(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 879 626 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
15.09.2021 Bulletin 2021/37

(51) Int Cl.:
H01Q 1/28 *(2006.01)* ***H01Q 15/16*** *(2006.01)*

(21) Application number: **21157199.7**

(22) Date of filing: **18.10.2013**

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

(62) Document number(s) of the earlier application(s) in accordance with Art. 76 EPC:
13792420.5 / 2 909 890

(71) Applicant: **Datashvili, Leri S.**
85748 Garching (DE)

(72) Inventor: **Datashvili, Leri S.**
85748 Garching (DE)

(74) Representative: **Fish & Richardson P.C.**
Highlight Business Towers
Mies-van-der-Rohe-Straße 8
80807 München (DE)

Remarks:
Claims filed after the date of filing of the application/after the date of receipt of the divisional application (Rule 68(4) EPC).

(54) DEPLOYABLE SPACE REFLECTOR

(57) The present invention relates to radio technique, namely to space structures, for example, large deployable space reflectors (symmetric, asymmetric, offset and other type of reflectors), radio and optical telescopes, sun-concentrators and other structures with analogous purpose. Advantages of this invention are in increasing deployed stiffness and stability, as well as in increasing reliability of deployment, achieving large deployed seized high accuracy of reflector realization and in decreasing height of the stowed package of the reflector.

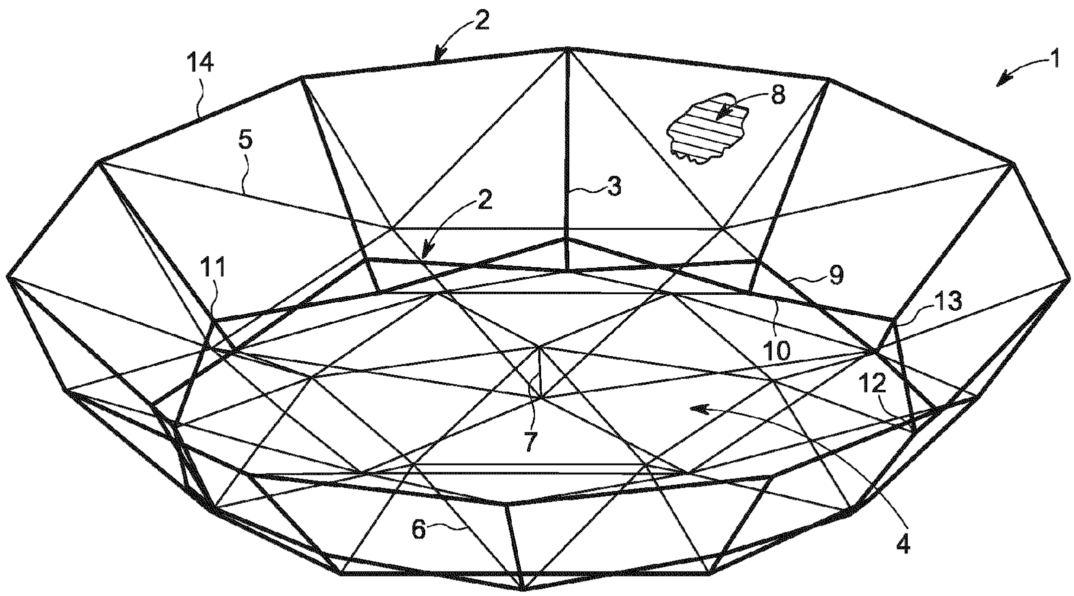

FIG. 1

EP 3 879 626 A1

Description

FIELD OF THE INVENTION

[0001] The present invention relates to radio technique, namely to space structures, for example, large deployable space reflectors (symmetric, asymmetric, offset and other type of reflectors), radio and optical telescopes, energo-concentrators and other structures with analogous purpose.

DESCRIPTION OF RELATED ART

[0002] The deployable Space reflector according to the patent US6323827, H01Q15/20, 2001, comprises peripheral support framework with two deployable peripheral polygonal rings consisting of interconnected rods, connecting rods of the rings providing a certain separation of the rings, a reflecting surface and a tensioning framework for shaping the reflecting surface, a deployment mechanism and a latching mechanism.

[0003] This reflector is characterized with a low stiffness and stability, while two polygonal rings and connecting rods of the rings form rectangular ring facets which need additional means for stiffening - diagonal rod or cables in the patent.

[0004] The other known deployable space reflector [Novel large deployable antenna backing structure concepts for foldable reflectors, ESA/ESTEC,NOORDWIJK, Netherlands, 2-3 October 2012, V.Fraux, M.Lawton, Reveles, Z.You] comprises a peripheral support framework with two deployable peripheral polygonal rings of interconnected rods, and connecting rods of the rings providing a certain separation of the rings. One of the rings of the supporting framework has pair-wise hinged cross rods and the other ring interconnected hinged rods of V-fold rods.

[0005] This reflector is also characterized with a low stiffness and stability, while it has a row of the V-fold rods as one of the ring of the support peripheral framework. In addition, it is characterized with a non-compact stowed package, while the other ring of the framework has angulated cross rods and the V-fold rods fold inside of the package, which limits the folding. Complexity of reaching the deployed state of the V-fold rods is a characteristic drawback of the mentioned peripheral framework.

[0006] The deployable Space reflector according to the patent US5680145, H01Q15/16, 1997, comprises a peripheral support framework with two deployable peripheral polygonal rings of interconnected rods, and connecting rods of the rings providing a certain separation of the rings, a reflecting surface and a tensioning framework for shaping the reflecting surface, a deployment mechanism and a latching mechanism.

[0007] This reflector is also characterized with drawbacks as a low stiffness and stability of the deployed configuration, as well as large height of the stowed package caused by such a folding scheme in which the height is a sum of the lengths of the ring rod and the connecting rod of the rings. This reflector is also characterized with complexity or even impossibility of reaching the large deployed sizes of the reflector. This drawback is a result of a presence of the tensioning framework, which has a shape of facetted double concave lens. Due to the character of the double concave lens, even if it has a near zero thickness at the center, it might reach larger heights at the periphery with large diameters, this fact limits the height of the reflector under the described concept to the small sizes.

[0008] The deployable Space reflector according to the "Concept of the Tension Truss Antenna", Koryo Miura and Yasuyuki Miyazaki, The Institute of Space and Astronautical Science, Yoshidai, Sagamihara, Kanagawa, Japan, AIAA Journal, vol. 28, № 6, which consists of a support framework, a reflecting surface, the tensioning framework forming the reflecting surface, a deployable and a latching mechanisms. The tensioning framework is made of front and rear cable networks, which are interconnected by flexible ties.

[0009] This reflector is characterized with similar drawbacks as the previous one, namely, low deployed stiffness and stability caused by the radial support frame, as well as large height of the stowed package of the reflector for large diameters. The latter one is caused again by the presence of the tensioning framework, which has a shape of facetted double concave lens.

SUMMARY DESCRIPTION OF THE INVENTION

[0010] Advantages of this invention are in increasing deployed stiffness and stability, as well as in increasing reliability of deployment, achieving large deployed seized high accuracy of reflector realization and in decreasing height of the stowed package of the reflector.

[0011] The mentioned advantages have been achieved by the fact that the structure of the deployable space reflector, which comprises a deployable peripheral a deployable peripheral support framework with two deployable peripheral polygonal rings consisting of interconnected rods, connecting rods of the rings providing a certain separation of the rings, a reflecting surface and a tensioning framework for shaping the reflecting surface, a deployment mechanism and a latching mechanism, has been given new features.

[0012] Namely, one of the deployable peripheral polygonal rings of the deployable support framework of the reflector is made of hinged full cross-rods placed in different planes and are connected to the connecting rods of the rings with the rotation possibilities in the said planes, so that one end of one of the rods is connected to the end of one of the connecting rod of the rings with a fixed hinge while the other end of the rod is connected to the other connecting rod of the rings with a hinge and with the possibility of translation over its length, and one end of the rod of the other peripheral ring is hinged fixed to the other end of one of the connecting rods of the rings while the other end of the rod is hinged to the other connecting rod of the rings with the translation along the connecting rod, or both peripheral rings of the peripheral support framework consist of a single row of the latter rods and connecting rods of the rings which are inclined to the reflector axis forming trapeze-shaped bays of the so formed pyramidal support framework for increasing of its stiffness.

[0013] In another configuration of the deployable space reflector, the advantages are achieved by the fact that the cross full rods of the peripheral support framework, which are placed in different planes, are not interconnected.

[0014] Still another configuration of the deployable space reflector, the advantages are achieved by the fact that peripheral support framework is inscribed in either cylindrical or conical shapes.

[0015] Achieving of the advantages is possible also because of the following configuration, for reducing the height of the stowed package, at least every second connecting rod of the peripheral polygonal rings of the peripheral support framework is made with inner and outer parts so that the cross full rods of the one ring are connected to the inner and outer parts of the connecting rods of the rings, while the ends of the rods of the other polygonal ring are connected to the either inner or outer parts of the connecting rods of the rings.

[0016] In another configuration of the deployable space reflector, for compactness of the stowed package, the rods of the polygonal rings, which are hinged to the connecting rods of the rings, either fixed or with translation possibilities, are joined pair-wise with rotation possibility around the axes of the connecting rods of the rings, with the limiting supports of the rotation angle, which in the end defines achieving the advantages of the invention.

[0017] A deployable space reflector in the new configuration reaches large sizes of the deployed reflector, decreased height of the stowed package, increased stiffness and stability of the reflector, as well as simplification, decreased weight and increased reliability of deployment of the peripheral support framework with the following new features and attributes. Namely, a deployable space reflector comprising a peripheral support framework, a tensioning framework made of substantially inextensible networks interconnected with the substantially elastic links and connected to the peripheral supporting framework, a reflecting surface connected to the tensioning framework, a deployable mechanism and a latching mechanism, is made in a way that, the networks of the tensioning frameworks supporting the reflecting surface are made with the possibility of forming of a facetted shapes of double convex lens surfaces around the axis of the reflector at least in the central part of it, with the formation possibility of facetted surfaces of a double concave lens shape at the rest, peripheral part of the reflector, with that, parts of the networks forming the facetted surfaces of the double convex lens shape are connected to each other with at least one substantially elastic link made of a stable rod of a radio transparent material and the front network surface part of the convex lens shape is made of the radio transparent material as well.

[0018] In another configuration of the reflector, the mentioned are achieved advantages by forming the facetted surfaces of the double convex lens shape via putting of the front and rear networks through each other.

[0019] Yet another configuration enables achieving the advantages in a way that facetted surfaces of the double convex lens shape are formed via bending of the front and rear networks and bonding together at the places of bending.

[0020] In another configuration of the reflector achieving of the advantages is realized in a way that for achieving of the large reflector dimensions and lowering the mass, one of the networks of the facetted lens shape surface is made with large facets while the second network is made with the small facets, so that they are linked with connecting links made of stable rods, at least with one link, which are placed at the vertex of the network with large facets and in a respective vertexes of the network with small facets, at least one in the center, and are continued beyond the second network, so that they form additional supports for a third network with small facets, which is supported by the same points of the peripheral framework as the first network and is connected to the second network with the substantially elastic links.

BRIEF DESCRIPTION OF THE DRAWINGS, 40 DRAWINGS IN TOTAL

[0021]

Fig. 1 illustrates a general view of the schematic (wire frame) configuration of the deployable space reflector.

Fig. 2-4 show close views of the bays of the peripheral support structure.

Fig. 5 and 6 show side views of detail of the peripheral support structure of a conical configuration, deployed and partly folded, where the upper ring consist of a cross full rods and the lower ring consists of a row of interconnected rods.

Fig. 7 and 8 show side views of detail of the peripheral support structure of a conical configuration, deployed and partly folded, where the upper ring consist of a cross full rods and the lower ring consists of a row of interconnected rods. In these figures cross rods show a high deployment angle, towards the near-parallel position to the lower rods.

Fig. 9 and 10 show side views of detail of the peripheral support structure of a conical configuration (wire frame scheme), deployed and partly folded, where the lower ring consist of a cross full rods and the upper ring consists of a row of interconnected rods.

Fig. 11 shows an end fitting of the cross full rods which are placed in different planes, enabling the rotation of the rods in that planes, general view.

Fig. 12 and 13 show side views of detail of the peripheral support structure of a conical configuration (wire frame scheme), deployed and partly folded, where the both rings consist of a row of interconnected rods.

Fig. 14-16 show different views of the connecting hinge of the cross full rods, placed in different planes, of the peripheral framework of the reflector.

Fig. 17 and 18 show side views of the peripheral support framework of the reflector in deployed and partly folded states.

Fig. 19 and 20 show general views of the peripheral support framework of the reflector in cylindrical and conical configurations respectively.

Fig. 21 shows side view of the peripheral support structure with its deployment mechanism which comprises e.g. two motors and a system of pulleys and cables.

Fig. 22 and 23 shows joints of the connection of the rods of the rings to the two parts connecting rods of the rings with inner and outer parts.

Fig. 24 shows side view of the tensioning framework of the reflector with the facetted surfaces of the double concave lens shape in the center of the reflector.

Fig. 25-29 show side views of the of the tensioning framework of the reflector with the facetted surfaces of the double concave lens shape in different versions and sizes as well as different shapes of the peripheral support framework of the reflector.

Fig. 30 shows the same with bended front and rear networks and bonded at the bending places.

Fig. 31 and 32 show side views of the tensioning framework of the reflector with large size facetted double concave lens shape surfaces, in different configurations.

Fig. 33 demonstrates an example of the tensioning framework of the present invention which uses a much smaller height of the peripheral support structure, therefore a much smaller height of the stowed package, with the same diameters as compared to the previously known reflectors (shown with additional dashed lines).

Fig. 34 and 35 show examples of the tensioning frameworks of the reflector with different number of facets of the small-facetted surfaces and with only a single connecting rod at the center, top view, corresponds to the Fig. 31.

