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NUNN(10) **Pub. No.: US 2017/0159280 A1**(43) **Pub. Date: Jun. 8, 2017**(54) **CONSTRUCTION AND HUB STRUCTURES
THEREFROM****Publication Classification**(71) Applicant: **KENNETH E. NUNN,**
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COLLEYVILLE, TX (US)(21) Appl. No.: **15/425,085**(22) Filed: **Feb. 6, 2017**(51) **Int. Cl.****E04B 1/19** (2006.01)**E04B 1/32** (2006.01)(52) **U.S. Cl.****CPC** **E04B 1/1909** (2013.01); **E04B 1/3211**
(2013.01); **E04B 2001/0061** (2013.01)

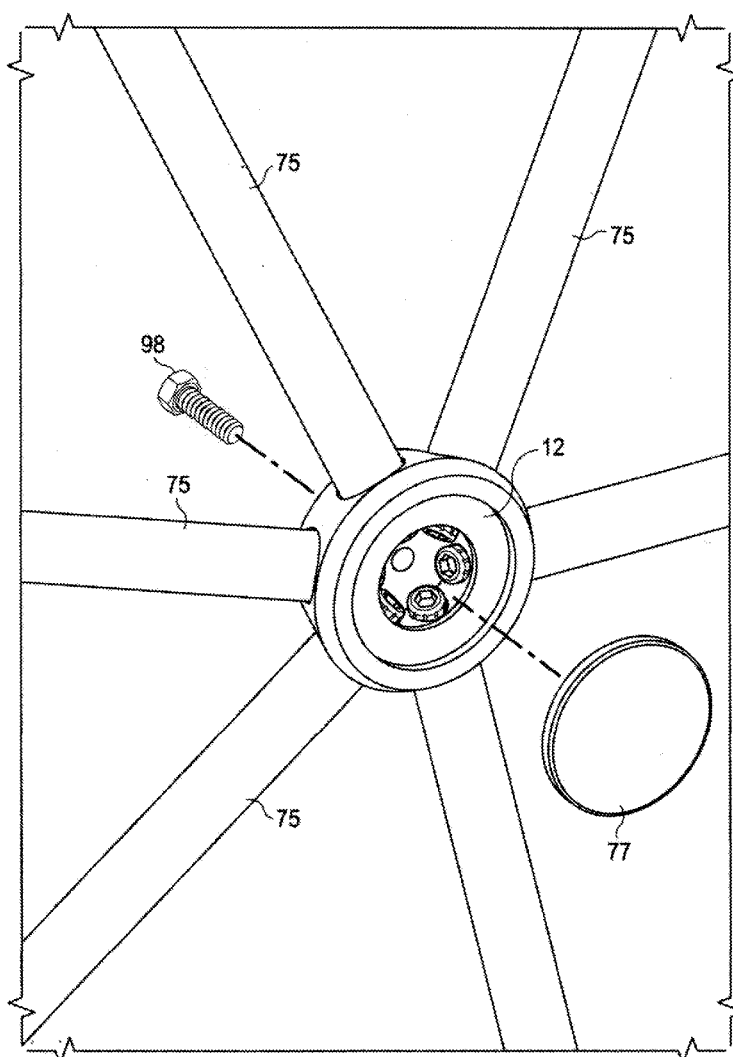
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ABSTRACT

Primary architectural hubs useful for providing geodesic structures, the hubs provided enabling a strut configuration interface having increased strength over analogous articles of the prior art. In some embodiments are provided secondary hubs attached to the primary hubs, which provide for truss configurations enabling rectangular apertures such as doors to be affixed to a geodesic structure without compromising the strength of the geodesic structure as a whole, which was the case with prior art geodesic structures.

Related U.S. Application Data

(63) Continuation of application No. 14/679,943, filed on Apr. 6, 2015, now abandoned, which is a continuation of application No. 14/121,297, filed on Aug. 15, 2014, now abandoned.



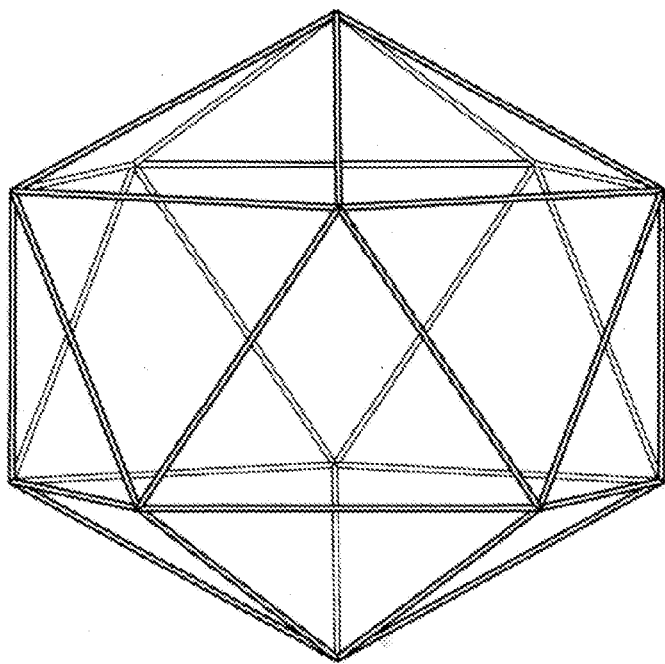


FIG. 1
(PRIOR ART)

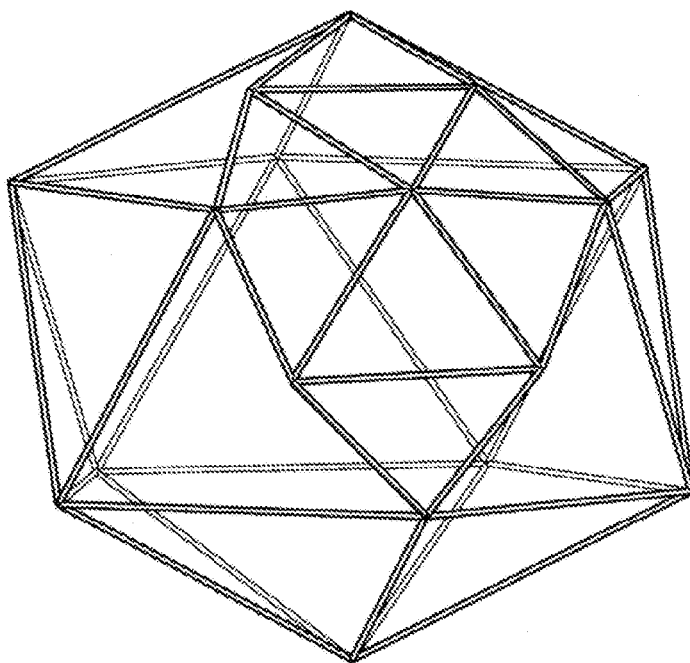


FIG. 2
(PRIOR ART)

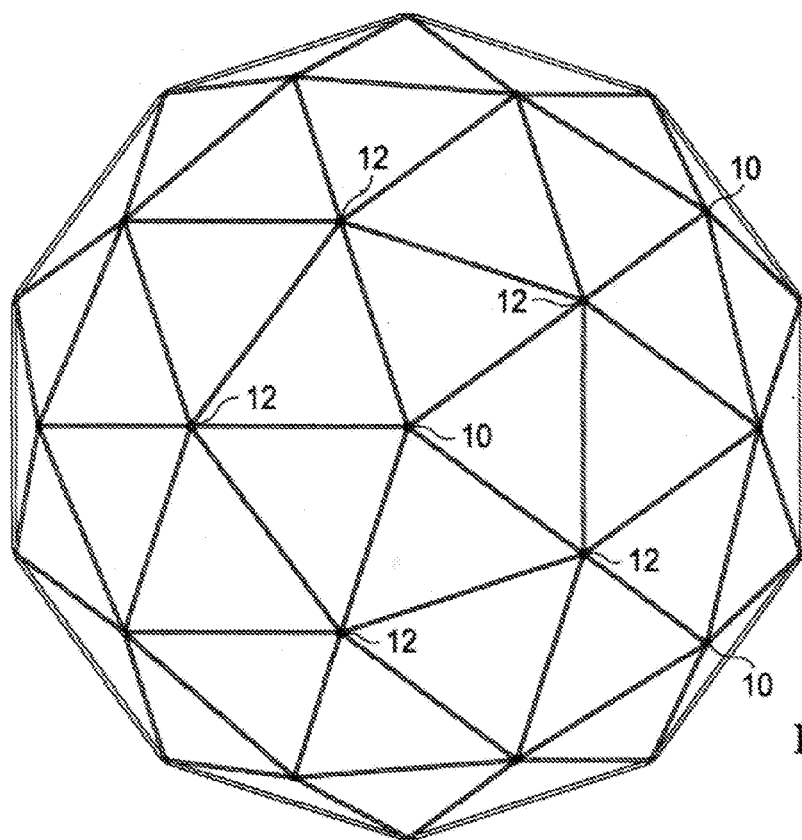
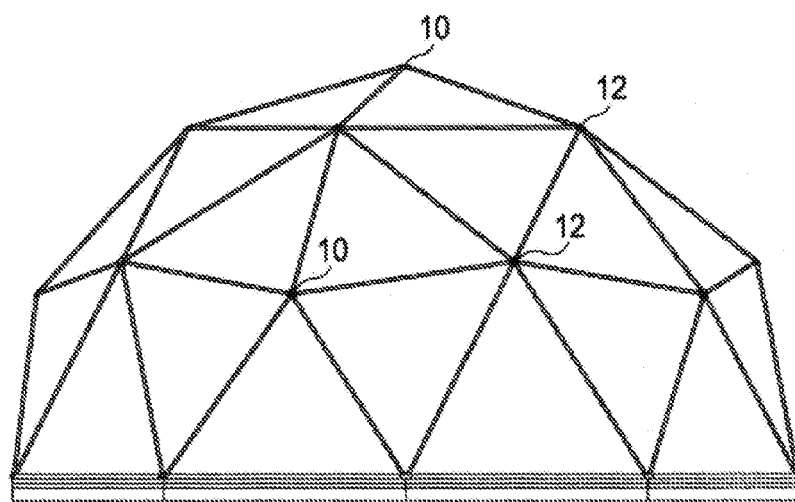


