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(71) Demandeur/Applicant:
BALTICO GMBH, DE

(72) Inventeur/Inventor:
BUCHLER, DIRK, DE

(74) Agent: RIDOUT & MAYBEE LLP

(54) Titre : STRUCTURE DE BARRES A ENROULEMENTS DE CONSTRUCTION COMPOSITE
(54) Title: ROD WINDING STRUCTURE IN COMPOSITE DESIGN

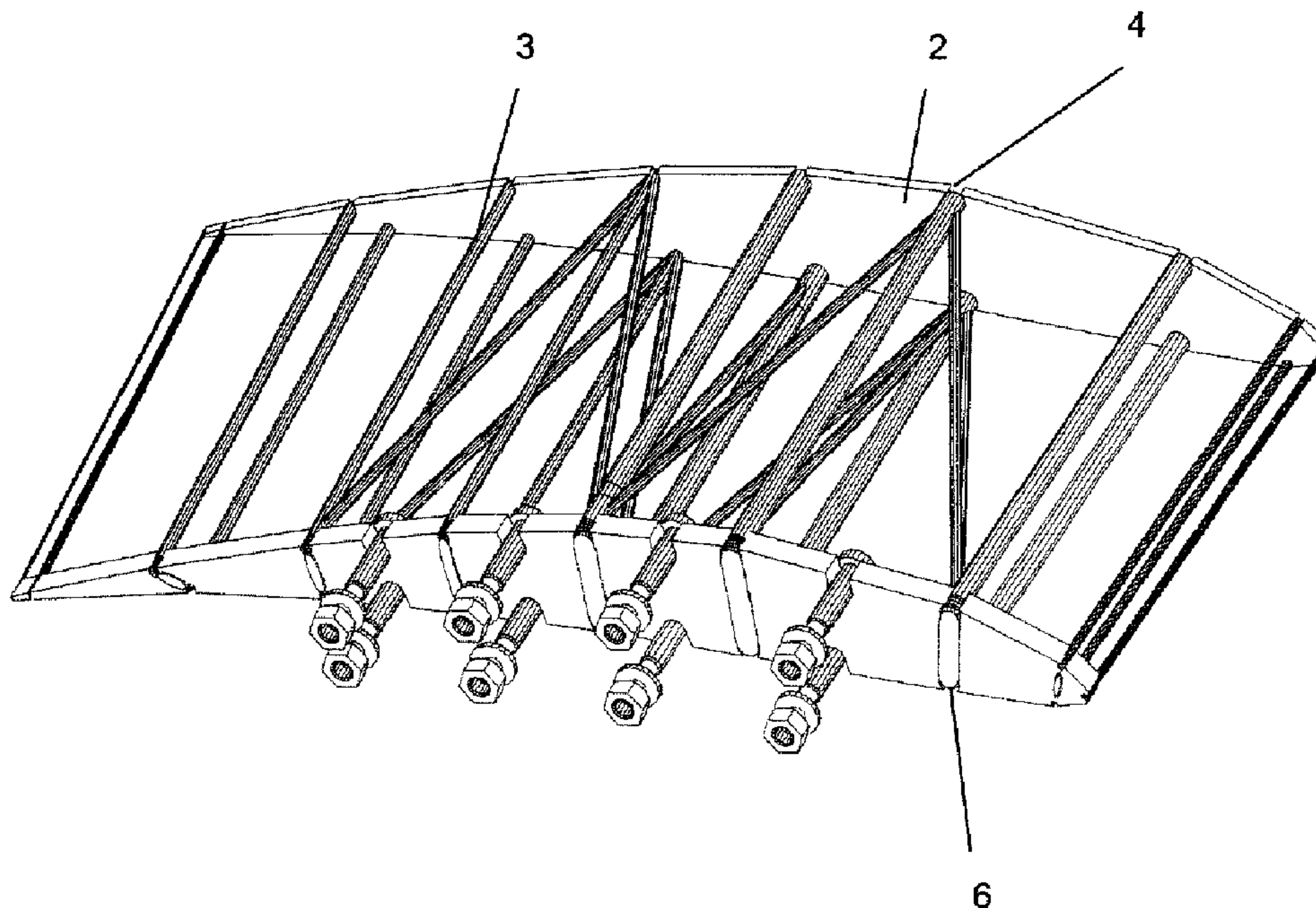


Figure 2

(57) Abrégé/Abstract:

The invention relates to rod winding structures in composite design, which can be used, for example, for airfoils for aircraft, or hydrofoils for ships, or rotor blades for wind power plants. According to the invention, a complex three-dimensional lattice made of

(57) **Abrégé(suite)/Abstract(continued):**

previously saturated fiber strands is placed over points of intersection, forming the main body of the structural member to be produced. The rod winding structure in composite design comprising a skeleton of ribs, which is formed by saturated fiber strands in a continuous winding and laying process, is characterized in that the ribs are solid ribs or lattice structure ribs which are prefabricated from fiber strands and which comprise points of intersection over which the saturated fiber strands are placed alternately and incrementally in diagonal, horizontal and vertical arrangements until the desired strand thickness is reached, and the rod winding structure can be divided if necessary. The solid ribs consist of fiber composite materials or aluminum or other lightweight materials.

Summary

The invention concerns rod winding structures in a composite design which can be used, for example, for airfoils for aircraft or hydrofoils for ships or rotor blades for wind power plants, but also in other areas in which a light structure is desired, as, for example, for hulls, superstructures, supporting structures for solar reflecting panels, and the like.

The aim of the invention, proceeding from the prior state of the art, is to further develop rod winding structures such that they are also suitable for the production of airfoils/hydrofoils and rotor blades.

According to the invention, a complex, three-dimensional lattice made of pre-saturated fibre strands is placed over points of intersection [or joints], thus forming the main body of the structural member to be produced.

The rod winding structure in composite design, comprising a skeleton of ribs formed by saturated fibre strands in a continuous winding and laying process, is characterized in that the ribs are solid ribs or lattice structure ribs which are fabricated from fibre strands and which form joints over which the saturated fibre strands are placed alternately and incrementally in diagonal, horizontal and vertical arrangements until the desired strand thickness is reached; and the rod winding structure can be divided if necessary. The solid ribs consist of fibre composite materials or aluminum or other lightweight materials.

Rod Winding Structure in Composite Design

Description

[0001] The invention concerns rod winding structures in composite design which can be used, for example, for airfoils/hydrofoils or rotor blades for wind power plants, but also in other areas in which a light structure is desired, as, for example, for hulls, superstructures, supporting structures for solar reflecting panels, and the like.

State of the Art

[0002] In the production of airfoils and rotor blades, for example, in aircraft manufacture or for wind power plants, but also in ship building, generally shell construction is employed. Thereby, the outer surface stretched as a shell over a usually centrally-located spar. The shell can take an appreciable proportion of the load.

[0003] That construction method has the disadvantage in that it can only be implemented with considerable manual effort. Thus all discrete structural elements must be cut to pattern, positioned and finally joined. That process makes reproducibility difficult, and production costs are high.

[0004] Moreover, optimizing the strength of the shell is only possible to a limited degree, since the technical input becomes prohibitive. Shell weight will, therefore, not be optimal.

[0005] Possibilities for effecting connections and attachments, especially those involving metallic construction elements, or among divided parts, are

both limited and expensive. Connecting additional construction elements is also complicated.

[0006] A targeted, built-in functionality, such as, for example, load-dependent torsion of the construction elements, will involve many constraints.

[0007] In order to produce the skeleton, an alternative is offered by the solution presented by WO 2008/115265 A1. A series of shapes, disposed at intervals from one another and forming the contour, are held together by numerous struts and cross girders, the latter forms made of pultruded glass fibre material.

[0008] The technological complexity, however, is considerable, even with this method, since the discrete structural elements must be cut to shape, positioned and joined, so that no great advance towards industrial production is achieved.

[0009] An alternative is offered by rod winding structures according German patent DE 102006038130 B3. This reveals both a method for producing supporting structures and the supporting structures thus produced. In a single, continuous winding and laying process, saturated carbon fibre strands are wound horizontally, vertically and diagonally around structural parts arranged in a grid. Should no structural parts be used, the saturated carbon fibre strands can also be laid above or below already wound or laid carbon fibre strands. A grid is created that features both great stability and high mechanical load capacity.

[0010] The application to airfoils/hydrofoils and rotors, hulls, auto bodies and support structures for solar reflecting panels is thereby not foreseen.