Fig. 36 and 37 show the same examples, with seven connecting rods of the networks of the tensioning framework, top view, corresponds to the Fig. 32.

Fig. 38 and 39 show examples of the tensioning frameworks of the reflector with different number of facets of the large-facetted surfaces and with seven and one connecting rods, top view, corresponds to the Fig. 32, 31 , 36, 37.

Fig. 40 shows a configuration of the bonding line or the line of crossing (when put through each other) of the front and rear networks, top view.

DETAILED DESCRIPTION OF THE INVENTION

[0022] A deployable space reflector comprises a deployable peripheral support framework 1. The support framework 1 has two deployable peripheral polygonal rings 2 consisting of interconnected rods and connecting rods 3 of the rings 2 providing a certain separation of the rings 2. The deployable space reflector has a tensioning framework 4 for shaping the reflecting surface, which comprises a front side network 5, a back side network 6 and connecting ties 7. A reflecting surface 8 is joined to the tensioning framework 4. For increasing of stiffness, stability and deployment reliability of the deployable space reflector, one of the deployable peripheral polygonal rings 2 of the deployable support framework 1 of the reflector is made of hinged full cross-rods 9 and 10 placed in different planes. Cross-rods 9 and 10 are connected to the connecting rods 3 of the rings 2 with the rotation possibilities in the said planes and are provided with angular fittings 11 to enable rotation of the cross-rods 9 and 10 in the said planes, these fittings 11 may be made like fittings that known from patent US5680145, H01Q15/16, 1997. One end of the rods 9 is connected to the end of one of the connecting rod 3 of the rings 2 with a fixed hinge 12 while the other end of the rods 9 is connected to the other connecting rod 3 of the rings 2 by joint 13 with a hinge and with the possibility of translation over its length. One end of the rod 14 of the other peripheral ring 2 is hinged fixed 12 to the other end of one of the connecting rods 3 of the rings 2 while the other end of the rod 14 is hinged 13 to the other connecting rod 3 of the rings 2 with the translation possibility along the connecting rod 3. Support framework 1 in a conical configuration offers some more advantages like high stiffness and lower mass than cylindrically shaped. These can be emphasized by achieving the size of the opening angle of the ring rods 9 and 10 near zero degrees in deployed configuration (Fig. 1 - 11).

[0023] According to the other alternative variant the both peripheral rings 2 of the peripheral support framework 1 consist of a single row of the rods 14. The support framework 1 has connecting rods 3 of the rings which are inclined to the reflector axis forming trapeze-shaped bays 141 (fig. 12 and 13) of the so formed many-sided pyramidal support framework for increasing of its stiffness. For increasing reliability of deployment of the peripheral support framework 1 different length rods 14 of the trapeze-shaped bays 141 have synchronizers of deployment of the reflector, for example such as known from patent US5680145, H01Q15/16, 1997, fig. 20 and made as gear set.

[0024] The full cross-rods 9 and 10 of the peripheral support framework 1 are joining each other by a hinge 15 which provided which provides high stiffness, transfer of high torsional and bending moments between the rods 9 and 10, and a gap-free rotation. The hinge 15 consist of parts, made for example as hoops 16, which are fixing on the rods 9 and 10 and having stop blocks 17 on the inner sides of them. One stop block 17 has housing 18, other stop block 17 - bearing 19 (fig. 15-16) for rotation in the housing and fixing device between the rods 9 and 10, made for example as a bolt inside the hole (which are known from prior technical art and are not shown in the figures).

[0025] In a particular configuration, the cross full rods 9 and 10 of the peripheral support framework 1, which are placed in different planes are not interconnected (fig. 17 and 18).

[0026] According to another embodiment of the deployable space reflector the peripheral support framework is inscribed in either cylindrical 20 or conical 21 shapes (fig. 19 and 20).

[0027] A deployment mechanism of the peripheral support framework 1 consists of rollers 22 which are installed on the ends of the rods 14 in the fixed 12, and moving 13 joints (rollers 22 are not shown in joints 13), and a cable 23 that is passing through the rollers 22 transmitted in one of bays of the peripheral support framework 1 along the ends of the rods 14, and by analogy transmitted in each next bay. The cables 23 are provided with unwinding/winding drams 24 with drive units, which are mounted on an at least one connecting rod 3 of the rings 2 of the peripheral support framework 1. The deployment mechanism further consists of rollers 25 which are mounted on the ends of the rods 9, 10 in the fixed 12, and moving 13 joints (rollers 25 are not shown in joints 13), and a cable 26 that passes through the rollers 25 and is transmitted in each bays of the peripheral support framework 1 along the cross-rods 9, 10, for example firstly from a fixed joint 12 to the moving joint 13, then along the rod 9 to the fixed joint 12, then to the moving joint 13 and back to the fixed joint 12, then along the rods 10 and by an analogy the cable 26 is transmitted in each next bays. The cables 26 are also provided by unwinding/winding drams 24 with drive units, which are setting on the at least one connecting rod 3 of the rings 2 of the peripheral support framework 1 (Fig. 21). Latching mechanism is known from a previous art and can be performed as springed-teeth on the moving j oints 13 and respective holes on the connecting rods 3 of the rings 2 of the support framework 1 of the reflector (not shown in drawings).

[0028] According to the next embodiment of the deployable space reflector for decreasing the stowed height, at least every second connecting rod 3 of the rings 2 of the peripheral support framework 1 is made with inner and outer parts 28 and 29 which have coupling bars 30. The cross full rods 9 and 10 of the one ring 2 are connected to the inner part 28 of the connecting rods 3 of the rings 2, while the ends of the rods 14 of the other polygonal ring 2 are connected to the outer 29 of the connecting rods 3 (fig. 22).

[0029] For compactness of the stowed package of the deployable space reflector, the rods 9, 10 and 14 of the polygonal rings 2 which are hinged to the connecting rods 3 of the rings, either fixed 12 or with translation possibilities 13, are joined pair-wise with rotation possibility around the axes of the connecting rods of the rings, with the limiting supports of the rotation angle 31 (fig. 23).

[0030] According to another main embodiment, a deployable space reflector comprising a peripheral support framework 1, a tensioning framework 4 made of substantially inextensible front side and rear side networks 5, 6, which are interconnected with the substantially elastic links 7 and connected to the peripheral supporting framework 1. The deployable reflector has a reflecting surface 8 connected to the tensioning framework 4, a deployable mechanism and a latching mechanism which are made such as mechanisms of the first main variant of reflector. For reaching deployed reflector large sizes and decreasing the height of the stowed package, increasing of the stiffness and stability of the reflector, as well as decreasing the weight, simplifying and increasing reliability of deployment of the peripheral support framework 1, the networks 5 and 6 of the tensioning framework 4 supporting the reflecting surface are made with the possibility of forming of a facetted shapes of double convex lens surfaces 32 around the axis of the reflector at least in the central part of it, with the formation possibility of facetted surfaces 33 of a double concave lens shape at the rest. Peripheral part of the reflector, with that, parts of the networks forming the facetted surfaces 32 of the double convex lens shape are connected to each other with at least one substantially elastic link 7. Elastic links 7 made of a stable rod of a radio transparent material inside of the surfaces 32 of the double convex lens shape. The front network surface 32 part of the convex lens shape is made of the radio transparent material as well (fig. 24).

[0031] The tensioning framework 4 supporting the reflecting surface made with the possibility of forming of a facetted shapes of double convex lens surfaces 32 around the axis of the reflector may be connected to each other with one substantially elastic link 7 made of a stable rod.

[0032] The tensioning framework 4 supporting the reflecting surface made with the possibility of forming of facetted shapes of double convex lens surfaces 32 around the axis of the reflector may be connected to each other with many substantially elastic links 7 made of stable rods. The deployable space reflector facetted surfaces 32 of the double convex lens shape are formed via putting the front and rear sides of networks 5, 6 through each other (fig. 25 and 26).

[0033] The tensioning framework 4 supporting the reflecting surface made with the possibility of forming of a facetted shapes of double convex lens surfaces 32 around the axis of the reflector may be used for the conical shapes peripheral support framework to make symmetrical and asymmetrical surfaces (fig. 27 and 28).

[0034] According additional embodiment of the deployable space reflector facetted surfaces 32 of the double convex lens shape are formed via bending of the networks 5 and 6 and bonding together at the places 321 of bending of the networks 5 and 6, for example gluing and/or sewing of them (fig. 29 and 30).

[0035] The tensioning framework 4 of the deployable space reflector has front side stable rods of a radio transparent material, made for example, as substantially elastic links 7. The tensioning framework 4 may be having circular, elliptical or other shaped supporting reflecting surface forming of facetted shapes of double convex lens surfaces 32.

[0036] In another configuration, for achieving of the large reflector dimensions and lowering the mass, one of the networks of the facetted lens shape surface 32 is made with large facets while the second network surface 34 is made with the small facets. The surfaces 32 and 34 are linked with connecting links 7 made of stable rods; at least with one link 35 placed at the vertex of the network surface 32 with large facets and in a respective vertexes of the network surface 34 with small facets, at least one in the center. Links 7 are continued beyond the second network surface 34, so that they form additional supports for a third network surface 36 with small facets, which is supported by the same joints 37 of the peripheral framework 1 as the first network surface 32 with large facets, the second and the third networks surfaces 34 and 36 with the small facets are connected to each other with the substantially elastic links 7 (fig. 31 - 40).

ASPECTS

[0037] Although the present invention is defined in the attached claims, it should be understood that the present invention can also (alternatively) be defined in accordance with the following aspects:

1. A deployable space reflector comprising a peripheral support framework (1), a tensioning framework (4) made of substantially inextensible front side and rear side networks (5, 6) interconnected with the substantially elastic links (7) and connected to the peripheral supporting framework (1), a reflecting surface (8) connected to the tensioning framework (4), a deployable mechanism and a latching mechanism, wherein the front side and rear side networks (5, 6) of the tensioning framework (4) supporting the reflecting surface form facetted shapes that include double convex lens surfaces (32) at least around an axis of the reflector, wherein the parts of the front side and rear side networks (5, 6) forming the double convex lens surfaces (32) are connected to each other by at least one substantially elastic link (7) that is made of a stable rod of a radio transparent material, and wherein the part of the convex lens surface (32) that corresponds to the front side network (5) is made of the radio transparent material.

2. The deployable space reflector of aspect 1, wherein the front side and rear side networks (5, 6) of the tensioning frameworks (4) form facetted surfaces of a double concave lens shape (33) about the periphery of the double convex lens surfaces (32).

3. The deployable space reflector of aspect 1 or 2, wherein the double convex lens surfaces (32) are formed by intersecting the front side and rear side networks (5, 6).

4. The deployable space reflector of any one of aspects 1 to 3, wherein the double convex lens surfaces (32) are formed by bending the front side and rear side networks (5, 6) opposite directions and bonding the front side and rear side networks (5, 6) together at their places of bending.

5. The deployable space reflector of aspect 4, wherein bonding the front side and rear side networks (5, 6) includes gluing and/or sewing the front side and rear side networks (5, 6) at their places of bending.

6. The deployable space reflector of any of aspects 1 to 5, wherein the deployable peripheral support framework (1) comprises two deployable peripheral polygonal rings (2) consisting of interconnected rods (14), and connecting rods (3) configured to separate the rings (2), wherein each of the peripheral polygonal rings (2) consists of a single row of rods (14), wherein in each peripheral polygonal ring (2), one end of one of the rods (14) is connected to an end of one of the connecting rods (3) with a fixed hinge (12) while the other end of the rod (14) is connected to an adjacent connecting rod (3) with a hinge (13) that allows translation along the length of the connecting rod (3).

7. The deployable space reflector of aspect 6, wherein the connecting rods (3) are inclined with respect to a reflector axis, such that the rods (14) and the

connecting rods (3) form trapeze-shaped bays (141) that form a pyramidal support framework.

8. The deployable space reflector of aspect 6 or 7, wherein the deployment mechanism includes a synchronizer to synchronize the deployment of the peripheral polygonal rings.

9. The deployable space reflector of any of aspects 6 to 8, wherein each connecting rod (3) is connected at one end to a pair of rods (14) of one peripheral polygonal ring (2) via fixed hinges (12) and the other end of the connecting rod (3) is connected to a pair rods (14) of the other peripheral polygonal ring (2) via a hinge (13) that allows translation along the length of the connecting rod (3).

10. The deployable space reflector of any of aspects 1 to 5, wherein the deployable peripheral support framework (1) comprises two deployable peripheral polygonal rings (2) consisting of interconnected rods (9, 10, 14), and connecting rods (3) configured to separate the rings (2),
wherein one deployable peripheral polygonal ring (2) of the deployable support framework (1) of the reflector is made of hinged full cross-rods (9, 10) that are placed in different planes and are connected to the connecting rods (3) with the rotation possibilities in the said planes, wherein for each pair of hinged full cross-rods (9, 10),
one end of each cross-rod (9, 10) connected to the end of a first connecting rod (3) with a fixed hinge (12), while the other end of the cross-rod (9, 10) is connected to a second adjacent connecting rod (3) with a hinge (13) that allows translation along the length of the connecting rod (3), and
one end of the other cross-rod (9, 10) is connected to the end of the second connecting rod (3) by a fixed hinge (12), while the other end of the rod (9, 10) is connected to the first connecting rod (3) with a hinge (13) that allows translation along the length of the connecting rod (3).

11. The deployable space reflector of aspect 10, wherein the cross full rods (9, 10) of the peripheral support framework (1), which are placed in different planes, are not interconnected.

12. The deployable space reflector of any one of aspects 6 to 11, wherein the peripheral support framework (1) forms a conical shape.

13. The deployable space reflector of any of aspects 6 to 11, wherein the peripheral support framework (1) forms a cylindrical shape.

14. The deployable space reflector of any one of aspects 6 to 13, wherein at least every second connecting rod (3) includes inner and outer parts (28, 29), wherein the rods (9, 10, 14) of one ring (2) are connected to the inner parts (28) of the connecting rods (3), and the ends of the rods (9, 10, 14) of the other ring (2) are connected to the outer parts (29) of the connecting rods (3).

