse cross-sectional shape of the structural component.

[0061] Further alternate embodiments include, but are not limited to, first and second braided material layers embedded in elastomeric matrices to provide a protective or decorative function, multiple layers of braided material in place of each first and second layer of braided material and structural components that deploy into partial toroidal shapes for columnar structures.

[0062] In addition to use of the structural component of the present invention in structures, the invention has expected utility in variable rigidization of airfoil structures to affect changes in lift corresponding to the conditions of wind or to deploy temporary modifications to airfoil structures to affect lift or flight characteristics. Further, such utility may be used to vary drag on high-speed trains or on vehicles to affect performance under varying environmental conditions.

[0063] While the above subject matter has been illustrated and described in detail in the drawings and foregoing discussion, the same is to be considered as illustrative and not restrictive in character, it being understood that exemplary embodiments have been shown and described and that all changes and modifications that come within the spirit of the invention are desired to be protected by the appended claims and equivalents thereof.

What is claimed is:

1. An inflatable structural component comprising a longitudinal first braided material layer and a longitudinal second braided material layer each forming a panel having a width-wise dimension transverse to a length-wise direction of the component bounded by first and second longitudinal edges along the length-wise direction of the component, the first and second braided material layers enveloping at least a portion of an inflatable longitudinal bladder, the first and second braided material layers arranged such that the first longitudinal edges of the first and second braided material layers are approximately aligned and connected together along a first side of the bladder and the second longitudinal edges of the first and second braided material layers are approximately aligned and connected together along a second side of the bladder.
2. The structural component as claimed in claim 1, further comprising a first reinforcing strip affixed to the first braided material layer and the second braided material layer along the first side of the bladder and a second reinforcing strip affixed to the first braided material layer and the second braided material layer along the second side of the bladder.
3. The structural component as claimed in claim 1, further comprising a first structural panel having a first joining edge affixed to the aligned first longitudinal edges.
4. The structural component as claimed in claim 1, further comprising a second structural panel having a second joining edge affixed to the aligned second longitudinal edges.
5. The structural component as claimed in claim 1, further comprising a sleeve affixed to the first braided material layer and the second braided material layer along the first side of the bladder.
6. The structural component as claimed in claim 5, where the sleeve is integral to the first braided material layer, the second braided material layer, or both.

7. The structural component as claimed in claim 1, where the first braided material layer comprises a biaxial braid having a predetermined bias angle as a function of a braid hose angle.
8. The structural component as claimed in claim 1, where the bladder comprises a braided sleeve embedded in an elastomeric matrix.
9. An inflatable structural component comprising a longitudinal first braided material layer and a longitudinal second braided material layer each forming a panel having a width-wise dimension transverse to a length-wise direction of the component bounded by first and second longitudinal edges along the length-wise direction of the component, the first and second braided material layers enveloping at least a portion of an inflatable longitudinal bladder, the first and second braided material layers arranged such that the first longitudinal edges of the first and second braided material layers are approximately aligned along a first side of the bladder and the second longitudinal edges of the first and second braided material layers are approximately aligned along a second side of the bladder, and a first structural panel having a first joining edge affixed to the aligned first longitudinal edges.
10. The structural component as claimed in claim 9, further comprising an edger strip affixed to the first joining edge of the first structural panel between the first and second braided material layers wrapping partially around the first side of the bladder.
11. The structural component as claimed in claim 10, where the edger strip is folded enclosing an outer edge of the first side of the bladder in a pre-deployed configuration.
12. The structural component as claimed in claim 9, further comprising a second structural panel having a second joining edge affixed to the aligned second longitudinal edges.
13. The structural component as claimed in claim 12, further comprising

an edger strip affixed to the second joining edge of the second structural panel between the first and second braided material layers wrapping partially around the second side of the bladder.

14. The structural component as claimed in claim 13, where the edger strip is folded enclosing an outer edge of the second side of the bladder in a pre-deployed configuration.
15. The structural component as claimed in claim 9, where the first braided material layer comprises a biaxial braid having a predetermined bias angle as a function of a braid hose angle.
16. The structural component as claimed in claim 1, where the bladder comprises a braided sleeve embedded in an elastomeric matrix.

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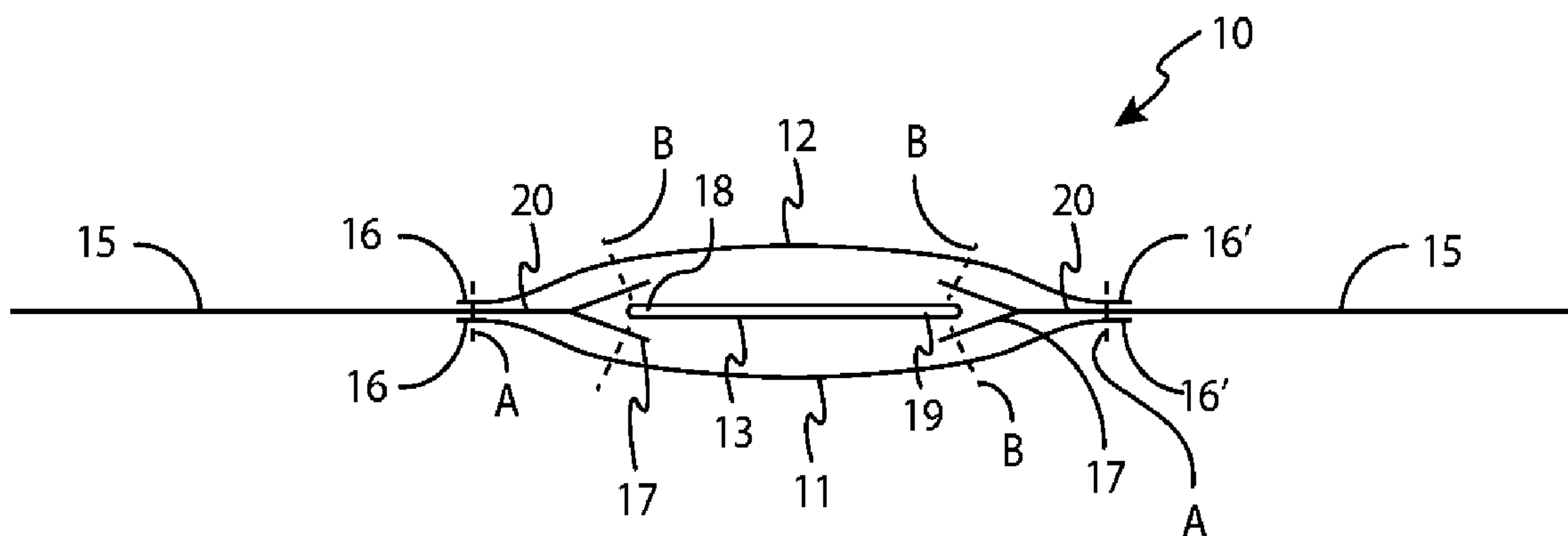