Description of the Invention

- [0011] The task of the invention, proceeding from the prior state of the art, is to further develop rod winding structures so that they are also suitable for the production of airfoils/hydrofoils and rotor blades.
- [0012] According to the invention, a complex, three-dimensional lattice made of pre-saturated fibre strands is placed over points of intersection, thus forming the main body of the structural member to be produced.
- [0013] The rod winding structure in composite design comprising a skeleton of ribs, formed by saturated fibre strands in a continuous winding and laying process, is characterized in that the ribs are solid ribs or lattice structure ribs which are prefabricated from fibre strands and which comprise points of intersection [or joints] over which the saturated fibre strands are placed alternately and incrementally in diagonal, horizontal and vertical arrangements until the desired strand thickness is reached; and the rod winding structure can be divided. The solid ribs consist of fibre composite materials or aluminum or other lightweight materials.
- [0014] The design of the ribs is dictated by the outer shape of the rod winding structure, and the rod winding structure is subdivided by the ribs into sections, whereby the length of the distances between the ribs is dependent on the overall structure and its stability requirements.
- [0015] In one embodiment, the joints are openings, oriented to the outer edges of the ribs and situated opposite each other; these openings are evenly distributed over the entire rib and feature a diameter that is related to the final thickness of the fibre strands to be laid, whereby the width of the openings of the joints are outwardly narrower than the expected final diameter of the cross section of the fibre strands.

- [0016] A further embodiment prefers, instead of joints, fastening parts arranged along the ribs. These fastening parts are concave, cylindrical parts with a flanged or otherwise thickened edge. They are provided with a centered bore hole or are produced as cylindrical, hollow parts. They may be made of aluminum, for example. The fastening parts may be removed from the construction element after production or they may remain in the construction element as additional supporting structures.
- [0017] In yet another embodiment, the ribs are designed as profiled flanges, in that a groove runs along their outer edges between any two openings or fastening parts; into this groove the fibre strands are laid. Thus, two ribs can be joined to each other, whereby an overall structure is created. This connection between the profiled flanges is made by means of a screw joint between them.
- [0018] At the base level of the rod winding structure, a metal flange is arranged that is equipped with threaded pins distributed over its girth and set at right angles to the fibre strands to be wound.
- [0019] The entire structure is then wrapped, planked, encapsulated or foam-coated.
- [0020] The rod winding structure according to the invention may be used as a rotor blade for a wind power plants, an airfoil for an aircraft or a hydrofoil for ships.
- [0021] The production process itself can be automated and carried out by handling robots. After the production process is complete, the material is hardened and thus becomes a stable skeleton. By winding sockets and/or pegs into place, these being preferably made of metal, an excellent connection with other construction elements or additions can be achieved.

[0022] In a subsequent production step, the resulting supporting structure may be planked or foam-coated in a mould with a foam material. Thereby, the desired geometry and surface quality will be achieved. To heighten wear resistance or for decorative purposes, a layer of foil or lacquer may also be applied.

Explanation of the Invention

[0023] The invention is further clarified by means of illustrations. These show:

Figure 1 Schematic presentation of an example of an embodiment of the invention as a rotor blade, consisting of a rod winding structure in composite design

Figure 2 Solid ribs wound with fibre strands

Figure 3 Solid rib with grooves and openings

Figure 4 Ribs mutually connected by means of a profile flange screw joint

Figure 5 Connection to a metal flange in the base area of a rotor blade (schematic presentation)

Figure 6 Connection to a metal flange in the base area of a rotor blade with solid ribs

Figure 7 Connection to a metal flange in the base area of a rotor blade with prefabricated, wound lattice-structure ribs

Figure 8 Rotor blade (section) with shell-shaped foam cover applied for purposes of both outer contour and seal

Figure 9 Ship's hull as supporting structure

Figure 10 Deck house as supporting structure

Figure 11 Supporting structure for a solar reflecting panel.

[0024] The solution put forth by the invention may be employed wherever lightweight structures are required. The explanation of the invention is

presented by way of the example of a rotor blade for wind power plants. However, it is equally possible to envision airfoils for aircraft produced on the same principle.

- [0025] Pursuant to the invention, a complex, three-dimensional lattice of pre-soaked strands of, for example, coal fibres or glass fibres are laid over joints and thus form the base body of the construction element to be made. "Joints" refers to the points along the ribs where several fibre strands come together. For example, the intersections may be formed directly within the ribs by means of outward-facing openings.
- [0026] Other intersections may be formed by fastening parts, concave, cylindrical parts finished with flanged or otherwise thickened edges. The cylindrical parts may be provided with a centered bore hole or they may be manufactured as cylindrical, hollow parts. As their material, aluminum would be preferred, but these parts can also be envisioned as being made of other light materials with a high mechanical load capacity.
- [0027] The shape of the rotor blade (1) in Figure 1, is formed by a rib skeleton made of solid ribs (2) (Figure 2) or of prefabricated, wound ribs in a lattice structure (5) (see Figure 7). The material of the solid ribs (2) is variable. Possibilities include both fibre composite materials and aluminum or any other light materials. The shape of the ribs is determined by the outer profile of the rotor blade (1). The ribs subdivide the rotor blade (1) into sections.
- [0028] The ribs feature openings (4,) oriented to the outer edges of the ribs, and situated in pairs opposite each other (joints), which, in this instance, are evenly distributed over the length of the ribs. The distances between joints may also vary. The opening (4) has a previously calculated diameter, which will depend on the ultimately expected thickness of the

fibre strands (3) to be laid. The width of the opening of joints 4 is smaller towards the outside than the final expected diameter of the laid fibre strand.

[0029] As an alternative to joints, fastening parts (7) are arranged along the ribs, which may be removed from the construction element after production or may remain in the construction elements as additional supporting structures.

[0030] Between the ribs, which are spaced at definite distances from one another, depending on the total length of the rotor blade and its required stability (in the example, between 10 cm and 500 cm), saturated fibre strands (3) are laid in a continuous winding and laying process into the openings 4 or over the fastening parts (7), alternately and incrementally, in a diagonal, horizontal and vertical direction. Whereby the laying process over the individual joints continues until the desired strand strength is reached, and the chronological sequence of the winding of the fibre strand is calculated so that a largely continuous process of winding over all of the joints can take place. Depending on the construction, the distances from rib to rib may differ in length.

[0031] Should the rotor blade (1) have to be divided, for example, to avoid transportation problems, a targeted substitution can be made of a profile flange (8) for the rib at the edge to be connected. This is shown in Figure 3. On the outer edge of the profile flange (8) a groove (6) runs between any two openings (4) or fastening parts (7). Because of the groove (6), the fibre strands (3) do not lie on the surface but are even with the surface of the profile flange (8), so that a flush connection between two ribs can be achieved.

- [0032] The connections among the distinctive sections of the rotor blade (1) is effected by means of screw joints (9) on the profile flange (8) (Figure 4). The individual strands of fibre length (3) are thereby led back over the profile flange (8) and enclose the same. Along the contact surface with the opposite flange, the fibre strands (3) are embedded in the flange and thus make possible a flush fit between the two flange halves. In this embodiment, the construction can also be envisioned as having exchangeable ribs.
- [0033] Figure 5 shows a schematic connection to a metal flange (10) in the base region of the rotor blade (1). The metal flange (10) represents a special embodiment of a rib. The shape of the metal flange is dictated by its purpose. In the case of a rotor blade for a wind power plant, as a rule it is circular. Other cross sections, however, can be produced as well. The metal flange (10) features threaded pins (11) distributed over its girth; these are perpendicular to the fibre strands to be wound (3). It is around these threaded pins (11) that the fibre strands (3) are wound. This process assures a very close connection that is also highly resilient.
- [0034] Figure 6 shows the connection to a metal flange (10) in the base region of the rotor blade (1) using solid ribs (2) in one embodiment, and Figure 7 shows the connection to a metal flange (10) in the base region of a second embodiment of the rotor blade (1) with alternate ribs (5) that are part of a lattice structure prefabricated of wound coal fibre strands.
- [0035] Finally, Figure 8 depicts the entire lattice structure or part of the structure that has been foam-coated with foam or some synthetic material, encapsulated or coated with pour-and-set foam. It is also possible to combine several techniques. Thereby the foaming (12) can be used to complete the shape of the structure or applied to the outer contour as a shell. Over the outer surface, a weather- and erosion-proof

seal (13) can subsequently be applied. Alternately, however, composite laminates or metal surface-plates can be used.