15. The deployable space reflector of any one of aspects 6 to 14, wherein the rods (9, 10, 14) of the polygonal rings (2), which are hinged to the connecting rods (3) by fixed hinges (12) or by hinges (13) that allow translation along the length of the connecting rods (3), are joined pair-wise with rotation possibility around the axes of the connecting rods (3).

Claims

1. A deployable space reflector comprising a peripheral support framework (1), a tensioning framework (4) made of substantially inextensible front side and rear side networks (5, 6) interconnected with the substantially elastic links (7) and connected to the peripheral supporting framework (1), a reflecting surface (8) connected to the tensioning framework (4), a deployable mechanism and a latching mechanism,
wherein the front side and rear side networks (5, 6) of the tensioning framework (4) supporting the reflecting surface form facetted shapes that include double convex lens surfaces (32) at least around an axis of the reflector, wherein the parts of the front side and rear side networks (5, 6) forming the double convex lens surfaces (32) are connected to each other by at least one substantially elastic link (7) that is made of a stable rod of a radio transparent material, and wherein the part of the convex lens surface (32) that corresponds to the front side network (5) is made of the radio transparent material.

2. The deployable space reflector of claim 1, wherein the front side and rear side networks (5, 6) of the tensioning frameworks (4) form facetted surfaces of a double concave lens shape (33) about the periphery of the double convex lens surfaces (32).

3. The deployable space reflector of claim 1 or 2, wherein the double convex lens surfaces (32) are formed by intersecting the front side and rear side networks (5, 6).

4. The deployable space reflector of any one of claims 1 to 3, wherein the double convex lens surfaces (32) are formed by bending the front side and rear side networks (5, 6) opposite directions and bonding the front side and rear side networks (5, 6) together at their places of bending.

5. The deployable space reflector of claim 4, wherein

bonding the front side and rear side networks (5, 6) includes gluing and/or sewing the front side and rear side networks (5, 6) at their places of bending.

6. The deployable space reflector of any of claims 1 to 5, wherein the deployable peripheral support framework (1) comprises two deployable peripheral polygonal rings (2) consisting of interconnected rods (14), and connecting rods (3) configured to separate the rings (2), wherein each of the peripheral polygonal rings (2) consists of a single row of rods (14),
wherein in each peripheral polygonal ring (2), one end of one of the rods (14) is connected to an end of one of the connecting rods (3) with a fixed hinge (12) while the other end of the rod (14) is connected to an adjacent connecting rod (3) with a hinge (13) that allows translation along the length of the connecting rod (3).

7. The deployable space reflector of claim 6, wherein the connecting rods (3) are inclined with respect to a reflector axis, such that the rods (14) and the connecting rods (3) form trapeze-shaped bays (141) that form a pyramidal support framework.

8. The deployable space reflector of claim 6 or 7, wherein the deployment mechanism includes a synchronizer to synchronize the deployment of the peripheral polygonal rings.

9. The deployable space reflector of any of claims 6 to 8, wherein each connecting rod (3) is connected at one end to a pair of rods (14) of one peripheral polygonal ring (2) via fixed hinges (12) and the other end of the connecting rod (3) is connected to a pair rods (14) of the other peripheral polygonal ring (2) via a hinge (13) that allows translation along the length of the connecting rod (3).

10. The deployable space reflector of any of claims 1 to 5, wherein the deployable peripheral support framework (1) comprises two deployable peripheral polygonal rings (2) consisting of interconnected rods (9, 10, 14), and connecting rods (3) configured to separate the rings (2),
wherein at least one deployable peripheral polygonal ring (2) of the deployable support framework (1) of the reflector is made of hinged full cross-rods (9, 10) that are placed in different planes and are connected to the connecting rods (3) with the rotation possibilities in the said planes, wherein for each pair of hinged full cross-rods (9, 10),
one end of each cross-rod (9, 10) connected to the end of a first connecting rod (3) with a fixed hinge (12), while the other end of the cross-rod (9, 10) is connected to a second adjacent connecting rod (3) with a hinge (13) that allows translation along the length of the connecting rod (3), and
one end of the other cross-rod (9, 10) is connected to the end of the second connecting rod (3) by a fixed hinge (12), while the other end of the rod (9, 10) is connected to the first connecting rod (3) with a hinge (13) that allows translation along the length of the connecting rod (3).

11. The deployable space reflector of claim 10, wherein the cross full rods (9, 10) of the peripheral support framework (1), which are placed in different planes, are not interconnected.

12. The deployable space reflector of any one of claims 6 to 11, wherein the peripheral support framework (1) forms a conical shape.

13. The deployable space reflector of any of claims 6 to 11, wherein the peripheral support framework (1) forms a cylindrical shape.

14. The deployable space reflector of any one of claims 6 to 13, wherein at least every second connecting rod (3) includes inner and outer parts (28, 29), wherein the rods (9, 10, 14) of one ring (2) are connected to the inner parts (28) of the connecting rods (3), and the ends of the rods (9, 10, 14) of the other ring (2) are connected to the outer parts (29) of the connecting rods (3).

15. The deployable space reflector of any one of claims 6 to 14, wherein the rods (9, 10, 14) of the polygonal rings (2), which are hinged to the connecting rods (3) by fixed hinges (12) or by hinges (13) that allow translation along the length of the connecting rods (3), are joined pair-wise with rotation possibility around the axes of the connecting rods (3).