FIG. 3A

FIG. 3B



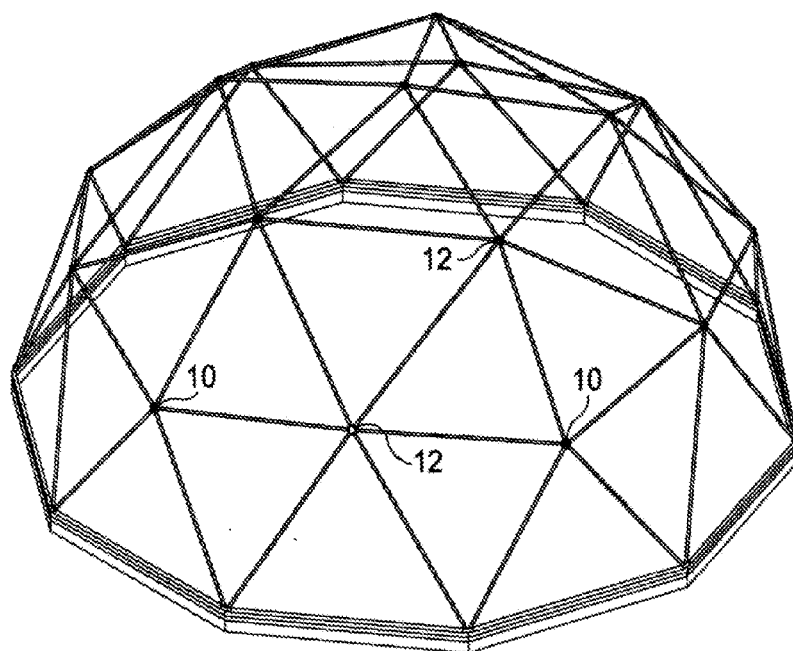


FIG. 3C

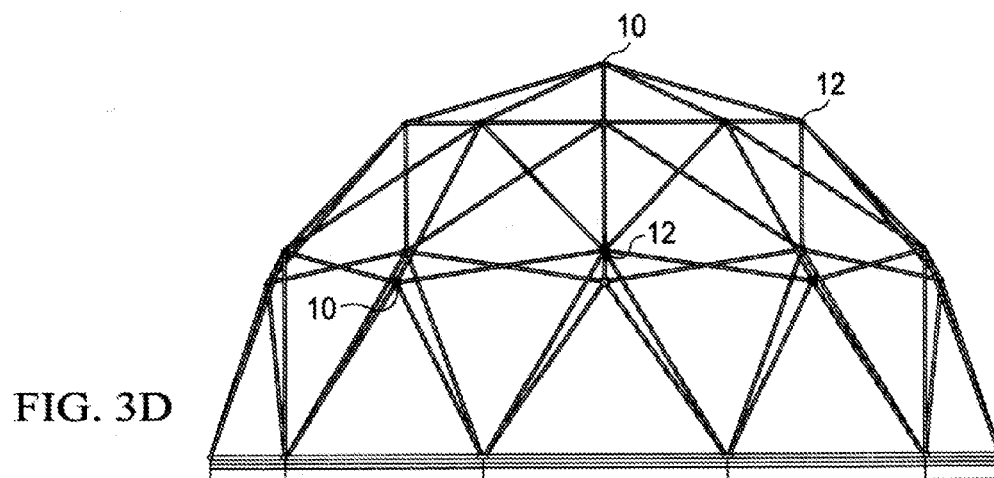
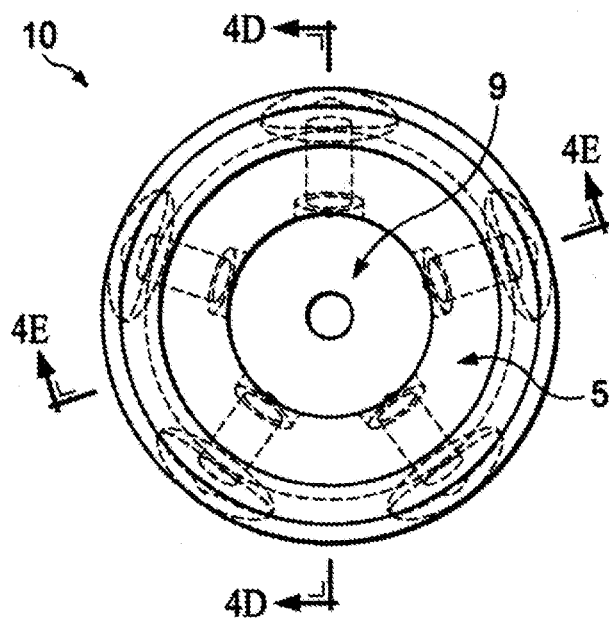
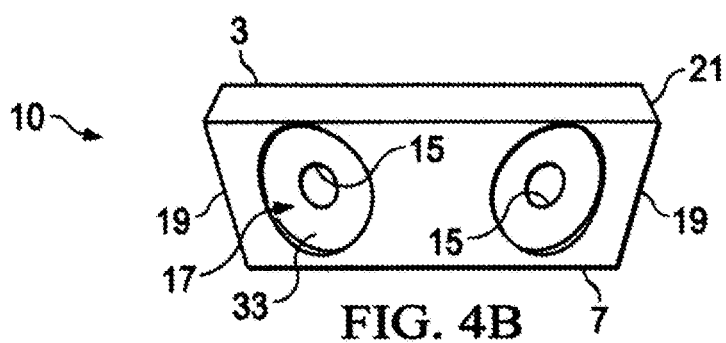
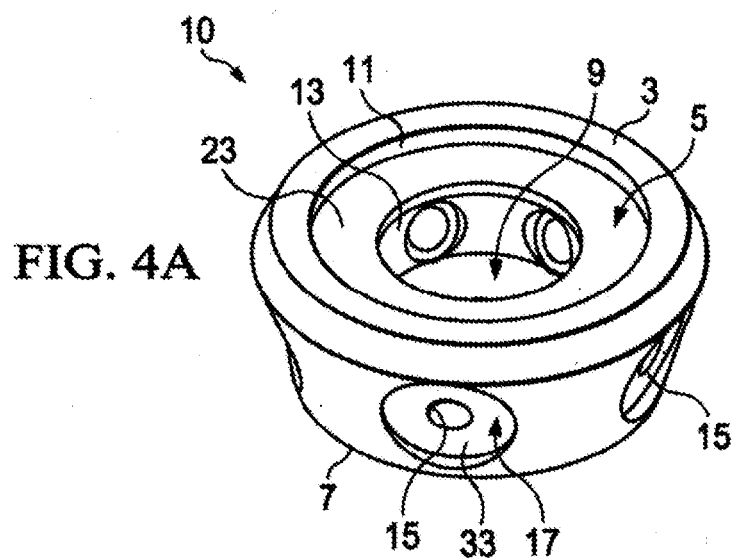
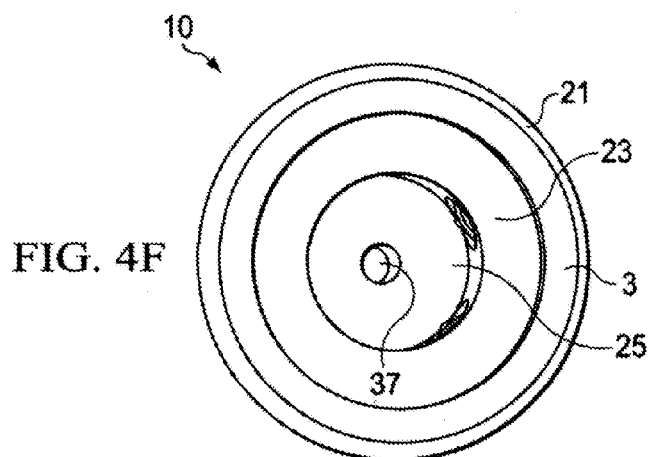
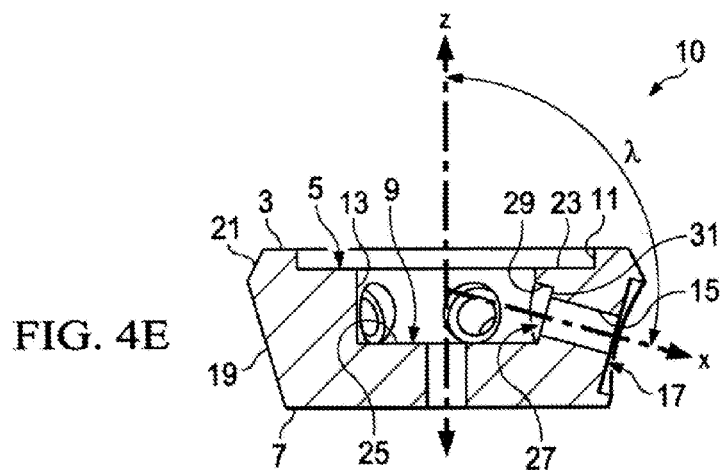
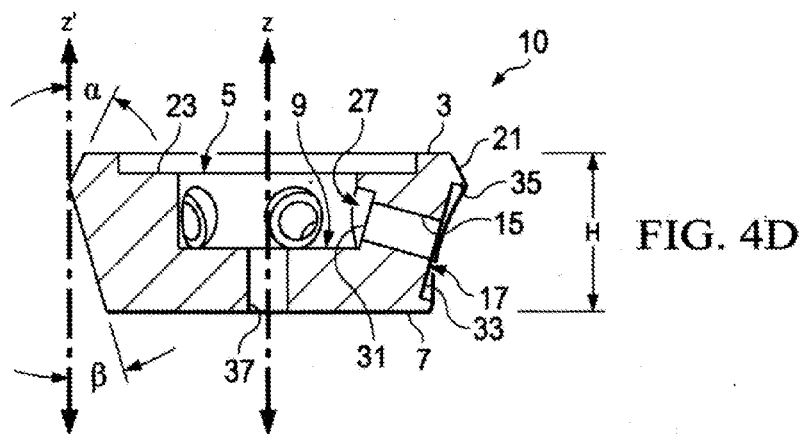
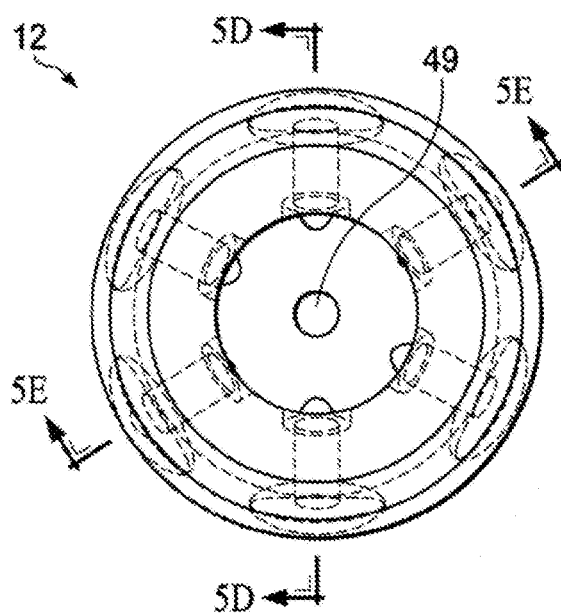
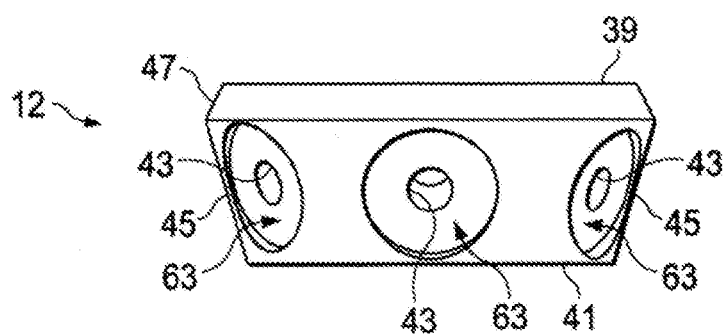
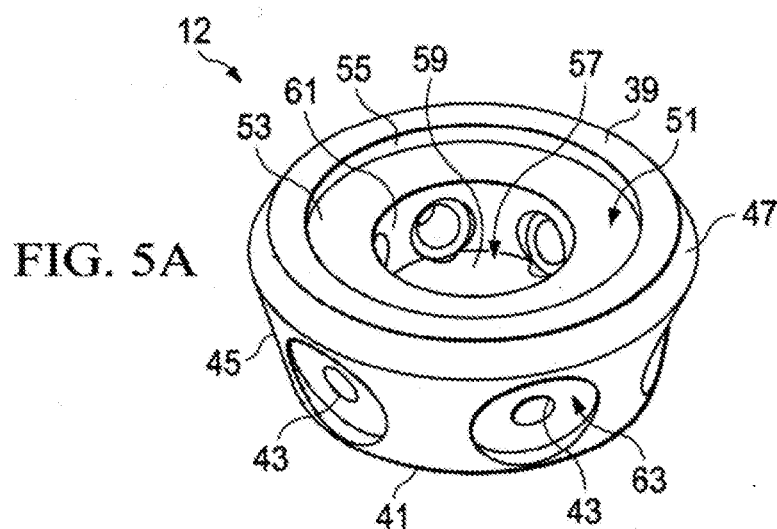
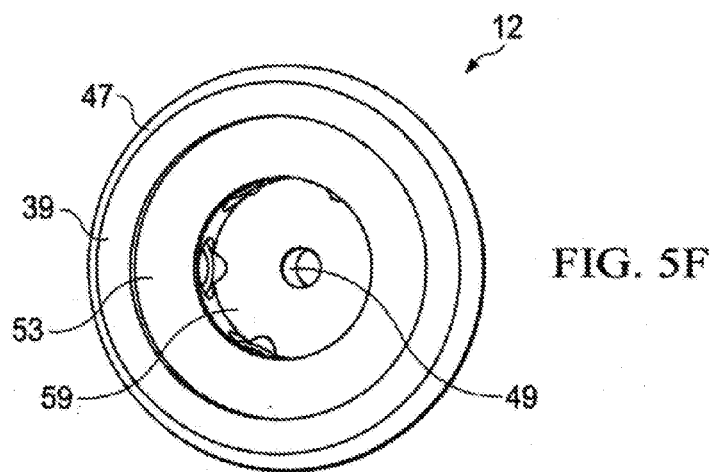
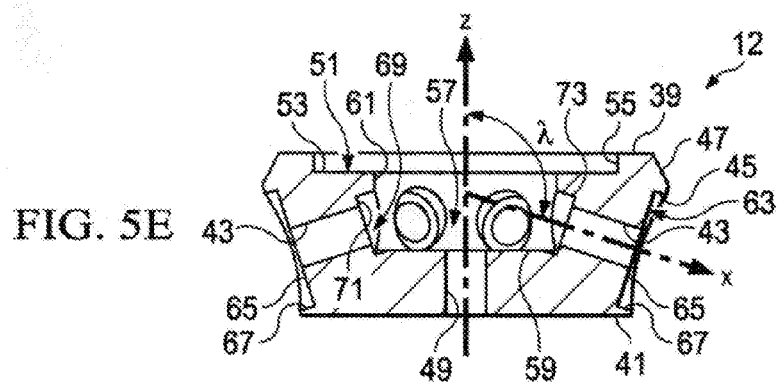
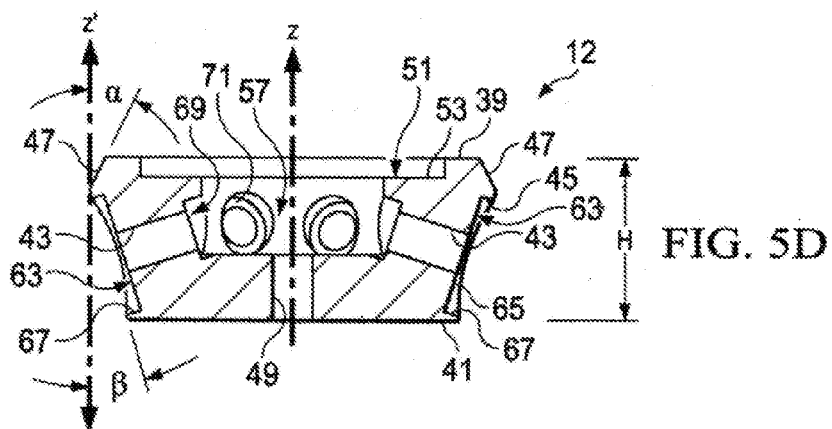