FIG. 1

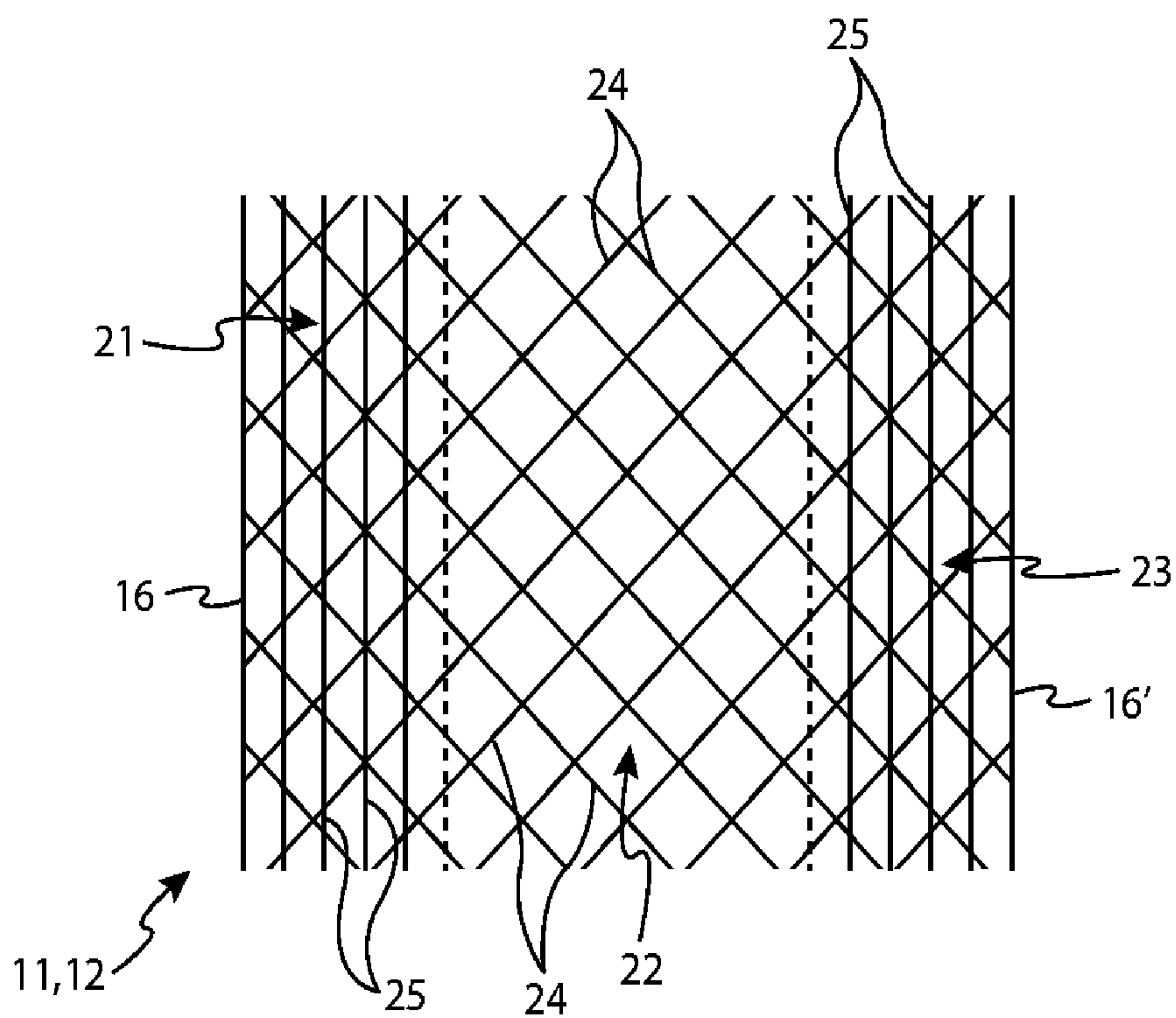


FIG. 2

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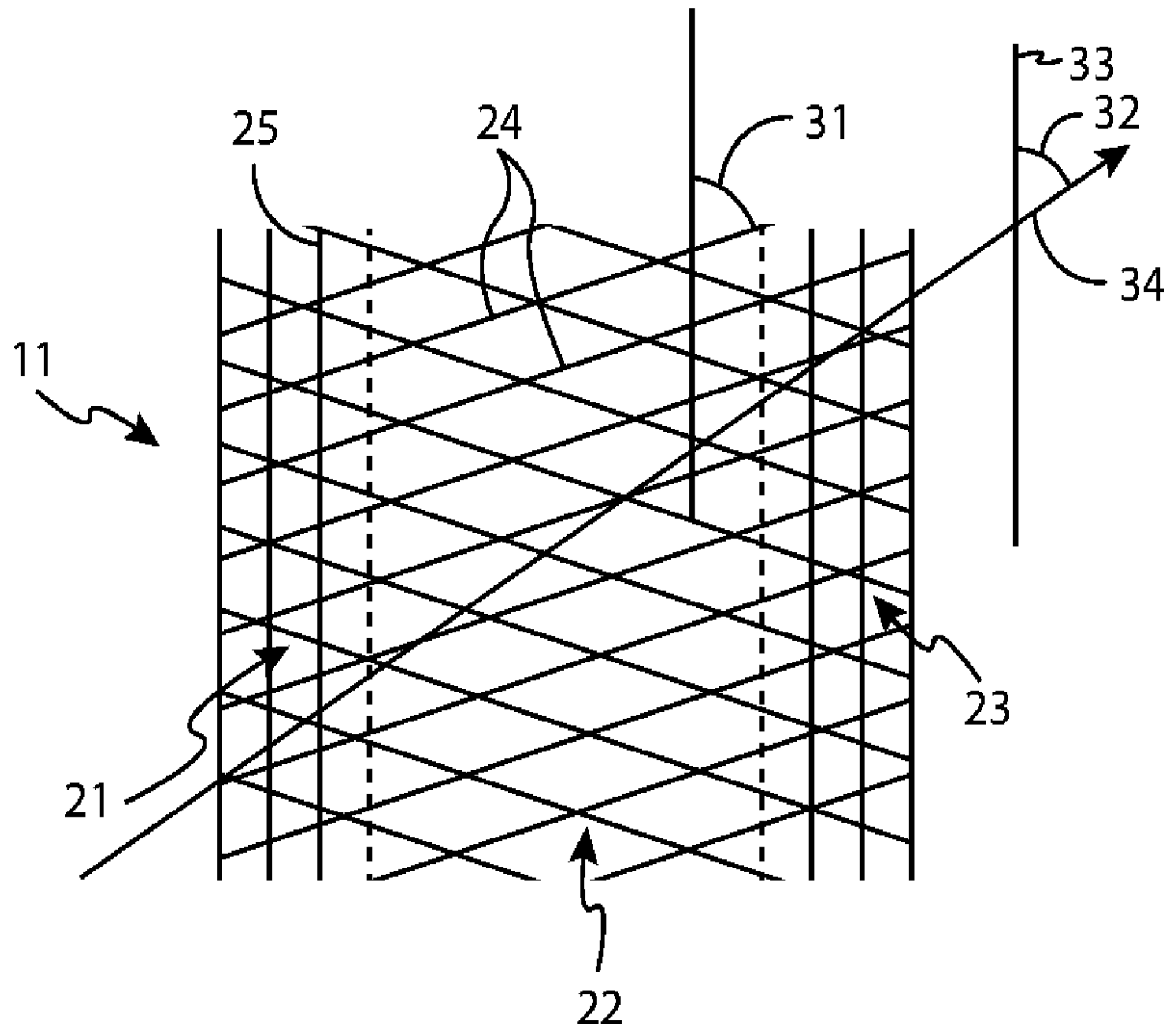


