

(19)



(11)

EP 3 862 497 A1

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:

11.08.2021 Bulletin 2021/32

(51) Int Cl.:

E04B 1/19 (2006.01)(21) Application number: **20156423.4**(22) Date of filing: **10.02.2020**

(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**

Designated Extension States:

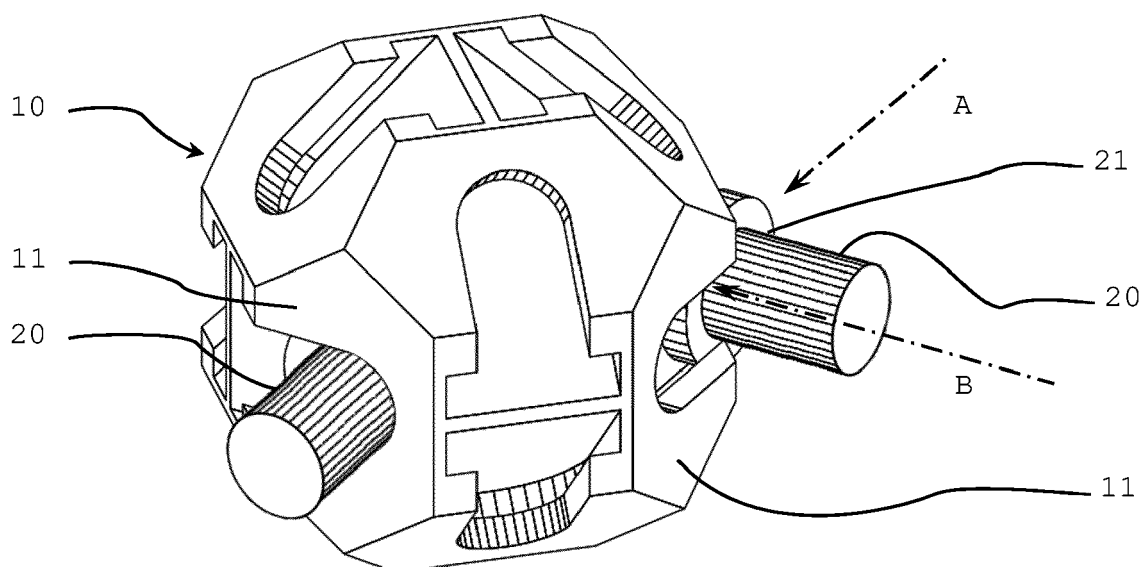
BA ME

Designated Validation States:

KH MA MD TN(71) Applicant: **Calderón, Xavier**
8032 Zürich (CH)(72) Inventor: **Calderón, Xavier**
8032 Zürich (CH)(74) Representative: **Bohest AG**
Holbeinstrasse 36-38
4051 Basel (CH)(54) **SPACE FRAME STRUCTURE**

(57) A space frame structure (1) comprises a plurality of nodes (10) and a plurality of struts (20). Each strut (20) connects two nodes (10) of the plurality of nodes (10). Each strut (20) has a longitudinal direction (B), two ends and a connector (21) at each end. Each node (10) has a plurality of receivers (11) for receiving connectors (21). Each receiver (11) comprises a lateral insertion opening

for inserting one of the connectors (21) of one of the struts (20) in an insertion direction (A). The insertion direction (A) is substantially perpendicular to the longitudinal direction (B) of the strut (20). A connector (21) of a strut (20) is connected to a receiver (11) of a node (10) by a snap-fit connection.

**Fig. 9****EP 3 862 497 A1**

Description

[0001] The present patent application relates to a space frame structure comprising a plurality of nodes and a plurality of struts.

[0002] Space frame structures are widely known in the prior art and are sometimes also denoted as a space framework, a spatial framework or as a space frame. They comprise a plurality of struts able to transmit tensile force and/or compression force and a plurality of nodes for connecting said struts. Space frame structures can be divided into single layer structures and multilayer structures. Single layer structures are planar, i.e. two-dimensional, even though that they can form a part of a sphere or the like. Multilayer space frame structures have nodes arranged in at least two parallel planes at a certain distance apart, wherein the nodes of said two layers are connected to each other by struts. In other words, the space frame is three-dimensional.

[0003] A space frame connection for joining elongated stringers in a three-dimensional framework is known from GB 2 132 306 A. The connecting element is made of two parts and comprises keyways for inserting a spline of a fitting of a stringer. The spline can be inserted into the keyway from a corner of the connecting element. After insertion, the spline is secured by inserting screws into the corner of the connecting element. In particular, screws are inserted into holes in the corner of the connecting element and screwed into nuts which are previously placed inside the connecting element. Hence, for securing the separate elements to each other, additional parts, such as screws, are necessary and the connecting element has to be prepared with some additional elements before using it. Furthermore, as soon as a first spline is inserted and secured with a screw, it is no more possible to insert a second spline from the same corner due to the presence of the screw.

[0004] An object of the present invention is to avoid at least some of the drawbacks of the prior art, and in particular to provide a space frame structure that is easy to manufacture and assemble.

[0005] This object is accomplished by the space frame structure according to independent patent claim 1. Further advantageous embodiments are described in the dependent patent claims.

[0006] The essence of the invention lies in the following: a space frame structure comprises a plurality of nodes and a plurality of struts. Each strut connects two nodes of the plurality of nodes. Each strut has a longitudinal direction, two ends and a connector at each end. Each node has a plurality of receivers for receiving connectors. Each receiver comprises a lateral insertion opening for inserting one of the connectors of one of the struts of the plurality of struts in an insertion direction substantially perpendicular to the longitudinal direction of the strut. A connector of a strut is connected to a receiver of a node by a snap-fit connection or by a friction connection.