FIG. 3D









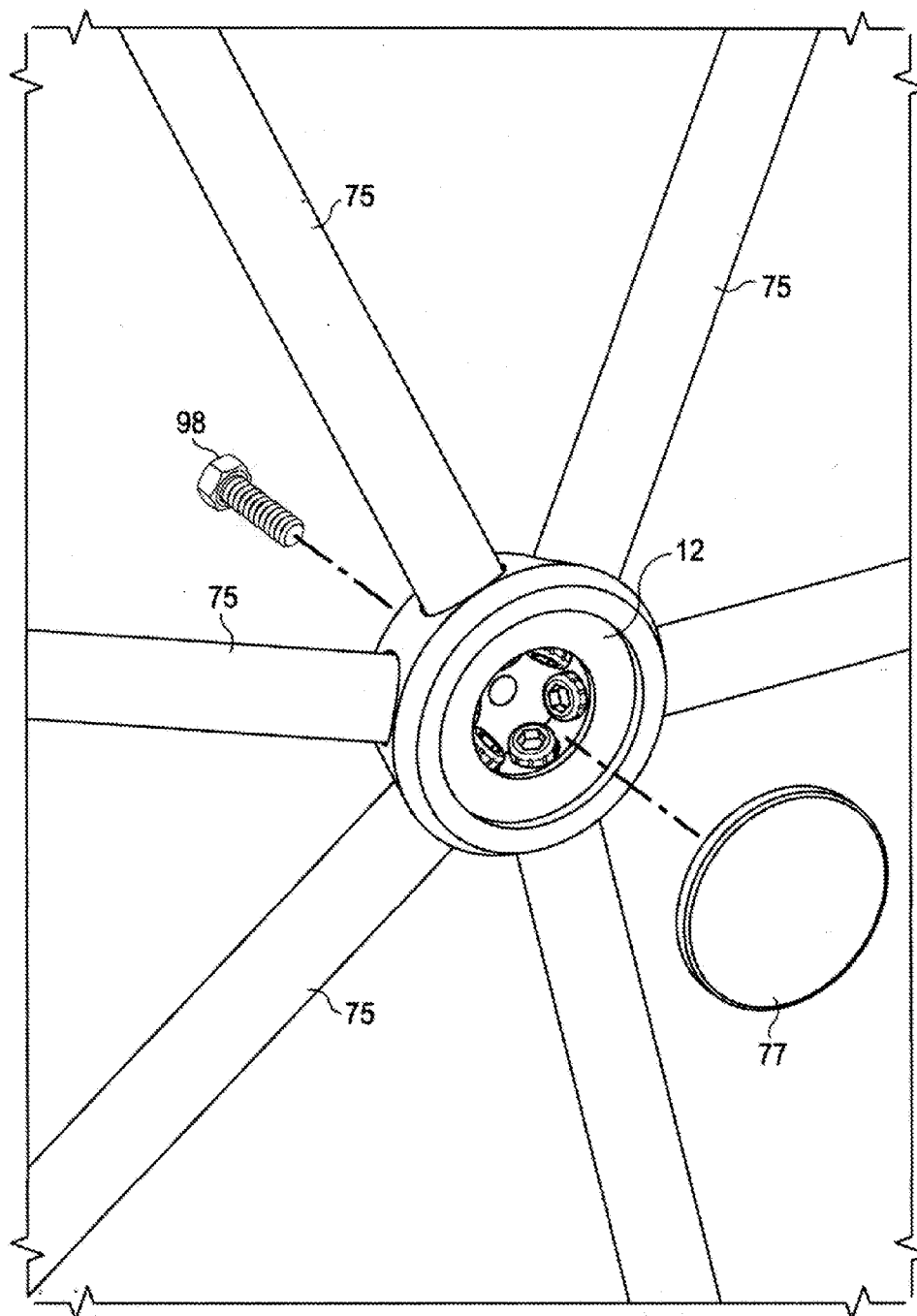


FIG. 6

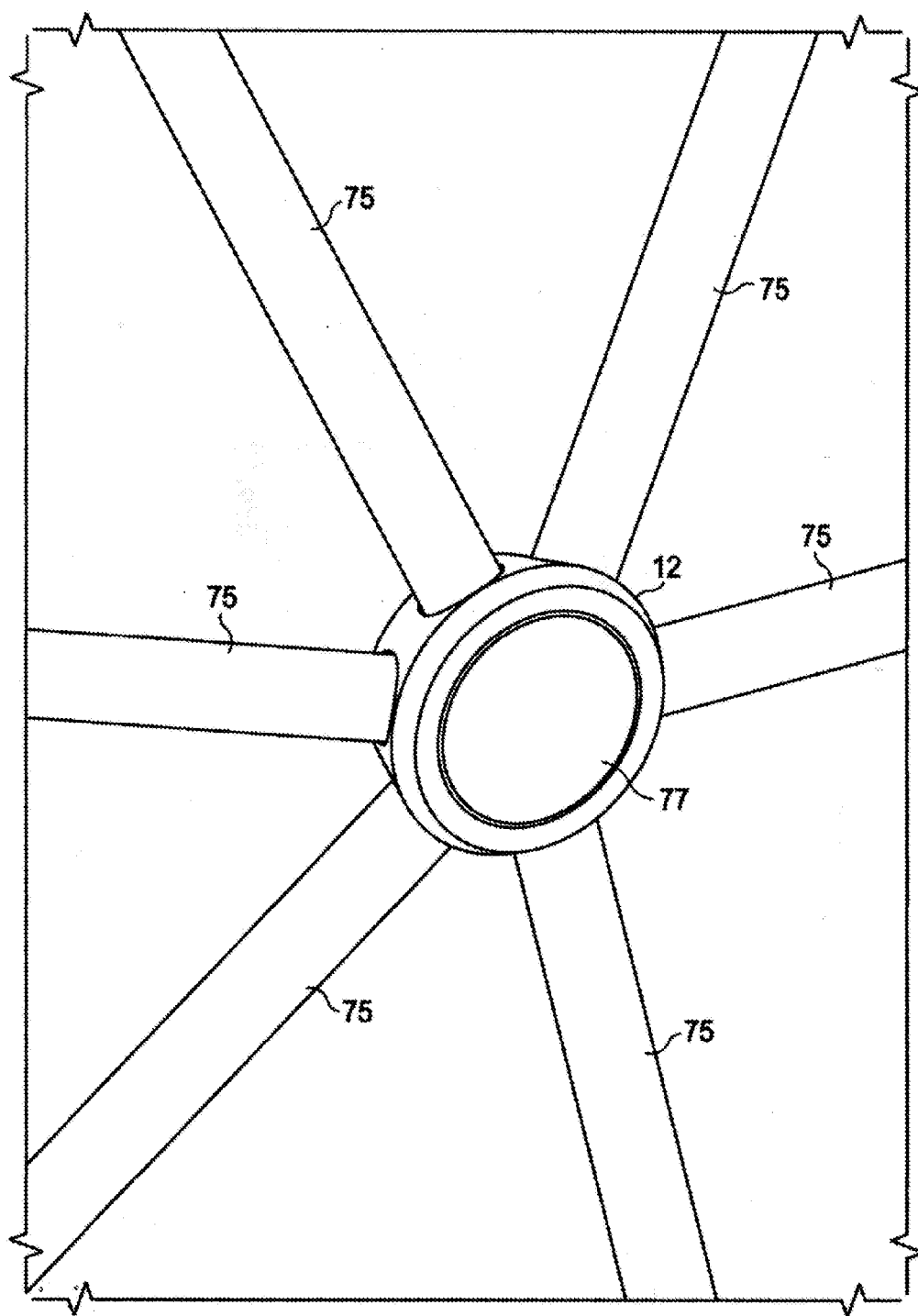


FIG. 7

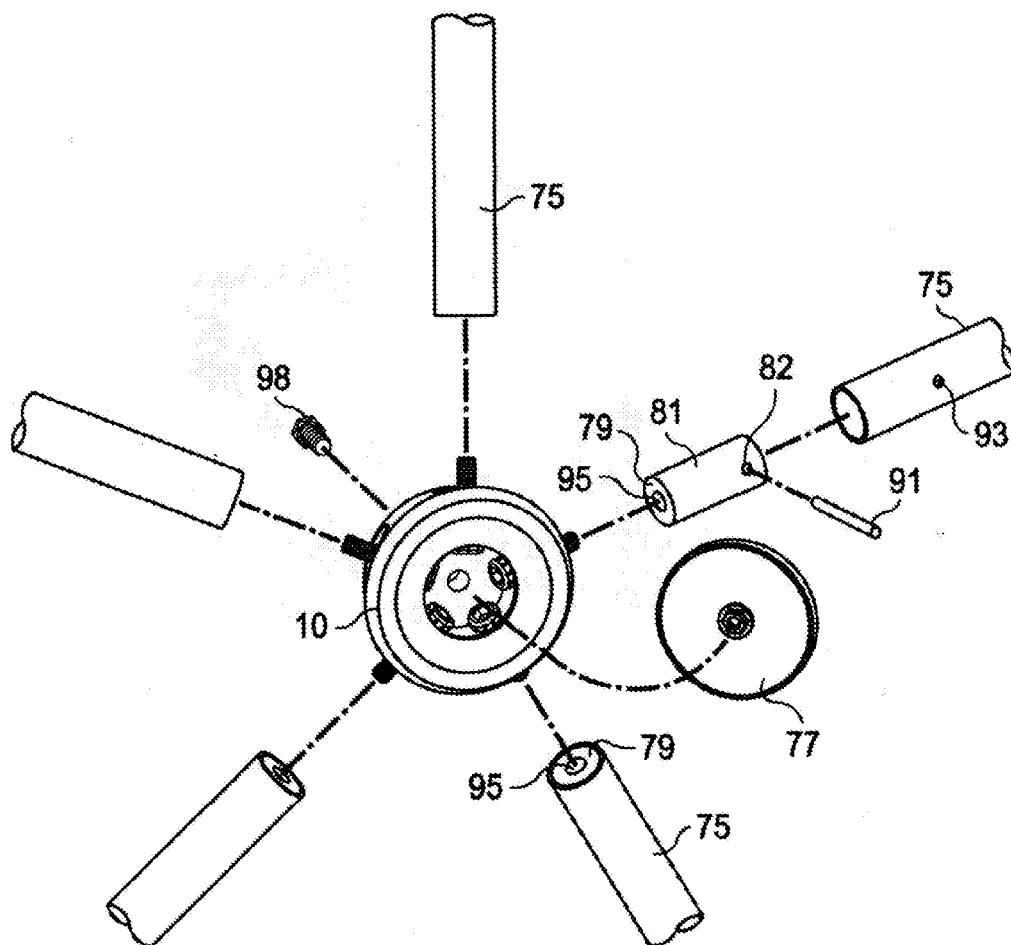


FIG. 8

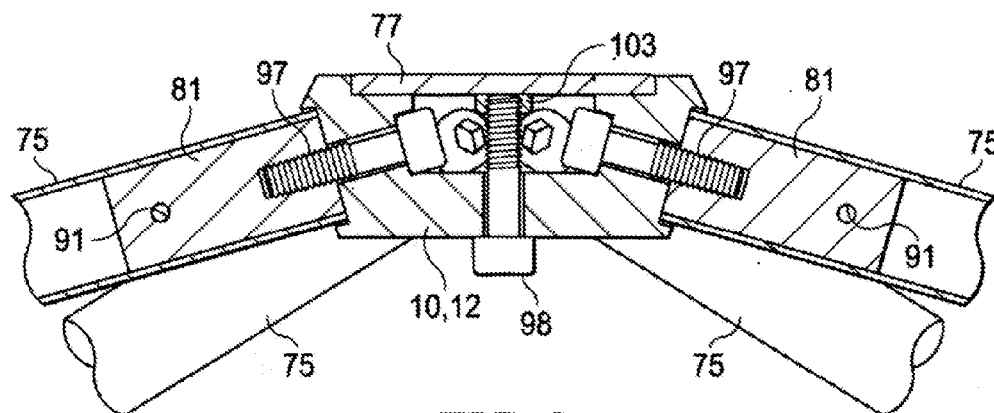


FIG. 9

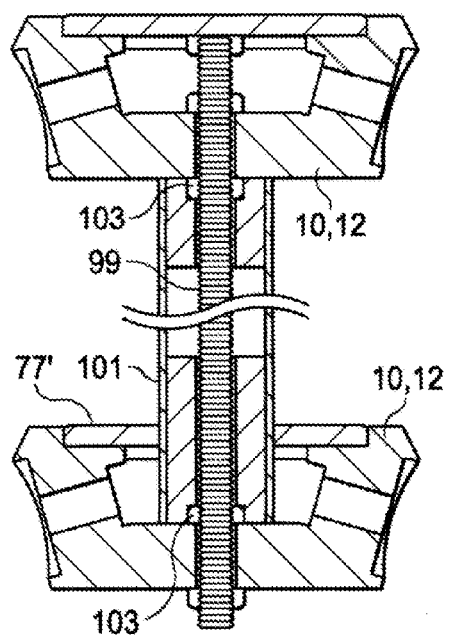
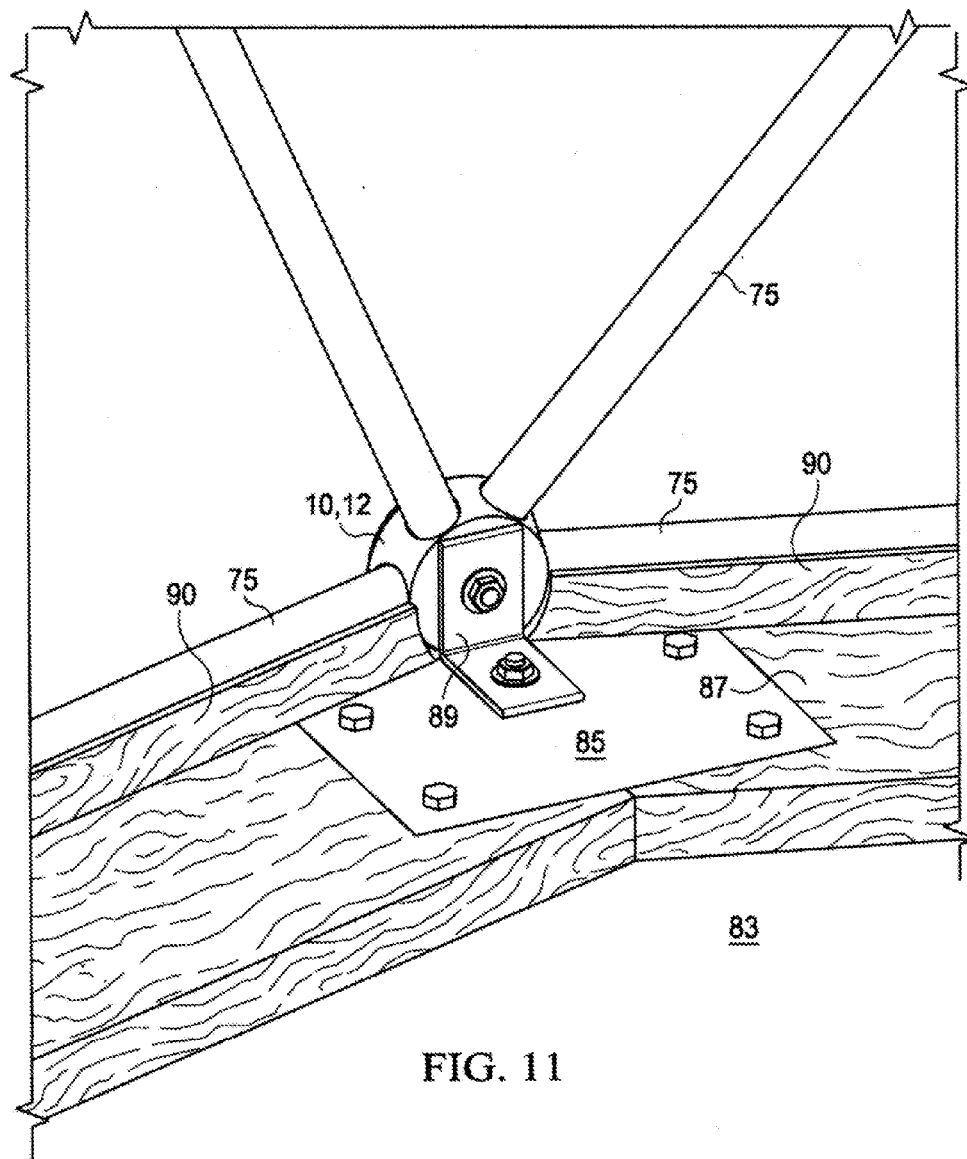