FIG. 3

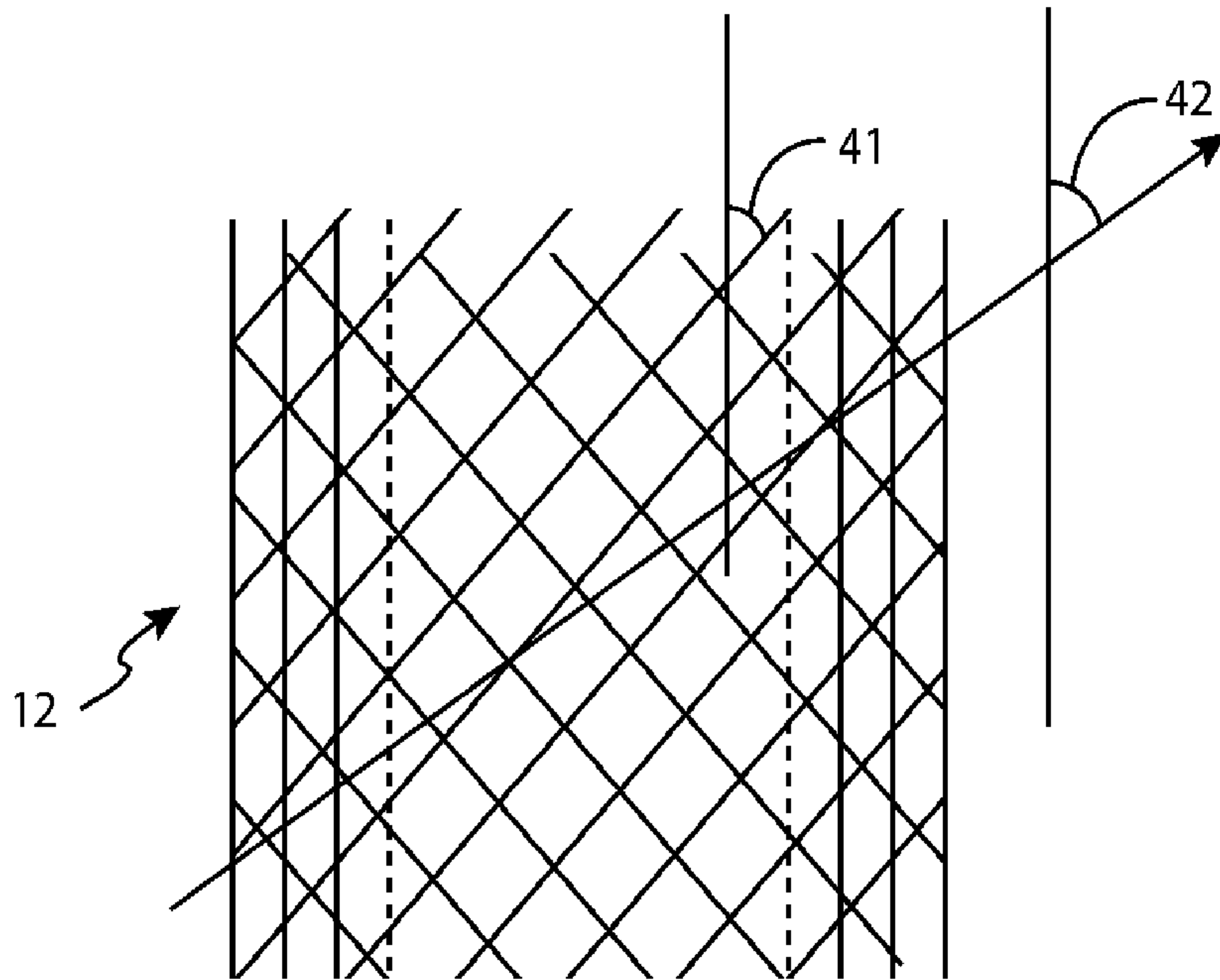


FIG. 4

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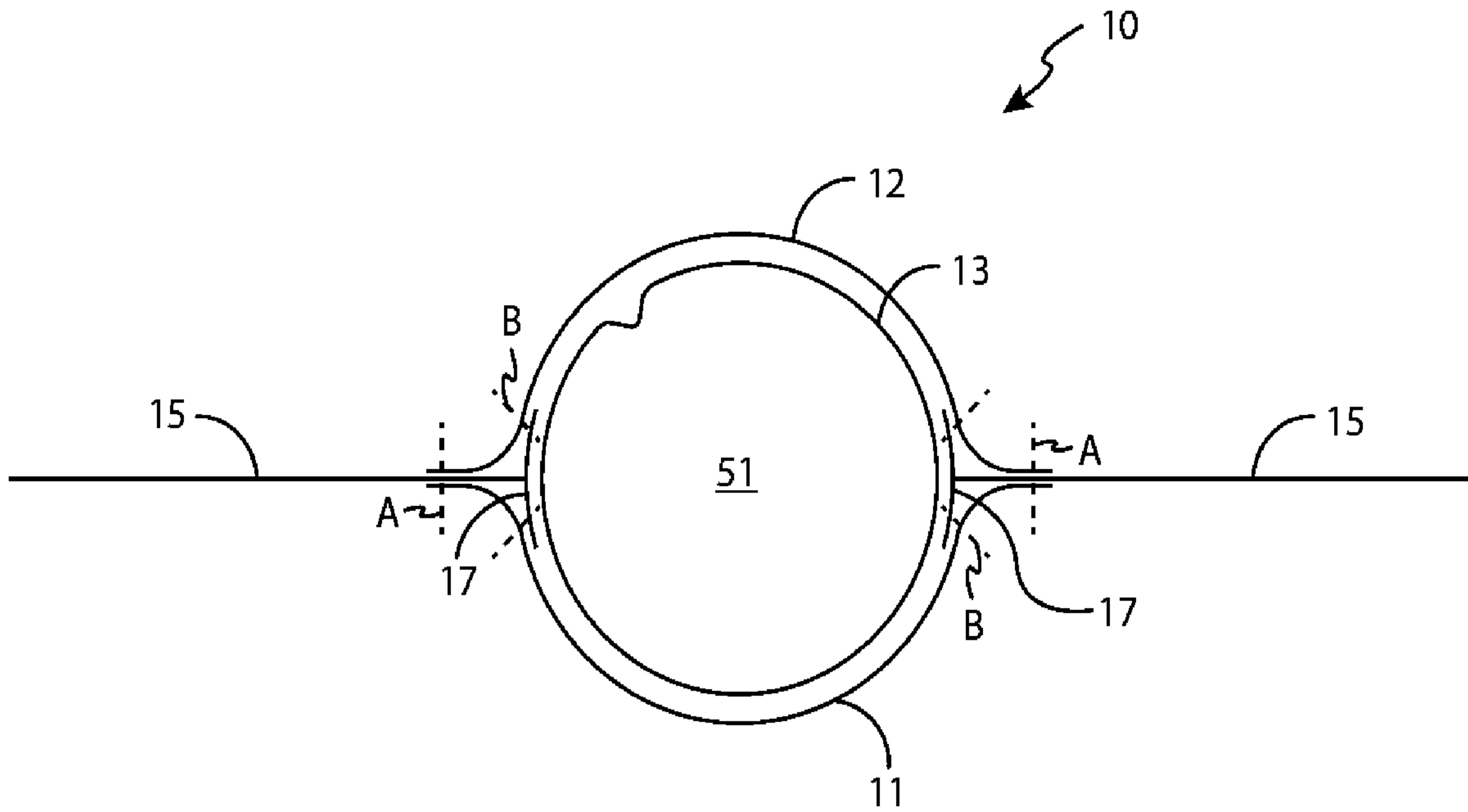