[0007] Typically, a strut of a space frame structure is of an elongate shape. The longitudinal direction is defined by an axis of the strut which extends through its ends, in particular by an axis which extends through the connectors of the strut. The longitudinal direction is not limited to one direction only, but has a bidirectional meaning.

[0008] It is self-evident that the longitudinal direction of a strut and the relation between this longitudinal direction and the insertion direction in a corresponding node are determined by the inserted state of the strut in the node.

[0009] Substantially as used herein does not exclude exactly. In the present case, substantially perpendicular encompasses all angles between 85° and 95°, including exactly 90°.

[0010] Snap-fit connections are connections which connect two parts after at least one part of the snap-fit connection has been temporarily deflected and brought into engagement with the other part or counterpart of the snap-fit connection. At least one part of the snap-fit connection thus provides a retention force which keeps the respective part of the snap-fit connection in engagement with its counterpart. After connecting of the two parts, the deflected portion can be completely unloaded or remain pretensioned. At least, a predetermined position of the deflected portion can be upheld.

[0011] Friction connections are connections which connect two parts brought into engagement by friction.

[0012] A snap-fit connection or a friction connection facilitates the connection of two parts, in particular facilitates the connection of a node and a strut in a space frame structure. Additional components for securing can be omitted and also tools for fastening or connecting said elements together, for example screwdrivers, wrenches or the like are not necessary. In other words, a tool-free installation is enabled.

[0013] The snap-fit connection can be made of two parts which engage each other, such as for example a flat spring having an engaging portion and a corresponding recess. Said two parts can be formed as separate elements and can be attached to a respective node and a respective strut.

[0014] In a preferred embodiment, the snap-fit connection comprises an elastically deformable portion on the connector or on the receiver or on both. In other words, at least one of the connector or the receiver provides a part of the snap-fit connection.

[0015] The retention force for the snap-fit connection can be provided by the connector or the receiver, respectively.

[0016] Preferably, the snap-fit connection comprises a connector retainer for retaining a connector inserted into a receiver. The connector retainer may be part of the connector or of the receiver and may be for example a protrusion.

[0017] The snap-fit connection is thus at least partially part of the connector or receiver, respectively, and can

thus be integrally formed. If a protrusion is formed on the receiver, the manufacturing is facilitated. No separate components are necessary.

[0018] The connector retainer can be integrally formed with a respective node or a respective strut.

[0019] Preferably, the connection between a connector of a strut and a receiver is at least as resistant with respect to tension and compression in the longitudinal direction of the strut as the remainder of the strut in its longitudinal direction.

[0020] For the sake of clarity, the remainder of the strut comprises in particular the portion of the strut between the two connectors. Typically, this portion has a substantially uniform cross section over its full length. If the cross section varies, the smallest cross sectional area of the strut between the two connectors is normally the weakest point and has to be taken into account for the resistance with respect to tension and compression.

[0021] The preferred configuration according to the invention provides a uniform stress distribution in the strut and in the connection between the strut and the node. In other words, the stress occurring in the connection, in particular on the surfaces of the connection, does not substantially exceed a stress occurring in the strut and is preferably in the same range.

[0022] Preferably, the connection is more resistant than the strut at its weakest point. Hence, for calculation of the space frame structure, only the stress occurring in the struts has to be taken into account as soon as the connection of the struts to the nodes is stronger. This facilitates the calculation of the space frame structure.

[0023] A connector of a strut which is connected to a receiver may comprise a first mating surface and a second mating surface. The connected receiver may comprise a third mating surface and a fourth mating surface. The first mating surface mates the third mating surface and the second mating surface mates the fourth mating surface for enabling tensile and compression force transmitting in the longitudinal direction of the strut.

[0024] Tensile forces as well as compression forces can be transmitted by the mating surfaces. In particular, different surfaces are used for transmitting tensile forces and for transmitting compression forces.

[0025] In an advantageous embodiment, the connector and the receiver are formed such that the first mating surface and the third mating surface have a force transmitting mating area that is not more than 5% smaller than the smallest force transmitting section area of any section of the remainder of the strut. Preferably, the force transmitting mating area is not smaller at all.

[0026] Preferably, the connector and the receiver are formed such that the second mating surface and the fourth mating surface have a force transmitting mating area that is not more than 5% smaller than the smallest force transmitting section area of any section of the remainder of the strut. Preferably, the force transmitting area is not smaller at all.

[0027] This ensures that substantially the whole tensile

and compression forces occurring in the strut can be transmitted via the force transmitting mating areas of the connection to the node.

[0028] Advantageously, each receiver comprises a chamber for receiving a connector inserted through the lateral insertion opening. The chamber has a neck part bordered by a neck portion of the receiver. The neck part opens out into a broader chamber part in a direction to a centre of the node.

[0029] In other words, the neck part of the chamber is determined or defined by a neck portion of the receiver.

[0030] Such a design of the receiver provides an undercut portion into which a connector can engage for a secure and reliable connection.

[0031] The direction to the centre of the node normally corresponds to the longitudinal direction of a respective strut in the inserted state and to a joining direction of two adjacent nodes of the space frame structure, which are joined by a respective strut.

[0032] In an advantageous embodiment, the third mating surface is formed on a surface of the neck portion of the receiver bordering the broader chamber part.

[0033] Hence, the third mating surface is arranged in an undercut area of the neck portion and is thus able to receive a force into a direction outwards of the broader chamber part in direction to the neck part.

[0034] Preferably, the first mating surface, the second mating surface, the third mating surface and the fourth mating surface extend substantially perpendicular to the longitudinal direction of the connected strut.

[0035] This enables an easy manufacturing and facilitates calculating of the transmission forces when calculating a space frame structure.