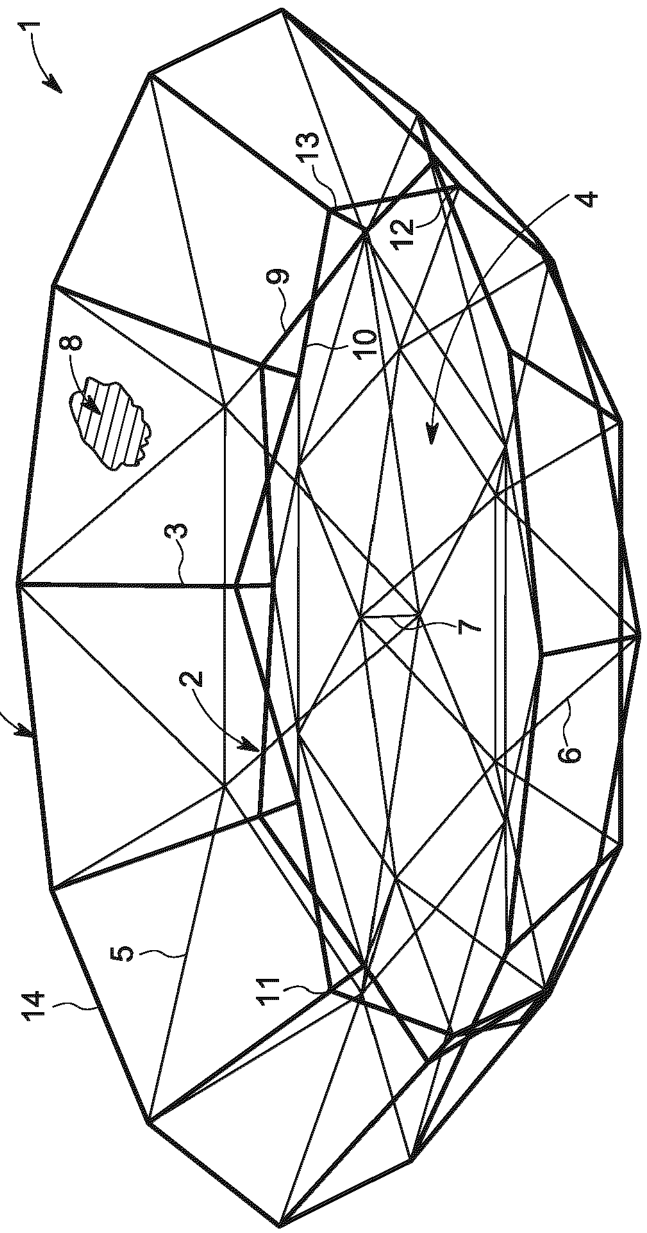

FIG. 1

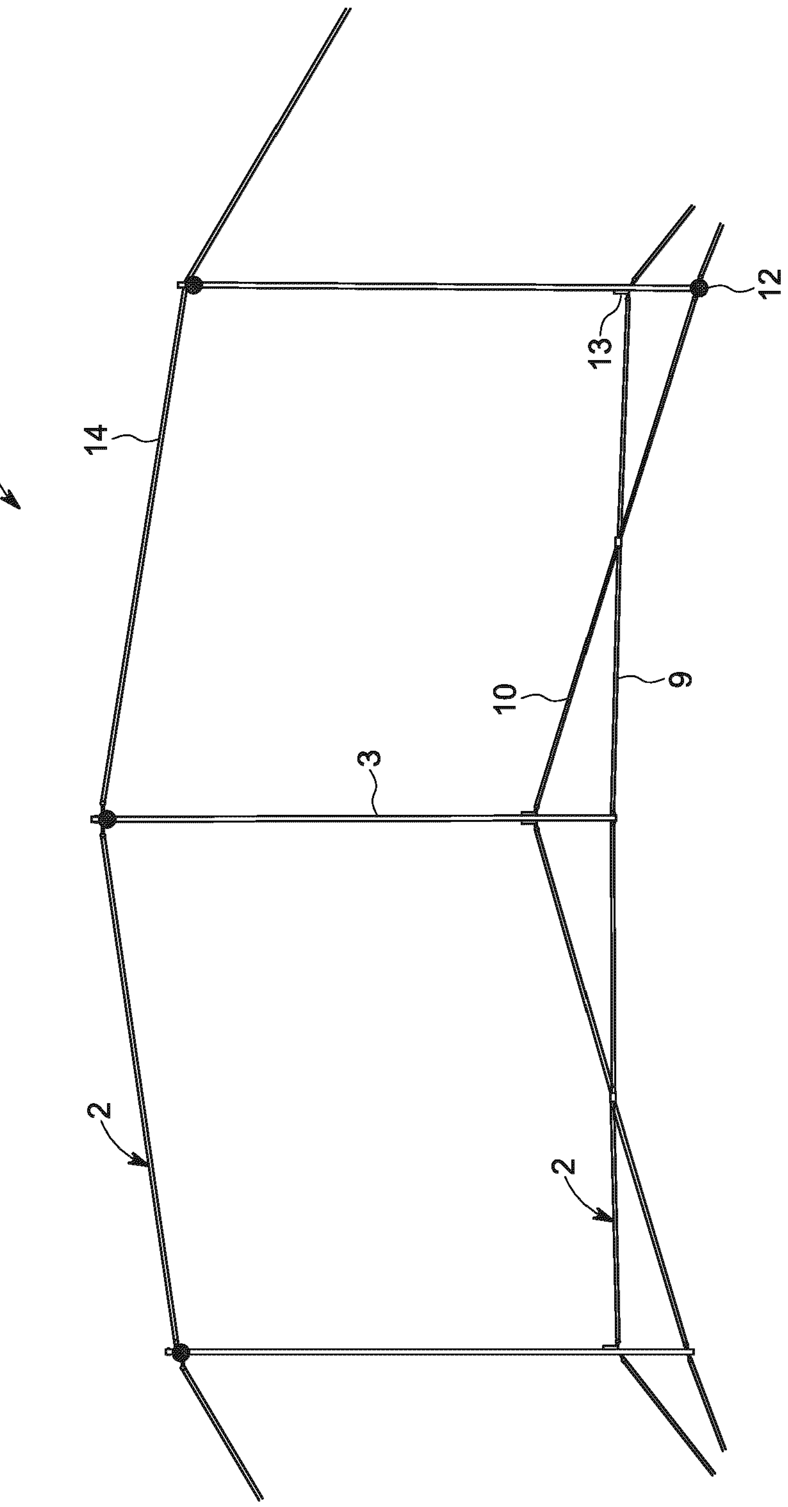

FIG. 2

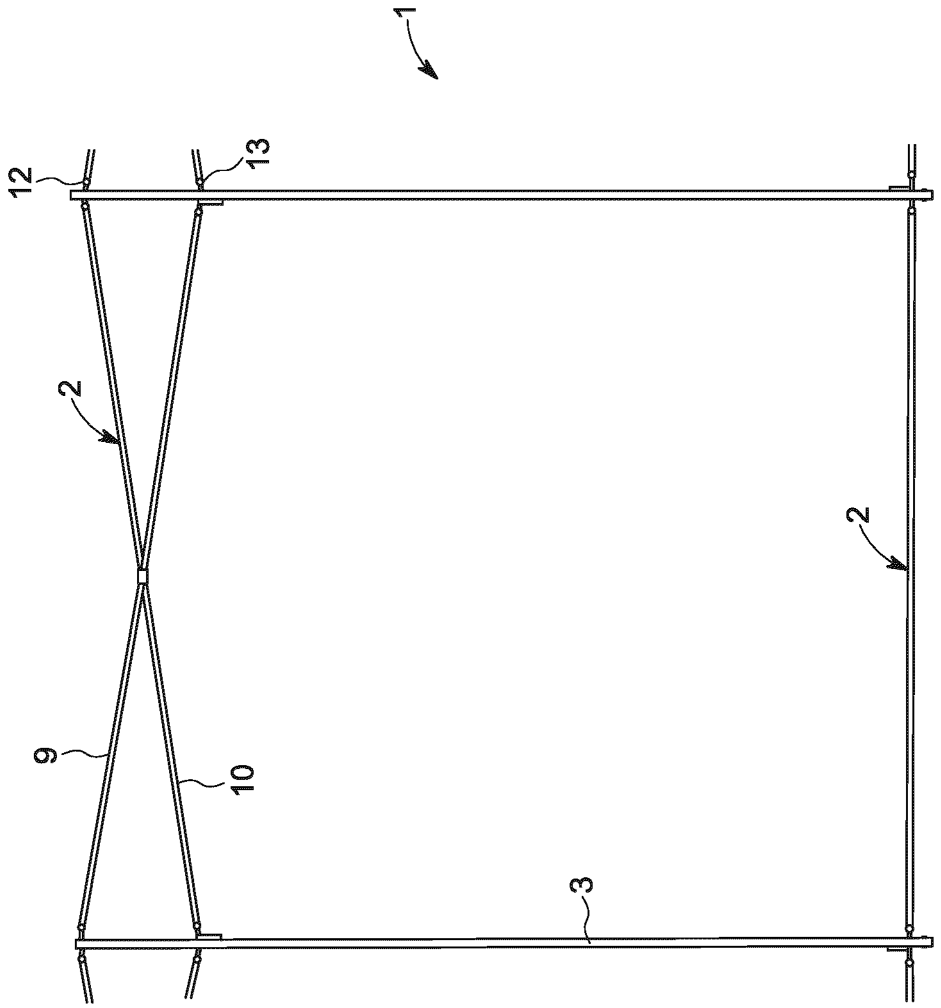

FIG. 3

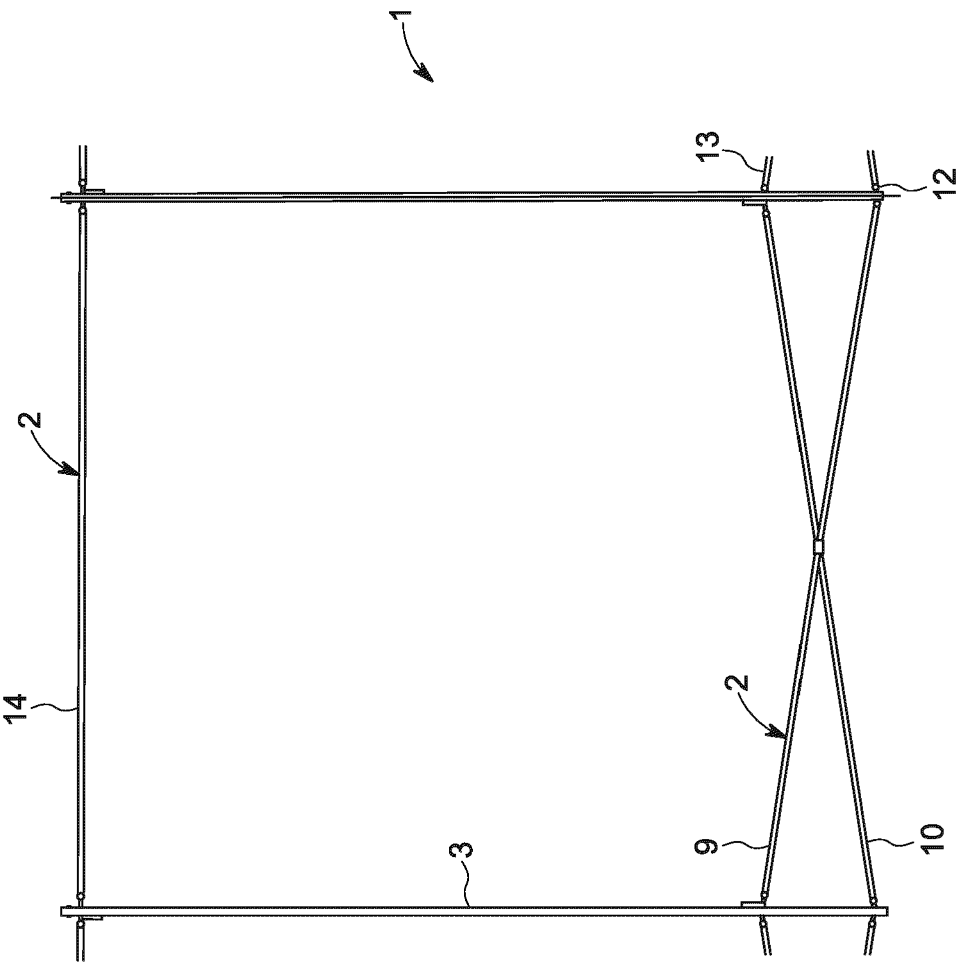

FIG. 4

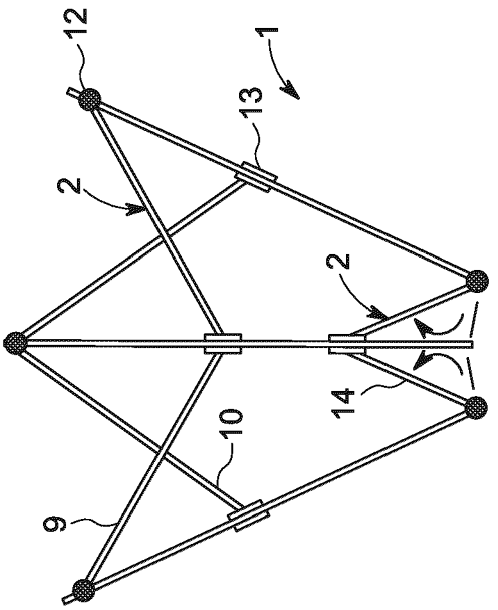

FIG. 6

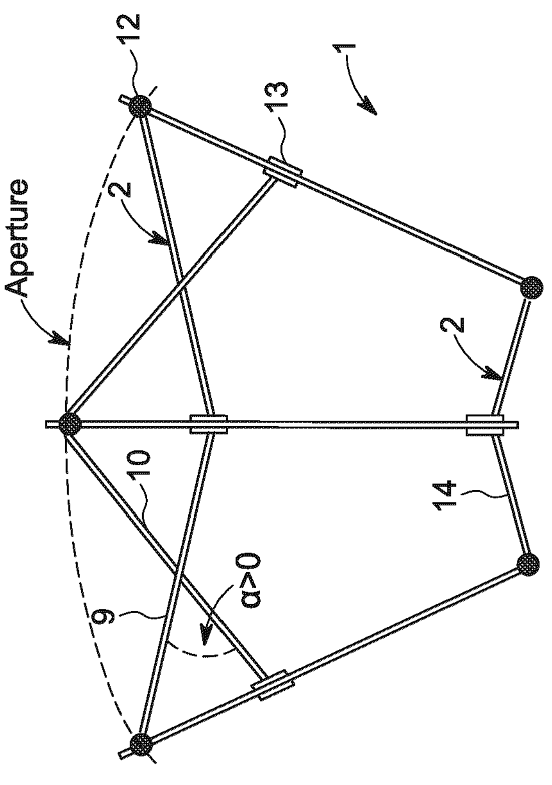

FIG. 5

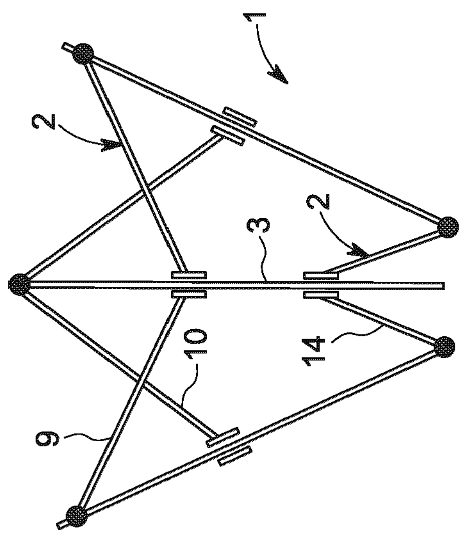

FIG. 8

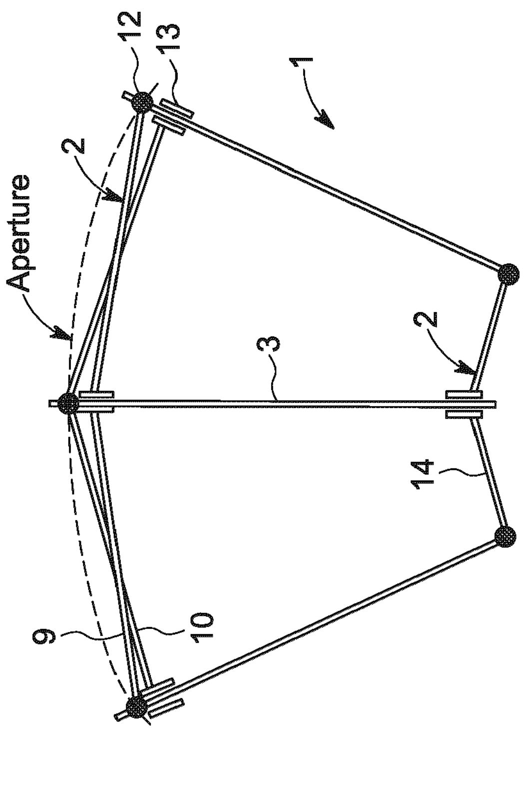

FIG. 7

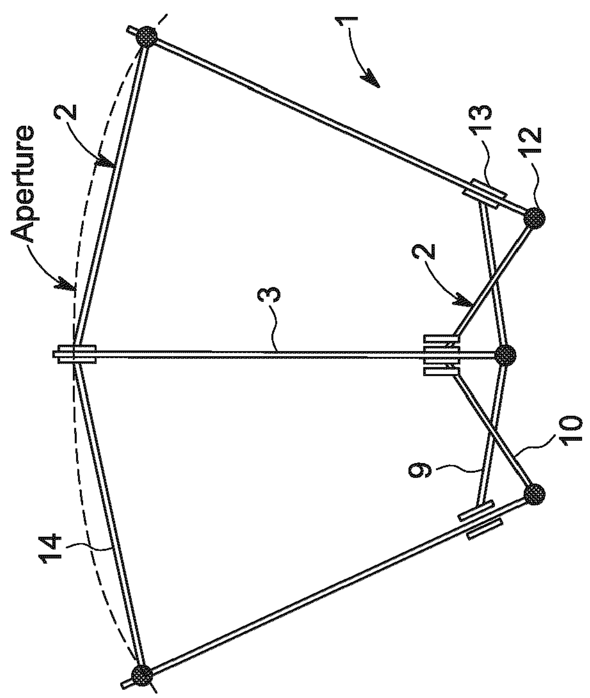

FIG. 9

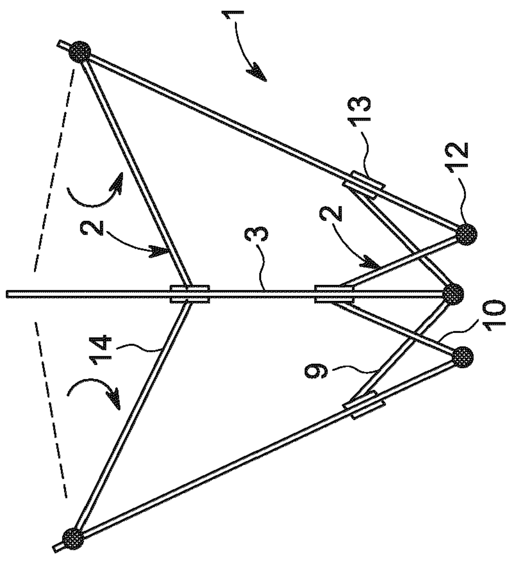

FIG. 10

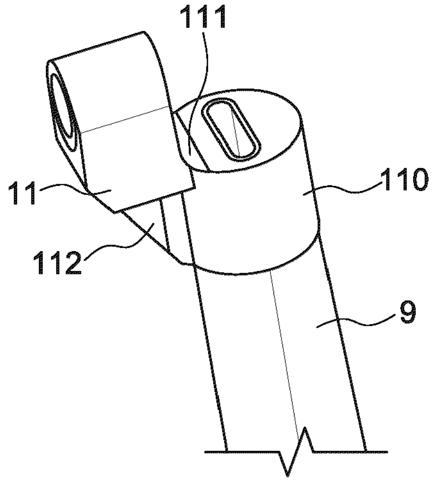

FIG. 11

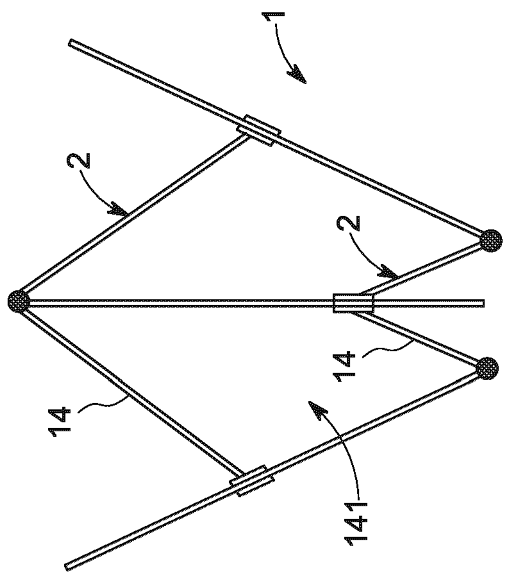

FIG. 13

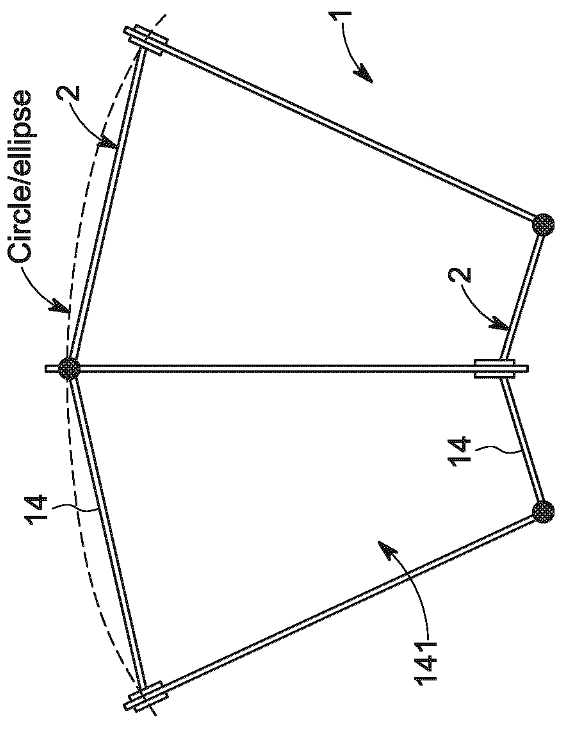

FIG. 12

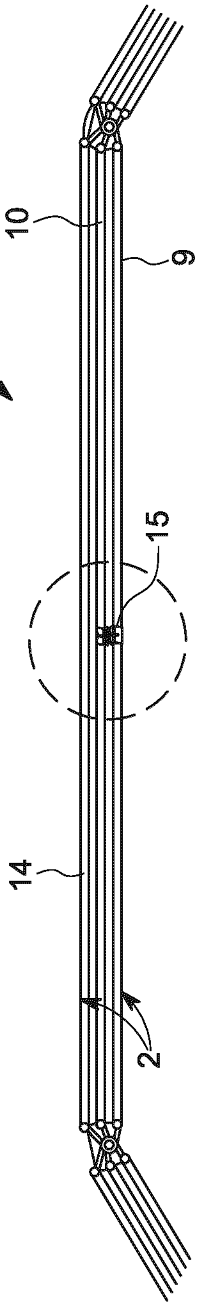

FIG. 14

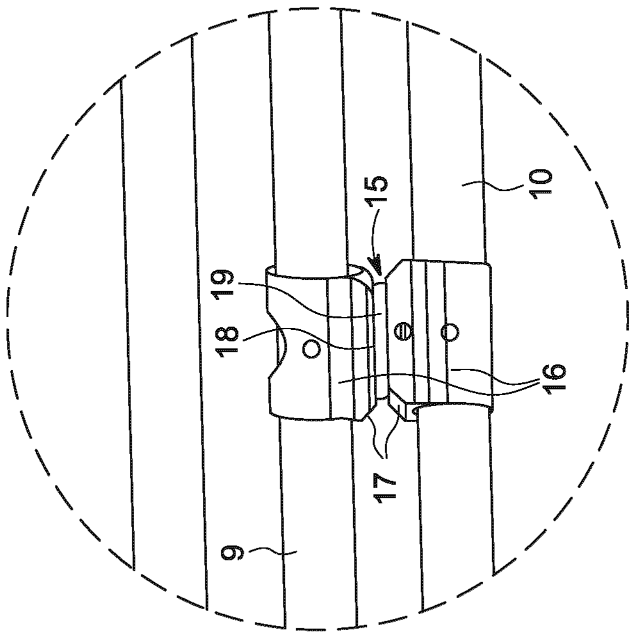

FIG. 15

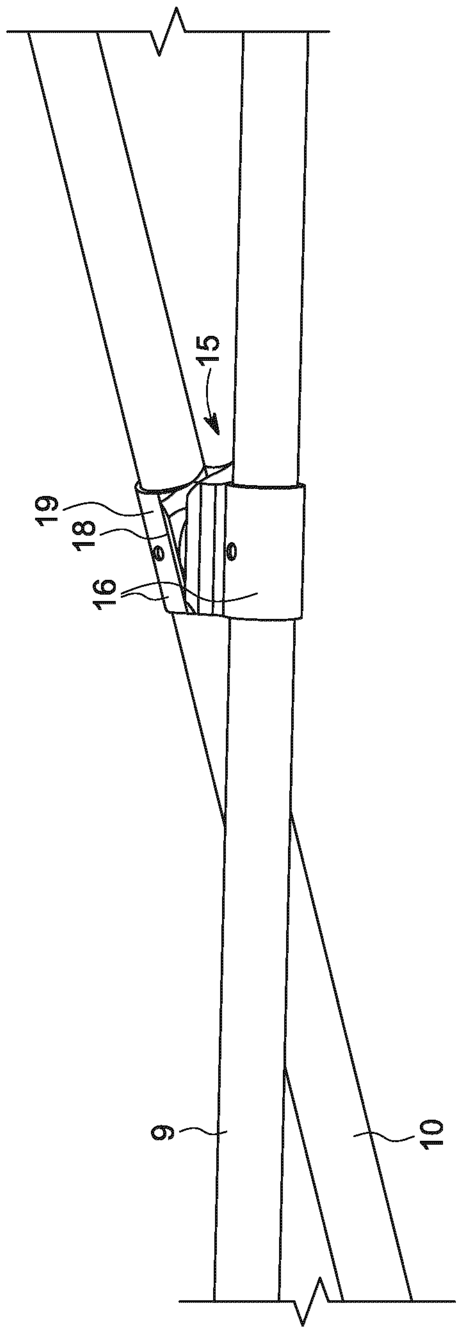

FIG. 16

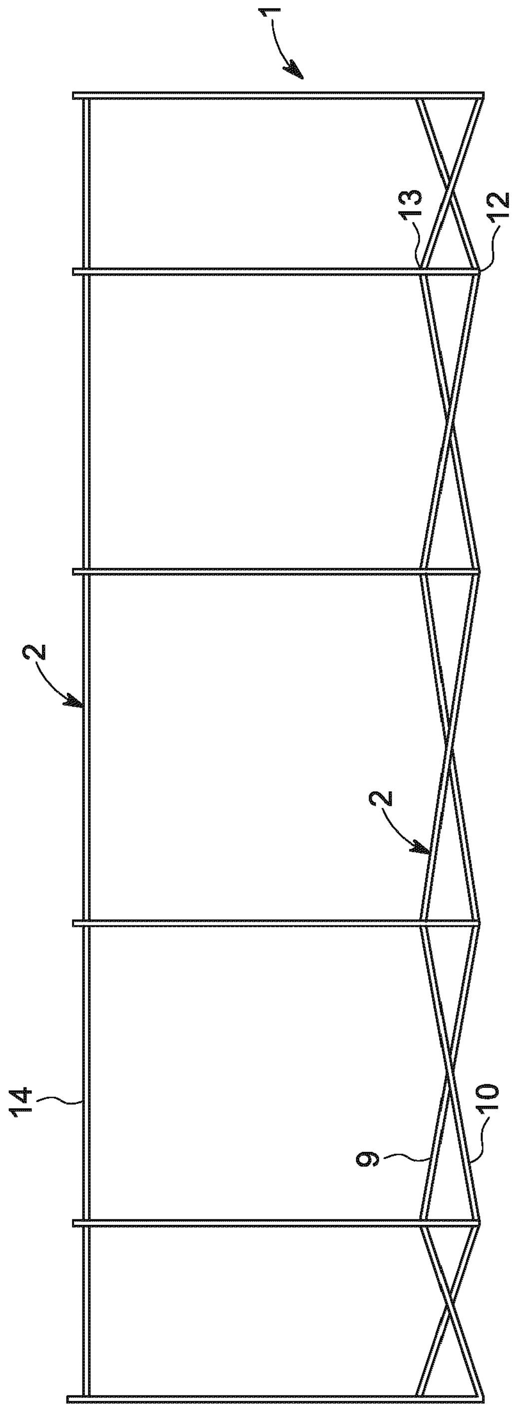

FIG. 17

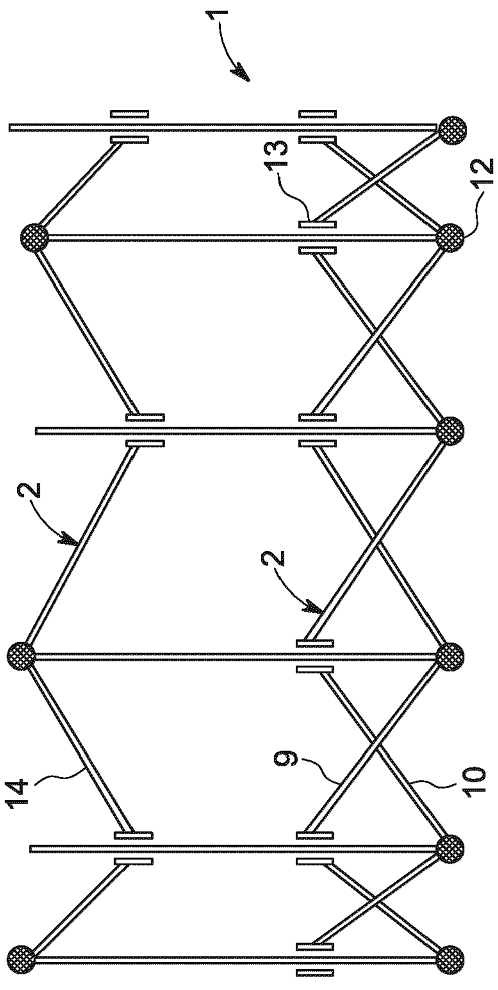

FIG. 18

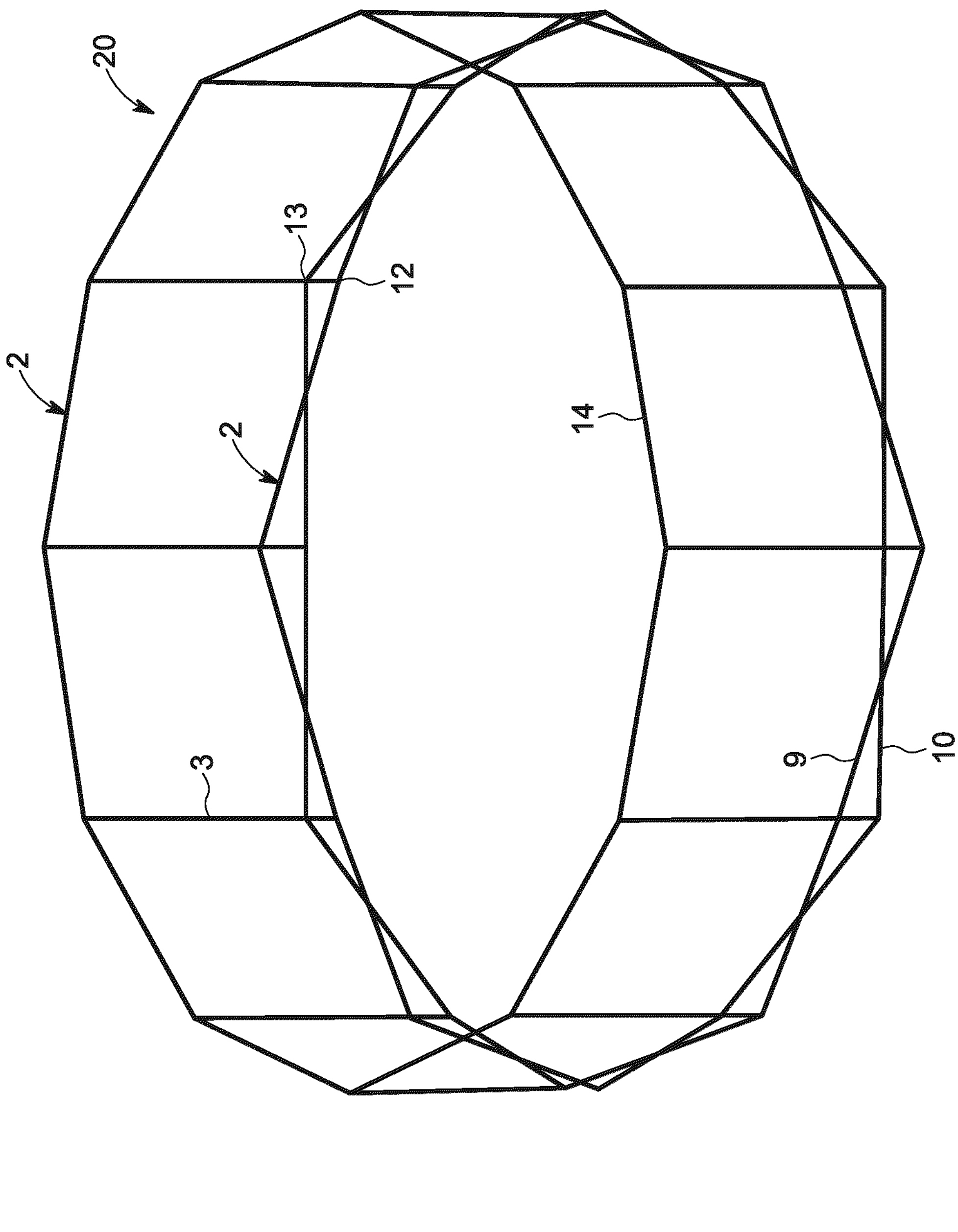

FIG. 19

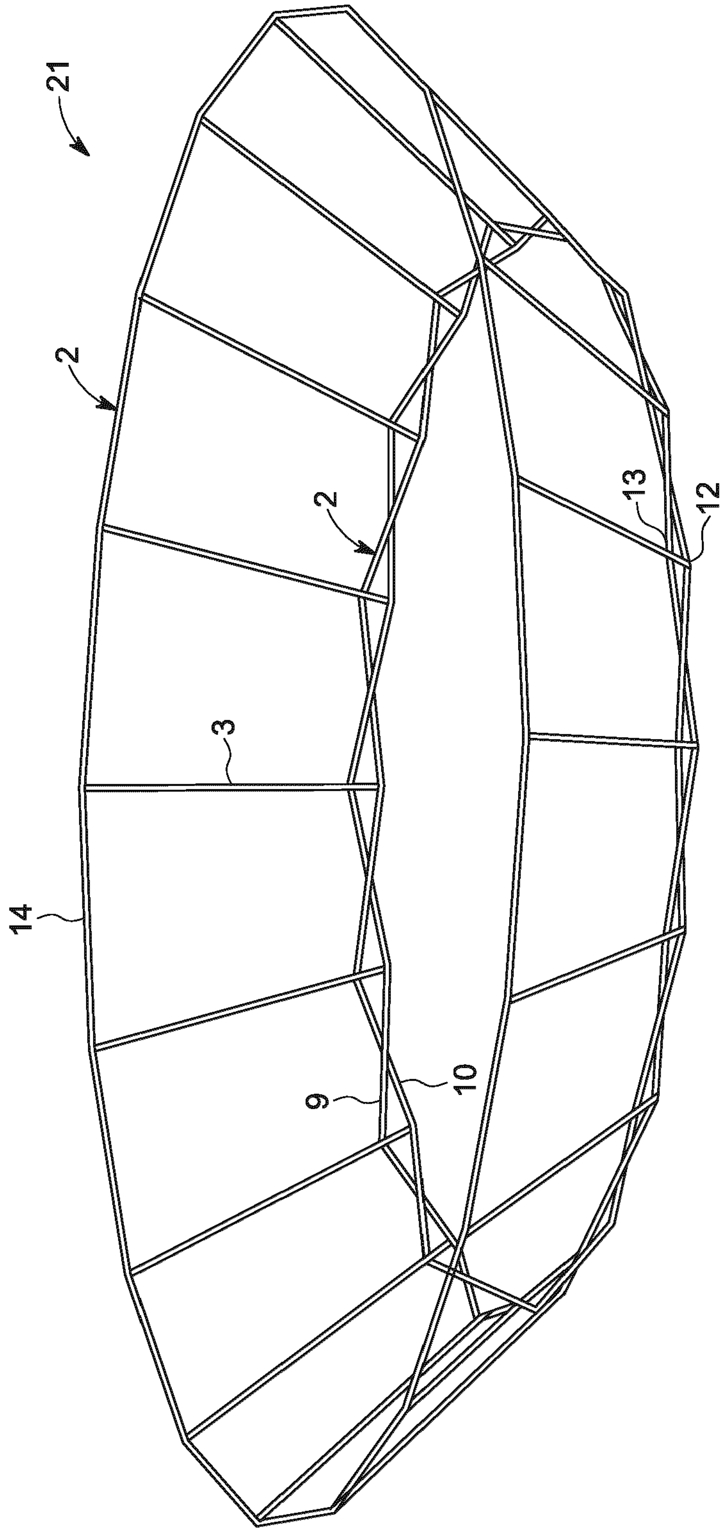