FIG. 5

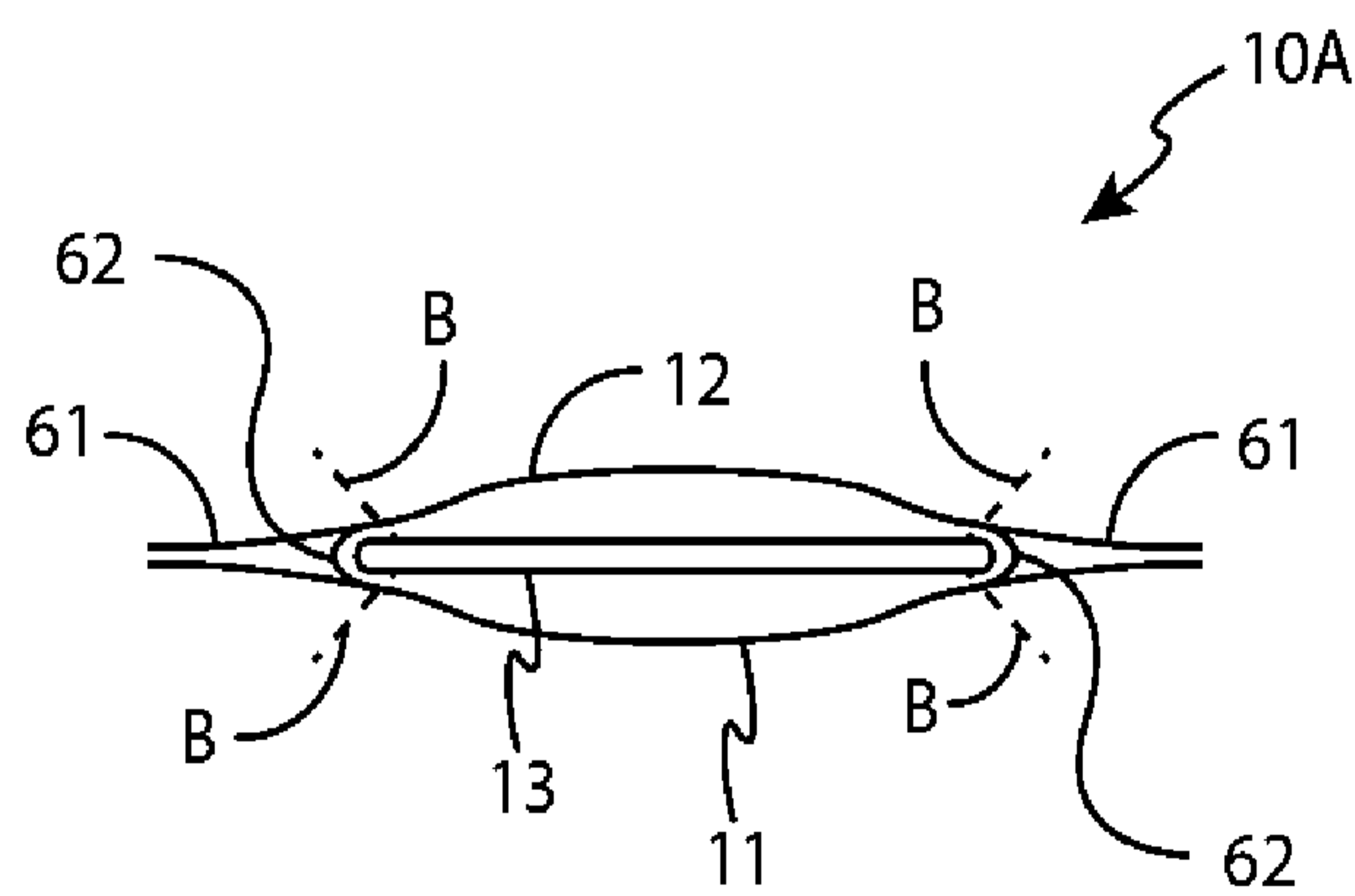


FIG. 6

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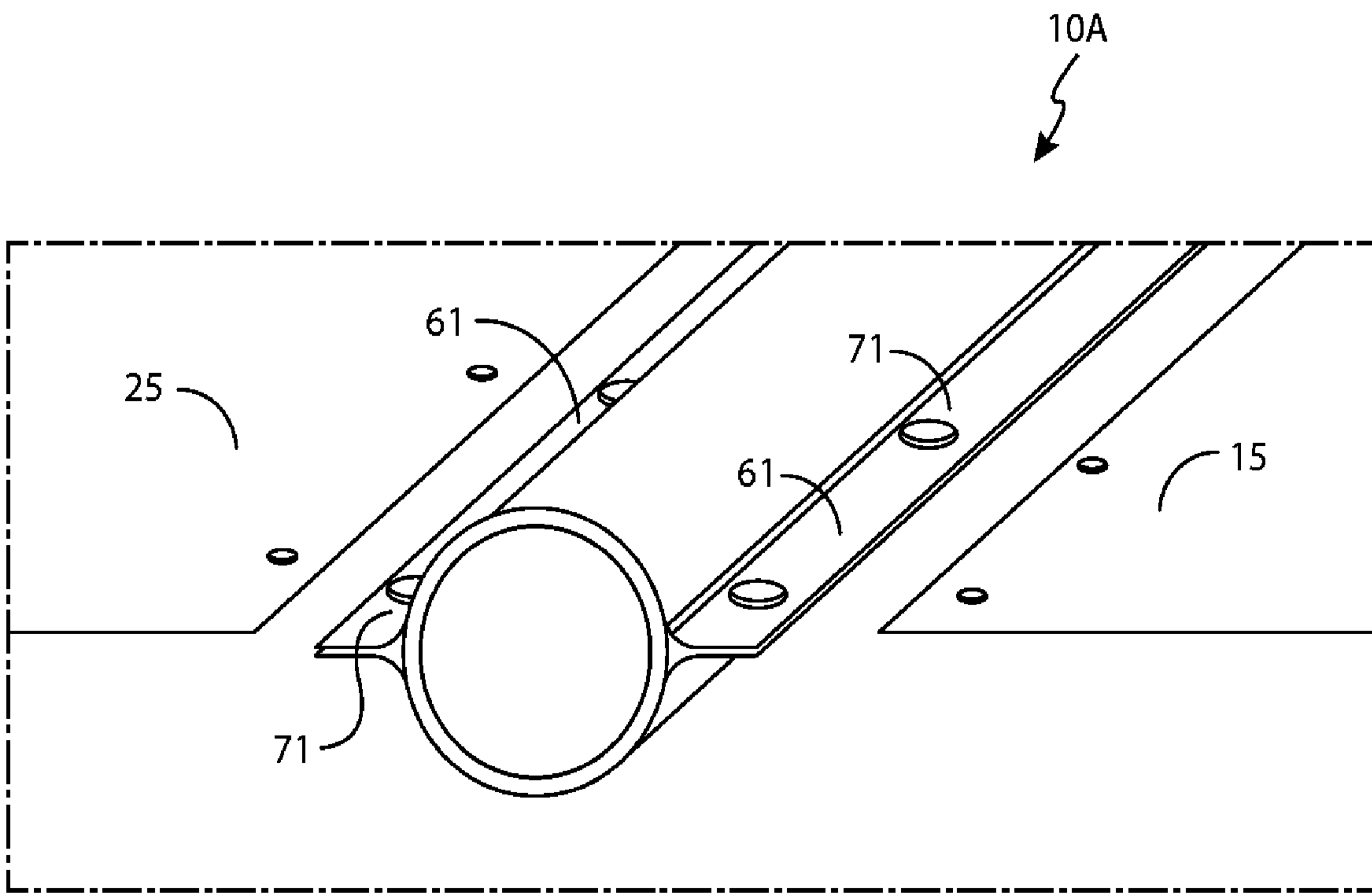


FIG. 7

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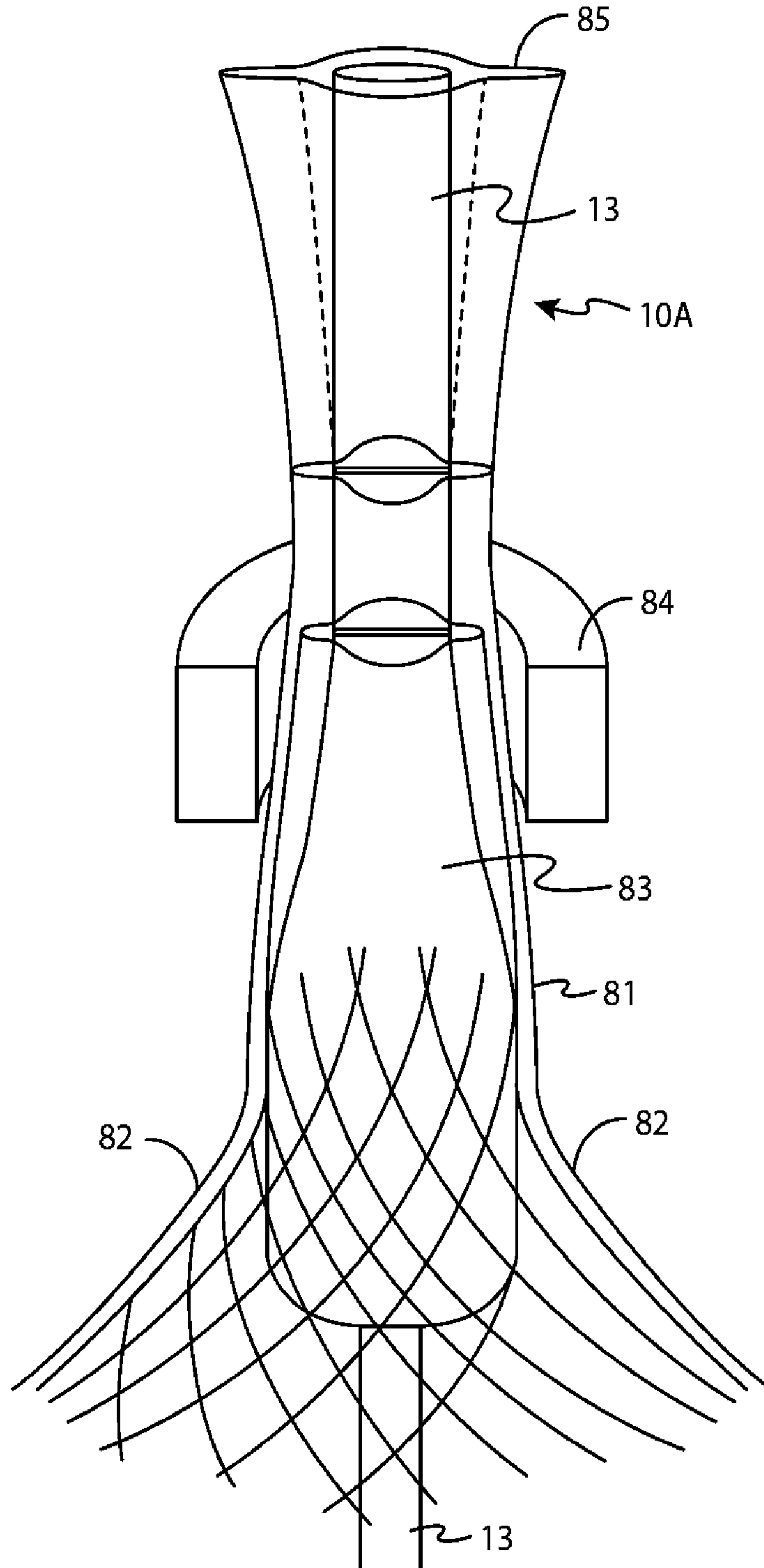


FIG. 8

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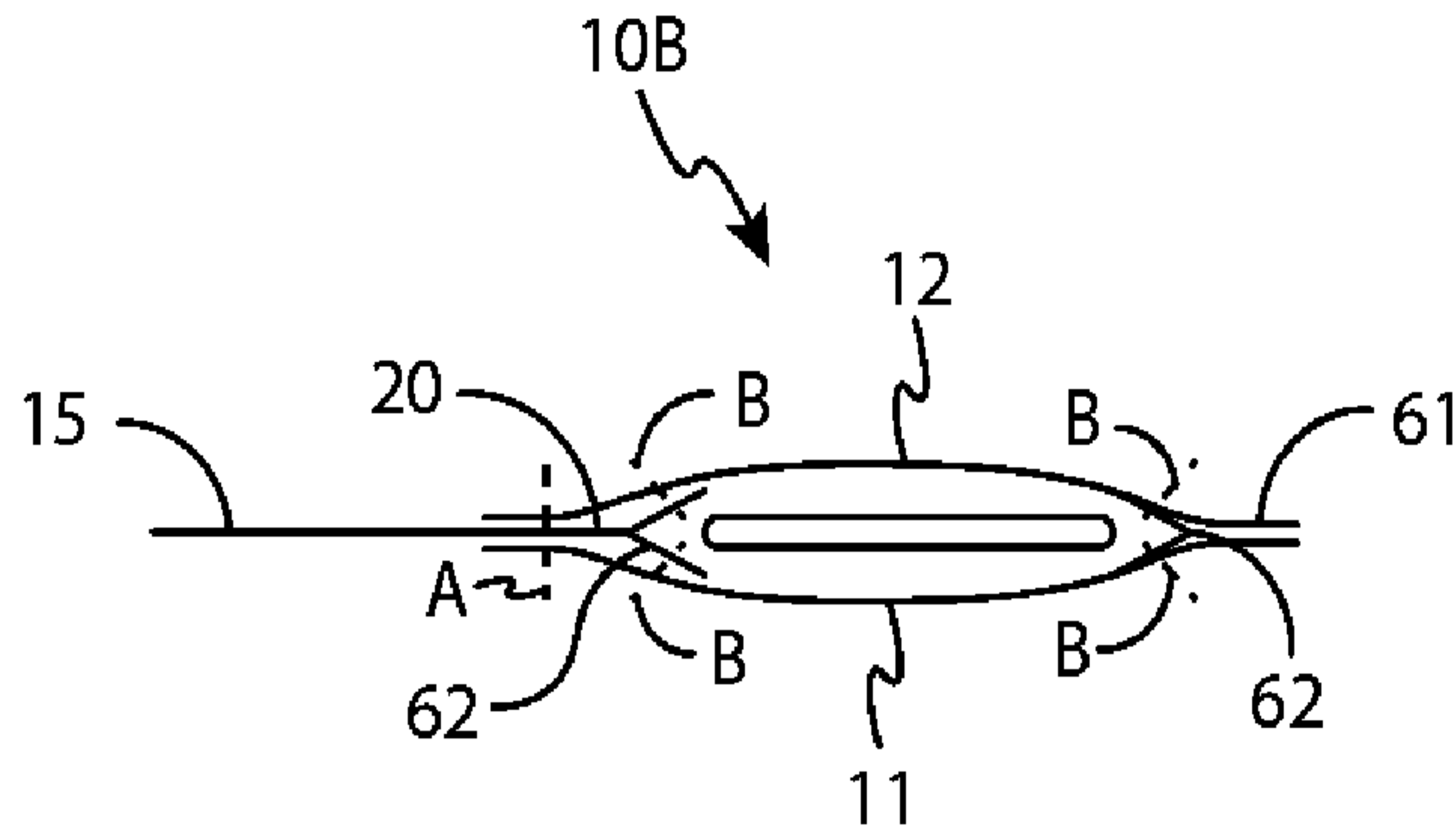