[0036] Should the structure be used as an airfoil for aircraft or as a hydrofoil for ships (e.g., ground effect vehicles, hydrofoil vessels) only the shape of the ribs and their distance from one another need be changed. The basic construction is similar and, thus, requires no detailed explanation.

[0037] Figures 9 to 11 show examples of further possible applications. The invention makes possible the manufacture of complex bearing-structures such as the hull of a ship (Figure 9), car bodies, freight cars, engine cars or fuselages. For the hull as shown in Figure 9, the fibre strands (3) are wound, just as is explained in relation to figure 2 and not further expanded on here, in the openings in the ribs, which are distributed along the length of the hull. The outer skin is a laminate, attached with an adhesive to the lattice structure. The ribs themselves may remain in the structure or they can be designed as reusable tools.

[0038] Figure 10 shows a deckhouse, which can be built in the identical manner. Preferably, the individual wall elements, long walls, traverse walls and roof, will be constructed separately, and the ribs (14) will remain in the construction elements. The rib (14) can also be embodied as a wound structure.

[0039] The deck house in Figure 10, as well as the supporting structure for a solar reflecting panel, represent further examples of possible embodiments. For the supporting structure for a solar reflecting panel (11), the structure consists of previously wound lattice components (ribs (15)). These are slid onto shapes (here, pipes), which located centrally and along the edges, and then glued into place. As the shapes, metal pipes or pultruded, synthetic pipes can be used.

[0040] The above list is not meant to be exhaustive; other possible uses can be found in all areas of technology.

Reference Numbers

1	Rotor blade
2	Solid ribs
3	Fibre strands
4	Openings
5	Wound lattice structure ribs
6	Groove
7	Fastening parts
8	Profile flange
9	Screw joint
10	Metal flange
11	Threaded pins
12	Foam coating
13	Seal
14	Rib, deck house
15	Rib, solar reflector panel

Claims

1. The rod winding structure in composite design formed by saturated fibre strands (3) wound in a continuous winding and laying process, alternately and incrementally, in diagonal, horizontal and vertical arrangements, until the desired stand thickness is reached, with a rib structure that contains joints and is characterized in that the ribs are solid ribs (2) or prefabricated lattice structure ribs (5) made of fibre strands (3), their joints being openings (4) directed to the outer edges of the ribs, facing opposite openings, the said openings being evenly distributed along the entire rib and having a diameter related to the cross section of the fibre strand (3) to be laid, whereby the width of the opening facing the outer edge of the rib is narrower than the ultimately expected cross section of the fibre strand (3) to be laid.
2. Rod winding structure according to Claim 1, characterized in that the shape of the ribs are dictated by the outer profile of the rod winding structure and the rod winding structure is divided into sections by the ribs, whereby the distances between the ribs depend on the overall structure and its stability requirement.
3. Rod winding structure according to Claim 1 or 2, characterized in that the solid ribs consist of fibre composite materials or aluminum or other light materials.
4. Rod winding structure according to Claim 1, characterized in that fastening parts, arranged along the ribs, serve as joints.
5. Rod winding structure according to Claim 4, characterized in that the fastening parts are concave, cylindrical parts with a flanged or otherwise thickened edge.

6. Rod winding structure according to Claim 4 or 5, characterized in that the fastening parts are provided with a central bore hole or are produced as cylindrical hollow parts.
7. Rod winding structure according to Claims 4 through 6, characterized in that the fastening parts may be removed from the construction element after it is finished or they may remain in the construction elements as additional supporting structures.
8. Rod winding structure according to Claims 1 through 7, characterized in that the ribs are embodied as profile ribs (8), in which a groove (6) runs along their outer edge between any two openings (4) or fastening parts, into which groove the fibre strands are laid.
9. Rod winding structure according to Claim 8, characterized in that two ribs are connected together, whereby an overall structure is formed that can, if need arises, be divided again.
10. Rod winding structure according to Claim 9, characterized in that the two ribs are connected by means of screw joints (9) in the profile flange (8).
11. Rod winding structure according to Claim 1, characterized in that, in the base region of the rod winding structure, a metal flange (10) is arranged, provided with threaded pins (11) distributed along its length, the pins being set perpendicularly to the fibre strands to be wound.
12. Rod winding structure according to Claim 11, characterized in that the shape of the metal flange is circular.

13. Rod winding structure according to any of the Claims 1 through 12, characterized in that the entire structure is wrapped, planked, encapsulated or foam-coated.
14. Rod winding structure according to any of the Claims from 1 to 13, characterized in that it can be used as a rotor blade for wind power plants, an airfoil for aircraft or a hydrofoil for ships.

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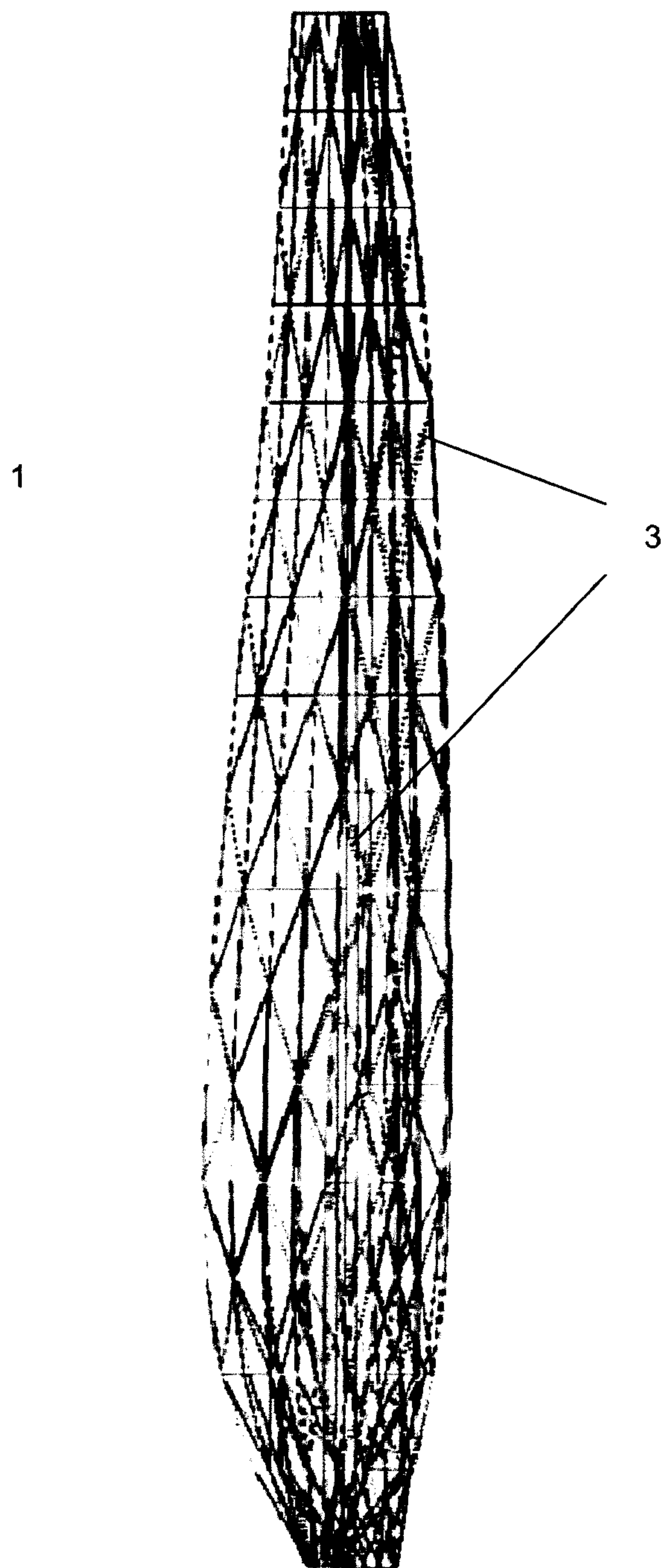