FIG. 20

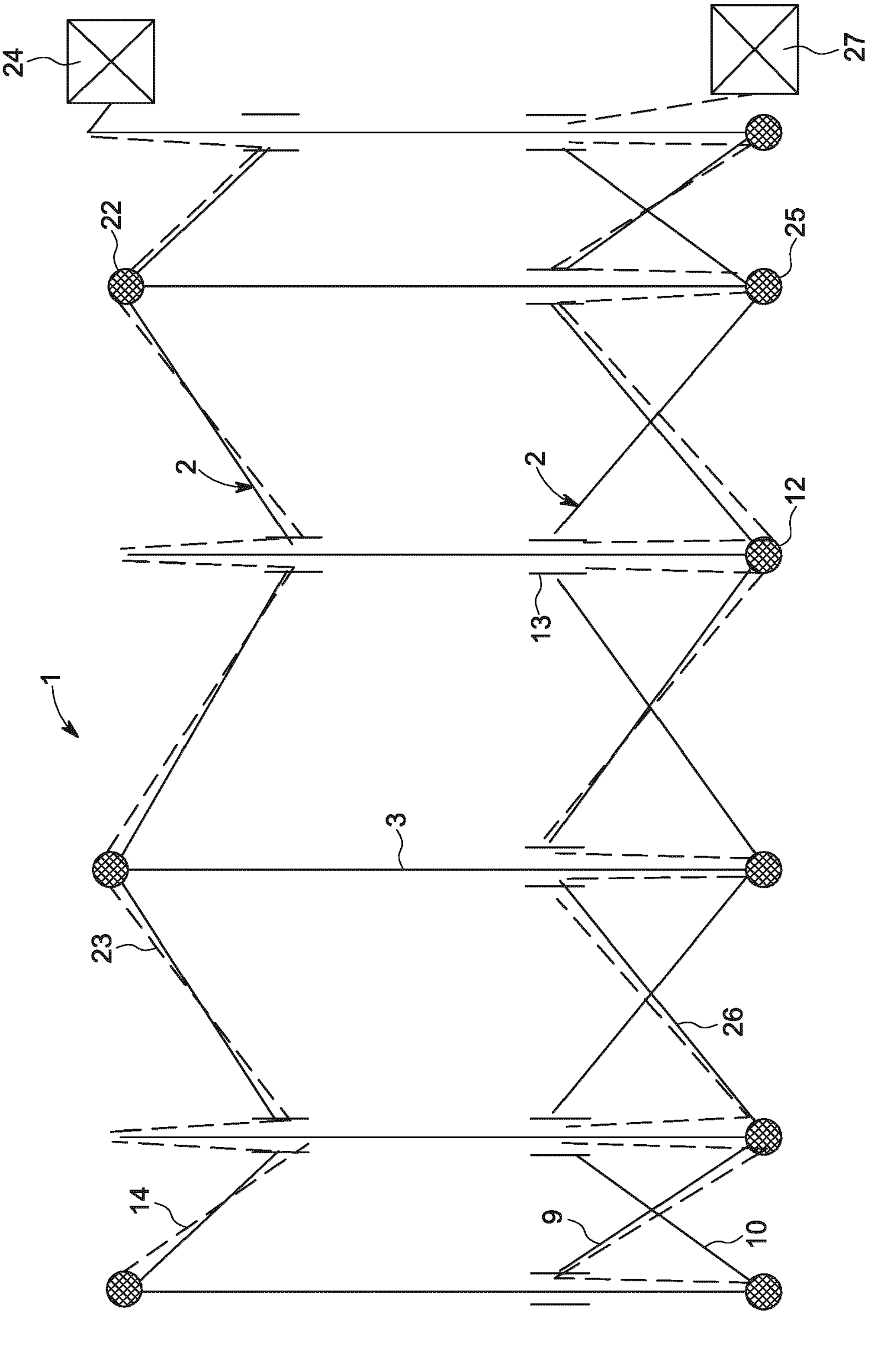

FIG. 21

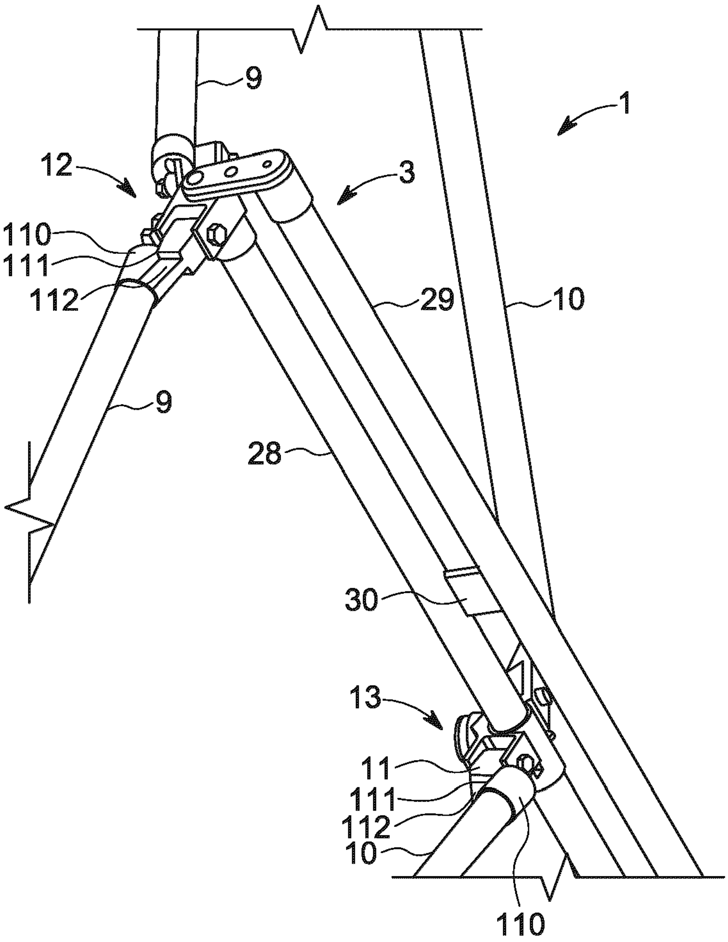

FIG. 22

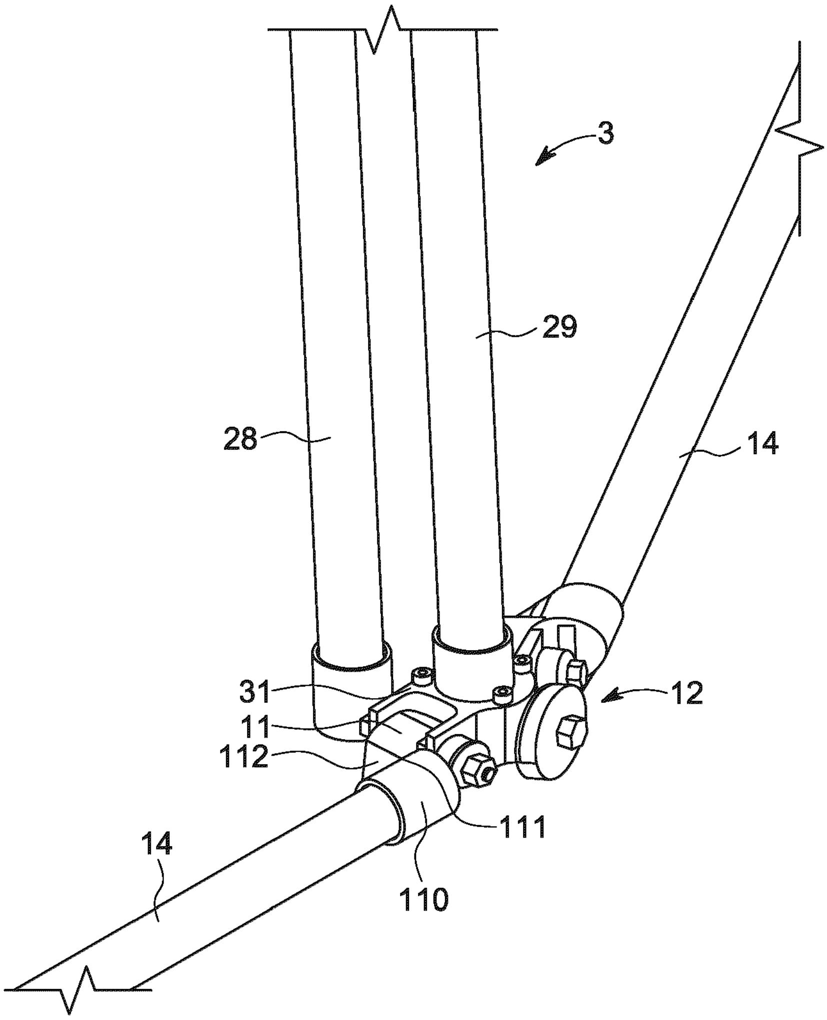

FIG. 23

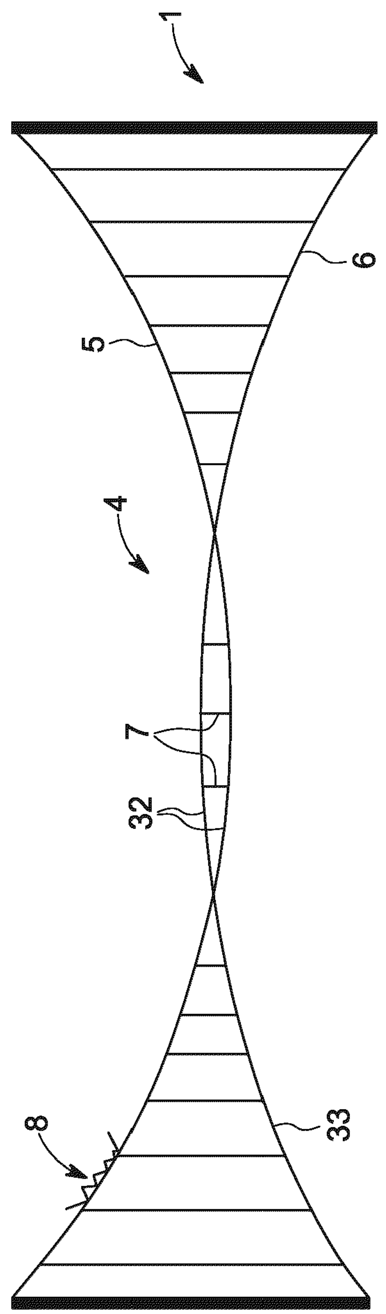

FIG. 24

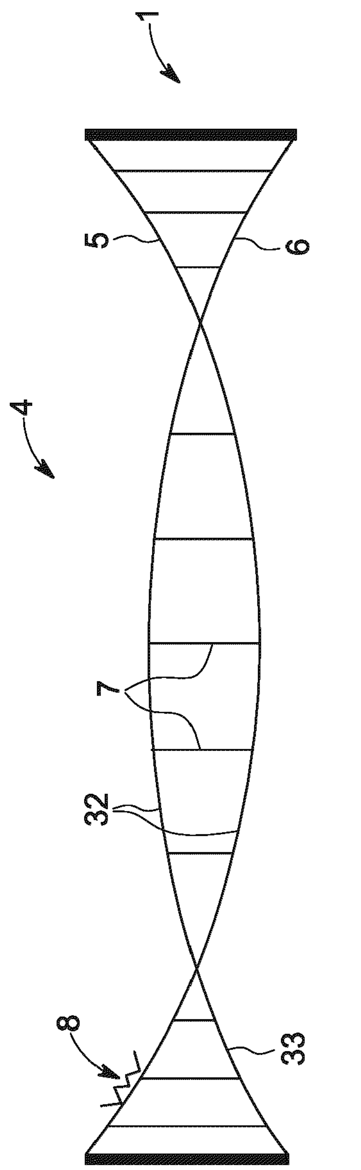

FIG. 25

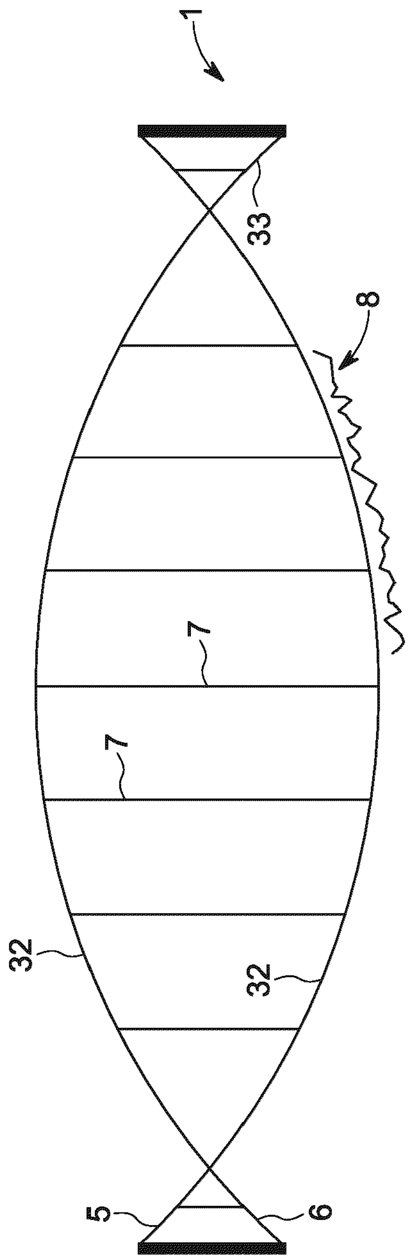

FIG. 26

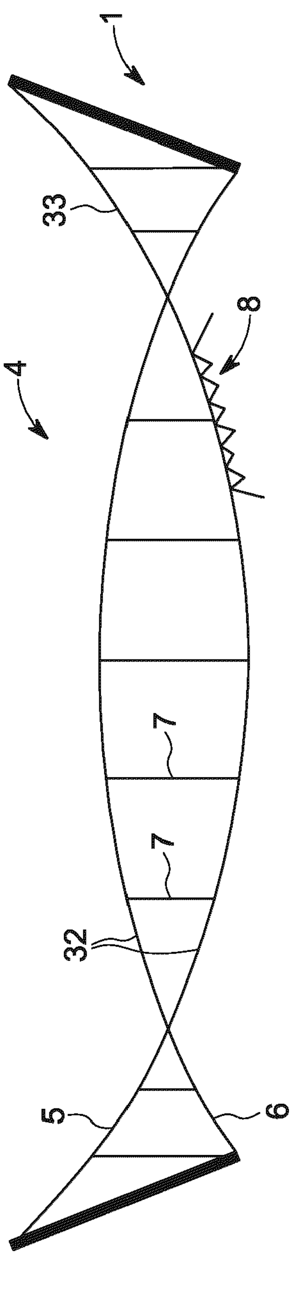

FIG. 27

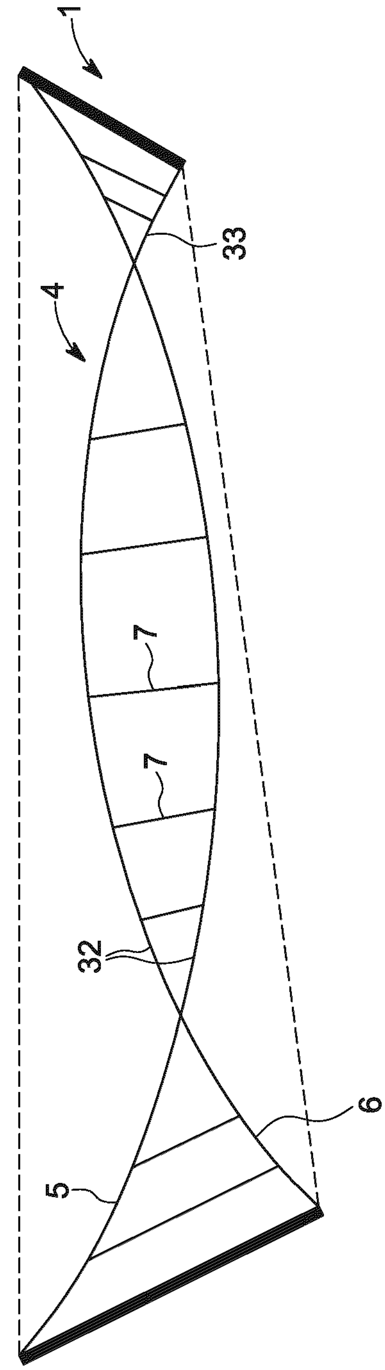

FIG. 28

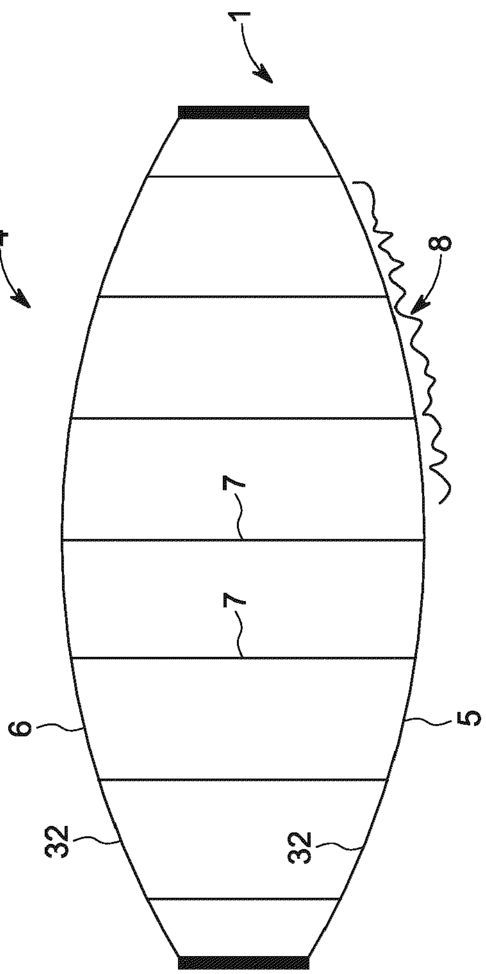

FIG. 29

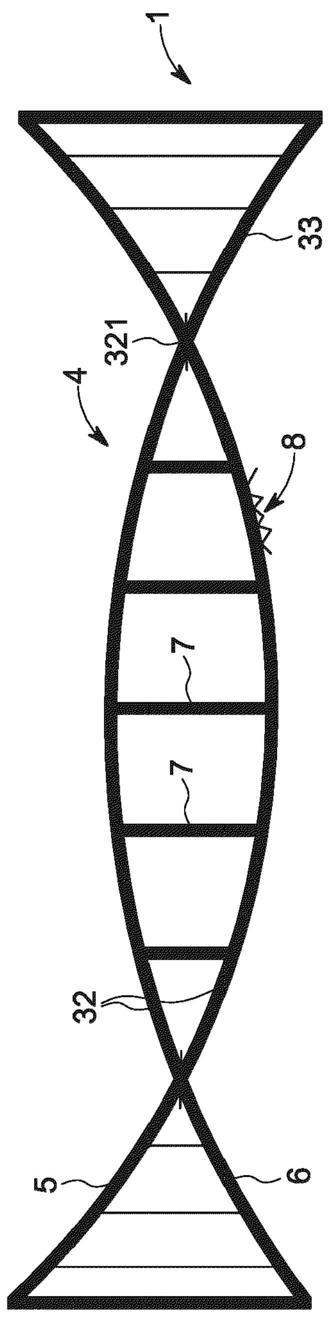

FIG. 30

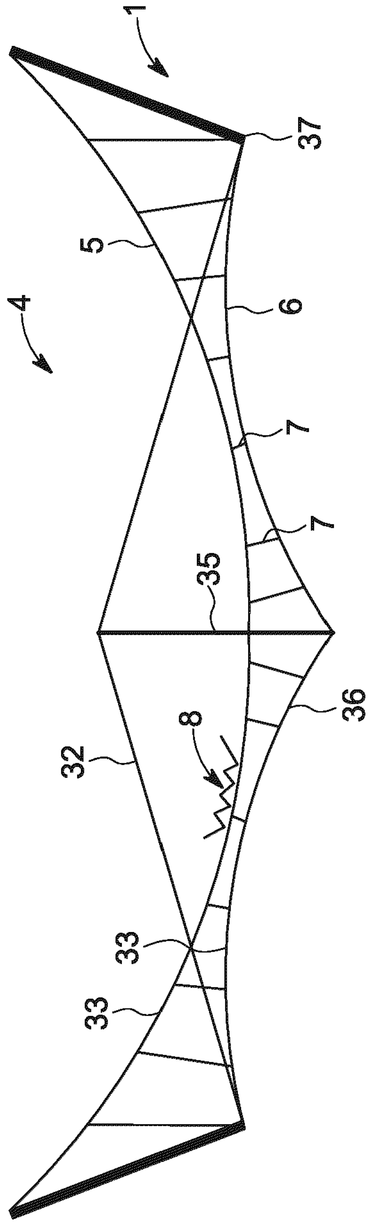

FIG. 31

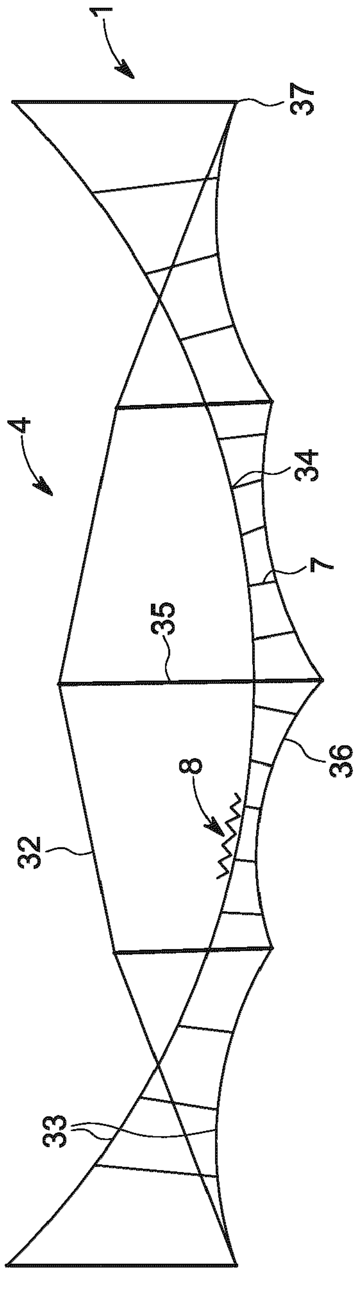

FIG. 32

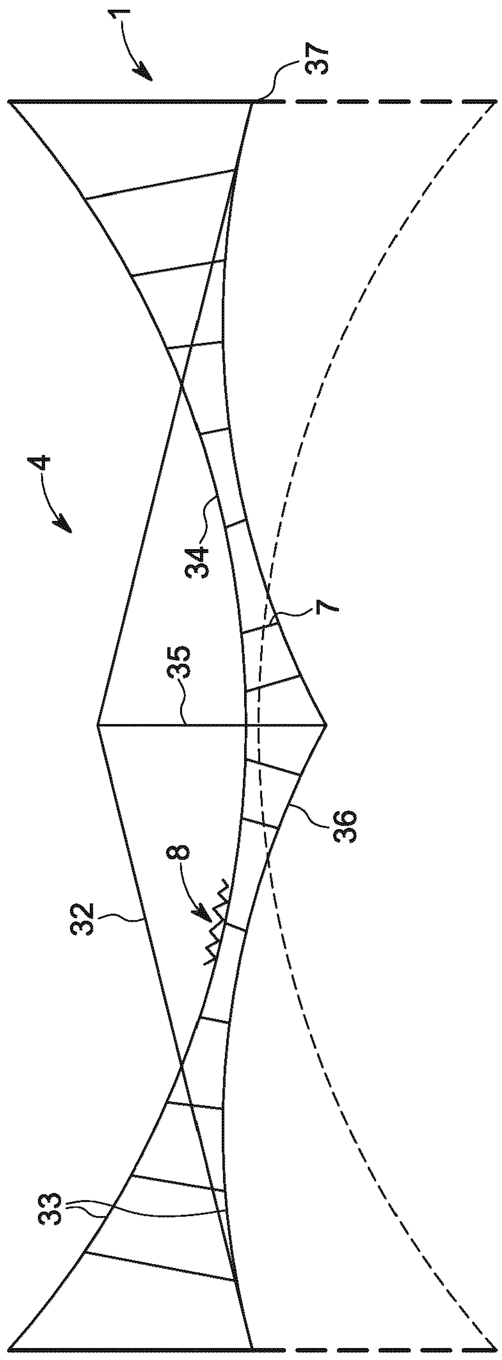

FIG. 33

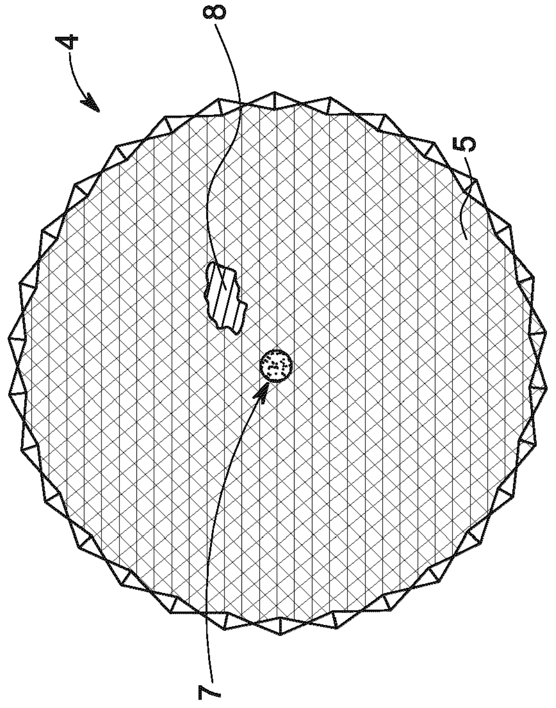

FIG. 35

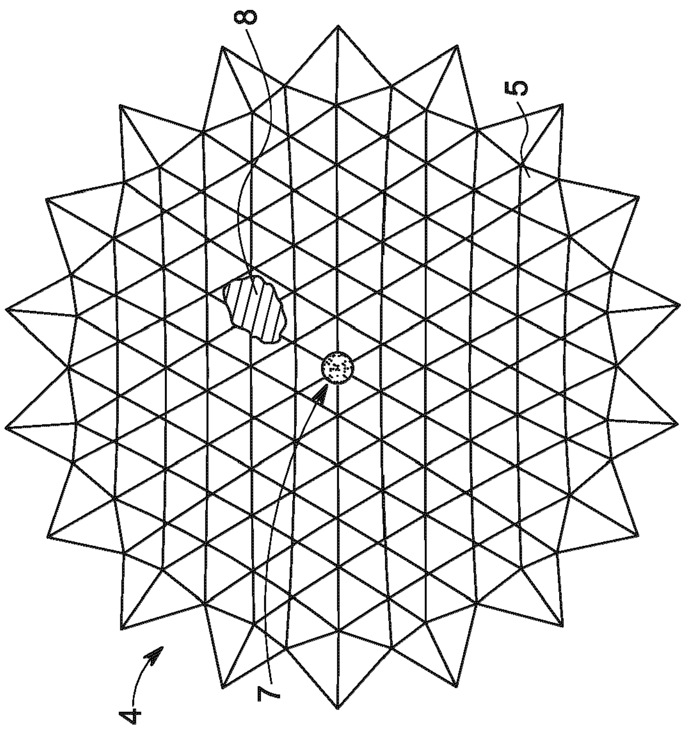

FIG. 34

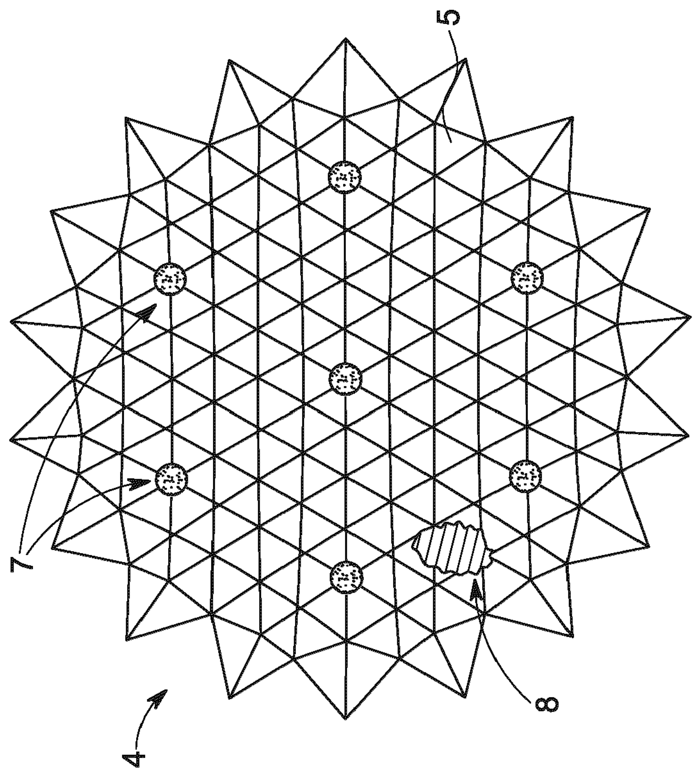

FIG. 36

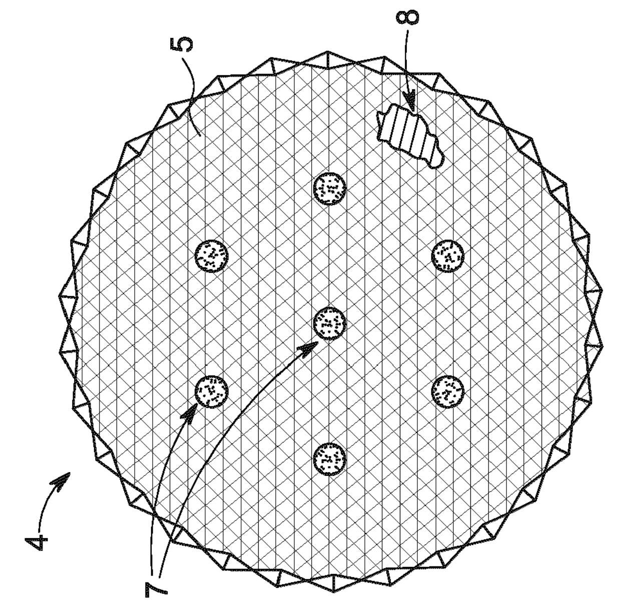

FIG. 37

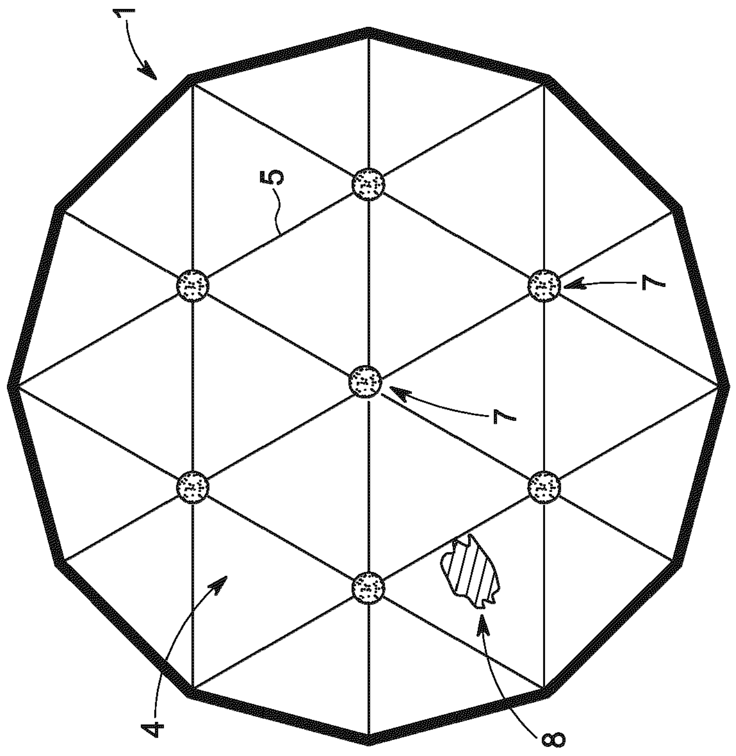

FIG. 38

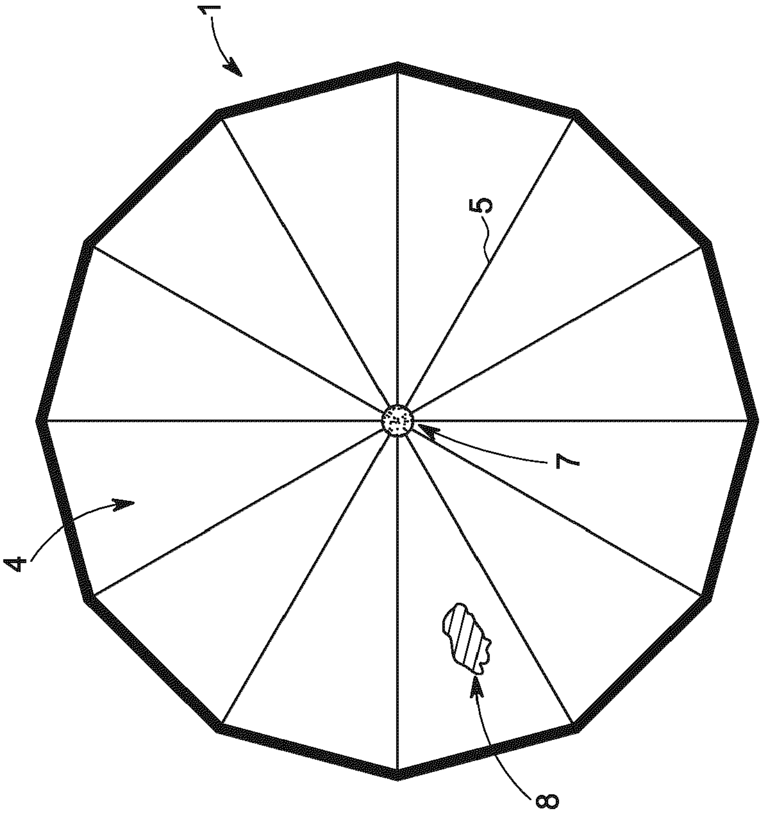

FIG. 39