FIG. 10



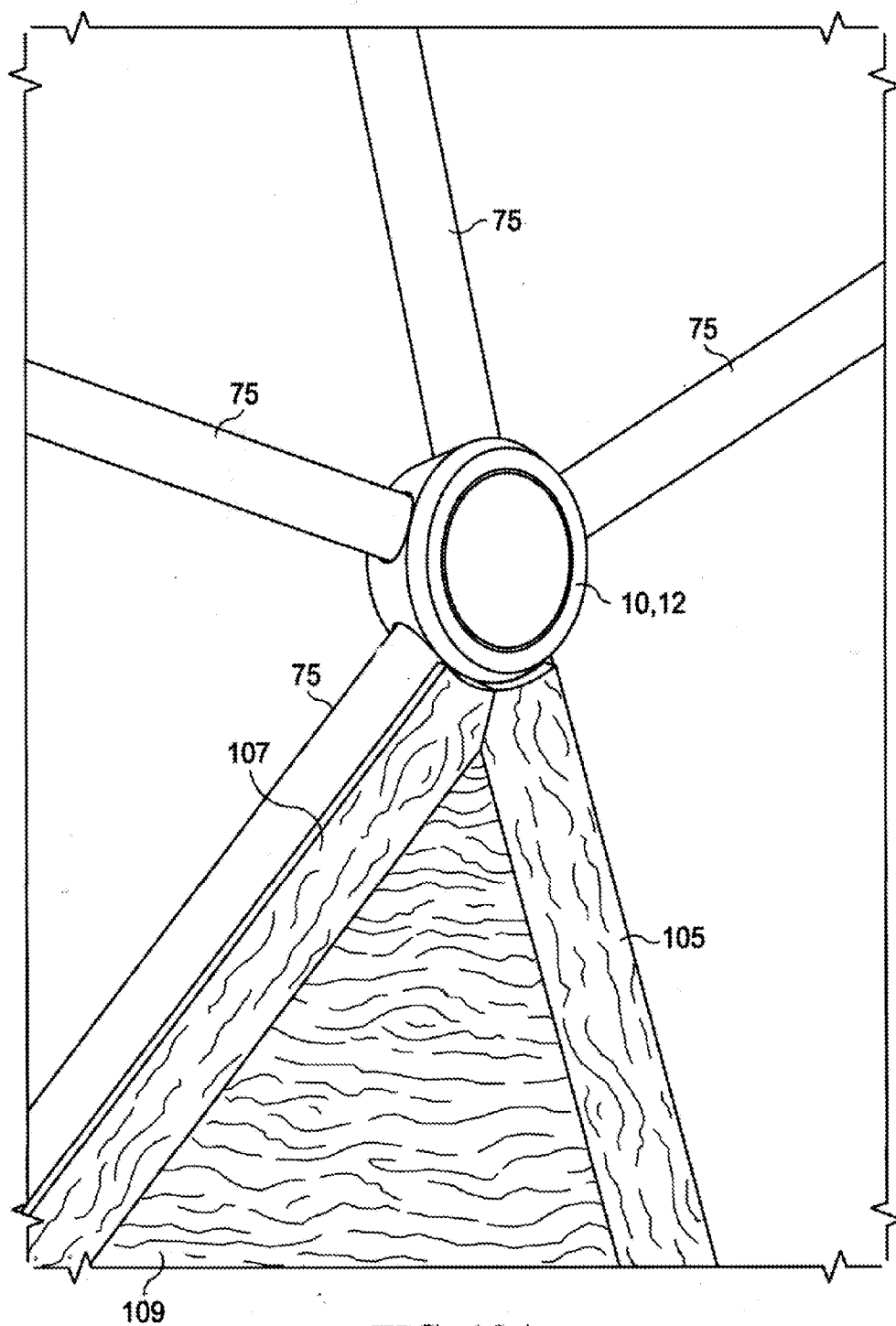


FIG. 12A

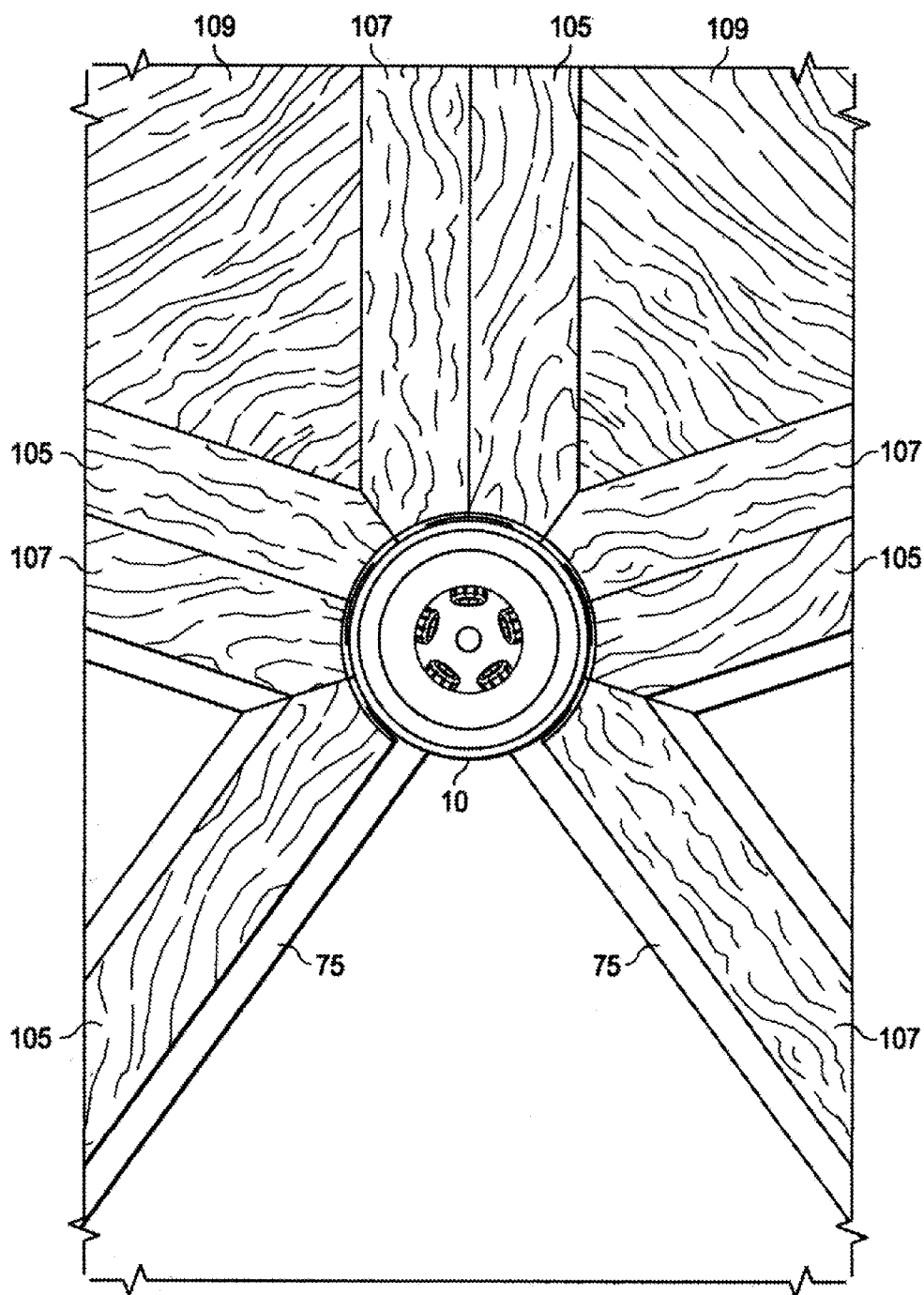


FIG. 12B

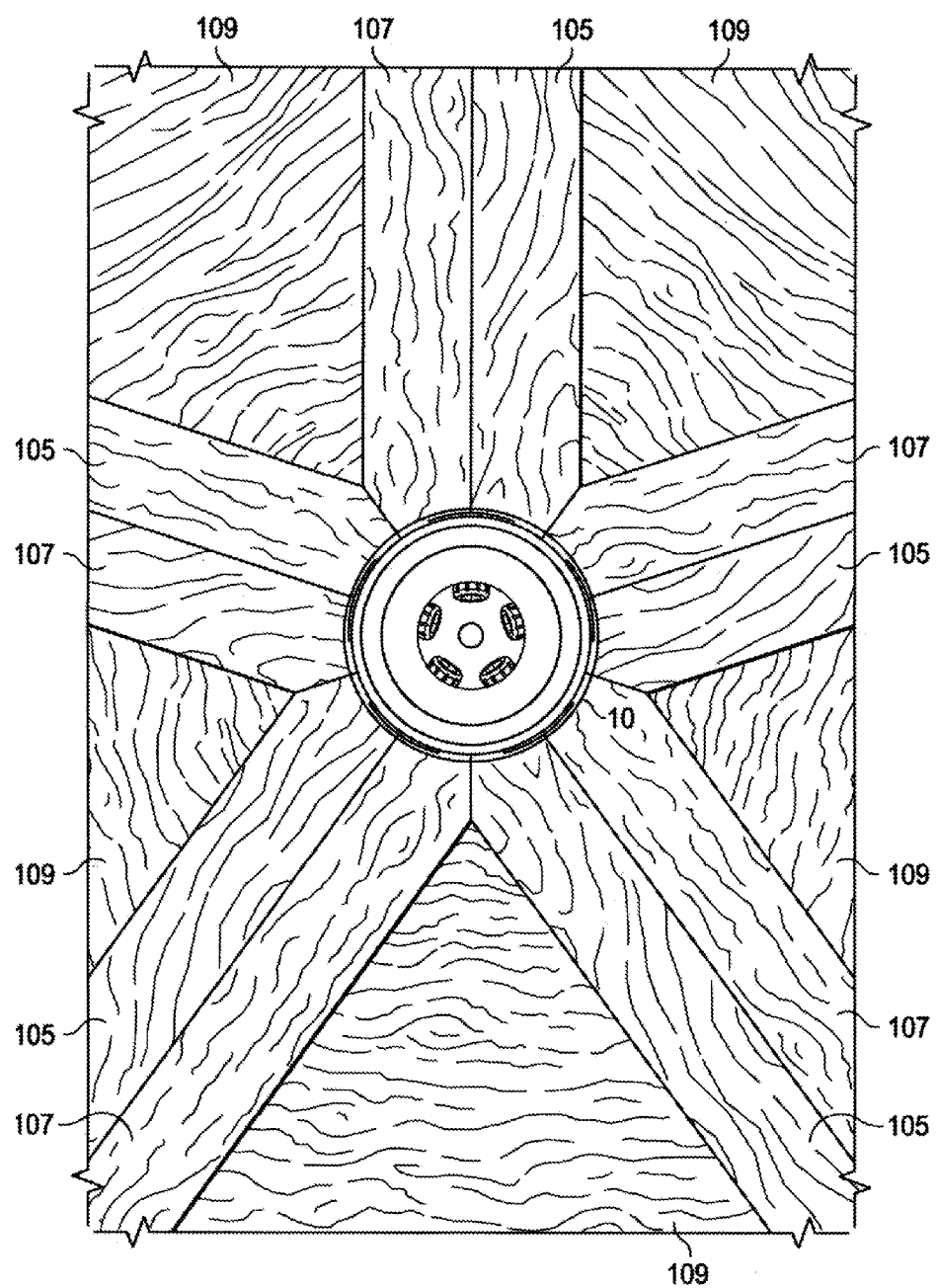


FIG. 12C

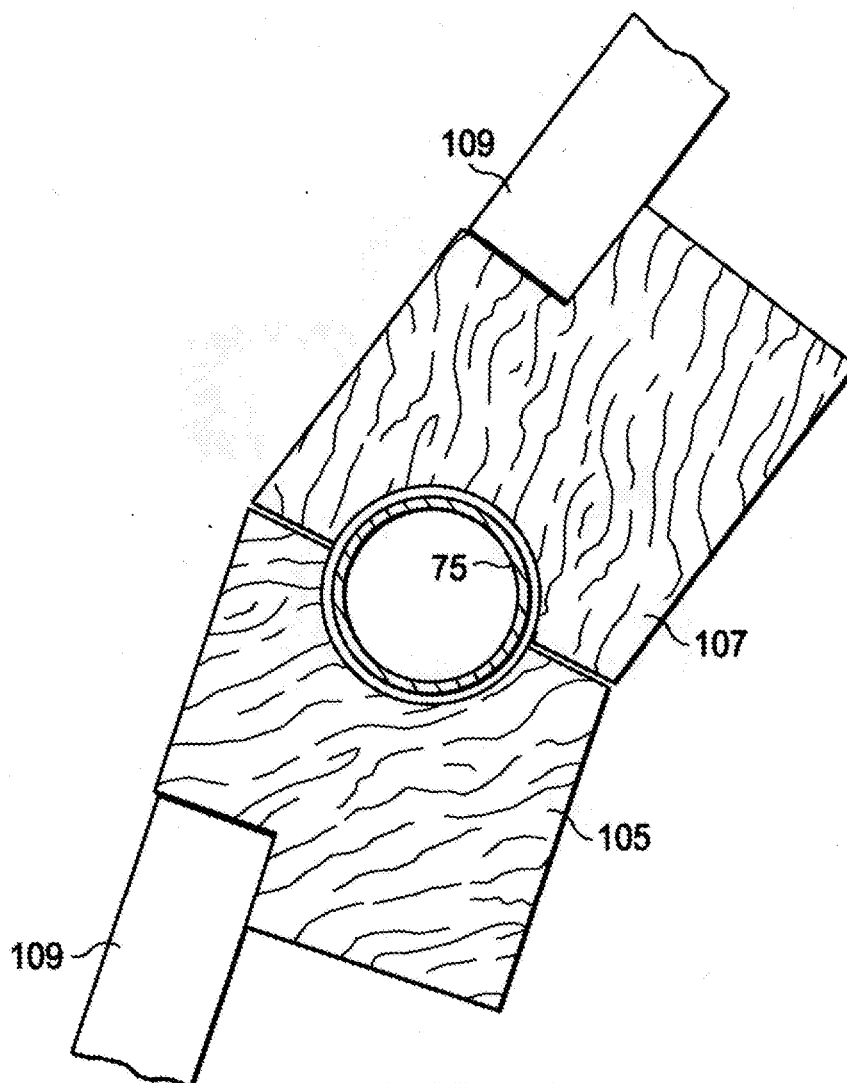


FIG. 13

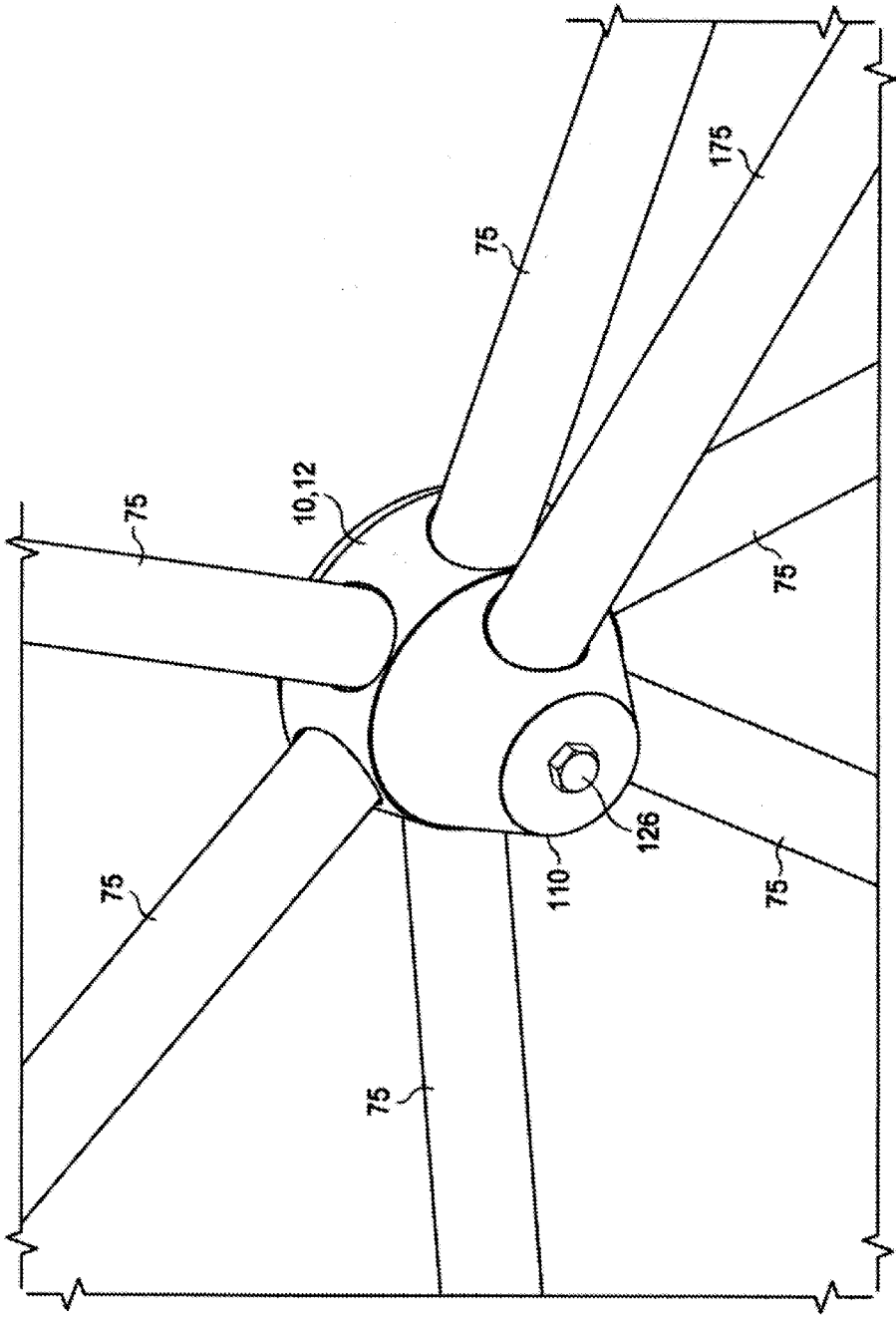


FIG. 14

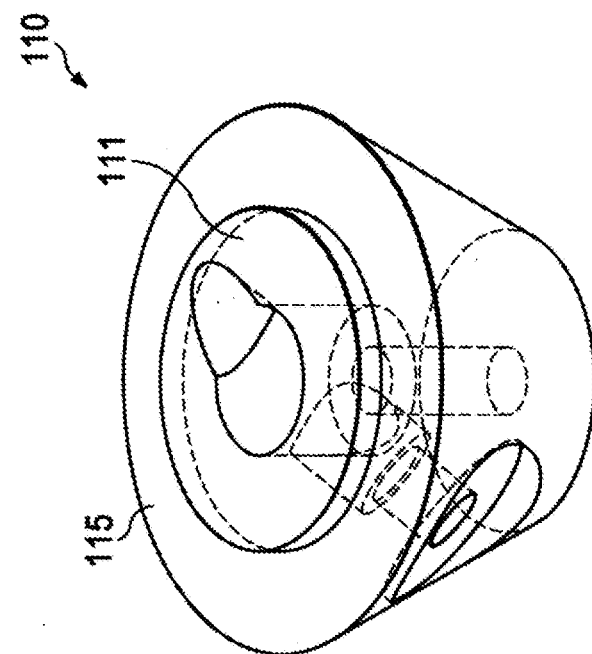


FIG. 15B

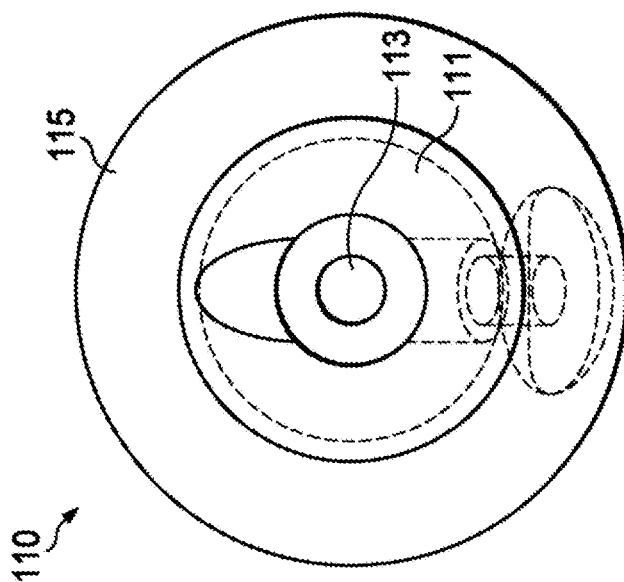


FIG. 15A

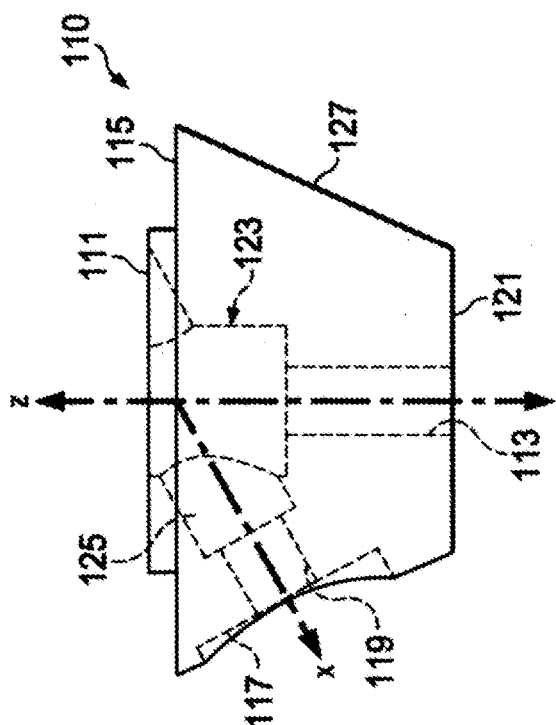


FIG. 15D

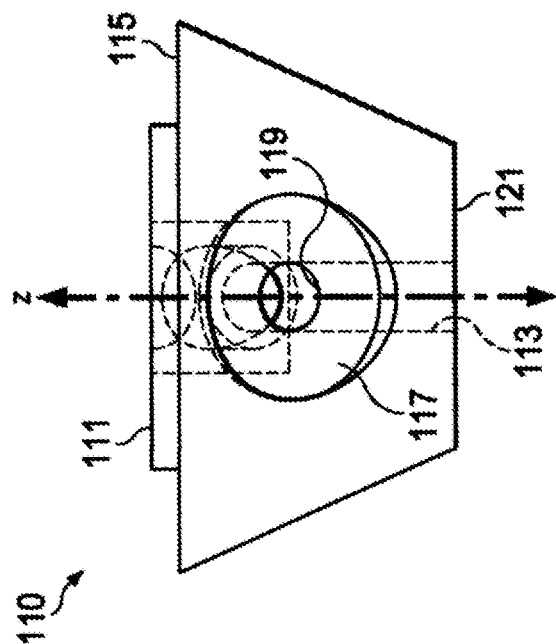
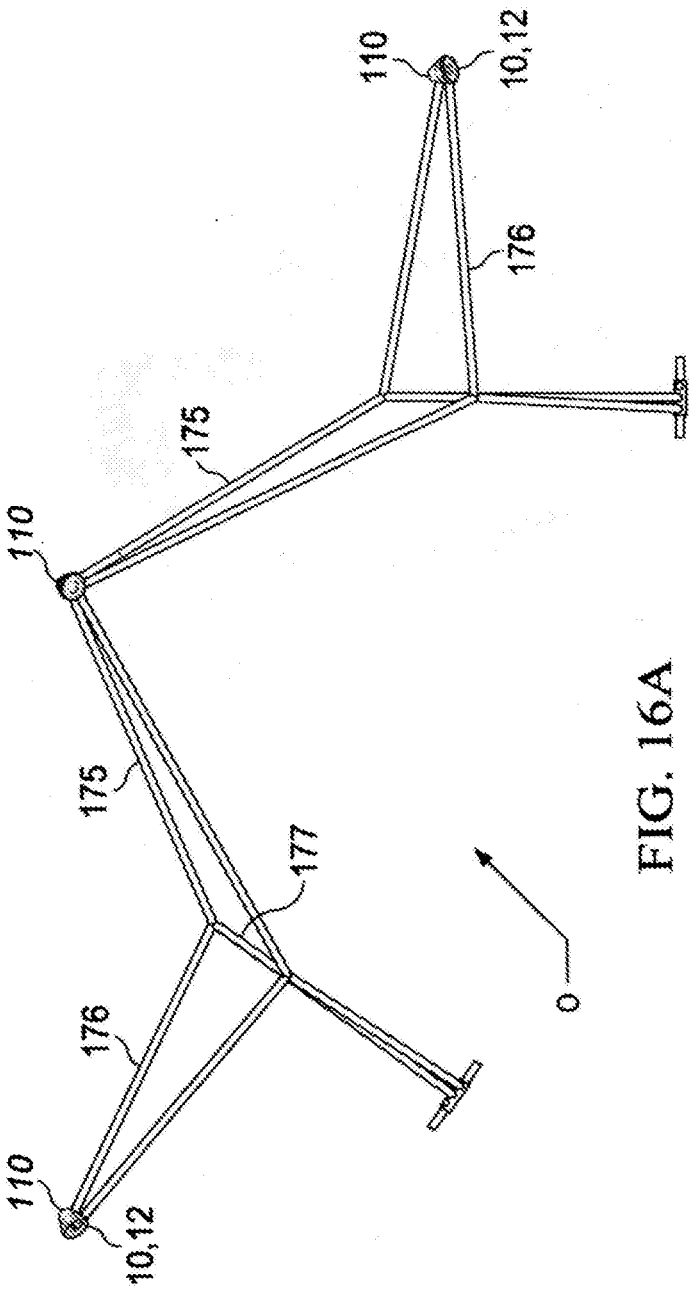