Figure 1

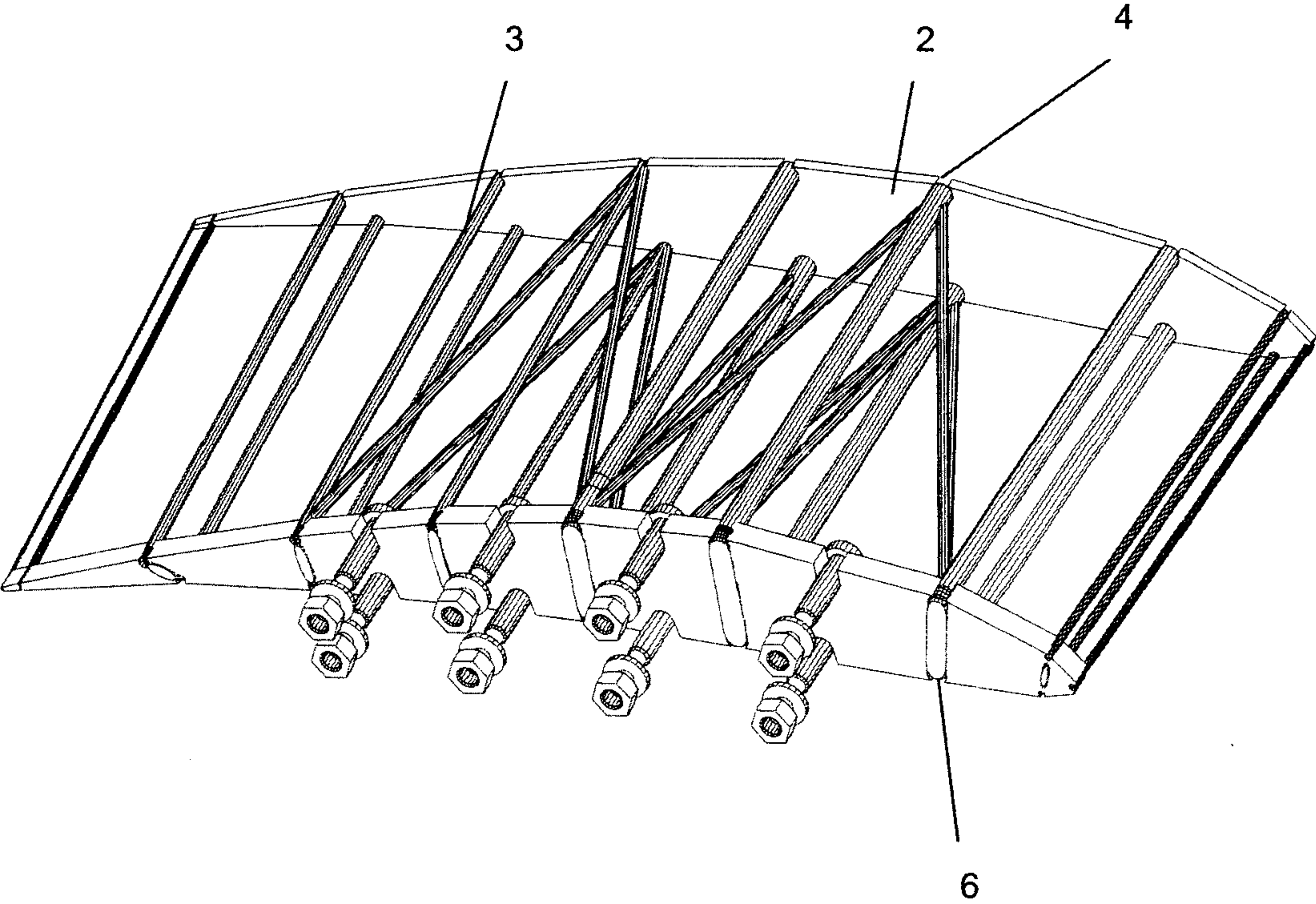


Figure 2

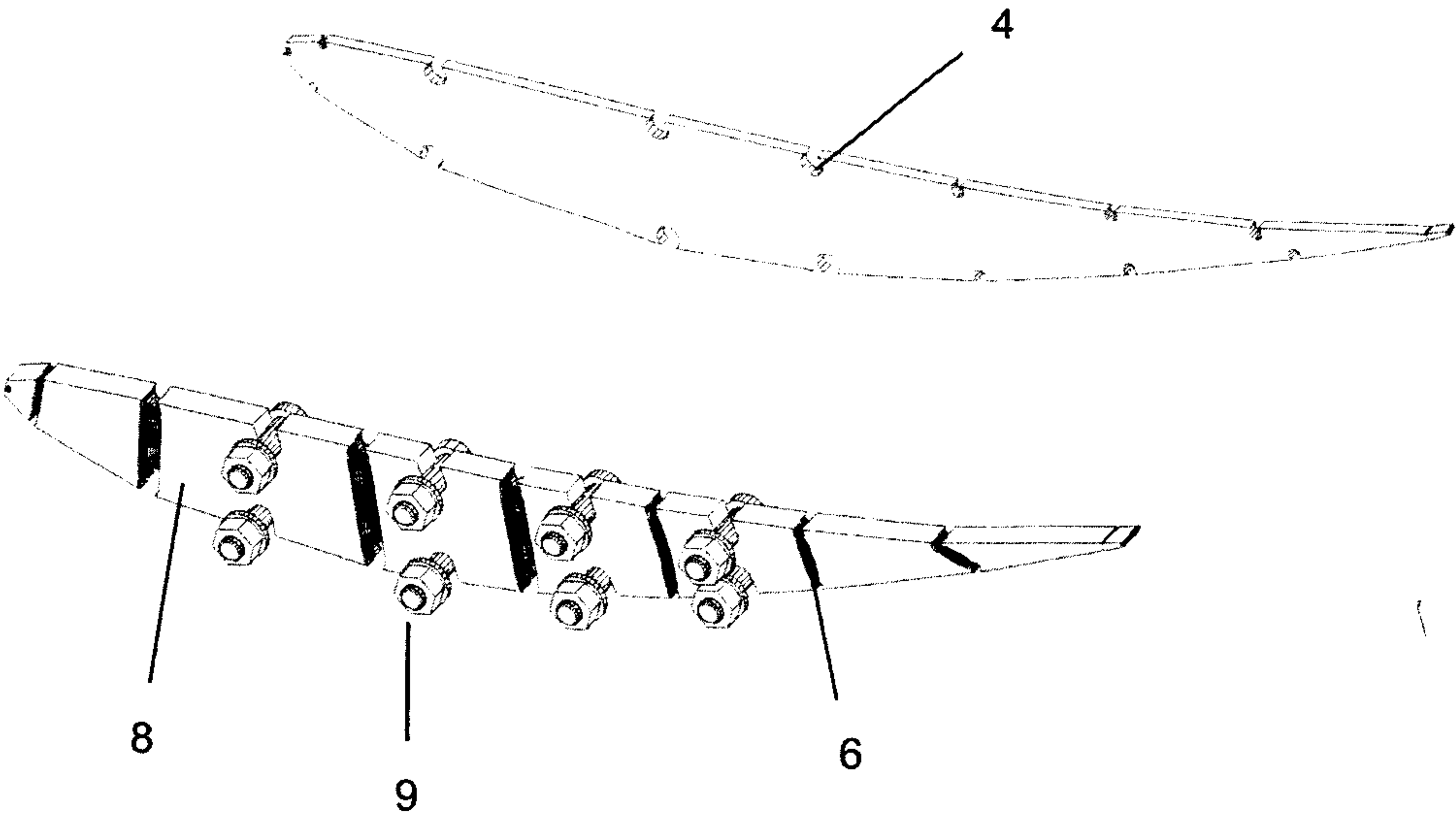


Figure 3

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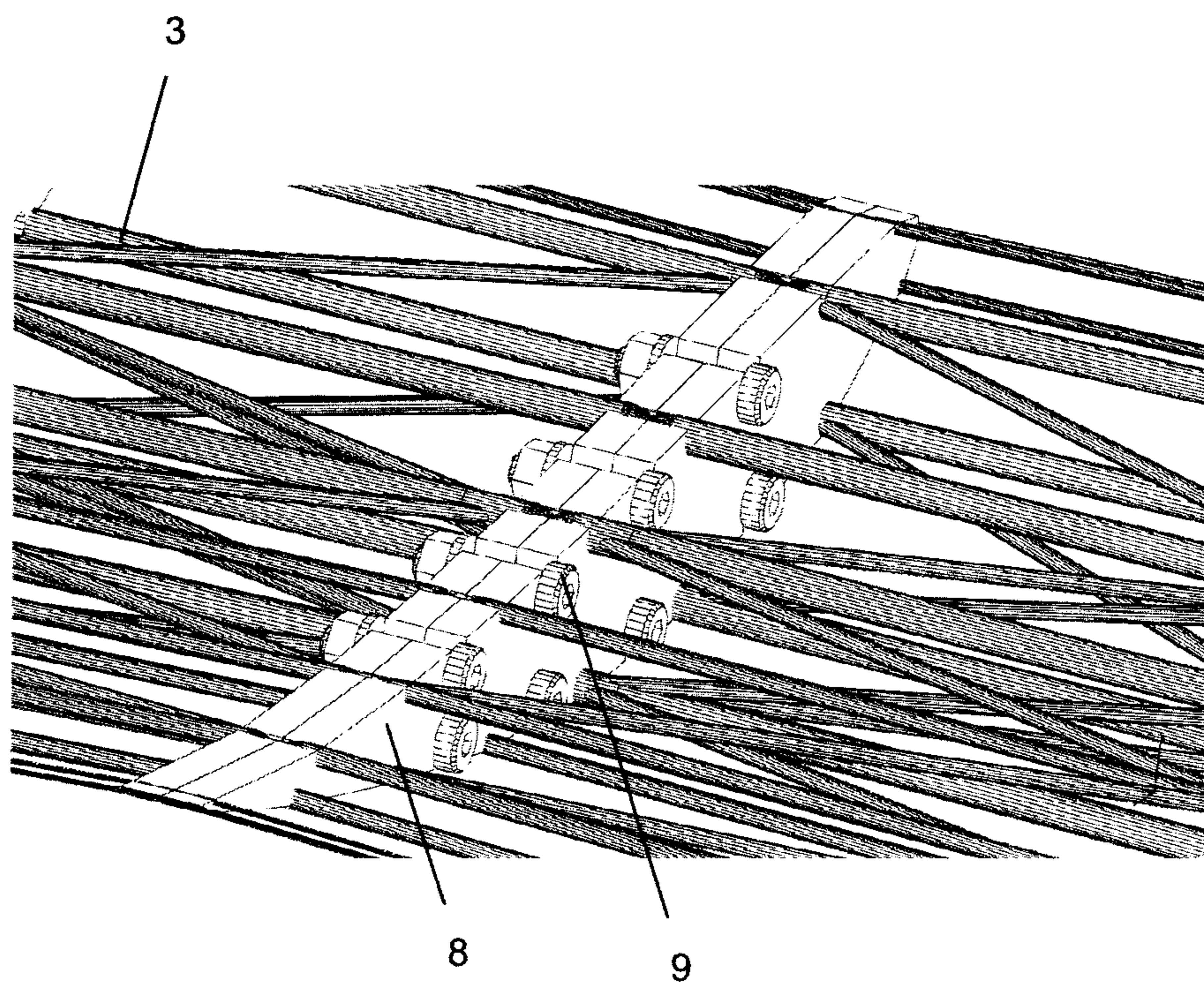