[0036] In an advantageous embodiment, the connector retainer extends into the chamber of the receiver.

[0037] Such an arrangement has the advantage that the connector retainer is protected by the receiver which forms the chamber.

[0038] Advantageously, the connector retainer is arranged on the neck portion of the receiver.

[0039] This facilitates the manufacturing of the receiver. Furthermore, the connector retainer and/or the correct connection of the strut to the node can be visually checked.

[0040] In an advantageous embodiment, each strut comprises a cylindrical base portion and one connector at each end of the cylindrical base portion. The connectors may preferably comprise at least one disk portion and a neck portion, and more preferably also a second disk portion. The neck portion may be arranged between the at least one disk portion and the second disk portion.

[0041] The strut may thus be rod-like and, along its longitudinal axis, rotationally symmetric. This enables an easy manufacturing and facilitates calculating of the transmission forces when calculating a space frame structure. Furthermore, when assembling the space frame structure, no attention has to be paid to a specific rotational position of the strut.

[0042] In a preferred embodiment, the plurality of nodes is connected with the plurality of struts forming a multilayer space frame structure. Said multilayer space frame structure has a first end layer and a second end layer. At least one first face element is attached to the first end layer. Preferably, at least one second face element is attached to the second end layer.

[0043] Such a space frame structure may provide a complete wall, for example a wall of a building.

[0044] Said first face element and said second face element may comprise several separate layers, such as for example an insulation layer and a top layer or a protection layer, which protects the wall or the space frame structure against influences from the outside and/or environmental influences.

[0045] Each node of the plurality of nodes of the space frame structure as described herein may be formed as a single piece. This enables a uniform manufacturing and additional components for assembling the nodes themselves may be omitted.

[0046] Alternatively, each node of the plurality of nodes of the space frame structure as described herein may be formed in two pieces. This allows providing the node with a specific interior, which may not easily be achievable with a single piece node. Furthermore, if the nodes are made in two pieces, preferably in two halves, the two halves may be embodied differently. For example, the nodes of the first end layer and of the second end layer may have first node halves which have receivers oriented in several different directions for building up the space frame structure, whereas the second node halves may have only one receiver for attaching a first or a second face element or may even have different connection means.

[0047] Each node of the plurality of nodes of the space frame structure as described herein may be formed as a hollow body. In this way, the nodes can be manufactured lightweight. The overall weight of the space frame structure can be reduced and the handling of the nodes is facilitated.

[0048] Exemplary embodiments of the space frame structure according to the invention and their components are explained with respect to the following figures, in which:

- Fig. 1 - shows a first embodiment of a space frame structure according to the invention in a perspective view;
- Fig. 2 - shows three nodes and two struts of the space frame structure of Fig. 1;
- Fig. 3 - shows a perspective view of a node;
- Fig. 4 - shows a detail of a cut through the node of Fig. 3;
- Fig. 5 - shows a perspective view of a strut;

Figs. 6A, 6B

- show isolated views of specific surfaces / cross sections of the strut of Fig. 5;

5 Fig. 7

- shows a detail of a sectional view according to line C-C in Fig. 4;

Figs. 8A, 8B

- show isolated views of specific surface areas of the detail of Fig. 7;

10

Fig. 9

- shows two connections of struts according to Fig. 5 and the node of Fig. 3;

15

Figs. 10A-10D

- show schematic sectional views through the assembly of Fig. 9 illustrating the insertion steps while connecting a strut with a node;

20

Fig. 11

- shows the detail X of Fig. 10B;

Figs. 12A, 12B

- show perspective views of alternative embodiments of nodes according to the invention;

25 Fig. 13

- shows a sectional view of the node of Fig. 12A with connected struts;

Fig. 14

- shows a sectional view of the node of Fig. 12B with connected struts;

30

Fig. 15

- shows a further alternative embodiment of a node according to the invention in a perspective view; and

35 Fig. 16

- shows a perspective view of a part of a building comprising a space frame structure according to Fig. 1.

[0049] Fig. 1 shows a space frame structure 1 in a perspective view. The space frame structure 1 comprises a plurality of nodes 10 and a plurality of struts 20. For the sake of simplicity, only one node and only one strut are provided with a reference number. The space frame structure 1 according to Fig. 1 is a multilayer space frame structure, which comprises several layers of nodes 10, which are connected with struts 20. The space frame structure also comprises a first face element 4 and a second face element 5. The first face element 4 and the second face element 5 are each made of a plurality of layers, such as insulating layers and top layers, which are not referenced separately. The first face element 4 is attached to a first end layer 2 of the space frame structure 1 and the second face element 5 is attached to a second end layer 3. A layer of a space frame structure, and therefore an end layer, too, is defined by a plurality of nodes 10 which are arranged in a common plane. The common plane may be planar (flat) or curved and is in this case planar. The space frame structure 1 of Fig. 1

thus comprises five layers, namely a first end layer 2, a second end layer 3 and three layers between said first end layer 2 and said second end layer 3.

[0050] Fig. 2 shows three nodes 10 and two struts 20 of the space frame structure 1 of Fig. 1. Two adjacent nodes 10 are connected or joined to each other by one strut 20. The joining direction of said two adjacent nodes 10 is defined by a connecting line of the two adjacent nodes 10 through their centres via the connecting strut 20. This joining direction corresponds to a longitudinal direction B of the struts 20 inserted in the nodes 10. Therefore, the terms "joining direction" and "longitudinal direction B" may be used interchangeably.