FIG. 15C



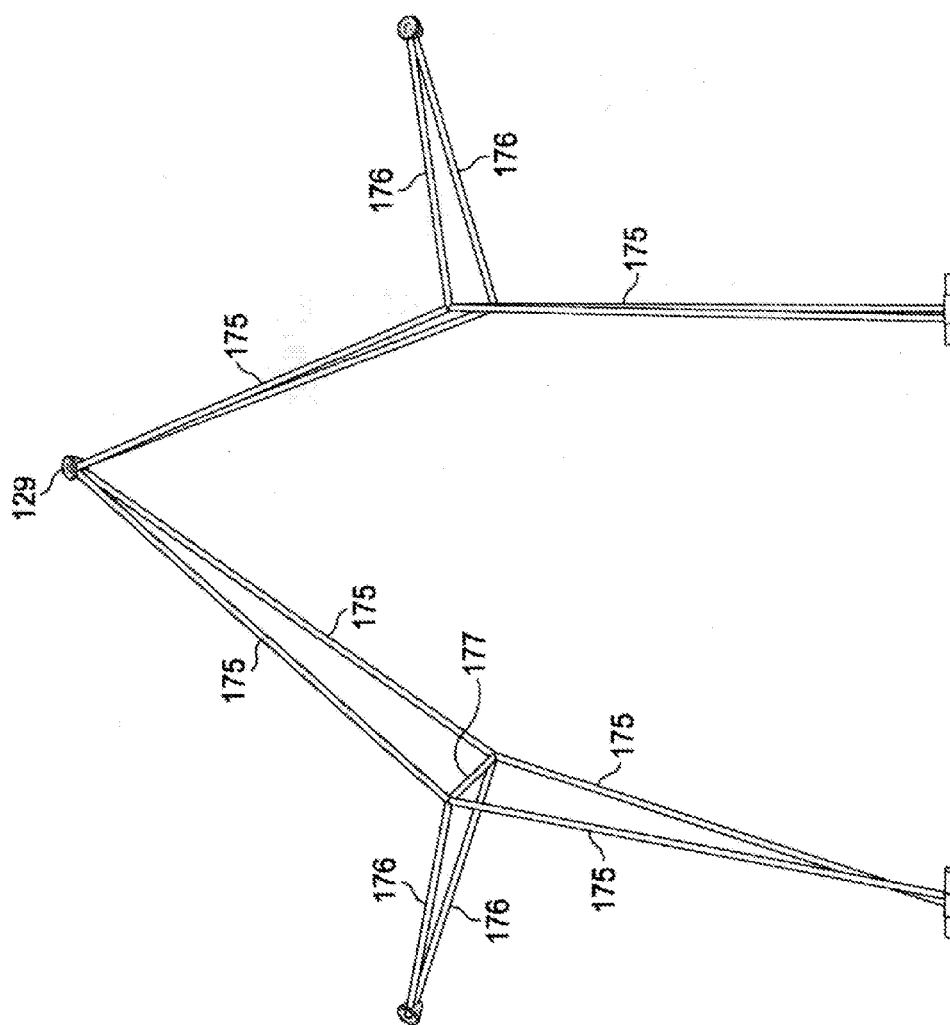


FIG. 16B

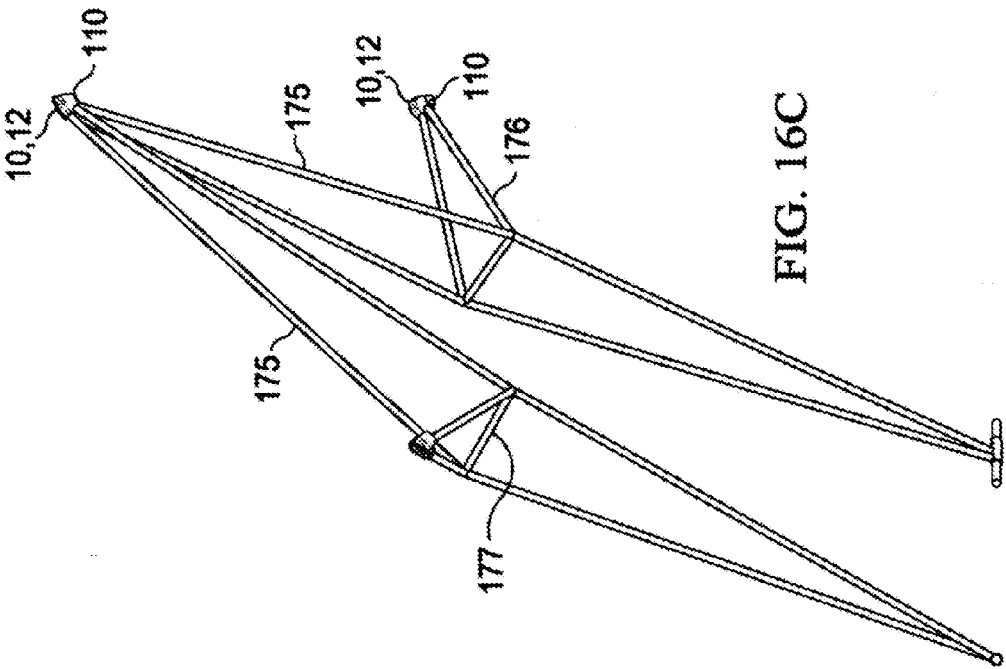
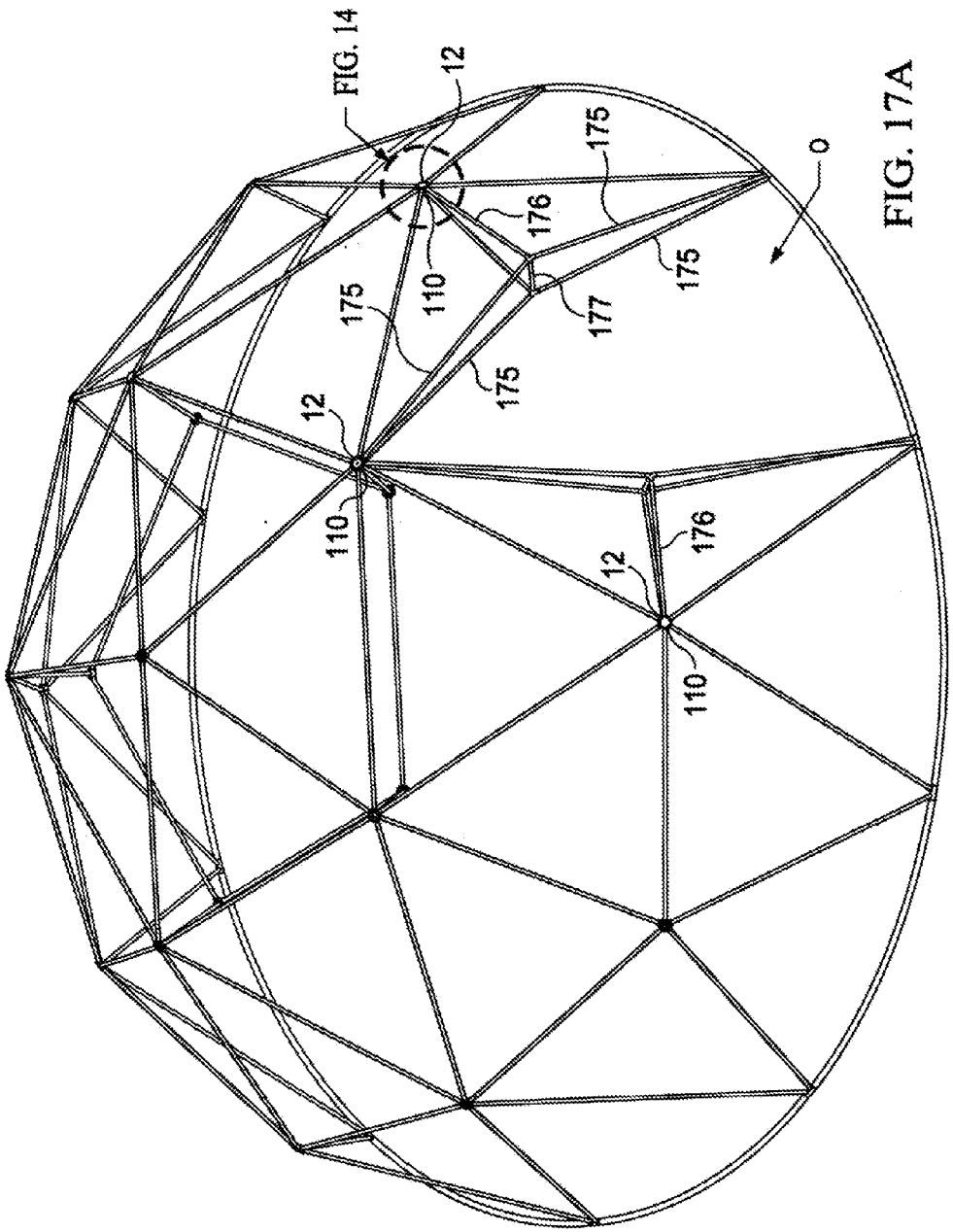


FIG. 16C



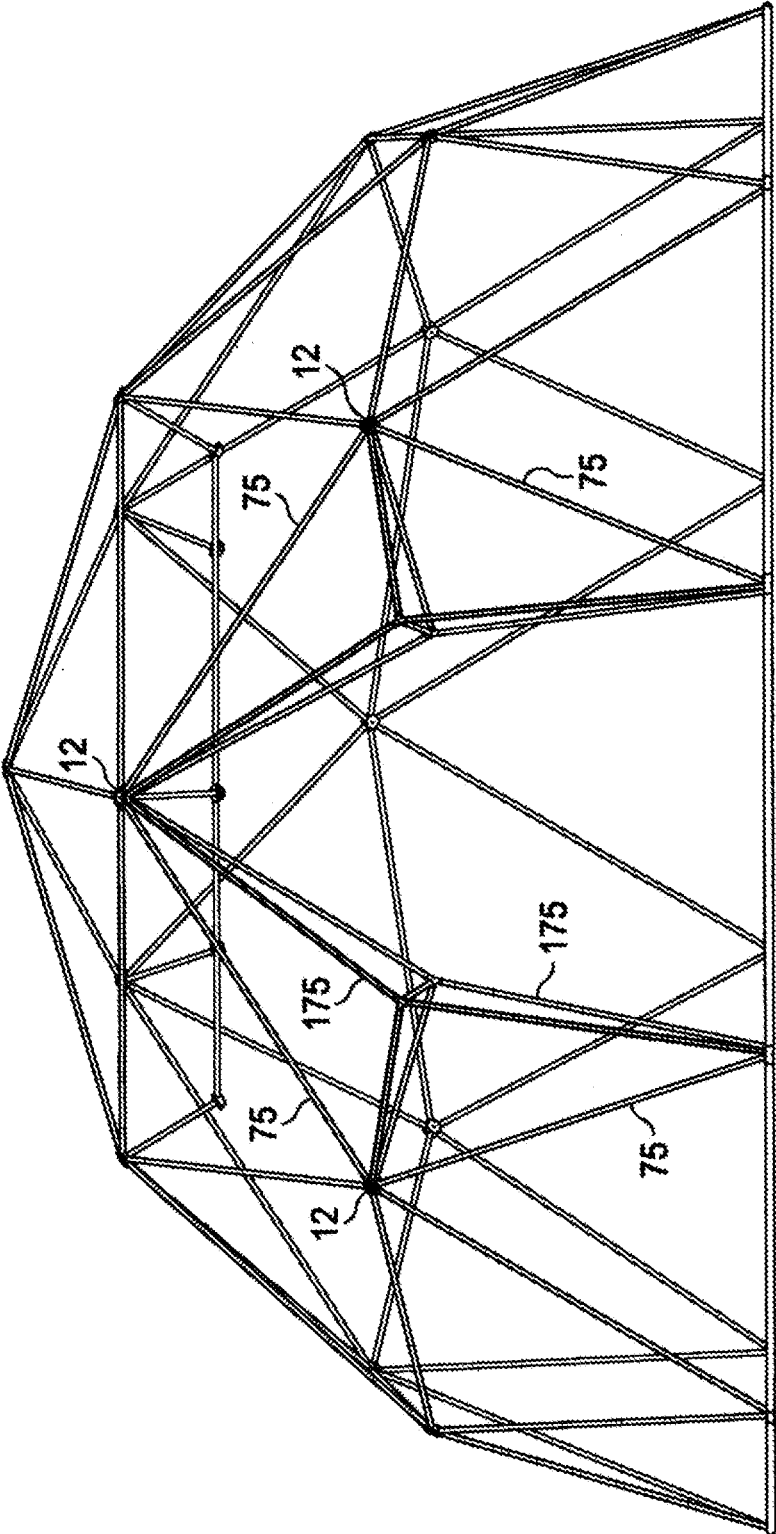


FIG. 17B

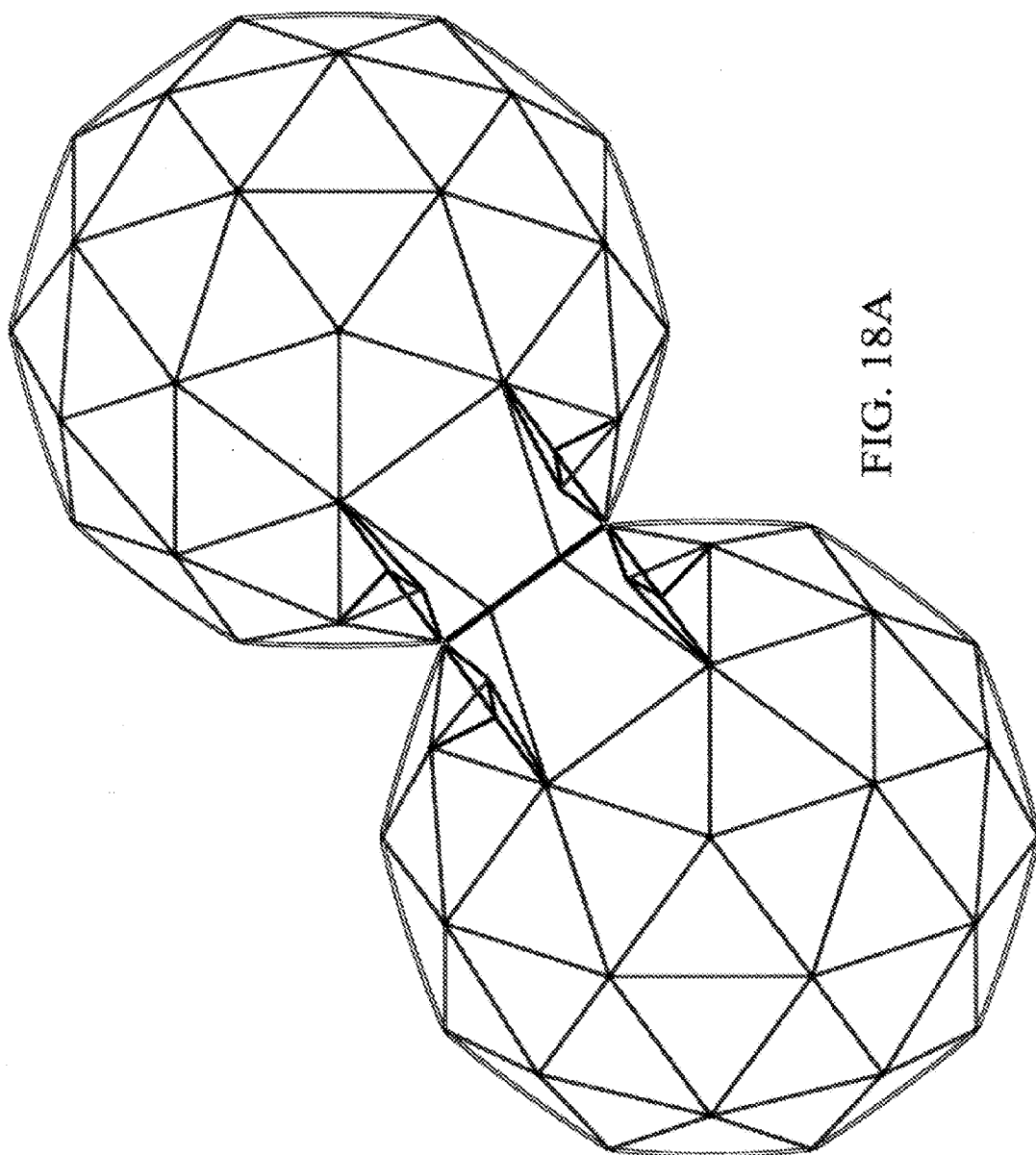


FIG. 18A

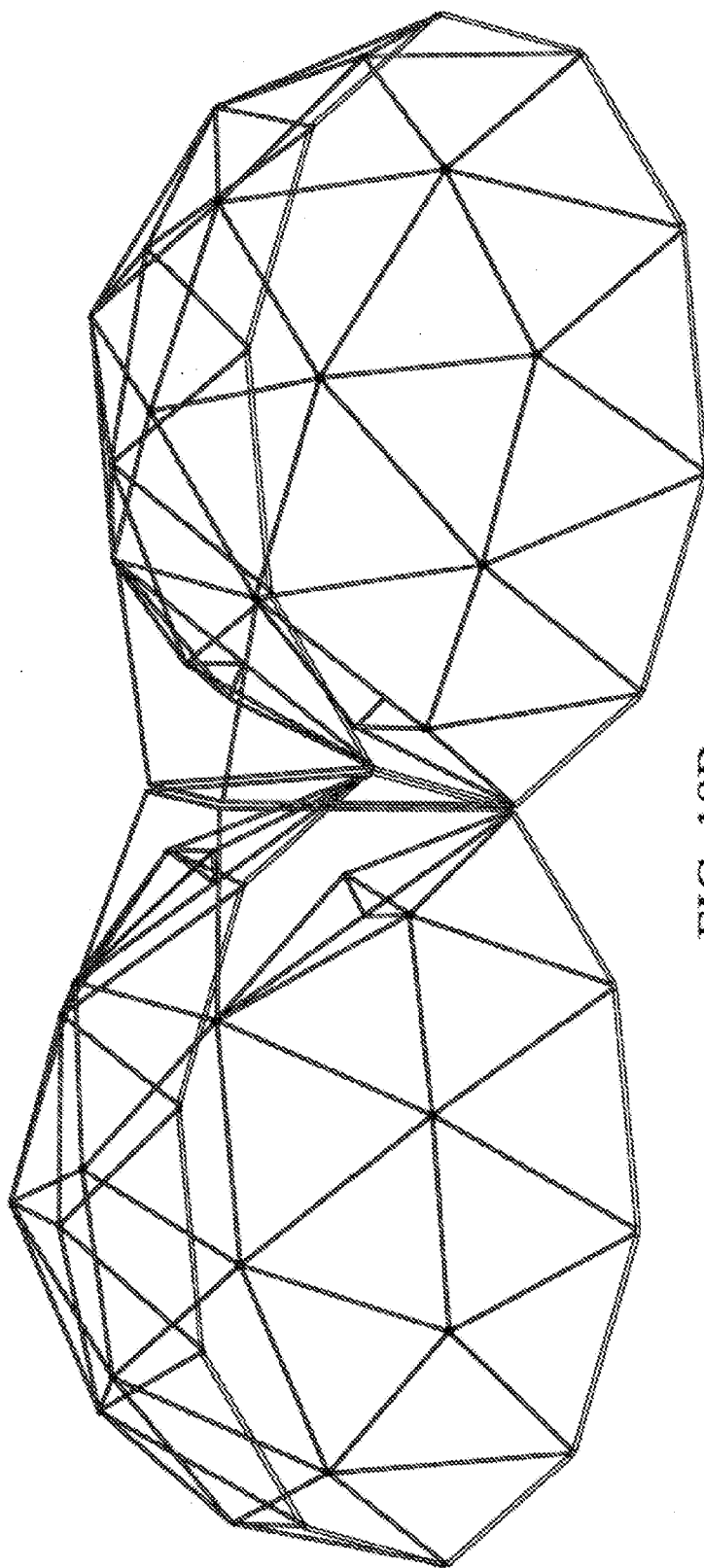


FIG. 18B

CONSTRUCTION AND HUB STRUCTURES THEREFROM

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a Continuation of US Non-Provisional application Ser. No. 14/679,943 Titled “Construction and Hub Structures Therefrom” having file date Apr. 6, 2015

[0002] which is a Continuation of U.S. Non-Provisional application Ser. No. 14/121,297 Titled “Construction and Hub Structures Therefrom” having file date Aug. 15, 2014

TECHNICAL FIELD

[0003] This invention relates generally to construction, and more particularly to geodesic dome and dome-like structures, including advancements in components therefor and their cooperative connection.