Figure 4

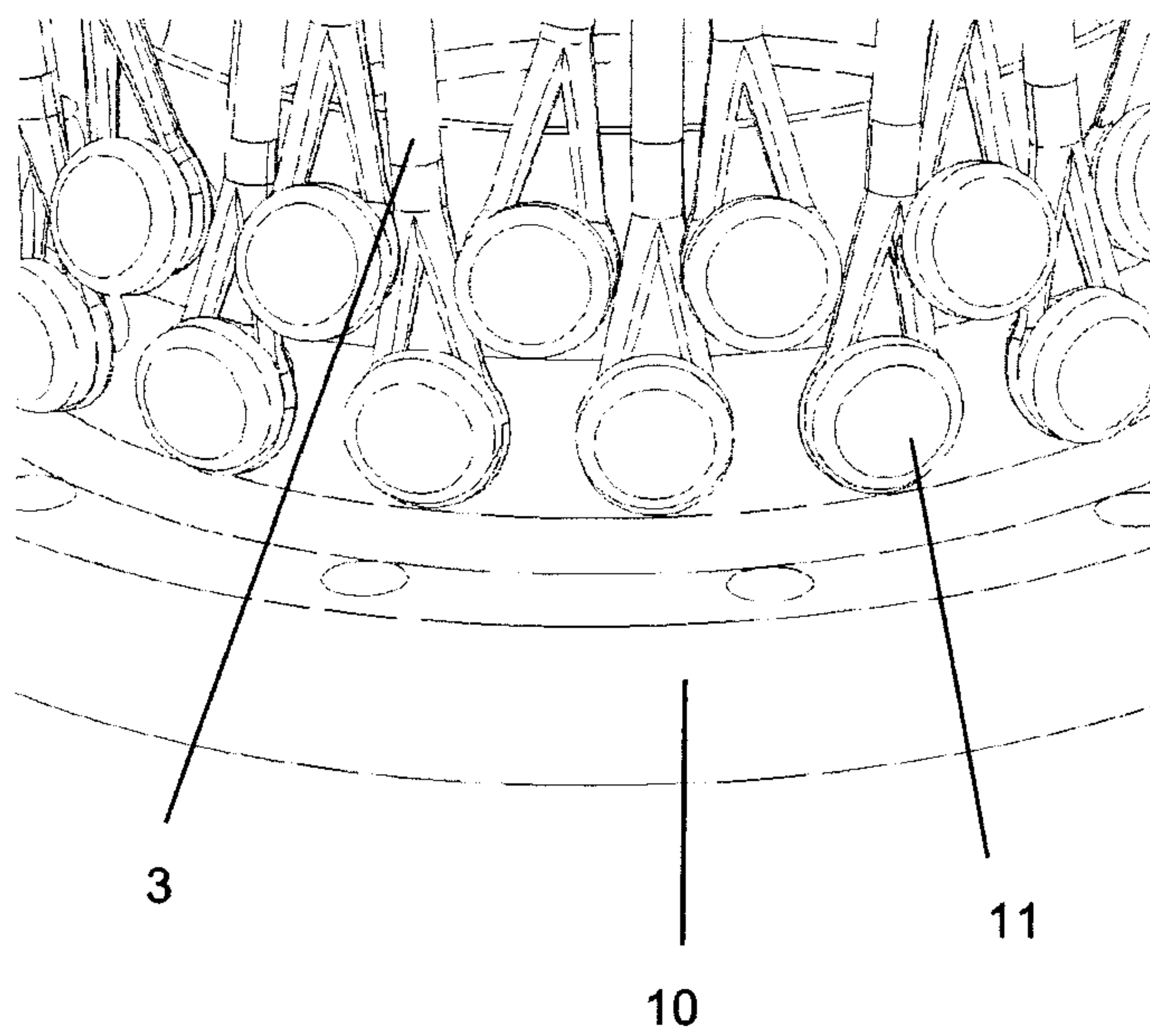


Figure 5

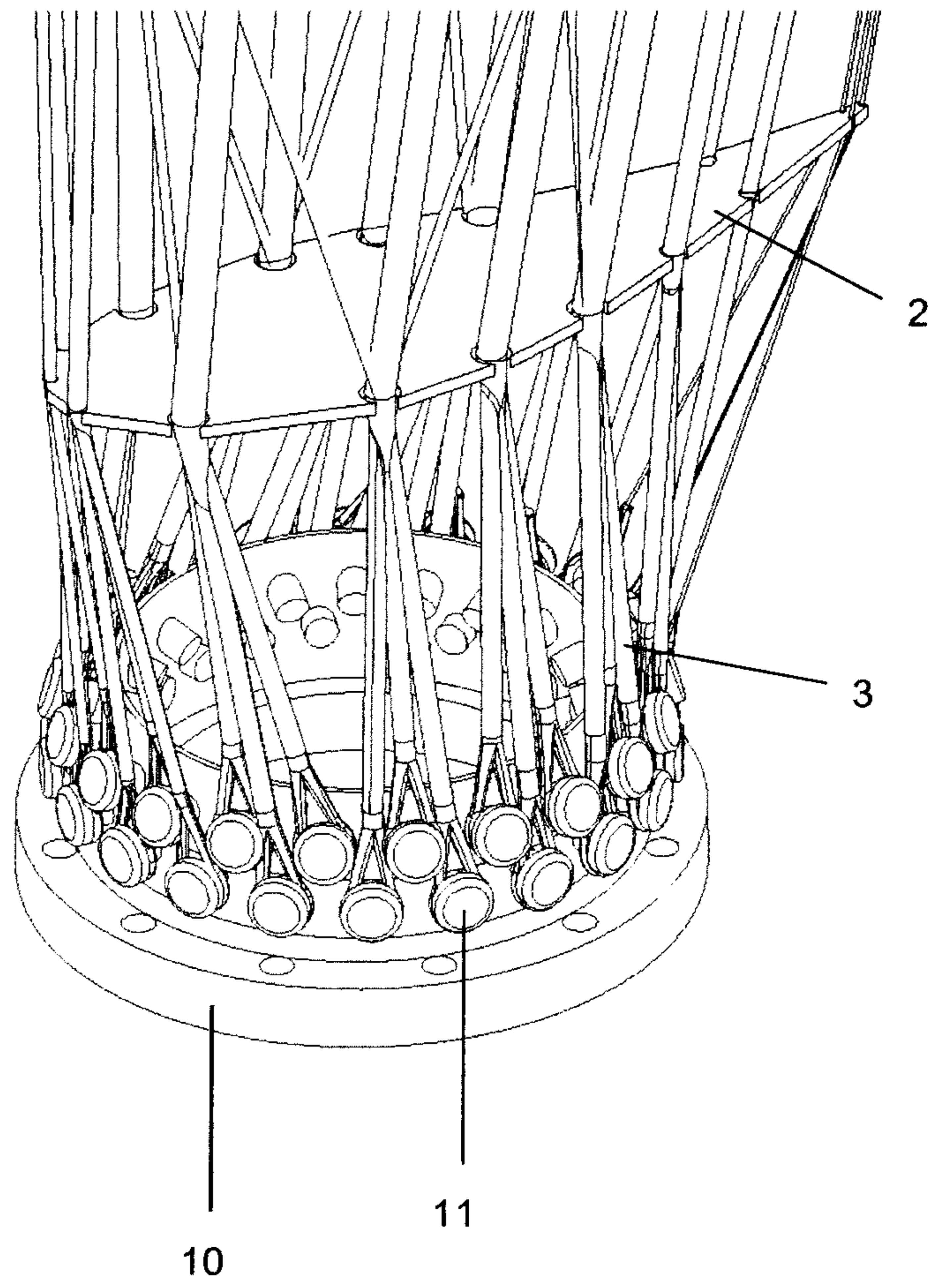