[0051] Fig. 3 shows a node 10 in a perspective view. The node 10 comprises a plurality of receivers 11, in this case twelve receivers 11, of which only two are provided with reference numbers. A receiver 11 is to be understood as a portion of the node 10 which receives a strut 20 and which connects the node 10 with the strut 20 (see Fig. 2 for example). The receiver 11 comprises a lateral insertion opening 111 and a chamber 13. The joining direction or longitudinal direction B of the strut in its inserted state is illustrated. The lateral insertion opening 111 has a T-like shape and provides access to the chamber 13. The chamber 13 forms a channel with a T-like section and defines an insertion direction A which is perpendicular to the joining direction or longitudinal direction B of the strut 20 (see Fig. 2 for example) in the inserted state.

[0052] A sectional view of a strut 20 inserted into a receiver 11 is shown in Fig. 13.

[0053] Fig. 4 shows a detail of a cut through the node 10 of Fig. 3. The sectional view is taken at a plane extending through the arrow of the longitudinal direction B of the strut 20 and perpendicular to the direction A as shown in Fig. 3. Fig. 4 shows in particular a cut through a receiver 11 of the node 10 of Fig. 3. The receiver 11 comprises a chamber 13, which has a neck part 131 and a broader chamber part 132. The neck part 131 and the broader chamber part 132 are successively arranged in a direction to the centre of the node 10. This direction corresponds to the joining direction. The broader chamber part 132 provides an undercut with respect to the neck part 131. The neck part 131 is bordered by a neck portion 112 of the receiver 11. On the neck portion 112 a third mating surface 1121 is arranged. The broader chamber part 132 is bordered by side walls and a bottom of a broader chamber portion 113 of the receiver 11 and by the side of the neck portion 112 on which the third mating surface 1121 is arranged. On the bottom of the broader chamber portion 113 a fourth mating surface 1131 is arranged. The neck portion 112 has an opening with a neck width D1. The broader chamber portion 113 has a chamber width D2. The neck portion 112 extends perpendicular to the joining direction or to the longitudinal direction B of the strut 20 (see Fig. 2 for example) in the inserted state of the strut. The chamber 13 has in the sectional view of Fig. 4 a generally T-like shape, which corresponds to the T-like shape of the insertion opening

111 (see Fig. 3 for example). The arms of the T correspond to the broader chamber part 132 and their total length corresponds to the chamber width D2, whereas the middle part of the T corresponds to the neck part 131 and its width to the neck width D1.

[0054] Fig. 5 shows a perspective view of a strut 20. The strut 20 has a cylindrical base portion 22 with two ends. At each end a connector 21 is arranged. Each connector 21 comprises a disk portion 214 and a neck portion 213, wherein in the present case the neck portion 213 is a continuation of the cylindrical base portion 22. As explained with reference to Fig. 2, the strut has a longitudinal direction B (see Fig. 2). The disk portion 214 of the connector 21 comprises a first mating surface 211 and a second mating surface 212. The first mating surface 211 and the second mating surface 212 are perpendicular to the longitudinal direction B (see Fig. 2). The second mating surface 212 provides the end face of the strut 20.

[0055] Figs. 6A and 6B show isolated views of specific surfaces / cross sections of the strut 20 of Fig. 5. In particular, Fig. 6A shows a cross sectional view of the cylindrical base portion 22 of the strut 20 of Fig. 5 and Fig. 6B shows a view onto the first mating surface 211 of the connector 21 of the strut 20 of Fig. 5 in direction from the cylindrical base portion 22 towards the connector 21 (see Fig. 5).

[0056] The cross sectional area as shown in Fig. 6A is the area of the cylindrical base portion 22 of the strut 20 which transmits forces in the longitudinal direction B (see Fig. 2) and, in the present case, corresponds to a cross sectional area of the neck portion 213 of the strut 20. Said area is denoted as force transmitting section area S1. The cylindrical base portion 22, and in the present case the neck portion 213, of the strut 20 has a diameter D3, which substantially corresponds to the neck width D1 of the neck portion 112 of the receiver 11 (see Fig. 4). In the present case, the diameter D3 is slightly smaller than the neck width D1 in order that the neck portion 213 of the strut 20 can be inserted into the neck portion 112 of the receiver 11 (see Fig. 4).

[0057] In the inserted state of the strut 20 in a node 10, or more precisely of a connector 21 in a receiver 11 (see Fig. 2 for example), a tensile force in the strut 20 is transmitted by the first mating surface 211 to the third mating surface 1121 of the receiver 11 (see Fig. 4) in a force transmitting mating area S2 of the connector 21. The shape of the force transmitting mating area S2 of the connector 21 corresponds to the shape of a force transmitting mating area A2 of the receiver 11 (see Figs. 7, 8A and 8B) and its area is equal to said force transmitting mating area A2 and at least 95% of the force transmitting section area S1 of Fig. 6A. In other words, the force transmitting mating area A2 is not more than 5% smaller than the force transmitting section area S1. In the present case, the force transmitting mating area S2 is equal to the force transmitting section area S1. An outer diameter D4 of said force transmitting mating area S2 is slightly

smaller than the chamber width D2 of the broader chamber portion 113 (see Fig. 4) in order that the disk portion 214 of the strut 20 can be inserted into the broader chamber portion 113 of the receiver 11 (see Fig. 4).

[0058] Fig. 7 shows a detail of a sectional view according to line C-C in Fig. 4. The neck portion 112 of the receiver 11 extends alongside the broader chamber part 132 (see Fig. 4 for example) to the insertion opening 111 and provides the third mating surface 1121 for mating with a connector 21 of a strut 20 (see Fig. 5 for example). The third mating surface 1121 is in the present case a part of the neck portion 112.