BACKGROUND OF THE INVENTION

[0004] The statements in this background section merely provide background information related to the present disclosure and may not constitute prior art.

[0005] Geodesic dome structures, and geodesic dome-like structures (collectively “geodesic structures”) have been contemplated and constructed for quite some time since at least the time when R. Buckminster Fuller pioneered the mathematics of such structures. Over the past several decades various workers have contrived different geodesic structures, as well as hardware means for attachment of their essential elements. Geodesic structures of prior art have included a plurality of linear members or “struts” attached to one another using a variety of hardware and methodologies in such fashion that leads to a stable structure. Due to varying geometric design concepts in the prior art, geodesic structures provided thereby have varying degrees of stability and levels of desirable features.

[0006] One desirable feature is the strength at the location where a plurality of struts of prior art geodesic structures meet one another, which can be considered as being a “joint location.” Geodesic structures of the prior art have a plurality of joint locations. In some prior art joint locations, ends of individual struts are directly attached to one another such as by use of a nut and bolt, welding, or other conventional fastening means. Another prior art joint is exemplified in U.S. Pat. No. 5,566,516.

[0007] Another desirable feature for some instances of geodesic structures is portability. Portability includes the ability of hubs and struts to be easily disassembled or re-assembled at each joint. In nearly all prior art the geodesic sphere is sectioned horizontally at a mid plane and the structure is attached to a substrate to provide stability for the hubs of the section plane. The base as described herein provides the necessary stability to preclude the need to attach the structures to another substrate for stability.

[0008] Another desirable feature of geodesic structures is their having an aperture such as a door that enables a person or objects such as pieces of equipment to be selectively admissible from the outside of a geodesic structure to its interior, and vice versa. Generally speaking, geodesic structures (spherical) not only do not like being sectioned, they do not like having an individual hub removed. If a hub is

removed to provide for a conventional door for example, all the hubs adjacent to the hub which was removed are significantly weakened and must be stabilized by some other means including auxiliary hubs and strut configurations.

[0009] Another desirable feature of geodesic structures is their ability to have an underlying framework of struts and joint locations which are covered with an outer sheathing structure, such as to protect the interior of such geodesic structures from environmental conditions of wind, rain, sunlight, etc. In some embodiments of the prior art, sheathing structures have included fabric such as woven canvas, cotton, linen and the like prior art fabrics. In other embodiments of the prior art, such sheathing structures have included rigid panels of varying materials including plywood, reinforced composites such as fiberglass, reinforced concrete, stucco, and the like prior art rigid panels.

[0010] In the prior art covers are permanently attached to underlying structural members of geodesic domes, or panels are fastened directly together by mechanical means. With this hub/strut combination, panels can be pre-assembled and locked into place during assembly of the basic structure thereby providing for an exterior cover without additional fasteners.

SUMMARY OF THE INVENTION

[0011] The present disclosure provides hub useful in construction of geodesic structures. In some embodiments a hub as provided is frustoconical in appearance and comprises a top surface; a bottom surface; and a side wall. A hub further features a fourth recessed region present at the top surface which has a first floor and a first wall, the first wall of the fourth recessed region extending from the top surface to the first floor. There is also a first recessed region present at the first floor which has a second floor and a second wall, the second wall of the first recessed region extending from the first floor to the second floor. There are also a plurality of second recessed regions radially disposed about the side wall, each having a third floor and a third wall, the third wall of the second recessed regions extending from the side wall to the third floor. A plurality of third recessed regions equaling the number of second recessed regions are also present, which are radially disposed about the second wall, with each having a fourth floor and a fourth wall, the fourth wall of the third recessed regions extending from the second wall to the floor of the third recessed regions. A plurality of radially-disposed bores equaling both the number of second recessed regions and third recessed regions are also present, that extend from the third floor to the fourth floor, each of the radially-disposed bores having an axis. There is a central bore having an axis which is disposed through the center of the hub and hence the second floor substantially perpendicular to the top surface and extending to the bottom surface. The axes of the radially-disposed bores intersect the axis of the central bore at any selected angle in the range of between 94 and 122 degrees. The invention also includes any and all known geodesic structures made using the hubs provided with appropriately-dimensioned struts.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] The drawings shown and described herein are provided for illustration purposes only and are merely exemplary of different embodiments provided herein, not intended to be construed in any delimitive fashion.

[0013] FIG. 1 illustrates a basic single-frequency geometry of the prior art associated with geodesic dome structures according to the prior art;

[0014] FIG. 2 illustrates a basic geometry of the prior art associated with geodesic dome structures having a frequency greater than one, according to the prior art;

[0015] FIG. 3A is an overhead view of a geodesic structure provided in accordance with some embodiments of the disclosure;

[0016] FIG. 3B is a side view of a geodesic structure provided in accordance with some embodiments of the disclosure;

[0017] FIG. 3C is a perspective view of a geodesic structure provided in accordance with some embodiments of the disclosure;

[0018] FIG. 3D is an alternate side view of a geodesic structure provided in accordance with some embodiments of the disclosure;

[0019] FIG. 4A is a perspective view of a hub element useful in providing geodesic structures in accordance with some embodiments of the disclosure;

[0020] FIG. 4B is a side view of a hub element useful in providing geodesic structures in accordance with some embodiments of the disclosure;

[0021] FIG. 4C is an overhead view of a hub element useful in providing geodesic structures in accordance with some embodiments of the disclosure;

[0022] FIG. 4D is a section view of the hub element of FIG. 4C useful in providing geodesic structures in accordance with some embodiments of the disclosure;

[0023] FIG. 4E is a section view of the hub element of FIG. 4C useful in providing geodesic structures in accordance with some embodiments of the disclosure;

[0024] FIG. 4F is an overhead view of a hub element useful in providing geodesic structures in accordance with some embodiments of the disclosure;

[0025] FIG. 5A is a perspective view of a hub element useful in providing geodesic structures in accordance with some embodiments of the disclosure;

[0026] FIG. 5B is a side view of a hub element useful in providing geodesic structures in accordance with some embodiments of the disclosure;

[0027] FIG. 5C is an overhead section view of a hub element useful in providing geodesic structures in accordance with some embodiments of the disclosure;

[0028] FIG. 5D is a section view of the hub element of FIG. 5C useful in providing geodesic structures in accordance with some embodiments of the disclosure;

[0029] FIG. 5E is a section view of the hub element of FIG. 5C useful in providing geodesic structures in accordance with some embodiments of the disclosure;

[0030] FIG. 5F is an overhead view of a hub element useful in providing geodesic structures in accordance with some embodiments of the disclosure;

[0031] FIG. 6 is a perspective view of a hub having struts attached thereto in accordance with some embodiments of the disclosure;

[0032] FIG. 7 is a perspective view of a hub having struts attached thereto in accordance with some embodiments of the disclosure;

[0033] FIG. 8 is an exploded perspective view of a joint useful in providing a geodesic structure according to some embodiments of this disclosure;

[0034] FIG. 9 is a side cutaway view of a joint useful in providing geodesic structures according to some embodiments of the disclosure;

[0035] FIG. 10 is a side cutaway view of two joints each useful in providing geodesic structures according to some embodiments of the disclosure, connected to one another;

[0036] FIG. 11 is a perspective view of a base joint of a geodesic structure in accordance with some embodiments of the disclosure;

[0037] FIG. 12A shows a perspective view of a joint present on a geodesic dome according to some embodiments of the disclosure;

[0038] FIG. 12B shows an overhead view of a joint present on a geodesic dome according to some embodiments of the disclosure;

[0039] FIG. 12C shows an overhead view of a joint present on a geodesic dome according to some embodiments of the disclosure;

[0040] FIG. 13 is a cross-sectional view of components useful for enclosing a geodesic structure according to some embodiments of the disclosure;

[0041] FIG. 14 is a close-up perspective view of a secondary hub attached to a joint hub in accordance with some embodiments of the disclosure;

[0042] FIG. 15A is an overhead view of a secondary hub according to some embodiments of the disclosure;

[0043] FIG. 15B is a perspective view of a secondary hub according to some embodiments of the disclosure;

[0044] FIG. 15C is a side perspective view of a secondary hub according to some embodiments of the disclosure;

[0045] FIG. 15D is an alternate side perspective view of a secondary hub according to some embodiments of the disclosure;

[0046] FIG. 16A is a perspective view of an aperture truss according to some embodiments of the disclosure;

[0047] FIG. 16B is a perspective view of an aperture truss according to some embodiments of the disclosure;

[0048] FIG. 16C is a perspective view of an aperture truss according to some embodiments of the disclosure;

[0049] FIG. 17A is a perspective view of a geodesic structure having a truss aperture according to some embodiments of the disclosure;

[0050] FIG. 17B is a frontal view of a geodesic structure having a truss aperture according to some embodiments of the disclosure;

[0051] FIG. 18A is an overhead view of two geodesic structures directly attached to one another according to some embodiments of the disclosure;

[0052] FIG. 18B is a perspective view of two geodesic structures each having an aperture truss, which are attached to one another according to some embodiments of the disclosure;

DETAILED DESCRIPTION

[0053] The following description is exemplary in nature and is in no way intended to limit the present disclosure, application, or uses.

[0054] Referring now to the drawings, and initially to FIG. 1, there is shown a basic single-frequency geometry of the prior art associated with geodesic dome structures, for which mathematical equations necessary to define such structures were developed by R. Buckminster Fuller. All geodesic structures assign points on the surface of a theoretical sphere, with the most basic being a single frequency

whereby 12 points are equally spaced over the surface of a theoretical sphere, one point on each pole and the remaining 10 equally spaced around the sphere. When these points are connected with lines or struts the single frequency geodesic structure is formed. The frequency of such a structure can be increased by several methods well-known in the art, the frequency being the number of facets such a theoretical sphere is divided into.

[0055] FIG. 2 is illustrative of how the frequency of the structure of FIG. 1 can be increased, by subdividing each linear member of the single frequency dome into two or more segments or equidistant points along this line. A radial line is established from the spherical center through the point along the line to the spherical surface, thus establishes additional points on the spherical surface and when these points are connected with lines (or struts) each of the single facets of the single frequency structure become four facets, with three of the new facets being identical to one another and the remaining fourth facet being differently shaped from the other three. Such increase of frequency also inherently gives rise to the struts needing to be of two different lengths, and the angles of struts at different joint locations no longer being congruent to one another, rather requiring two different angles of adjoinment of the various struts at the joint locations.

[0056] FIGS. 3A, 3B, 3C, and 3D are non-limiting exemplary views of a geodesic structure which can be provided using a hub element and other articles shown and described herein. Geodesic structures of many different frequencies are well-known that are possessed of differing numbers of joint locations.

[0057] Referring to FIG. 4A there is shown a perspective view of a hub 10 useful as a joint in providing geodesic structures in accordance with some embodiments of the disclosure. Hub 10 in some embodiments is generally cylindrically shaped, as shown, in some embodiments with the top of such cylinder having a larger diameter than the bottom, resembling a cone that is truncated at its top and bottom, or frustoconical. There is a top surface 3 which in some embodiments is a planar surface shaped as a ring and extending circumferentially about the top of hub 10. Hub 10 has a bottom surface 7, also shown in FIG. 4B, bottom surface 7 being planar in some embodiments. Hub 10 features a first recessed region 9 having a floor 25 (FIG. 4E) and a wall 13 disposed within the interior of hub 10. In some embodiments, there are a plurality of second recessed regions 17 present on side wall 19 (FIG. 4B) of hub 10, circumferentially disposed thereabout. Each second recessed region 17 has a floor 33 (FIG. 4D) and a wall 35 (FIG. 41)), as well as a radial bore 15 through the center of floor 33. Radial bores 15 each extend from floor 33 of the second recessed region 17 through side wall 19 and towards first recessed region 9, the radial bore 15 terminating at the floor 31 of third recessed region 27 (FIG. 4E).

[0058] Hub 10 also features a plurality of third recessed regions 27 (FIGS. 4D, 4E), radially disposed about the wall 13 of first recessed region 9. Each third recessed region 27 has a wall 29 and a floor 31. In some embodiments, each radial bore 15 is disposed between the floor 33 of the second recessed regions 17 and the floor 31 of the third recessed regions 27, with each second recessed region 17 being paired with a third recessed region 27 and connected to one another by way of a radial bore 15. In such embodiments, viewing these recessed regions end-on means aligning one's

sight with the axis X (FIG. 4E) of radial bore 15, either from within first recessed region 9 to view third recessed region 27 end-on, or from outside the side wall 19 of hub 10 when viewing second recessed region 17 end-on.

[0059] In some embodiments, there is an optional fourth recessed region 5 disposed towards the top of hub 10, the fourth recessed region having a wall 11 and a floor 23 (FIG. 4D). In some embodiments fourth recessed region 5 is cylindrically-shaped. An end-on view of the first recessed region 9 and fourth recessed region 5, is seen in the overhead view of FIG. 4C, which is equivalent to viewing FIG. 4B from above top surface 3.

[0060] In some embodiments each of the recessed regions 9, 17, 27 and 5 when present are circular as viewed end-on, and their volumes cylindrical. In other embodiments one or more than one of these recessed regions can independently be substantially-cylindrical, which means more like a cylinder than any other geometric construct, however, thus the invention includes various other alternative embodiments wherein any one, two, three or all four of the recessed regions 5, 9, 17, 27 are not circular as viewed end-on, including those having the shape of any polygon, ovoid, or any other shape that accomplishes the same substantial functions as taught herein, and a corresponding inherent volume shape.

[0061] In some embodiments, first recessed region 9 and fourth recessed region 5 when present appear circular as viewed end-on, when the volume of these regions are cylindrical, and the fourth recessed region 5 and first recessed region 9 each have a common center corresponding to the axis of the respective cylinders they define. In some embodiments the centers of the first recessed region 9 and fourth recessed region 5 when present are coincident with one another, as shown in FIG. 4C, axis Z of FIGS. 4D, 4E passing through such centers and representing such axes.

[0062] In some embodiments, the same is true regarding second and third recessed regions 17, 27 as they each appear circular when viewed end-on when their volumes define a cylinder, and they share a common center corresponding to the axes of the respective cylinders they define, as represented by axis X in FIG. 4E. In some embodiments floors 31, 33 are planar and normal to axis X in FIG. 4E. In other embodiments floor 33 is not planar but is contoured to match the end of a strut attached to hub 10.

[0063] FIG. 4B is a side view of a hub 10 useful in providing geodesic structures in accordance with some embodiments of this disclosure, showing the respective locations of second recessed regions 17, radial bores 15, top surface 3, bottom surface 7, side wall 19, and beveled edge 21, optional beveled edge 21 being a flat surface in some embodiments disposed about the perimeter at the top portion of hub 10, adjacent to top surface 3 and side wall 19.

[0064] FIG. 4C is an overhead view of a hub 10 useful in providing geodesic structures in accordance with some embodiments of the disclosure, depicting sections 4D and 4E, shown in more detail in FIGS. 4D and 4E respectively. In such embodiments, hub 10 is configured to receive five strut elements of a geodesic structure, as hub 10 includes five radial bores 15, the radial bores 15 having a first end and a second end, with a second recessed region 17 being present at the first end of a radial bore 15 and a third recessed region 27 being present at the second end of a radial bore 15.

[0065] FIG. 4D is a section view of the hub element 10 of FIG. 4C useful in providing geodesic structures in accor-

dance with some embodiments of this disclosure. Depicted in FIG. 4D are the respective locations of first recessed region 9, second recessed region 17, third recessed region 27 and fourth recessed region 5. Also shown are top surface 3, beveled edge 21, wall 35 of second recessed region 17, radial bore 15, floor 33 of second recessed region 17, bottom surface 7, central bore 37, and floor 31 of third recessed region 27. In some embodiments central bore 37 is a bore that extends from the floor 25 (FIG. 4E) of first recessed region 9 through hub 10 to the exterior of bottom surface 7. Axis Z is shown, which is the centerline axis of central bore 37 that is also coincident with the axes of fourth recessed region 5 when present and first recessed region 9. In this side perspective view of FIG. 41), also depicted is line Z', which runs parallel to axis Z. There is an angle α , representing the angle that beveled edge 21 makes with respect to Z', which can be any angle in the range of between twenty and forty degrees, including all angles and ranges of angles therebetween. In some embodiments angle α is thirty (30) degrees. There is also shown an angle β , representing the angle that side wall 19 makes with respect to Z' which can be any angle in the range of between 0 and 32 degrees, including all angles and ranges of angles therebetween. In some embodiments angle β is seventeen (17) degrees. As shown in the embodiment depicted in FIG. 4D, the floor portions of each of the first, second, third, and fourth recessed regions 9, 17, 27, 5 are flat or planar. It is however within this disclosure for each of these floor portions to be independently or all non-planar, having any topographical profile purposefully selected in accordance with this invention by the engineer. Height H is also shown, which is the height of hub 10, representing the distance between top surface 3 and bottom surface 7. In some embodiments top surface 3 and bottom surface 7 are parallel to one another, and in alternate embodiments these surfaces are planar but are angled with respect to one another in an amount of any degree between one degree and twenty degrees, including all angles and ranges of angles therebetween.

[0066] In some embodiments each of the first, second, third, and fourth recessed regions 9, 17, 27, 5 feature a depth with respect to the surface from which they're recessed. In some embodiments, the depth or distance of recession of a floor portion under consideration for any given one of the floor portions of these recessed regions are independently selected without regards to the depths of the floor portions of the other or remaining recessed regions.

[0067] In some embodiments, floor 23 of fourth recessed region 5 when selected to be present is recessed from top surface 3 in any selected amount of distance in the range of 3% and 15% of height H, which range includes all amounts of distance and all ranges of distances therebetween. In some embodiments, the floor 23 of fourth recessed region 5 is recessed from top surface 3 by an amount of distance of 8.5% of height H.