Figure 6

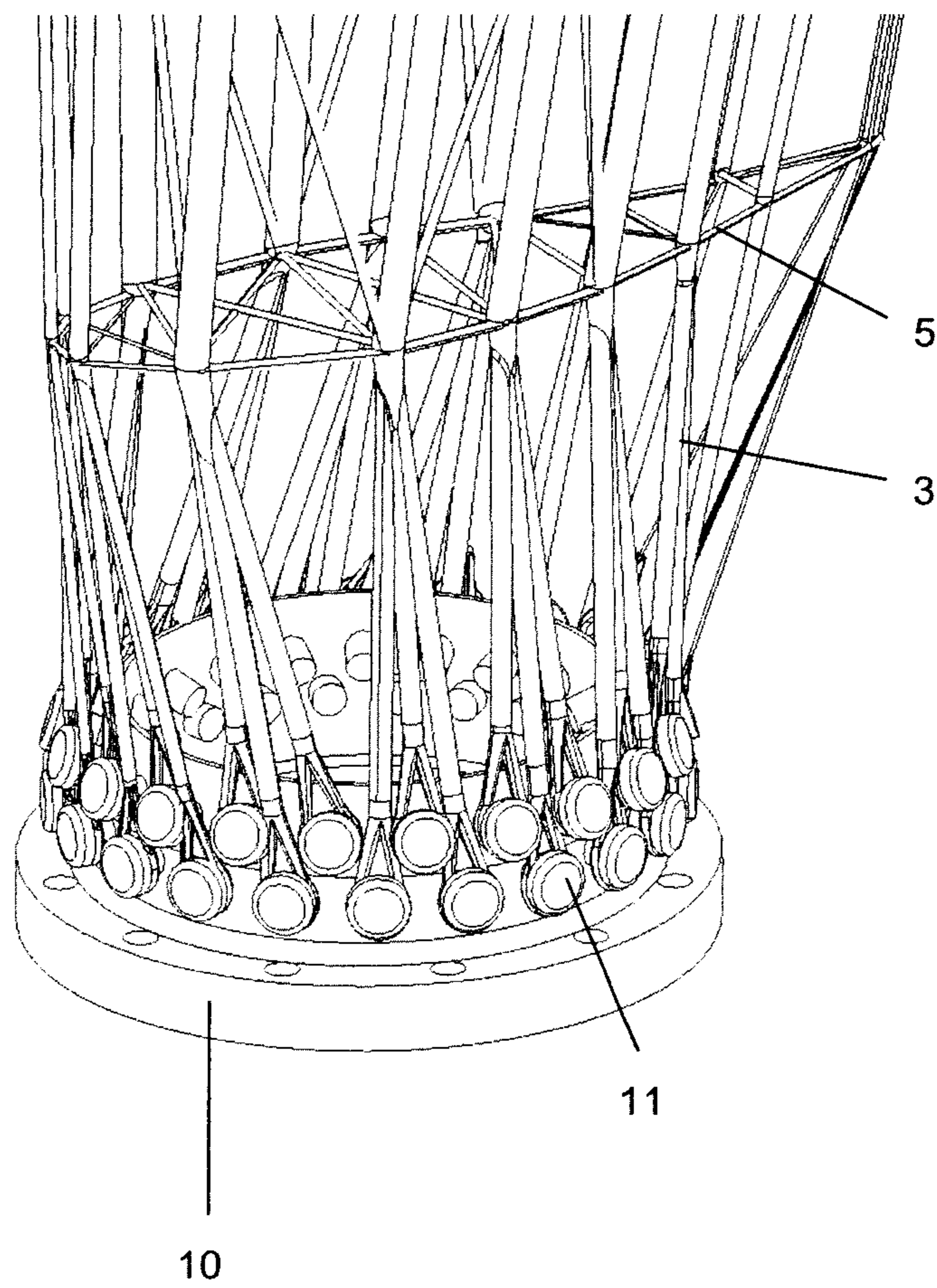


Figure 7

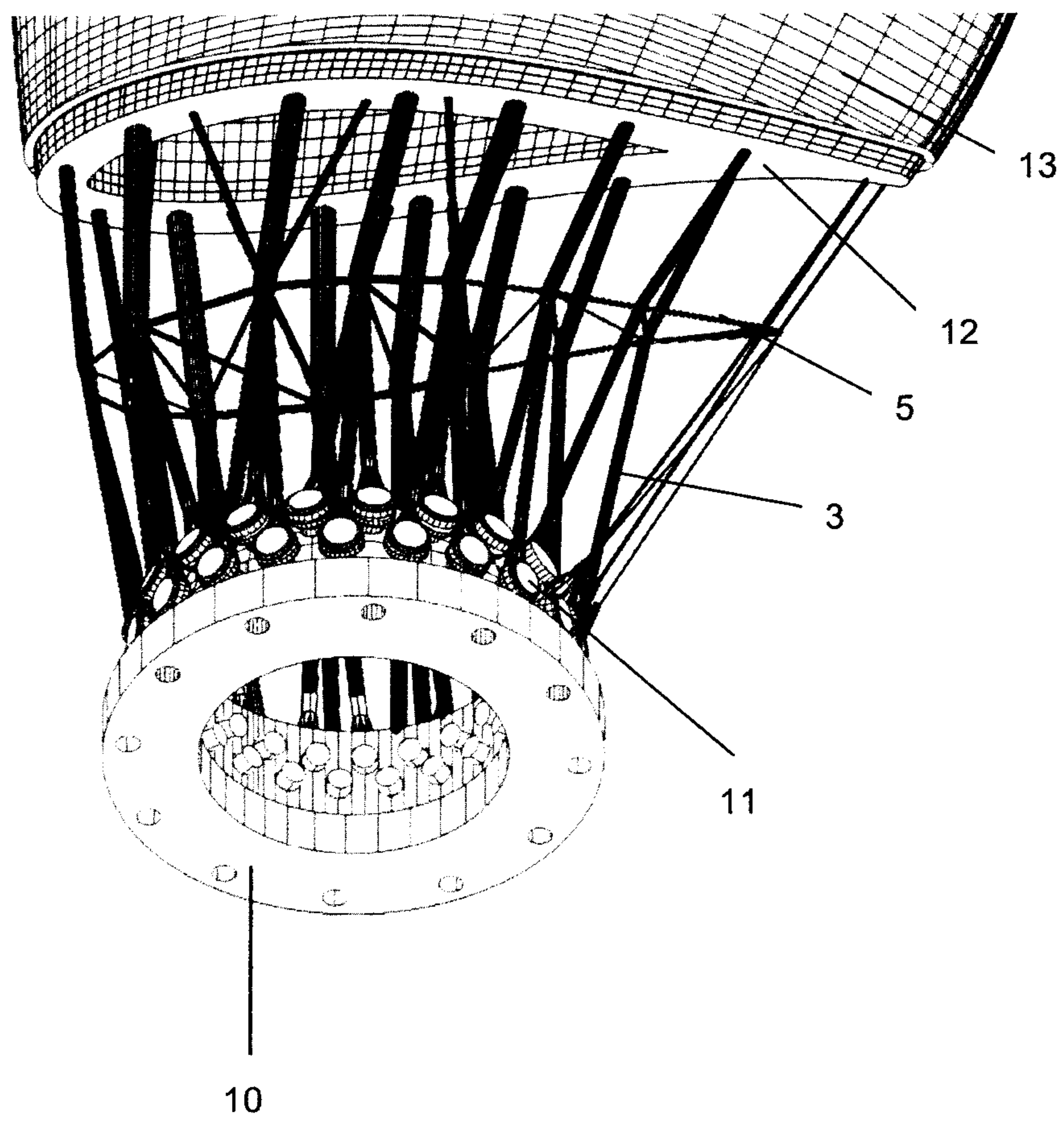