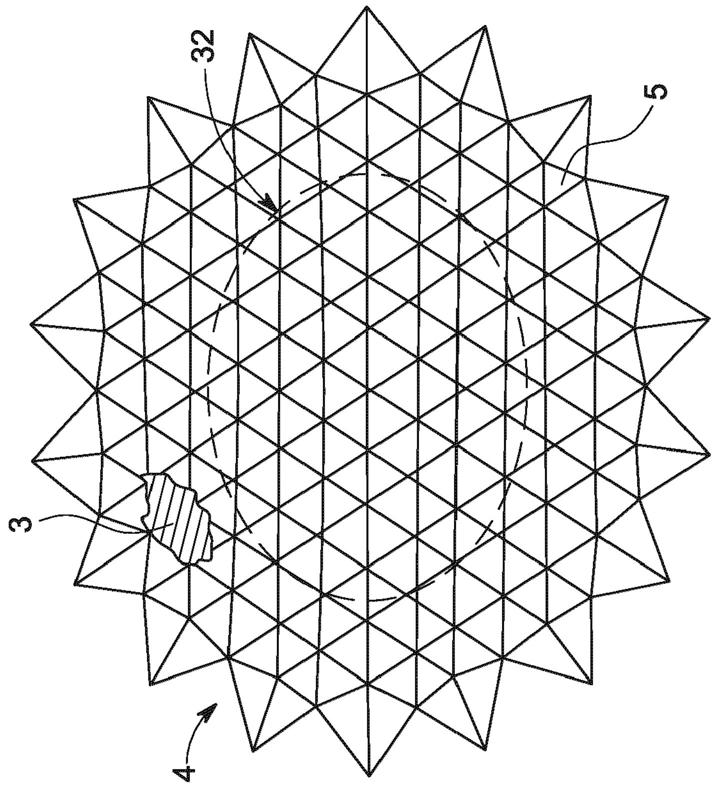

FIG. 40

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 21 15 7199

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	WO 03/003517 A1 (MEDZMARIASHVILI ELGUJA [GE]) 9 January 2003 (2003-01-09) * page 1, line 5 - line 23 * * page 8, line 9 - line 19 * * page 17, line 20 - page 18, line 26; figures 1-11 * * page 19, line 25 - page 23, line 12; figures 24-76 * -----	1 6-9, 12-15	INV. H01Q1/28 H01Q15/16
Y	WO 2012/065619 A1 (EUROP AGENCE SPATIALE [FR]; SANTIAGO PROWALD JULIAN B [NL]; SUCH TABOA) 24 May 2012 (2012-05-24) * page 15, line 6 - line 16; figures 7,8 * * page 17, line 18 - page 18, line 24; figures 11A-14d * -----	6-9, 12-15	
A	US 2002/063660 A1 (HARLESS RICHARD I [US]) 30 May 2002 (2002-05-30) * paragraph [0034] - paragraph [0037]; figures 1, 24, 25 * * paragraph [0042] - paragraph [0044]; figures 3-7 * * paragraph [0050] - paragraph [0056]; figures 15-18 * -----	1-15	TECHNICAL FIELDS SEARCHED (IPC) H01Q