[0059] Illustrated in Fig. 7 is a cross sectional area A1 which is circular and has a diameter D1* (see Fig. 8A), which substantially corresponds to the neck width D1 of the neck portion 112 (see Fig. 4) in a manner that a rod having said diameter D1* can be inserted into the neck portion 112 having the neck width D1 (see Fig. 4). This means that the diameter D1* is slightly smaller than the neck width D1. In the present case, the diameter D1* is equal to the diameter D3 of the strut 20 (see Figs. 5 and 6A) such that the strut 20 can be inserted.

[0060] Furthermore, a force transmitting mating area A2 of the third mating surface 1121 is illustrated in Fig. 7. The force transmitting mating area A2 is the area that transmits tensile forces between the node 10 and the strut 20 in the inserted state of the strut 20 (see Fig. 2). In the case shown in Fig. 7, the force transmitting mating area A2 is generally annular with an opening in its centre having a width equal to the neck width D1 (see Fig. 4). The relation of the cross sectional area A1 and the force transmitting mating area A2 will be described with reference to Figs. 8A and 8B.

[0061] Figs. 8A and 8B show isolated views of specific surface areas of the detail of Fig. 7. In particular, Fig. 8A shows the cross sectional area A1 of Fig. 7 and Fig. 8B shows the force transmitting mating area A2 of Fig. 7. As mentioned above, the cross sectional area A1 is circular and has a diameter D1*. The force transmitting mating area A2 is of a general annular configuration with an inner diameter D1, which is the width of the neck part 131 (see Fig. 4). The outer diameter D2* is slightly smaller than the chamber width D2 of the broader chamber portion 113. This is due to that a connector 21 (see Fig. 7), which is inserted into the chamber 13 (see Fig. 4) cannot have the exact same dimension as the chamber 13, but has to be slightly smaller, such that insertion is possible. In the present case, the outer diameter D2* is equal to the outer diameter D4 shown in Fig. 6B. The force transmitting mating area A2 has an opening having a width corresponding to the neck width D1 of the neck portion 112 (see Fig. 4). The size of the force transmitting mating area A2 is at least 95% of the size of the cross sectional area A1 and in the present case as large as the cross sectional area A1.

[0062] In other words, based on the diameter D3 of the neck portion 213 of the strut 20 (see Figs. 5 and 6A), a neck width D1 is chosen, and an outer diameter D4 of

the connector 21 of the strut can be calculated via the force transmitting section area S1 (see Fig. 6B) and the force transmitting mating area S2 (see Fig. 6B), which subsequently defines the chamber width D2.

[0063] Besides the case of a transmission of a tensile force from a strut 20 to a node 10 or vice versa, which has been explained above, there exists also the case of a transmission of a compression force from a strut 20 to a node 10 or vice versa. In the embodiment shown in Figs. 1 to 8B, the compression force is transmitted via the fourth mating surface 1131 of the receiver 11 (see Fig. 4) and the second mating surface 212 of the strut 20 (see Fig. 5). These surfaces encompass the respective cross sectional area A1 (see Fig. 8A) and the respective force transmitting section area S1 (see Fig. 6A).

[0064] Fig. 9 shows the connection of two struts 20 of Fig. 5 and the node 10 of Fig. 3. One strut 20 has already been inserted into a receiver 11 of the node 10 and a second strut 20 has been brought into contact with the node 10, or more precisely with an insertion opening 111 (see Fig. 3) of the node 11. Said second strut 20 has been placed next to the insertion opening 111 (see Fig. 3) and will be moved in the insertion direction A into the receiver 11 for connecting the strut 20 with the node 10. For this reason, the connector 21 will be inserted into the chamber 13 (see Fig. 4). This connection of the strut 20 and the node 11 and a snap-fit connection between said node 10 and said strut 20 will be explained with reference to Figs. 10A to 11. As an alternative to a snap-fit connection a friction connection could be used.

[0065] Figs. 10A to 10D show schematic sectional views through the assembly of Fig. 9 illustrating the insertion steps while connecting the strut 20 with the node 10 (see Fig. 9). The sectional views are taken at a plane extending through the neck portion 112 (see Fig. 4) parallel to the plane according to line C-C in Fig. 4.

[0066] Fig. 10A shows the neck portion 213 of one of the connectors 21 of the strut 20 (see Fig. 5) before connecting to the receiver 11 of the node 10 (see Fig. 3). For connection of the strut 20 (see Fig. 5) to the node (see Fig. 3) the strut 20 with its neck portion 213 (see Fig. 5) will be moved in the direction of the arrow which is illustrated in Fig. 10A. This arrow corresponds to the insertion direction A (see Fig. 3).

[0067] Fig. 10B shows the state after the neck portion 213 of the strut 20 has been brought into engagement with the neck portion 112 of the receiver 11 (see Fig. 4). The neck portion 213 of the strut 20 comes into contact with a connector retainer in form of two protrusions 12, which are integrally formed in opposite sides of the neck portion 112 of the receiver 11 (see Fig. 4). The protrusions 12 and the neck portion 112 of the receiver 10 (see Fig. 4) together form an elastically deformable portion of a snap-fit connection.

[0068] Fig. 11 shows the detail X of Fig. 10B. The neck width D1 is illustrated in a schematic manner. One of the protrusions 12 is visible within the neck portion 112. The neck width D1 of the neck portion 112 (see Fig. 4) is

reduced in the area of the protrusions 12 by two times the height R of the protrusions 12 in direction of the neck width D1. In other words, the remaining width is $D1 - 2R$. The diameter D3 of the neck portion 213 of the strut 20 is larger than the remaining width. Hence, while inserting the neck portion 213 of the strut 20 into the neck portion 112 of the receiver 11 in the insertion direction A (see Fig. 9), the neck portion 213 of the strut 20 hits the protrusions 12.