Figure 8

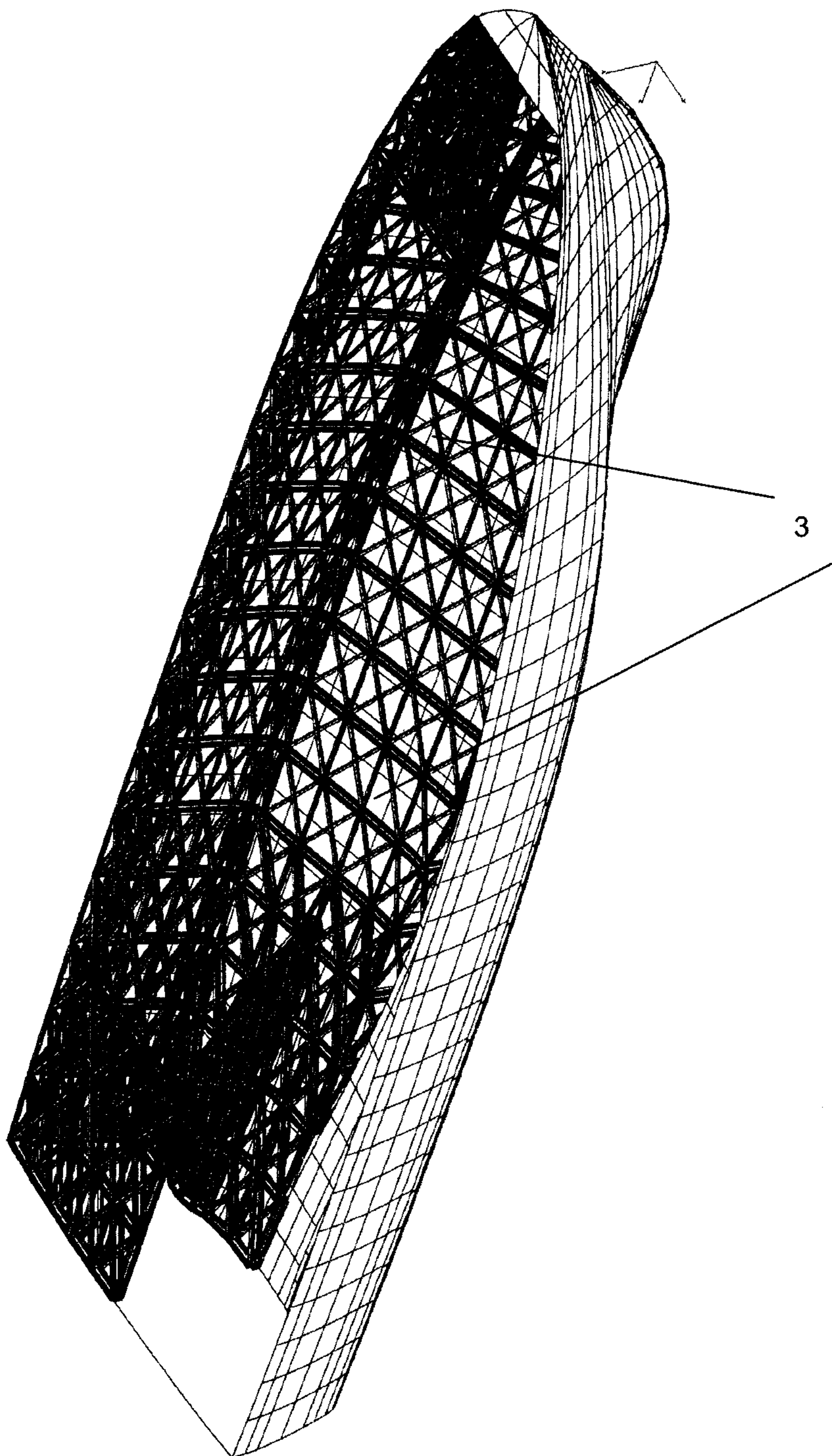


Figure 9

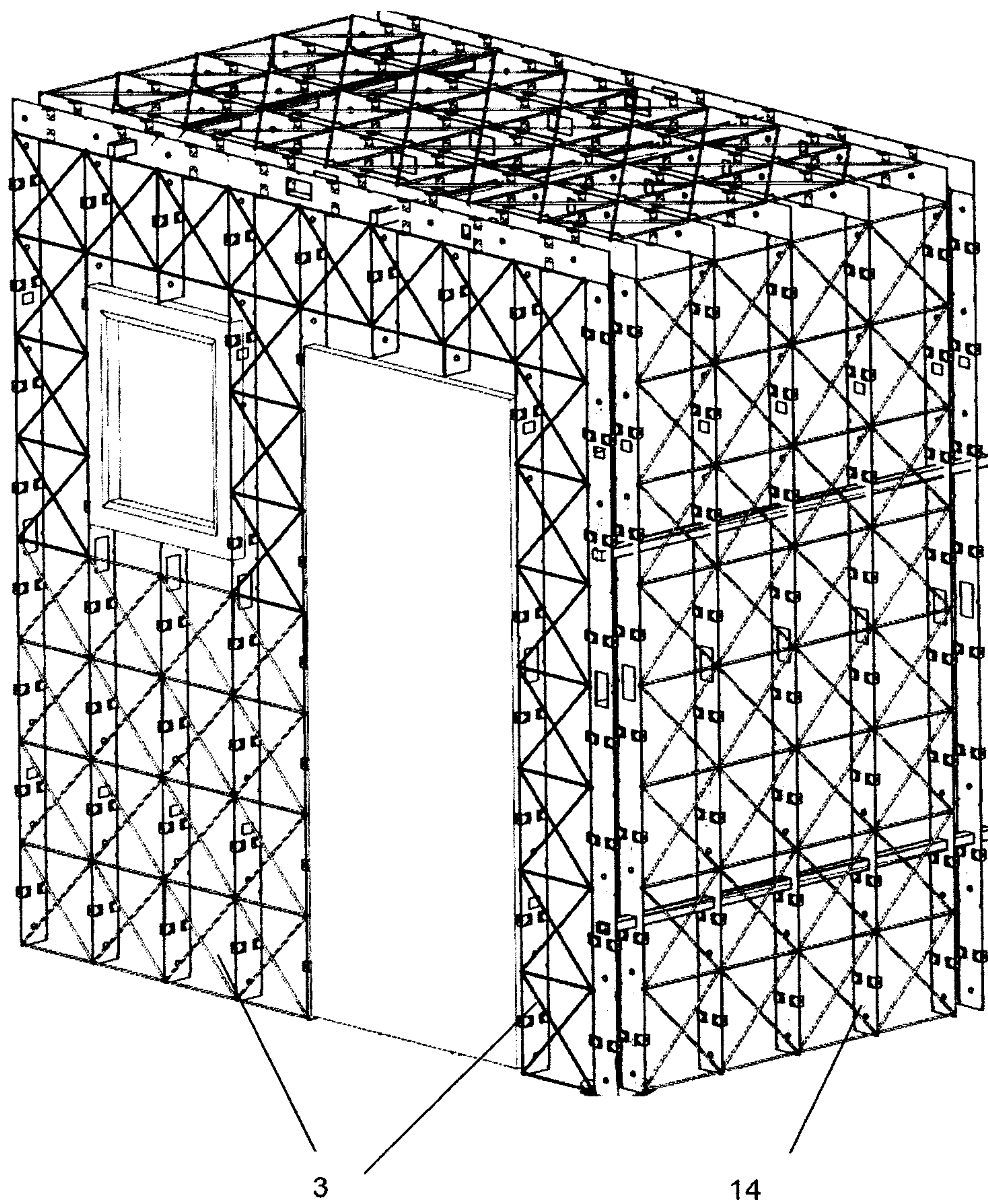