FIG. 9

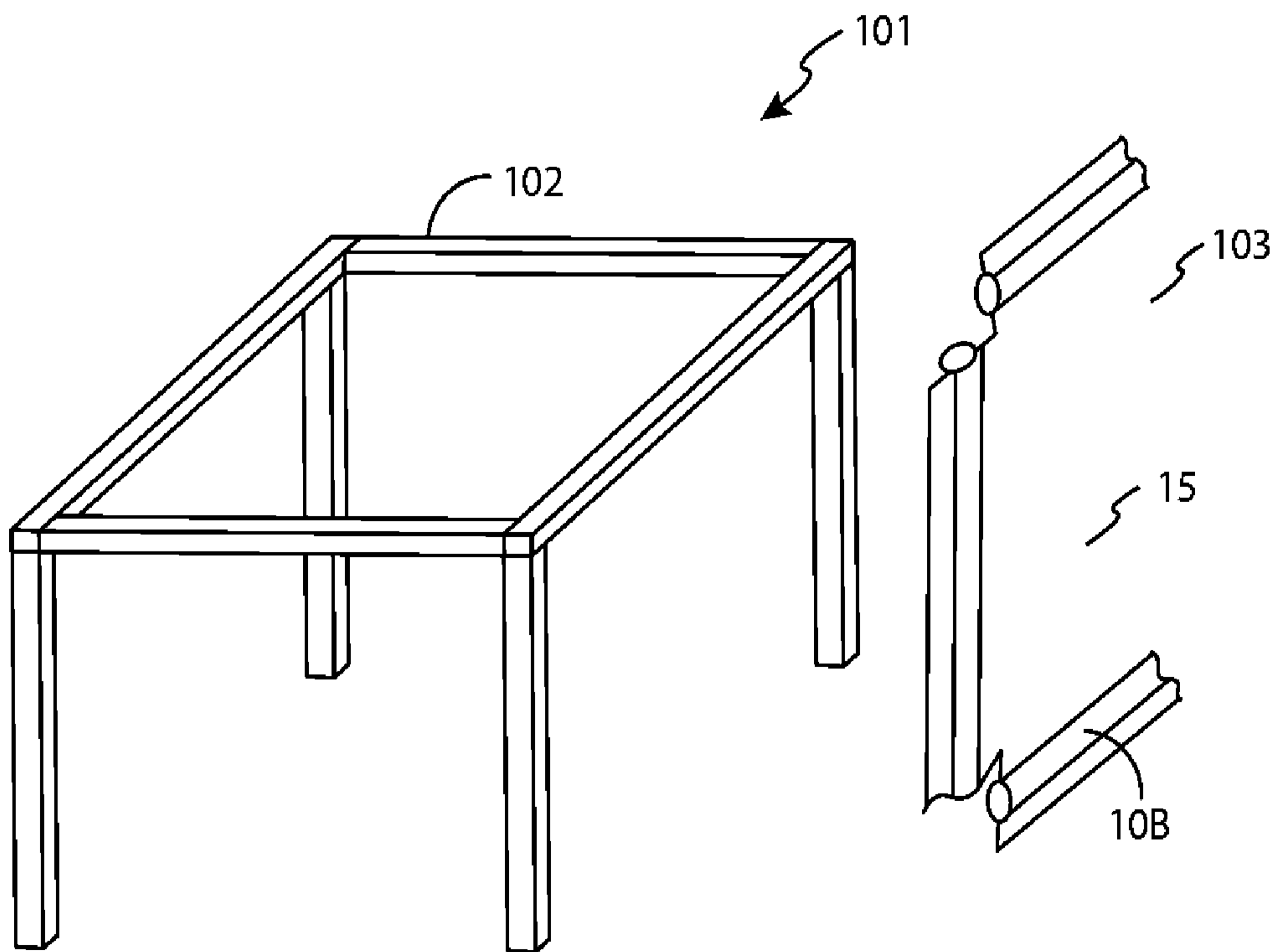


FIG. 10

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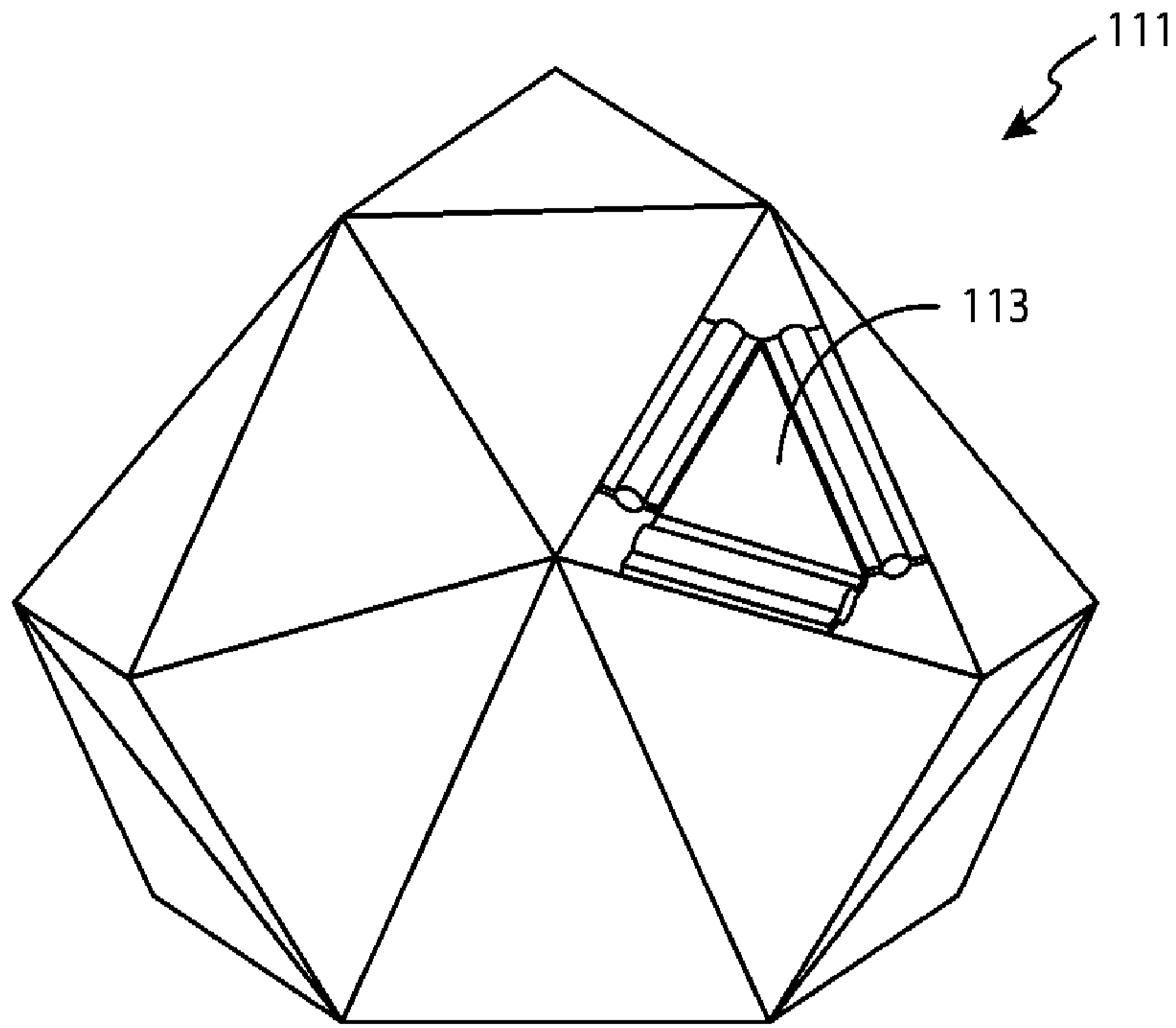