[0069] Fig. 10C shows the situation in which the neck portion 213 of the strut 20 (see Fig. 5) has been brought exactly between the protrusions 12. The neck portion 213 of the strut 20 has been elastically compressed, indicated with the arrows P2. As a consequence of this compression, the neck portion 213 of the strut 20 is elongated in a direction perpendicular to the direction P2, as indicated by the arrows P3. Hence, the neck portion 213 of the strut 20 provides an elastically deformable portion of the snap-fit connection.

[0070] In a similar way, the neck portion 112 of the receiver 11 (see Fig. 4) is widened in a direction of the arrows P1.

[0071] Subsequently, the neck portion 213 of the strut 20 is moved further in direction of the furthest left arrow illustrated in Fig. 10C, which corresponds to the insertion direction A (see Fig. 3), and into the receiver 11. The final position of the neck portion 213 of the strut 20 within the neck portion 112 of the receiver 11 is shown in Fig. 10D. The neck portion 213 of the strut 20 now lies in the insertion direction A (see Fig. 3) partially behind a line connecting the two protrusions 12 and is retained by these two protrusions 12. The deformations explained with reference to Fig. 10C are dissolved and the neck portion 213 of the strut 20 (see Fig. 5) and the neck portion 112 of the receiver 11 (see Fig. 4) are brought back into their original shape. The neck portion 213 of the connector 21 of the strut 20 is now retained by the two protrusions 12.

[0072] Figs. 12A and 12B show perspective views of alternative embodiments of nodes according to the invention.

[0073] Fig. 12A shows a node 10' which is made of two halves. The node 10' is partially hollow. The receivers 11, of which only one is referenced, are after joining of the two halves of the node 10' identical to the receivers 11 as described with respect to Figs. 1 to 11.

[0074] Fig. 12B shows a node 10" made of two halves which is completely hollow. The receivers 11" are slightly different to the receivers 11 as explained with reference to Figs. 1 to 11. These different receivers 11" make it necessary to have a strut 20" (see Fig. 14) which is slightly different to the strut 20 as described with reference to Figs. 1 to 11. The differences will be explained below with reference to Fig. 14.

[0075] Fig. 13 shows a sectional view of the node 10' of Fig. 12A in a plane through the joining direction, seen from the insertion direction A (see Fig. 3). A strut 20 (see Fig. 5) is connected to the node 10'. The connection of the strut 20 to the node 10' is identical to the connection

of the node 10 to the strut 20 as described with respect to Figs. 1 to 11. Hence, the connector 21 of the strut 20 (see Fig. 5) is inserted into the chamber 13 of the receiver 11 (see Fig. 4). The first mating surface 211 is in contact with the third mating surface 1121 and the second mating surface 212 is in contact with the fourth mating surface 1131. The strut 20 is held in position by the snap-fit connection as explained with reference to Figs. 10A to 11.

[0076] In the sectional view of Fig. 13, a second embodiment of the strut according to the invention is shown, in particular a strut 20' with a reduced diameter of the cylindrical base portion 22' compared with the diameter of the cylindrical base portion 22 of the strut 20 according to Fig. 5. In some embodiments of a space frame structure 1 (see Fig. 1), not all struts have to take the same load. For example, horizontally arranged struts may have a lower load as diagonally arranged struts. The horizontal struts can therefore be made as struts 20' with a reduced diameter of the cylindrical base portion 22". For reasons of uniform manufacturing, struts 20' with a reduced diameter preferably have a connector 21 which is identical to the connector 21 of the previously described struts 20. Thus, the receivers 11 for struts 20' with a reduced diameter and for the struts 20 remain identical.

[0077] Fig. 14 shows a sectional view of the node 10" of Fig. 12B in a plane through the joining direction, seen from the insertion direction A (see Fig. 3). The connection of the strut 20" to the node 10" is only partially identical to the connection of the node 10 to the strut 20 as described with respect to Figs. 1 to 11.

[0078] The node 10" has receivers 11" which comprise a neck portion 112 (see Fig. 4). The neck portion 112 of the receiver 11" is identical to the neck portion 112 of the receiver 11 of the node 10 of Fig. 4. The receiver 11" distinguishes from the receiver 11 in that it does not comprise a bottom which provides a fourth mating surface. Instead, the fourth mating surface 1131" is realised on an outer surface of the receiver 11". For this reason, the strut 20" for connecting to the node 10" is designed slightly differently from the strut 20 for connection to the node 10. The strut 20" comprises a connector 21" also comprising a first disk portion 214" and a neck portion 213", but further comprising a second disk portion 215". The neck portion 213" is arranged between the first disk portion 214" and the second disk portion 215". Contrary to the connector 21 of the strut 20, the second mating surface is not arranged at the very end of the strut 20", but instead, the second mating surface 212" is arranged on the second disk portion 215", wherein the first mating surface 211" is arranged on the disk portion 214". In the connected state, the neck portion 112 of the receiver 11" lies between the first disk portion 214" and the second disk portion 215". Both, tensile force and compression force can be transmitted.

[0079] Fig. 14 also shows a further embodiment of a strut 20''' having a cylindrical base portion 22''' with a reduced diameter compared to the cylindrical base portion 22" of the strut 20".

[0080] Fig. 15 shows a further alternative embodiment of a node according to the invention in a perspective view. The node 10''' differs from the node 10 in that the node 10''' is manufactured of rod-like elements which are joined at a common centre of the node 10''', whereas the node 10 may be formed as a single piece, where all receivers are machined out. The node 10''' of Fig. 15 has twelve receivers 113''', of which only one receiver 11''' is provided with a reference number. The receivers 11''' of the node 10''' differ from the receivers 11 as described with respect to Figs. 1 to 11 only in the way that a part of their outer boundaries are defined by the outer surfaces of the rod-like elements.