A	THOMSON M W ED - INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS: "THE ASTROMESH DEPLOYABLE REFLECTOR", IEEE ANTENNAS AND PROPAGATION SOCIETY INTERNATIONAL SYMPOSIUM. 1999 DIGEST. APS. ORLANDO, FL, JULY 11 - 16, 1999; [IEEE ANTENNAS AND PROPAGATION SOCIETY INTERNATIONAL SYMPOSIUM], NEW YORK, NY : IEEE, US, 11 July 1999 (1999-07-11), pages 1516-1519, XP000927142, ISBN: 978-0-7803-5640-5 * the whole document * ----- -/--	1-15	

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	29 June 2021	Pastor Jiménez, J

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons
& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 21 15 7199

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	US 6 388 637 B1 (DAVIS DANIEL [US]) 14 May 2002 (2002-05-14) * column 2, line 65 - page 3, line 61; figures 1-3 * -----	1-15	
			TECHNICAL FIELDS SEARCHED (IPC)

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	29 June 2021	Pastor Jiménez, J

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons
& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

page 2 of 2

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 21 15 7199

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

29-06-2021

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 03003517 A1	09-01-2003	GE P20053604 B	25-08-2005
		WO 03003517 A1	09-01-2003
WO 2012065619 A1	24-05-2012	EP 2640643 A1	25-09-2013
		ES 2640986 T3	07-11-2017
		US 2013340373 A1	26-12-2013
		WO 2012065619 A1	24-05-2012
US 2002063660 A1	30-05-2002	NONE	
US 6388637 B1	14-05-2002	NONE	

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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

Patent documents cited in the description

- US 6323827 B **[0002]**
- US 5680145 A **[0006] [0022] [0023]**

Non-patent literature cited in the description

- **KORYO MIURA ; YASUYUKI MIYAZAKI.** Concept of the Tension Truss Antenna. The Institute of Space and Astronautical Science **[0008]**
- *AIAA Journal,* vol. 28 (6 **[0008]**