[0068] The first recessed region 9 is in some embodiments recessed from the floor 23 of fourth recessed region 5 when present in any selected amount of distance in the range of between 40% and 65% of height H, which range includes all amounts of distance and all ranges of distances therebetween. Stated another way, the floor 25 of first recessed region 9 is disposed in some embodiments at a distance between 40% and 65% of height H from the floor 23 of fourth recessed region 5. In some embodiments the floor 25 of first recessed region 9 is disposed at a distance of 54% of

height H from the floor 23 of fourth recessed region. In some embodiments, fourth recessed region 5 is not present, and the floor 25 of first recessed region 9 is disposed in some embodiments at any distance between 40% and 65% of height H from top surface 3, including all depths and ranges of depths therebetween. In some embodiments when fourth recessed region 5 is not present, the floor 25 of first recessed region 9 is disposed at a distance of 54% of height H from top surface 3.

[0069] The second recessed region 17 is in some embodiments recessed from the side wall 19 of hub 10 in any selected amount of distance in the range of between 5% and 30% of height H, which range includes all amounts of distance and all ranges of distances therebetween. Stated another way, the floor 33 of second recessed region 17 is disposed in some embodiments at any selected distance between 5% and 30% of height H from the side wall 19 of hub 10. In some embodiments the floor 33 of second recessed region 17 is disposed at a distance of 5% of height H from the side wall 19 of hub 11.

[0070] The floor 31 of third recessed region 27 is in some embodiments recessed from the wall 13 of first recessed region 9 in any selected amount of distance in the range of between 5% and 30% of height H, which range includes all amounts of distance and all ranges of distances therebetween. Stated another way, the floor 31 of third recessed region 27 is disposed in some embodiments at any selected distance between 5% and 30% of height H from the wall 13 of first recessed region 9 in the direction parallel to the axis X of radial bore 15. In some embodiments the floor 31 of third recessed region 27 is disposed at a distance of 12% of height H from the wall 13 of first recessed region 9 in the direction parallel to the axis X of radial bore 15.

[0071] FIG. 4E is a section view of the hub element 10 of FIG. 4C useful in providing geodesic structures in accordance with some embodiments of the disclosure. In this FIG. 4E are shown the respective locations of top surface 3, fourth recessed region 5, first recessed region 9, floor 23 of fourth recessed region 5, wall 11 of fourth recessed region 5, beveled edge 21, wall 29 of third recessed region 27, radial bore 15, second recessed region 17, bottom surface 7, floor 25 of first recessed region 9, side wall 19, and wall 13 of first recessed region 9.

[0072] Also depicted in FIG. 4E is axis Z, the centerline axis of central bore 37 that is also coincident with the axes of fourth recessed region 5 when present and first recessed region 9. Also depicted is axis X, which is the centerline axis of radial bore 15. The remaining four radial bores present in this exemplary embodiment also have a centerline axis analogous to axis X, axis X being an inherent feature of all radial bores 15 present on a hub 10. As apparent from FIG. 4E, axis X intersects axis Z at an angle λ . Generally, angle λ is greater than 90 degrees and may be any selected angle in the range of between 94 and 122 degrees including all angles and all ranges of angles within that range. In some embodiments, angle λ is 105.8 degrees on a hub 10 according to this disclosure. In some embodiments, the angle λ that the axis X for each of the radial bores 15 present intersects the Z axis is the same angle. Thus, the axis X is angled downward from the horizontal for each of the radial bores 15 present on this hub 10 from the perspective shown. These same descriptions apply also to some embodiments of a hub 12 and secondary hubs 110 described later herein. In some embodiments,

angle λ is not the same for all axes X of each radial bore 15 present. In some embodiments radial bores 15 are provided having an angle λ for each radial bore 15 present being independently selected from one another from selected angles within the range above. In some embodiments, any number of radial bores 15 between 1 and 6 (inclusive) present can have an angle λ that are congruent to one another, and also with any number of radial bores 15 present between 1 and 6 (inclusive) being non-congruent to one another in alternate embodiments.

[0073] FIG. 4F is an overhead view of a hub 10 useful in providing geodesic structures in accordance with some embodiments of the disclosure, depicting the respective locations of top surface 3, floor 23 of fourth recessed region 5, floor 25 of first recessed region 9, beveled edge 21, and central bore 37. Not depicted in the figures is an underside or bottom view of hub 10, however such a view would appear circular with central bore 37 in its center.

[0074] In FIG. 5A there is shown a perspective view of a hub 12 useful as a joint in providing geodesic structures in accordance with some embodiments of this disclosure. Hub 12 is generally cylindrically shaped, having a taper as shown, with the top of such cylinder having a larger diameter than the bottom, resembling a cone that is truncated at its top and bottom, or frustoconical. There is a top surface 39 which in some embodiments is a planar surface shaped as a ring and extending circumferentially about the top of hub 12.

[0075] Hub 12 features a first recessed region 57 having a floor 59 (FIG. 5E) and a wall 61 disposed within the interior of hub 12. In some embodiments first recessed region 57 is cylindrically-shaped. Also shown are top surface 39, fourth recessed region 51 having floor 53, beveled edge 47, bottom surface 41, second recessed regions 63, side wall 45, and radial bores 43, these features being analogous to such features present on hub 10.

[0076] FIG. 51 is a side view of a hub element 12 useful in providing geodesic structures in accordance with some embodiments of the disclosure, showing the respective locations of second recessed regions 63, radial bores 43, top surface 39, bottom surface 41, side wall 45, and beveled edge 47, optional beveled edge 47 being a flat surface in some embodiments disposed about the perimeter at the top portion of hub 12, adjacent to top surface 39 and side wall 45.

[0077] In some embodiments, there are a plurality of second recessed regions 63 present on side wall 45 (FIG. 5B) of hub 12, circumferentially disposed thereabout. Each second recessed region 63 has a floor 65 and a wall 67 (FIG. 5D), as well as a radial bore 43 through the center of floor 65. Radial bores 43 each extend from floor 65 of the second recessed regions 63 through side wall 45 and towards first recessed region 57, radial bores 43 terminating at the floors 71 of third recessed regions 69 (FIG. 5E).

[0078] FIG. 5C is an overhead view of a hub 12 useful in providing geodesic structures in accordance with some embodiments of the disclosure, depicting sections shown in more detail in FIGS. 5D and 5E respectively, and central bore 49. In some embodiments, hub 12 is configured to receive six strut elements of a geodesic structure, as hub 12 includes six radial bores, the radial bores having a first end and a second end, with a second recessed region 63 being present at the first end of a radial bore 43 and a third recessed region 69 being present at the second end of that same radial bore 43, for each radial bore present.

[0079] FIG. 5D is a section view of the hub element 12 of FIG. 5C useful in providing geodesic structures in accordance with some embodiments of the disclosure. Depicted in FIG. 5D are the respective locations of fourth recessed region 51, first recessed region 57, second recessed regions 63 and third recessed regions 69. Also shown are top surface 39, beveled edge 47, side wall 45, radial bore 43, floor 65 of second recessed region 63, wall 67 of second recessed region 63, floor 71 of third recessed region 69, bottom surface 41, central bore 49, and floor of fourth recessed region 51. Central bore 49 is a bore that extends from the floor 59 (FIG. 5E) of first recessed region 57 through hub 12 to the exterior of bottom surface 41. Axis Z is shown, which is the centerline axis of central bore 49 that is also coincident with the axes of fourth recessed region 51 when present and first recessed region 57. In this side perspective view of FIG. 5D, also shown is line 'Z', which runs parallel to axis Z. There is an angle α , representing the angle that beveled edge 47 makes with respect to Z', which can be any angle in the range of between twenty and forty degrees, including all angles and ranges of angles therebetween. In some embodiments angle α is thirty (30) degrees. There is also shown an angle β , representing the angle that side wall 45 makes with respect to Z' which can be any angle in the range of between zero and thirty-two degrees, including all angles and ranges of angles therebetween. In some embodiments angle β is seventeen (17) degrees. As shown in the embodiment depicted in FIG. 5D, the floor portions of each of the first, second, third, and fourth recessed regions 57, 63, 69, 51 are flat. It is however within this disclosure for each of these floor portions to be independently or all non-planar, having any selected topographical profile. Height H is also shown, which is the height of hub 12, representing the distance between top surface 39 and bottom surface 41. In some embodiments top surface 39 and bottom surface 41 are parallel to one another, and in alternate embodiments these surfaces are planar but are angled with respect to one another in an amount of any degree between one degree and thirty-two degrees, including all angles and ranges of angles therebetween.

[0080] Hub 12 also features a plurality of third recessed regions 69 (FIGS. 5D, 5E), radially disposed about the wall 61 of first recessed region 57. Each third recessed region 69 has a wall 73 and a floor 71. In some embodiments, each radial bore 43 is disposed between the floor 65 of the second recessed regions 63 and the floor 71 of the third recessed regions 69, with each second recessed region 63 being paired with a third recessed region 69 and connected to one another by way of a radial bore 43. In such embodiments, viewing these recessed regions end-on means aligning one's sight with the axis of radial bore 43, either from within first recessed region 57 to view third recessed region 69 end-on, or from outside the side wall 45 of hub 12 when viewing second recessed region 63 end-on. The first and fourth recessed regions 57, 51 are visible in the overhead view of FIG. 5C, which is equivalent to viewing FIG. 5B from above top surface 39.

[0081] In some embodiments there is a fourth recessed region 51 disposed towards the top of hub 12, the fourth recessed region having a wall 55 and a floor 53 (FIG. 5E). Hub 12 has a bottom surface 41, as shown in FIG. 5B, bottom surface 41 being planar for some embodiments and non-planar in optional embodiments. In some embodiments first recessed region 57 is cylindrically-shaped.

[0082] In some embodiments, each of the four recessed regions **51**, **57**, **63**, **69** are circular as viewed end-on, and their volumes cylindrical or substantially-cylindrical, which means more like a cylinder than any other geometric construct, however, the present disclosure includes various other alternative embodiments wherein any one, two, three or all four of the recessed regions **51**, **57**, **63**, **69** are not circular as viewed end-on, including those having the shape of any polygon, ovoid, or any other shape that accomplishes the same substantial functions as taught herein, and a corresponding inherent volume shape.

[0083] In some embodiments, fourth recessed region **51** and first recessed region **57** appear circular as viewed end-on, when the volume of these regions are cylindrical, and the fourth recessed region **51** and first recessed region **57** each have a centerline corresponding to the axis of the respective cylinders they define. In some embodiments the centers of the fourth and first recessed regions **51**, **57** are coincident with one another, as shown in FIG. **5C**, axis **Z** of FIGS. **5D**, **5E** passing through such centers and representing such axes.

[0084] In some embodiments, the same is true regarding second and third recessed regions **63**, **69** as they each appear circular when viewed end-on when their volumes define a cylinder, and they share a common center corresponding to the axes of the respective cylinders they define, as represented by axis **X** in FIG. **5E**.

[0085] Each of the first, second, third, and fourth recessed regions **57**, **63**, **69**, **51** have a depth with respect to the surface from which they're recessed. In some embodiments, the depth or distance of recession of the floor portion under consideration of any given one of the floor portions of these recessed regions is/are independently selected without regards to the depths of the floor portions of the remaining recessed regions.

[0086] In some embodiments, the floor **53** of fourth recessed region **51** is recessed from top surface **39** in any selected amount of distance in the range of 0% (no recess) and 15% of height **H**, which range includes all distances and all ranges of distances therebetween. In some embodiments, the floor **53** of fourth recessed region **51** is recessed from top surface **39** by an amount of distance of 8.5% of height **H**.

[0087] The first recessed region **57** is in some embodiments recessed from the floor **53** of fourth recessed region **51** when present in any selected amount of distance in the range of between 40% and 65% of height **H**, which range includes all distances and all ranges of distances therebetween. Stated another way, the floor **59** of first recessed region **57** is present in some embodiments at a distance between 40% and 65% of height **H** from the floor **53** of fourth recessed region. In some embodiments the floor **59** of first recessed region **57** is disposed at a distance of 54% of height **H** from the floor **53** of fourth recessed region. In embodiments for which fourth recessed region **51** is selected to not be present, the first recessed region **57** is recessed from top surface **39** in any amount of distance purposefully selected in accordance with this invention by the engineer in the range of between 40% and 65% of height **H**, which range includes all distances and all ranges of distances therebetween. Stated another way, in some of such embodiments the floor **59** of first recessed region **57** is disposed or present at any selected distance between 40% and 65% of height **H** from top surface **39**. In some embodiments the floor **59** of

first recessed region **57** is disposed at a distance of 54% of height **H** from top surface **39**.

[0088] The second recessed region **63** is in some embodiments recessed from the side wall **45** of hub **12** in any selected amount of distance in the range of between 5% and 30% of height **1**, which range includes all amounts of distance and all ranges of distances therebetween. Stated another way, the floor **65** of second recessed region **63** is disposed in some embodiments at any selected distance between 5% and 30% of height **H** from the side wall **45** of hub **12** including all distances and ranges of distances therebetween. In some embodiments the floor **65** of second recessed region **63** is disposed at any selected distance within in the range of 5% to 20% of height **H** from the side wall **45** of hub **12**, including all distances and ranges of distances therebetween.

[0089] The third recessed region **69** is in some embodiments recessed from the wall **61** of first recessed region **57** in any amount of distance selected purposefully selected in accordance with this invention by the engineer in the range of between 5% and 30% of height **H**, which range includes all distances and all ranges of distances therebetween. Stated another way, the floor **71** of third recessed region **69** is disposed in various embodiments at any distance purposefully selected in accordance with this invention by the engineer between 5% and 30% of height **H** from the wall **61** of first recessed region **57** in the direction parallel to the axis **X** of radial bore **43**. In some embodiments the floor **71** of third recessed region **69** is disposed at a distance of 12% of height **1H** from the wall **61** of first recessed region **57** in the direction parallel to the axis **X** of radial bore **43**.

[0090] FIG. **5E** is a section view of the hub element **12** of FIG. **5C** useful in providing geodesic structures in accordance with some embodiments of the disclosure. In this FIG. **5E** are shown the respective locations of top surface **39**, central bore **49**, fourth recessed region **51**, first recessed region **57**, floor **53** of fourth recessed region **51**, wall **55** of fourth recessed region **51**, beveled edge **47**, wall **73** of third recessed region **69**, floor **71** of third recessed region **69**, radial bore **43**, second recessed region **63**, bottom surface **41**, floor **59** of first recessed region **57**, side wall **45**, and wall **61** of first recessed region **57**. Also shown are floor **65** and wall **67** of second recessed region **63**. Also depicted in FIG. **5E** is axis **Z**, the centerline axis of central bore **49** that is also coincident with the axes of fourth recessed region **51** when selected to be present, and first recessed region **57**.

[0091] Also shown in FIG. **5E** is axis **X**, which is the centerline axis of radial bore **43**. The remaining radial bores present in this exemplary embodiment also have a centerline axis that is analogous axis **X**, axis **X** being but representative of an inherent feature of all radial bores **43** present on a hub **12**. As apparent from FIG. **5E**, axis **X** intersects axis **Z** at an angle λ . Generally, angle λ is greater than 90 degrees and is any angle selected by the engineer in the range of between 94 and 122 degrees including all angles and all ranges of angles within that range. In some embodiments, angle λ is 105.8 degrees on a hub **12**. In some embodiments, the angle λ that the axis **X** for each of the radial bores **43** present intersects the **Z** axis is the same angle. In some embodiments radial bores **43** are provided having an angle λ for each radial bore **43** present being selected from chosen angles within the range above independently from the angle λ of other radial bores **43** present. In some embodiments, any number of radial

bores 43 between 1 and 6 (inclusive) present can have an angle λ that are congruent to one another, any number of them between 1 and 6 (inclusive) being independently non-congruent to the remaining radial bores 43 in other embodiments.

[0092] FIG. 5F is an overhead view of a hub 12' useful in providing geodesic structures in accordance with some embodiments of the disclosure, depicting the respective locations of top surface 39, floor 53 of fourth recessed region 51, floor 59 of first recessed region 57, beveled edge 47, and central bore 49. Not depicted in the figures is an underside or bottom view of hub 12, however such a view would appear circular with central bore 49 in its center.

[0093] Hubs 10, 12 have been described herein as exemplary embodiments of this disclosure, and both hubs 10 and 12 are employed in some end-use embodiments as joints in the same geodesic structure. FIGS. 6 and 7 depict a perspective view of hub 12 having struts 75 attached thereto, showing joints useful in providing geodesic structures as provided herein. Struts 75 are attached to such hubs 12 or 10, as may be selected generally by providing struts 75 to have flat or any other contoured end portions that fit, mate with, or otherwise abut floor 33, 65 of a second recessed region 17, 63 of a hub 10, 12 as provided herein. FIG. 6 shows hub cover 77 not affixed to hub 12, leaving the interior or first recessed region 57 of hub 12 open for assembly such as attachment of struts 75 to hub 12. Hub cover 77 can for some embodiments be generally disc-shaped and dimensioned to fit into and be received by fourth recessed region 5, 51 either by interference fit or by use of conventional fasteners including without limitation nuts, bolts, and screws. By affixing hub cover 77 to hub 10, 12 such as shown in FIG. 7, all external terrestrial weather and environmental factors can be excluded from the interior of such hubs including the first recessed region 9, 57 while still enabling access thereto when hub covers are removably attached to a hub, such as when conventional fasteners such as a nut(s) and bolt(s) is employed when hub cover 77 is itself provided with one or more holes or threaded portions therethrough or thereon for such purpose.

[0094] In some embodiments hub cover 77 features a threaded rod attached normally to its hub interior-facing side, the end of such threaded rod or bolt passing through central bore 37, 49 sufficiently to receive a nut or other conventional fastener in an engaging manner securing such hub cover to the hub. In alternate embodiments such as that shown in FIG. 9a nut or other threaded female fastener 103 is attached to one side of hub cover and a fastener 98 (FIG. 9) is inserted through central bore from the bottom of hub 10, 12 to engage such fastener and maintain hub cover 77 in position. Thus, the floor 31, 53 of fourth recessed region 5, 51 can be provided at a depth sufficient to receive a hub cover 77 of any desired thickness, with a thickness of about 0.125 inches being exemplary, but non-limiting.