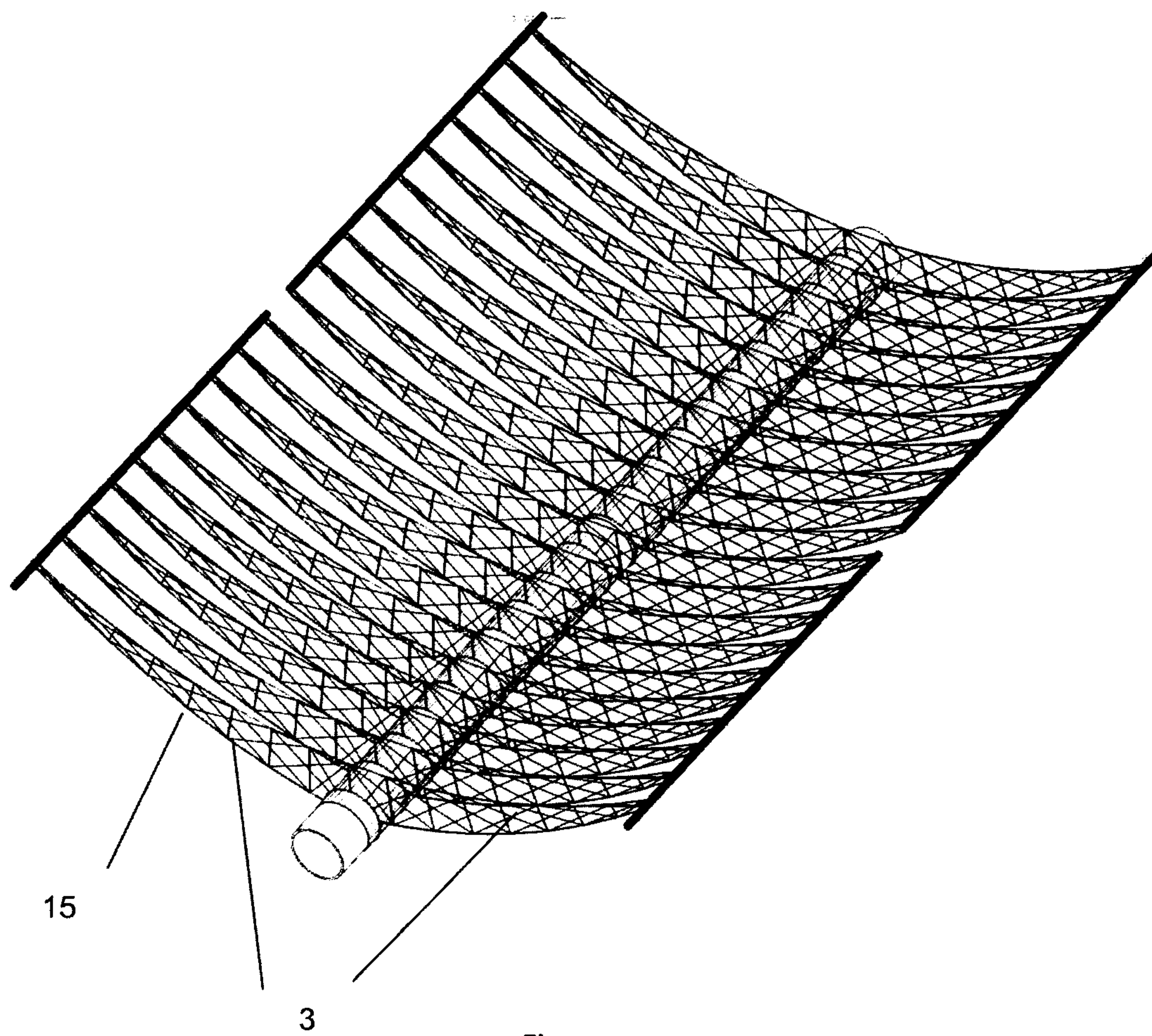


Figure 10



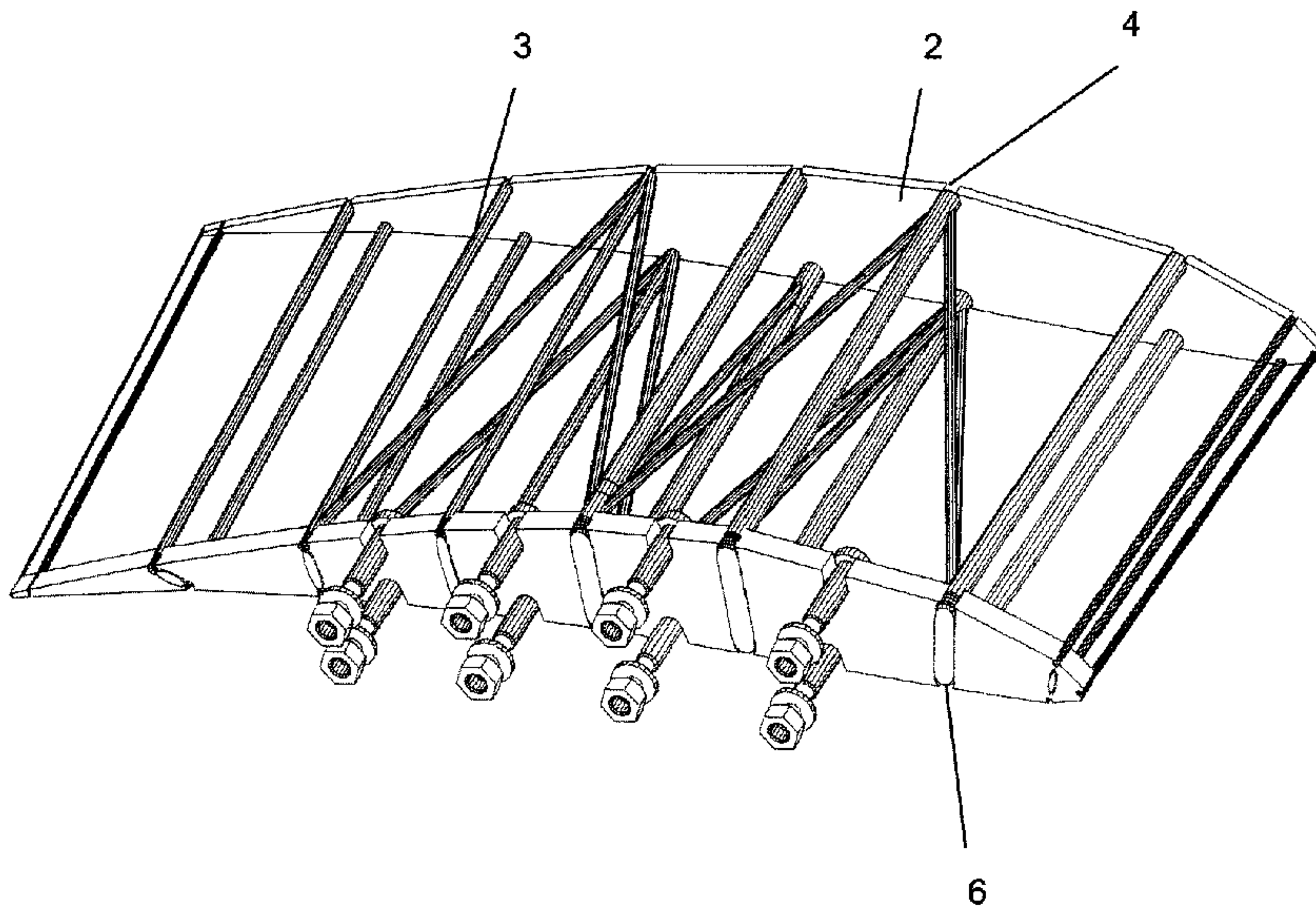


Figure 2