FIG. 11

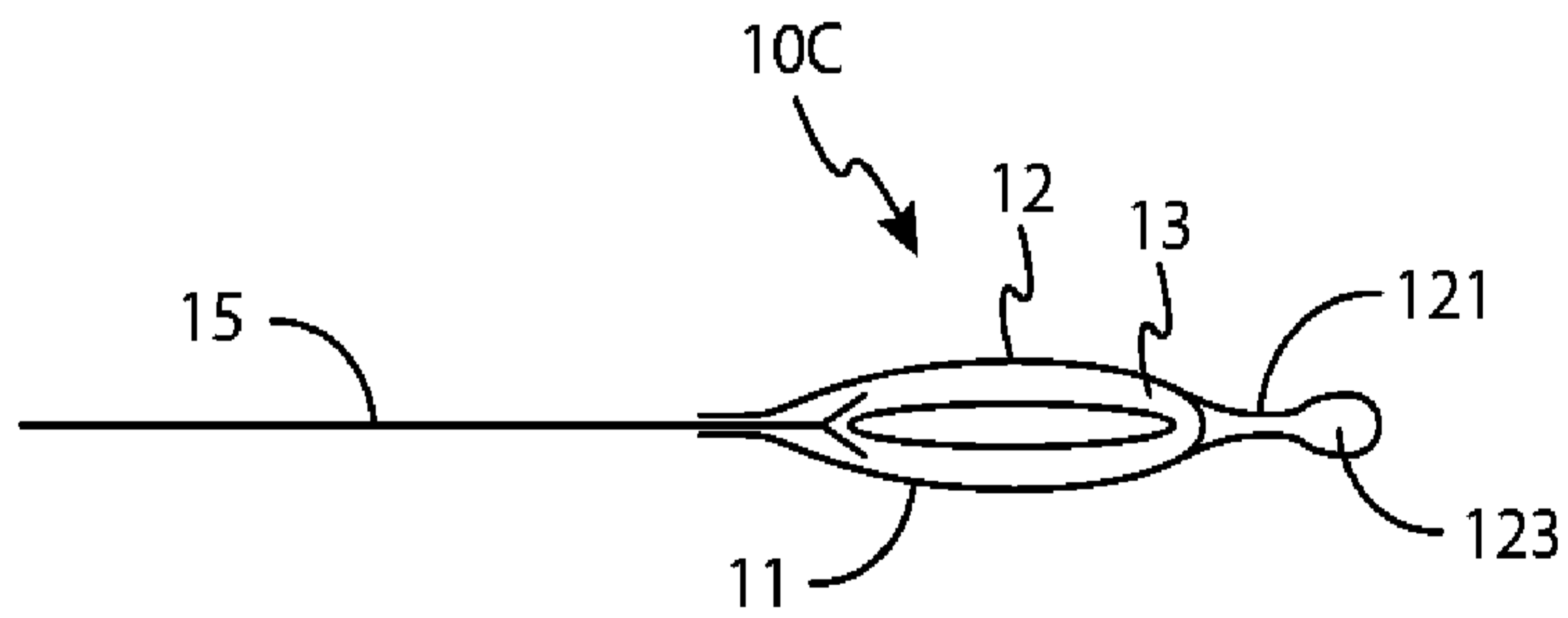


FIG. 12

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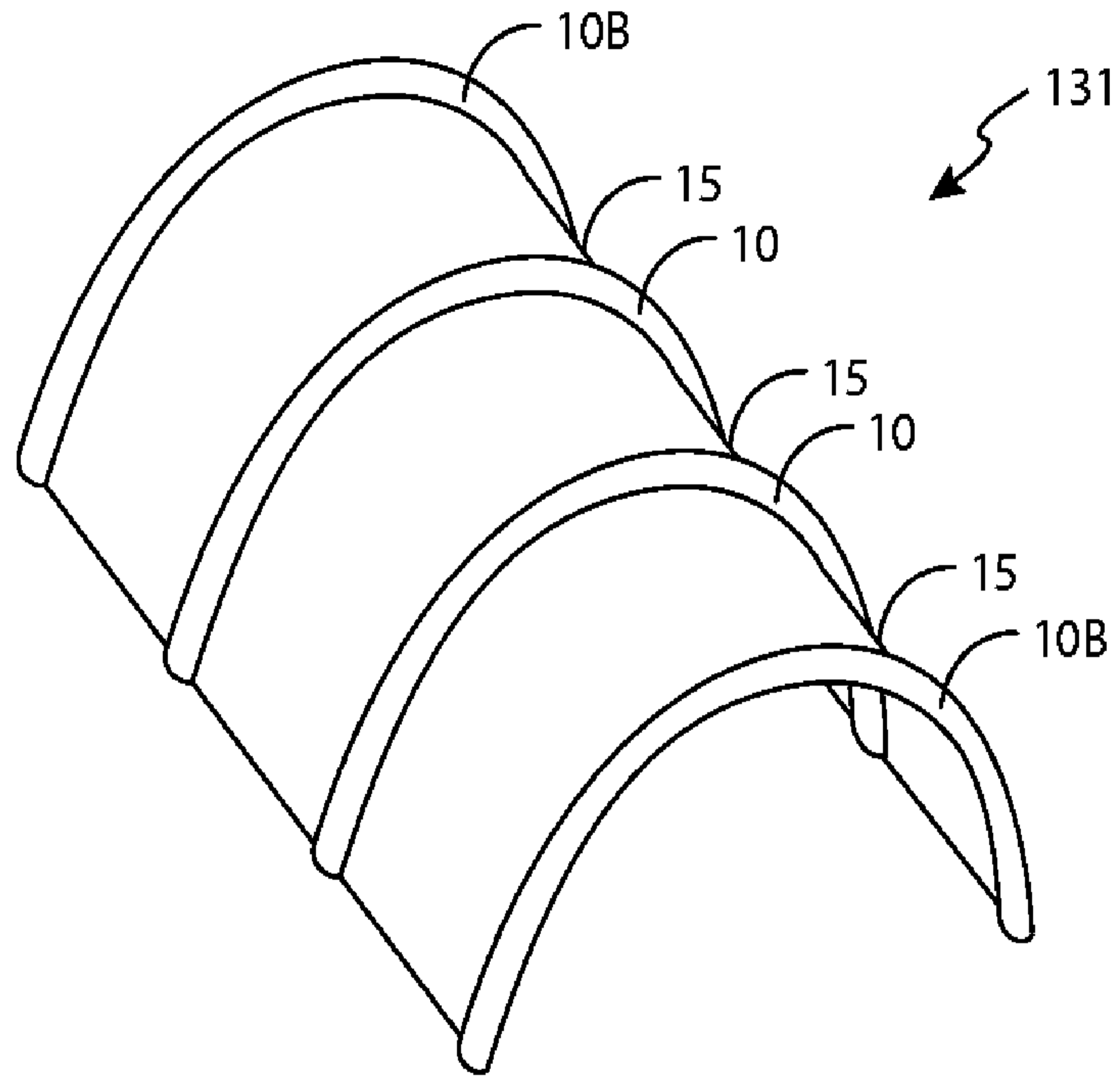