[0095] FIG. 8 is an expodxed perspective view of a joint useful in providing a geodesic structure according to some embodiments of this disclosure, showing its components including hub 10, hub cover 77, struts 75, strut insert 81 having hole 82 disposed through its side wall and threaded hole 95 at the end 79 of strut insert 81. Struts 75 in some embodiments include a hole 93 disposed through their wall portion of sufficient diameter to receive a pin 91. In some embodiments struts 75 are comprised of hollow tubular stock selected from the same materials of construction as

described herein for hubs 10, 12. Strut insert 81 in some embodiments is a solid cylinder of sufficient outer diameter to snugly fit inside of the hollow tubular stock material from, which struts 75 are comprised. In some embodiments, hole 95 at the end of strut insert 81 is a threaded hole, configured to engagingly receive a threaded fastener, such as a fastener disposed through radial bores 15. Strut insert 81 in some embodiments is inserted into the open end of a strut 75 until hole 82 is in alignment with hole 93, and pin 91 is subsequently inserted simultaneously through both holes 82, 93 to maintain strut insert 81 in position in the end of strut 75. In some embodiments holes 82, 93 are positioned sufficiently from the ends of strut insert 81 and strut 75 so that the end 79 of strut insert 81 is coplanar or coincident with the end of strut 75. In other embodiments, the holes are dimensioned such that the insert protrudes any amount of distance purposefully selected in accordance with this invention by the engineer from the end of strut 75.

[0096] For clarity, when multiple elements are mentioned herein such as "hub 10, 12", such context means that the embodiment is being described generally as it can pertain to either hub 10 or hub 12, or both as warranted by the context, and the selection of corresponding elements, for example, "radial bore 15, 27" should be understood by the reader for purposes of interpreting this disclosure to be dependent on which hub the reader selects to view and consider the particular drawing figure and text associated therewith. In FIG. 9 for example, this drawing figure can or should sometimes be interpreted with respect to the hub being either hub 10 or hub 12. When the reader elects to consider the hub therein as hub 10, reference to "radial bore 15, 27" should then be interpreted as the radial bore referring to radial bore 15, since hub 10 has been shown and described herein as having radial bore 15. This same line of thought applies to other portions of this description that recite and/or depict two reference characters associated with a similar element.

[0097] FIG. 9 shows a side cutaway view of a joint useful in providing geodesic structures according to some embodiments, depicting the hub 10, 12, having struts 75 attached thereto and using strut inserts 81 within the ends of the hollow struts. There are fasteners 97 present, with their heads disposed in third recessed region 27, 69 and their shanks passing through radial bore 15, 43, into the threaded ends of the strut inserts 81. In some embodiments, fasteners 97 are inserted into hub 10, 12 through the fourth recessed region 5, 51 and into a radial bore 15, 43 so that the end of the fastener 97 protrudes outward from side wall 19, 45 towards a strut 75. By purposefully selecting the lengths of struts 75, combinations of hubs 10, 12, and angle λ , the engineer can provide a wide variety of geodesic structures using the present disclosure. Also shown in FIG. 9 are fastener 98, pins 91, threaded female fastener 103, and hub cover 77.

[0098] Moreover, additional advantages are provided by this disclosure, as shown with reference to FIG. 10, the side cutaway view therein of two hubs which can alternately comprise two hubs 10, two hubs 12. For instances in which each of the hubs of FIG. 10 are a part of a different diameter geodesic structure, the present invention provides for joints each useful in providing geodesic structures according to some embodiments of the disclosure, to be connected to one another; providing for multiple geodesic structures to be rigidly attached to one another, in a selectively detachable fashion while providing a strong bond between two such

adjacent geodesic structures. Multiple geodesic structures can be connected to one another via the connection shown in FIG. 10, which includes a rod 99 that in some exemplary non-limiting embodiments is a threaded fastener or rod attached to each of the hubs shown using conventional fasteners, it being within the skill level of the person of ordinary skill in this art after reading this disclosure to connect such two hubs via central bores 37, 49, and in some alternate embodiments including use of support member 101. Support member 101 in some embodiments is a hollow tube that is dimensioned to fit within the walls 13, 61 of the first recessed region 9, 57 of each hub and its length is purposefully selected by the engineer to rest on or against the floor 25, 59 of each first recessed region 9, 57. In some embodiments, support member 101 interfaces with the bottom surface 7, 41 of a hub 10, 12. In other embodiments, support member 101 is solid of any material mentioned herein from which hubs 10, 12 and struts 75 can be comprised, and features threaded rod at each of its ends, which in some embodiments are selected sufficient lengths of threaded rod screwed into threaded holes caused to be present at each of the ends of such support member 101. Threaded female fasteners 103 are also shown as useful for this purpose. Although shown in FIG. 10 with the top surface of one hub facing the bottom surface of the other, the present disclosure includes embodiments where each hub from coincident geodesic structures has its bottom surface facing the other's bottom surface, as well as embodiments where each hub from an adjacent geodesic structure has its top surface facing the other's top surface.

[0099] The dimensions of hubs 10, 12 can be any dimensions purposefully selected by the engineer in accordance with this disclosure. In some embodiments, a hub 10, 12 is 5.6 cm in diameter at the extremities of its top surface, and first recessed region has a diameter of 2.85 cm and a depth from top surface 3, 39 of 1.58 cm. In some embodiments, the diameter of central bore 37, 49 is 1.25 cm and the diameter of fourth recessed region is 4.76 cm. In some embodiments, the diameter of hub 10, 12 at the bottom surface is 5.0 cm, and the diameter of hub 10, 12 at its largest diameter at beveled edge 21, 47 is 6.25 cm. In some embodiments, the diameter of third recessed region 27, 69 is 0.95 cm, and the diameter of the second recessed region is 1.9 cm. Angle gamma is 105.8 degrees. In some embodiments, the depth of third recessed region 27, 69 is any depth suitable to hold the head of the fastener selected, and the depth of second recessed region 17, 63 is 0.6 cm. The foregoing values are merely exemplary of some embodiments of this disclosure and are provided to be illustrative and not delimitive thereof in any way.

[0100] FIG. 11 is a perspective view of a base joint of a geodesic structure in accordance with some embodiments of the disclosure, wherein substructure 87 rests on a substrate 83, which can be the earth or any other selected surface. In some embodiments substructure 87 is a plurality of planks of wood and extends in a circular fashion to provide a base upon which a geodesic structure can rest. In some embodiments a plate 85 of metal or other selected material is fastened to substructure 87 by conventional fasteners, and hub 10, 12 is attached to plate 85 by means of an angle bracket 89 or like arrangement using conventional fasteners. Such arrangement is very strong, yet also provides for ease of subsequent dismantling and removal of a geodesic structure so anchored at any selected future time following its

construction. In some embodiments, a closeout 90 of wood or any other selected material provides support along the length of the lowermost struts 75, and is generally attached to the substructure 87 by conventional means.

[0101] FIG. 12A shows a perspective view of a joint present on a geodesic dome including hub 10, 12 according to the disclosure having a plurality of struts 75 attached thereto, and also panel support 105, panel support 107 and panel 109. FIG. 12B shows an overhead view of a joint present on a geodesic dome including hub 10, 12 according to the disclosure having a plurality of struts 75 attached thereto, and also a plurality of panel supports 105, panel supports 107 and panels 109. FIG. 12C shows an overhead view of a joint present on a geodesic dome including hub 10, 12 according to the disclosure having a plurality of struts 75 attached thereto (not visible), and also a plurality of panel supports 105, panel supports 107 and panels 109. In some embodiments, a panel is a merely a piece of planar construction material such as plywood, metal plate, composites, or other known construction material(s) supplied in sheet form. In other embodiments, a panel is a collective term used to denote a pre-assembled combination comprised of a plurality of panel supports 105, 107. In alternate embodiments, no panel 109 is present. By the construct of FIG. 12C the entire surface of a geodesic structure according to the disclosure can be covered with panels to define an interior volume within such geodesic structures that is protected from environmental conditions and effects existing on the exterior of such geodesic structure. That is, the construct of FIG. 12C when applied all across all joints and struts of a geodesic structure forms a roof or akin thereover that is impervious to wind, rain, snow, sleet, had and sun.

[0102] FIG. 13 is a cross-sectional view of components useful for enclosing a geodesic structure according to some embodiments of the disclosure, including those depicted in FIGS. 12A, 12B, and 12C illustrating the respective locations of strut 75, panel support 105, panel support 107, and panels 109.

[0103] One issue with geodesic structures when employed as housing units or storage buildings according to prior art, is that when installing a common rectangularly-shaped door or window to such structures, the geodesic structure must be broken and the inherent strength and stability of the geodesic structure is compromised. That is, geodesic structures do not "mix" well with non-geodesic structural geometries in terms of maintaining the strength and stability inherently present in a geodesic structure. According to other aspects of the present disclosure, hubs 10, 12 as provided herein enable heretofore unseen maintenance of the strength and stability of geodesic structures which feature rectangular apertures, including doors and any other chosen selectively-closable rectangularly-shaped openings therein. FIG. 14 shows secondary hub 110 attached to a hub 10, 12 by means of fastener 126 wherein the secondary hub 110 in some embodiments is shaped generally as a truncated cone, or frustoconical, and has recessed regions configured to receive the ends of secondary struts 175, in the same structural fashion using the same essential configuration, parameters, and features as hub 10, 12 to receive and maintain struts 75 in position in contact therewith.

[0104] FIG. 15A is an overhead view of a secondary hub 110 according to some embodiments of the disclosure, showing top surface 115, central bore 113, and optional raised region 111. FIG. 15B is a perspective view of the

secondary hub **110** of FIG. **15A**, and FIGS. **15C** and **15D** are side perspective views thereof and illustrate central bore **113** passing all the way through secondary hub **110** to the bottom surface **121** from the floor of a first recessed region **123**, analogous to the first recessed regions present on hubs **10**, **12**. Radial bore **119** is associated with second recessed region **117** and third recessed region **125**, just as in hubs **10**, **12** the radial bores had a recessed region at each of their termini. The purposes of radial bore **119**, second recessed region **117** and third recessed region **125** in a secondary hub **110** are the same as for hubs **10**, **12** concerning all aspects thereof, and the floors of the recessed regions are present at the same depths with respect to the height **H** of such secondary hub **110**. A secondary strut **175** is attached to hub **110** in the same fashion as previously described for struts **75**, the features of struts **175** being the same as struts **75**, and fourth recessed region **123** is sufficiently open at top surface **115** to enable a fastener to be inserted into radial bore **119** from the direction of top surface **115**. Fastener **126** (FIG. **14**) is disposed through central bore **113** of secondary hub **110** to maintain secondary hub **110** in fixed position with respect to the hub **10**, **12** it is attached to when in use. Secondary hubs **110** can feature any number of such combinations including 1, 2, 3, 4, and 5 of such combinations comprising a radial bore **119**, second recessed region **117** and third recessed region **125** disposed radially about such secondary hub **110**, at any selected locations about the periphery of side wall **127**. Axes **X** and **Z** for radial bores **119** are also shown in FIG. **15D**, being analogous to axes **X** and **Z** as shown and described with reference to hubs **10**, **12**. In a secondary hub **110** according to some embodiments of the disclosure the angle of intersection of axes **X** and **Z** on a secondary hub **110** is independently any selected angle in the range of between 85 and 135 degrees for each radial bore **119** present. FIG. **15D** shows secondary hub **110**, and the respective locations of top surface **115**, bottom **121**, radial bore **119**, and second recessed region **117**. There is an optional raised area **111**, which in some embodiments is contoured to match and snugly fit within a recess provided on the bottom **7**, **41** of a hub **10**, **12** respectively when secondary hub **110** is attached to either of hubs **10**, **12** in a geodesic structure provided according to this disclosure. Such feature provides increased rigidity and inhibits lateral movement of such hubs at their interface.

[0105] One issue with geodesic structures when employed as housing units or storage buildings according to the prior art, is that when installing a common rectangularly-shaped door or window to such structures, the geodesic structure must be broken and the inherent strength and stability of the geodesic structure is compromised. The present disclosure, by hubs **10**, **12**, struts **75**, secondary hubs **110** and secondary struts **175** and their associated hardware provides heretofore unseen advantages, inasmuch as these components enable construction of trusses useful in providing apertures such as doors and windows, etc. in a geodesic structure, without compromising the integrity and strength of such structures, as was the case within all prior art apertures.

[0106] A non-limiting example of such a geodesic structure aperture truss is depicted in FIG. **16A** having opening **O**, showing the respective locations of secondary hubs **110**, secondary struts **175**, **176**, **177**, trusses **75**, and combination **129** which is a secondary hub **110** attached to a hub such as **10**, **12**, as depicted more closely in FIG. **14**. FIGS. **16B** and **16C** show alternate views of a geodesic structure aperture

truss according to the disclosure. A geodesic structure having a truss for providing a geodesic structure with an aperture according to this disclosure features all of its joints normally present, featuring a hub(s) **10** or **12** or a combination of both in their normal positions, excepting that when an aperture is desired, the hub at a joint and struts associated therewith are removed from the structure sufficiently to provide an aperture of the size selected by the architect or engineer. Then, the remaining hubs which have had a strut(s) removed from them are structurally reinforced using secondary hub(s) **110** and secondary struts, generally in the shape of a truss. Secondary struts **175**, **176**, **177** when connected to one another are done so using any suitable known connection means including welding, clamps, nuts and bolts, rivets, etc. Removal of a pentagonal hub and the resulting truss reinforcement is illustrated with reference to FIG. **17A**, which shows a perspective view of a geodesic structure featuring a truss aperture according to some embodiments of the disclosure, depicting the respective locations of opening **O**, secondary hub **110** and secondary struts **175**. FIG. **17B** is a side perspective view of the geodesic structure of FIG. **17A**.

[0107] FIG. **18A** is an overhead view of two geodesic structures attached to one another according to some embodiments of the disclosure, and FIG. **18B** is a perspective view of two geodesic structures of FIG. **18A**, showing each having an aperture truss, and a door passageway therebetween.

[0108] Although the material of construction of a hub as herein described can be selected from various materials including known metals and their alloys useful and accepted by the construction industry, other materials are also suitable including polymers and blends thereof known useful in construction, composite materials, and reinforced composite materials. When metals and their alloys are selected, exemplary materials including without limitation iron and its alloys including various steels, stainless steel, aluminum and its known alloys, magnesium and its known alloys, titanium and its known alloys, it is desirable to select the material from which hub cover **77** is fabricated to be from the same metal or alloy as the hub itself. Such selection prevents existence of a galvanic potential between the hub and its cover. The same is true for some embodiments of the material from which struts **75** are comprised, as well as the other hardware selected to attach the struts **75** to a hub **10**, **12**. In some embodiments, a hub **10**, **12** according to this disclosure is of singular construction, i.e., it consists of a single piece, such as when beginning with a piece of stock that is cylindrical, and machining it to have the features taught herein, or provided for example by plastic moulding process including without limitation plastic injection molding.

[0109] Although shown and described herein as being frustoconical in shape, hubs having the essential features taught herein with a different external appearance, such as faceted, semispherical, rectangular, etc. are within the scope of this disclosure since such configurations can be easily provided by first providing a hub according to the invention and adding material to give the hub or primary hub/secondary hub combinations any desired external appearance, as readily envisioned by a person of ordinary skill in the art after having read this specification.

[0110] Consideration must be given to the fact that although this invention has been described and disclosed in

relation to certain embodiments, equivalent modifications and alterations thereof may become apparent to persons of ordinary skill in this art after reading and understanding the teachings of this specification, drawings, and the claims appended hereto. The present disclosure includes subject matter defined by any combinations of any one or more of the features provided in this disclosure with any one or more of any other features provided in this disclosure. These combinations include the incorporation of the features and/or limitations of any dependent claim, singly or in combination with features and/or limitations of any one or more of the other dependent claims, with features and/or limitations of any one or more of the independent claims, with the remaining dependent claims in their original text being read and applied to any independent claims so modified. These combinations also include combination of the features and/or limitations of one or more of the independent claims with features and/or limitations of another independent claims to arrive at a modified independent claim, with the remaining dependent claims in their original text or as modified per the foregoing, being read and applied to any independent claim so modified. The present invention has been disclosed and claimed with the intent to cover modifications and alterations that achieve substantially the same result as herein taught using substantially the same or similar structures, being limited only by the scope of the claims which follow.

1. A geodesic construction comprising:

- (1) a plurality of primary hubs, each primary hub having a top side, a bottom side and a side wall; the primary hub further comprising:
 - (a) a central primary hub recess with sides and a bottom;

- (b) a plurality of circumjacent recesses about the central primary hub recess;
 - (c) a plurality of bores within the circumjacent recesses communicating with the central primary hub recess;
 - (2) interconnectable with the primary hubs, a plurality of primary struts, each strut having length, sides, and an end insertable into one of the circumjacent recesses, that together with the primary hubs form a geodesic lattice;
 - (3) mateable to the primary hubs, an assembly including secondary hubs and secondary struts each having a length and sides; and,
 - (4) a plurality of panel support portions, each panel support portion having ends, a top side, a bottom side and edges having a longitudinal recess contoured to receive and mateably interlock with the sides of the primary or the secondary struts, wherein oppositely mountable panel support portions are adapted to substantially envelope the length of the primary struts or the length of the secondary struts.
2. The construction according to claim 1, further comprising environmental sealing means which includes a compressible juncture between panels and the primary or secondary struts.
3. The construction according to claim 1, further comprising a plurality of secondary hubs which are connectable to the primary hubs.
4. The construction according to claim 1 wherein the secondary struts are configured to reinforce the primary struts surrounding customized openings in the geodesic structure.

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