[0081] Fig. 16 shows a part of a building comprising a space frame structure as herein described, in particular a space frame structure according to Fig. 1. Illustrated in Fig. 16 are a floor and two walls of a building. The floor and the walls comprise a multi-layer space frame structure. The walls are embodied according to the space frame structure 1 of Fig. 1 and comprise an outer face and an inner face. The outer face comprises first face elements 4 and the inner face comprises second face elements 5. The floor has upper and lower face elements. Both, the upper and lower face elements can be embodied like the second face elements 5 of Fig. 1. Within the space frame structure 1, pipes and conductions for water, electrical current or the like may be arranged.

Claims

1. Space frame structure (1) comprising a plurality of nodes (10; 10'; 10"; 10''') and a plurality of struts (20; 20'; 20"; 20'''), each strut (20; 20'; 20"; 20''') connecting two nodes (10; 10'; 10"; 10''') of the plurality of nodes (10; 10'; 10"; 10'''), wherein each strut (20; 20'; 20"; 20''') has a longitudinal direction (B), two ends and a connector (21; 21'') at each end, and wherein each node (10; 10'; 10"; 10''') has a plurality of receivers (11; 11'; 11'') for receiving connectors (21; 21''), each receiver (11; 11'; 11'') comprising a lateral insertion opening (111) for inserting one of the connectors (21; 21'') of one of the struts (20; 20'; 20"; 20''') in an insertion direction (A) substantially perpendicular to the longitudinal direction (B) of the strut (20; 20'; 20"; 20'''), **characterized in that** a connector (21; 21'') of a strut (20; 20'; 20"; 20''') is connected to a receiver (11; 11'; 11'') of a node (10; 10'; 10"; 10''') by a snap-fit connection or by a friction connection.
2. Space frame structure (1) according to claim 1, **characterized in that** the snap-fit connection comprises an elastically deformable portion on the connector (21; 21'') or on the receiver (11; 11'; 11'') or on both.
3. Space frame structure (1) according to claim 1 or 2, wherein the snap-fit connection comprises a connector retainer, in particular a protrusion (12), for retaining a connector (21; 21'') inserted into a receiver (11; 11'; 11''), the connector retainer being part of the connector (21; 21'') or of the receiver (11; 11'; 11'').
4. Space frame structure (1) according to any one of claims 1 to 3, wherein the connection between a connector (21; 21'') of a strut (20; 20'; 20"; 20''') and a receiver (11; 11'; 11'') is at least as resistant with respect to tension and compression in the longitudinal direction (B) of the strut (20; 20'; 20"; 20''') as the remainder of the strut (20; 20'; 20"; 20''') in its longitudinal direction (B).
5. Space frame structure (1) according to any one of claims 1 to 4, wherein a connector (21; 21'') of a strut (20; 20'; 20"; 20''') connected to a receiver (11; 11'; 11'') comprises a first mating surface (211; 211'') and a second mating surface (212; 212''), and the connected receiver (11; 11'; 11'') comprises a third mating surface (1121) and a fourth mating surface (1131; 1131''), wherein the first mating surface (211; 211'') mates the third mating surface (1121) and the second mating surface (212; 212'') mates the fourth mating surface (1131; 1131'') for enabling tensile and compression force transmitting in the longitudinal direction (B) of the strut (20; 20'; 20"; 20''').
6. Space frame structure (1) according to claim 5, wherein the connector (21; 21'') and the receiver (11; 11'; 11'') are formed such that the first mating surface (211; 211'') and the third mating surface (1121) have a force transmitting mating area (S2) that is not more than 5% smaller than the smallest force transmitting section area (S1) of any section of the remainder of the strut (20; 20'; 20"; 20'''), preferably not smaller at all.
7. Space frame structure (1) according to claim 5 or 6, wherein the connector (21; 21'') and the receiver (11; 11'; 11'') are formed such that the second mating surface (212; 212'') and the fourth mating surface (1131; 1131'') have a force transmitting mating area that is not more than 5% smaller than the smallest force transmitting section area (S1) of any section of the remainder of the strut (20; 20'; 20"; 20'''), preferably not smaller at all.
8. Space frame structure (1) according to any one of claims 1 to 7, wherein each receiver (11; 11'; 11'') comprises a chamber (13; 13'') for receiving a connector (21; 21'') inserted through the lateral insertion opening (111), wherein the chamber (13; 13'') has a neck part (131) bordered by a neck portion (112) of the receiver (11; 11'; 11''), the neck part (131) opening out into a broader chamber part (132) in a direction to a centre of the node (10; 10'; 10"; 10''').

9. Space frame structure (1) according to claim 8, wherein the third mating surface (1121) is formed on a surface of the neck portion (112) of the receiver (11; 11"; 11'") bordering the broader chamber part (132). 5
10. Space frame structure (1) according to any one of claims 5 to 9, wherein the first, second, third and fourth mating surfaces (211; 211", 212; 212", 1121, 1131; 1131") extend substantially perpendicular to the longitudinal direction (B) of the connected strut (20; 20'; 20"; 20''"). 10
11. Space frame structure (1) according to claim 3 and any one of claims 8 to 10, wherein the connector retainer extends into the chamber (13; 13"). 15
12. Space frame structure (1) according to claim 3 and any one of claims 8 to 11, wherein the connector retainer is arranged on the neck portion (112) of the receiver (11; 11"; 11'"). 20
13. Space frame structure (1) according to any one of claims 1 to 12, wherein each strut (20; 20'; 20"; 20''") comprises a cylindrical base portion (22; 22'; 22", 22'") and one connector (21; 21") at each end of the cylindrical base portion (22; 22'; 22", 22'"), wherein the connectors (21; 21") preferably comprise at least one disk portion (214; 214") and a neck portion (213; 213"), and more preferably also a second disk portion (215"). 25 30
14. Space frame structure (1) according to any one of claims 1 to 13, wherein the plurality of nodes (10; 10'; 10"; 10''") is connected with the plurality of struts (20; 20'; 20"; 20''") forming a multilayer space frame structure (1) having a first end layer (2) and a second end layer (3), wherein at least one first face element (4) is attached to the first end layer (2) and preferably at least one second face element (5) is attached to the second end layer (3). 35 40