FIG. 13

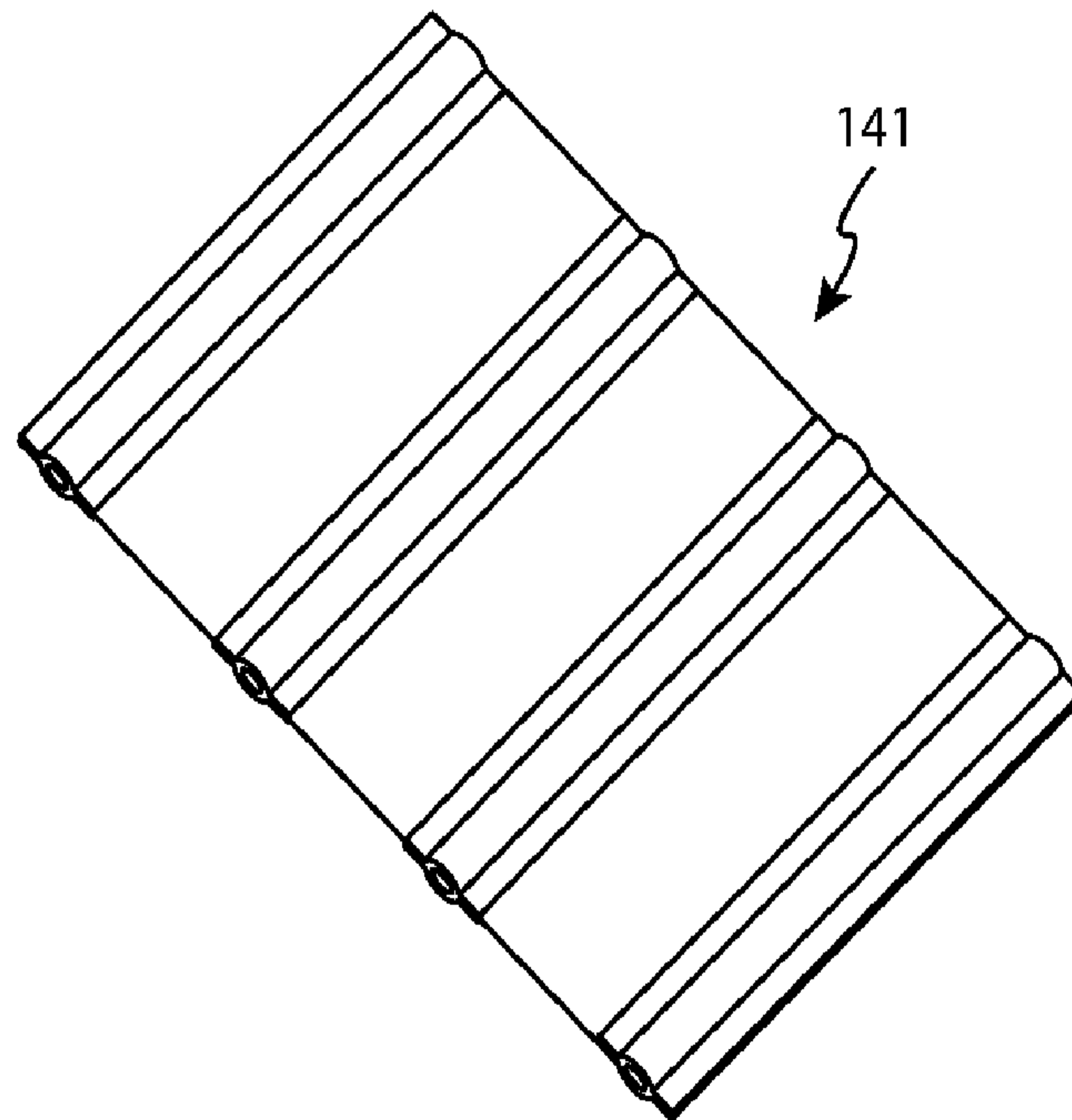


FIG. 14

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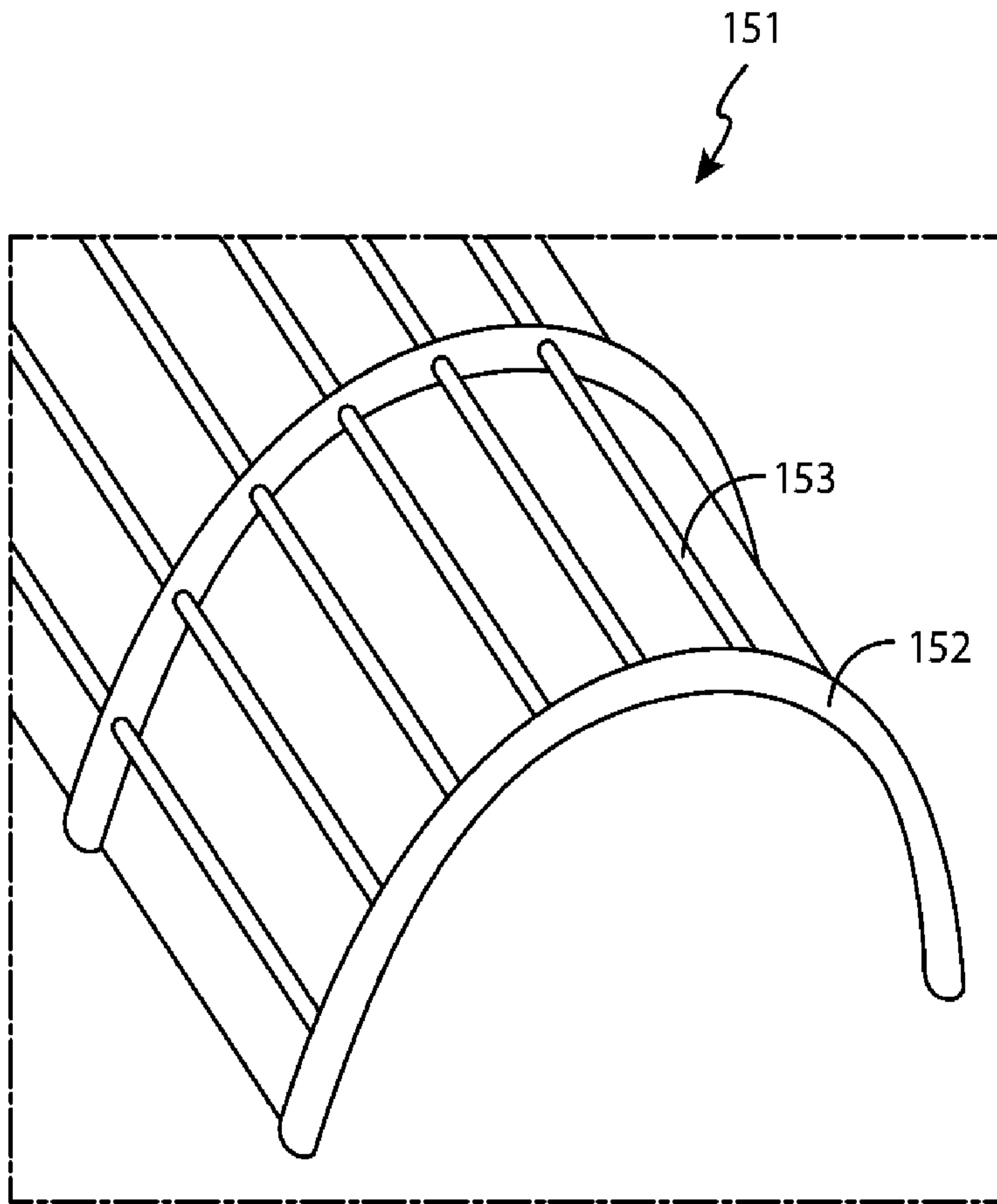


FIG. 15

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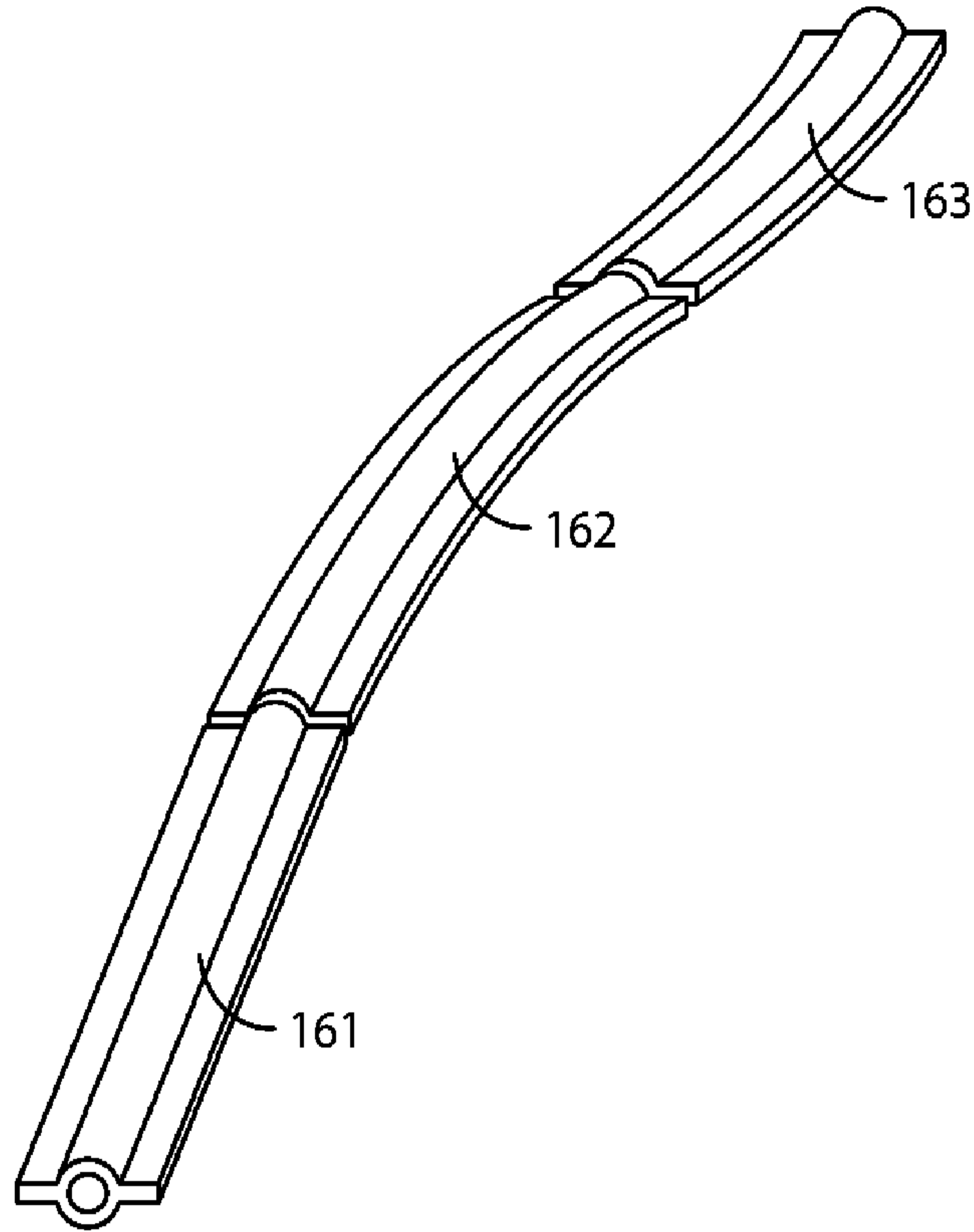


FIG. 16

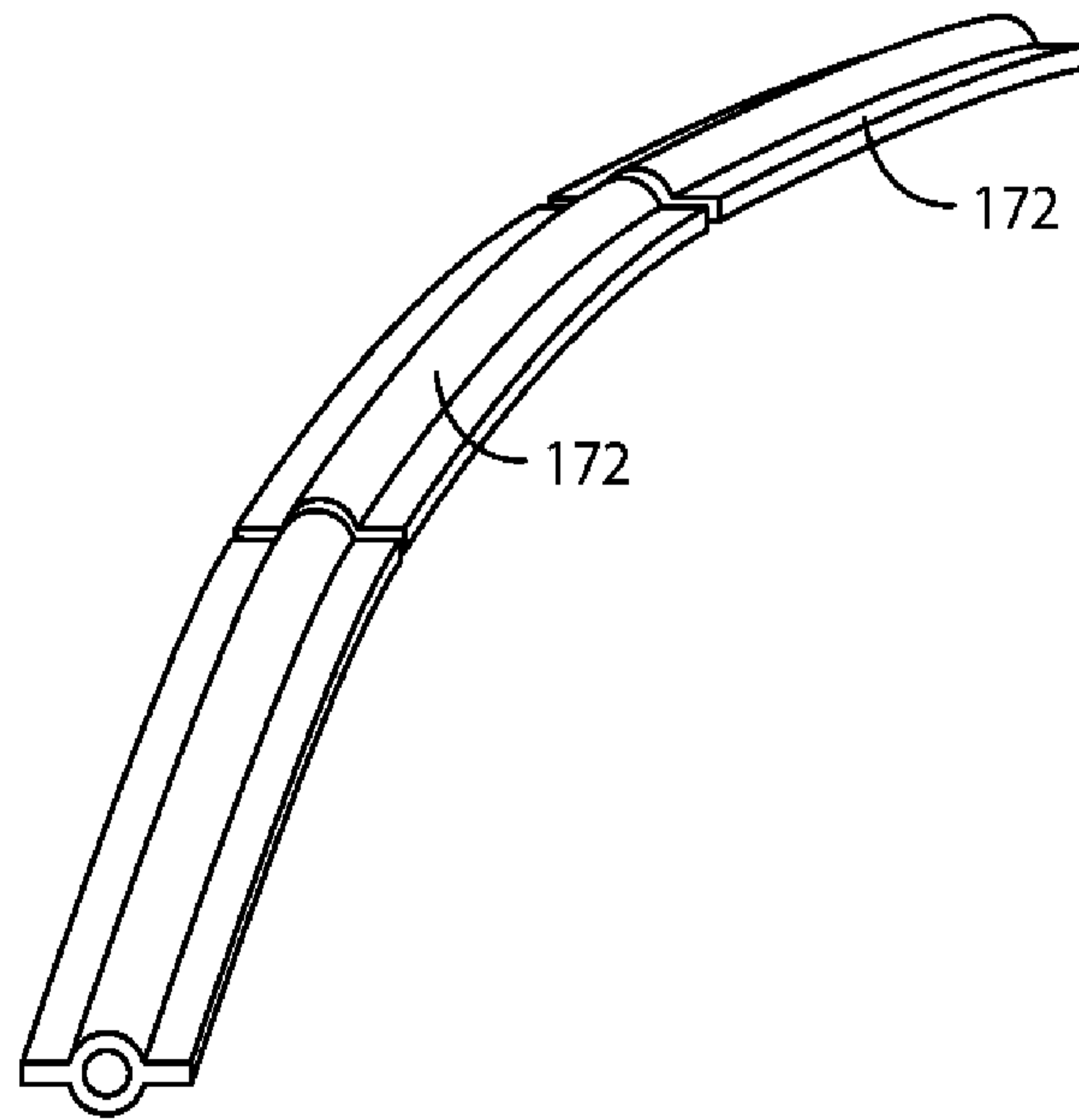


FIG. 17

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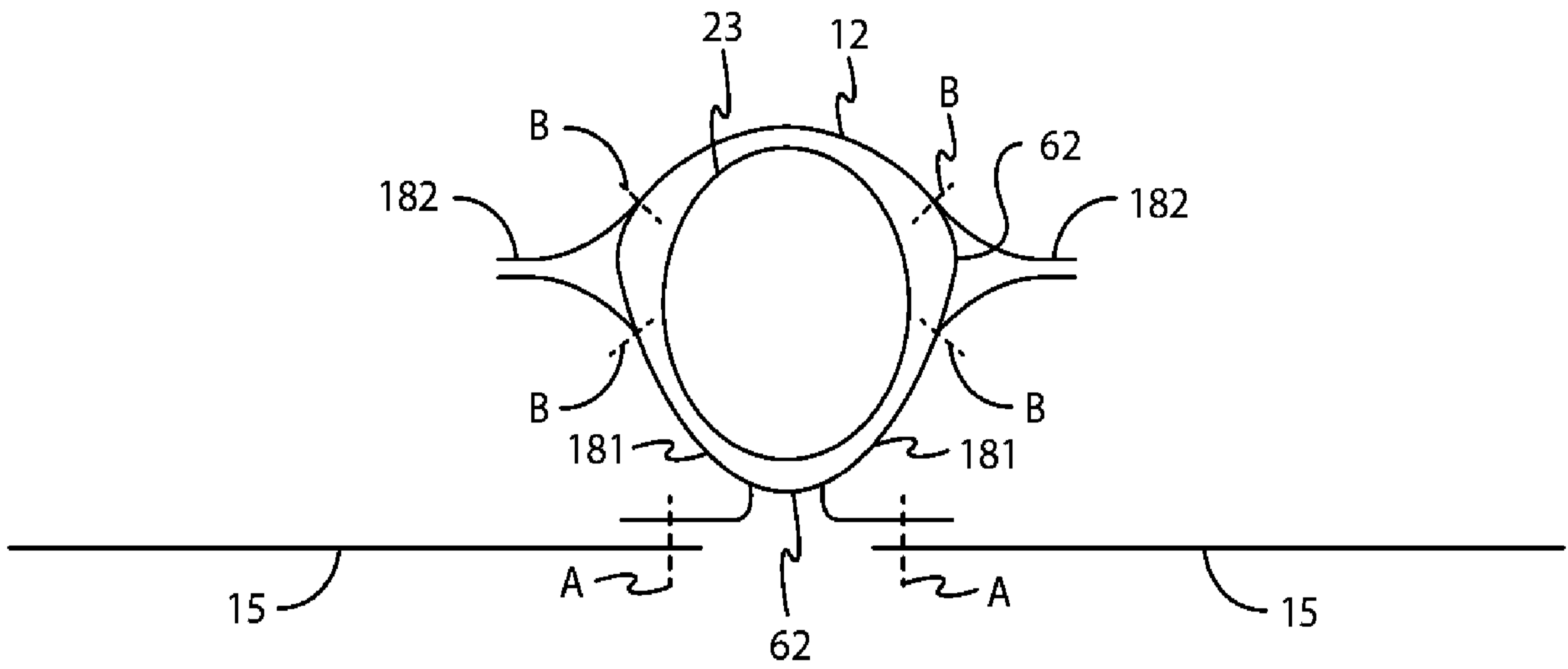


FIG. 18

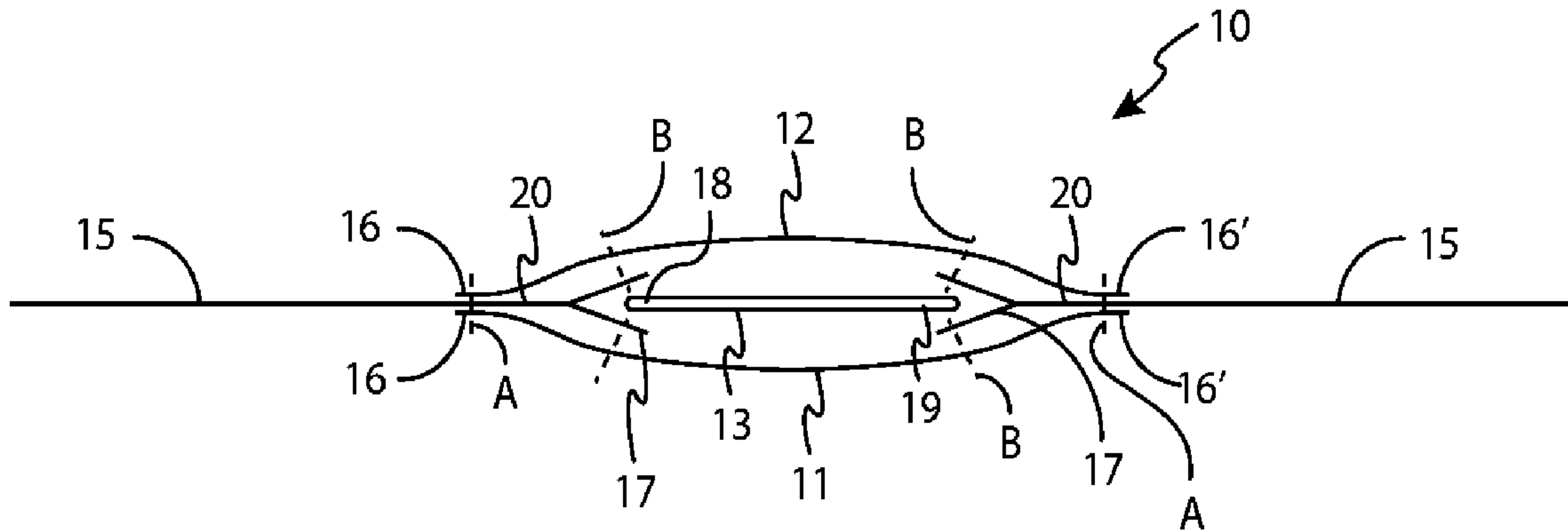


FIG. 1