45

50

55

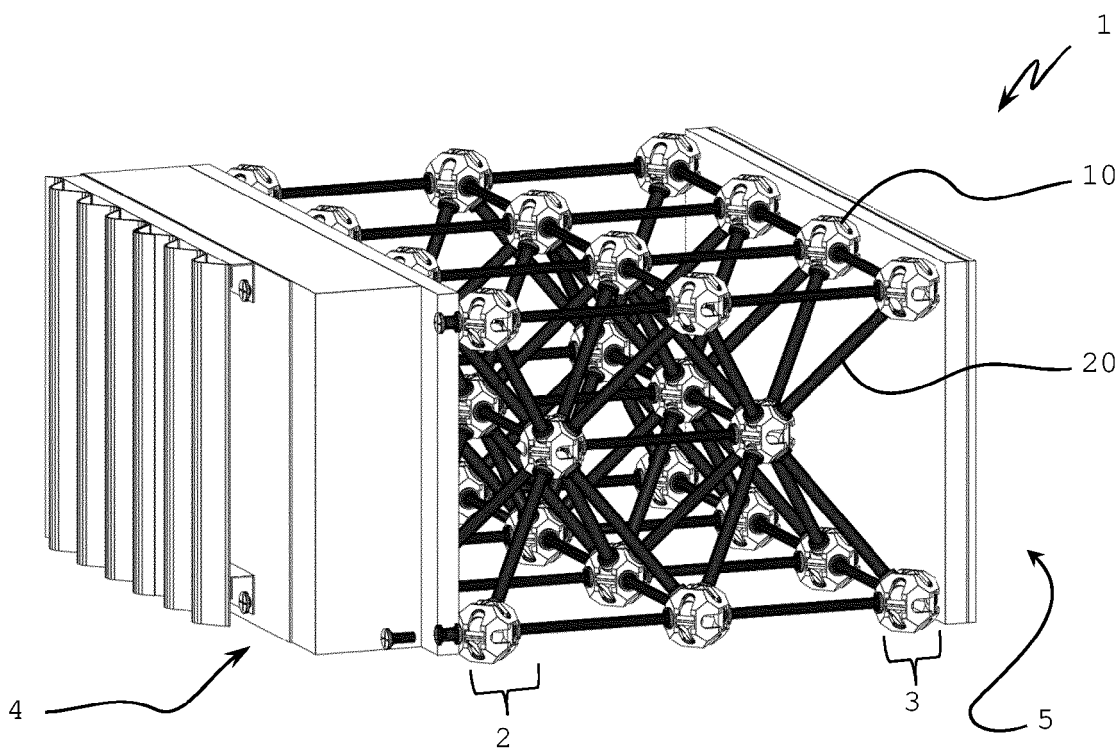


Fig. 1

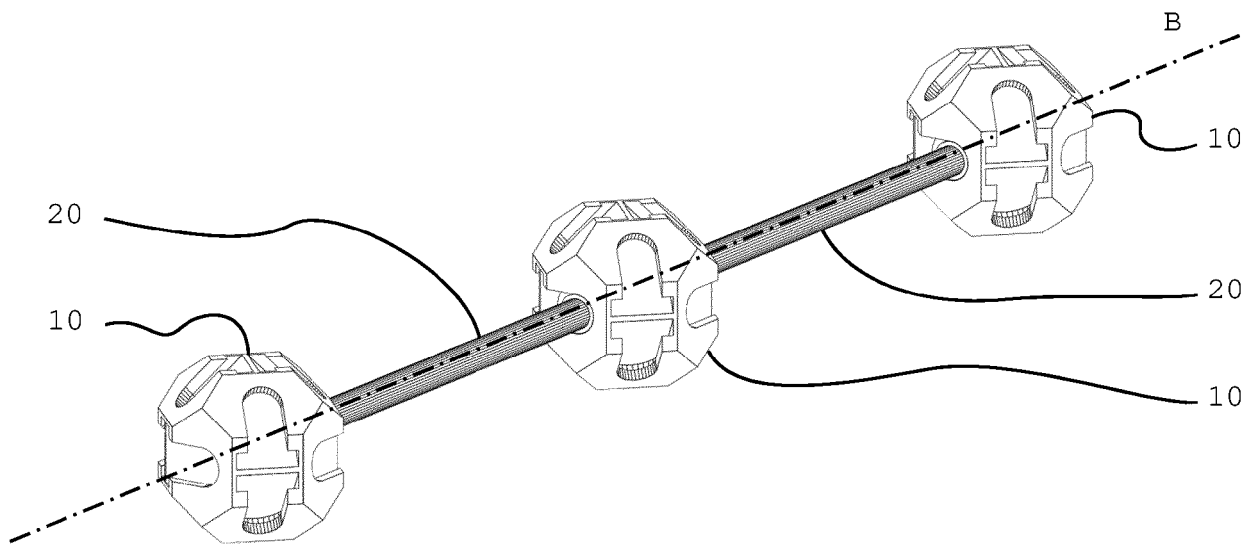


Fig. 2

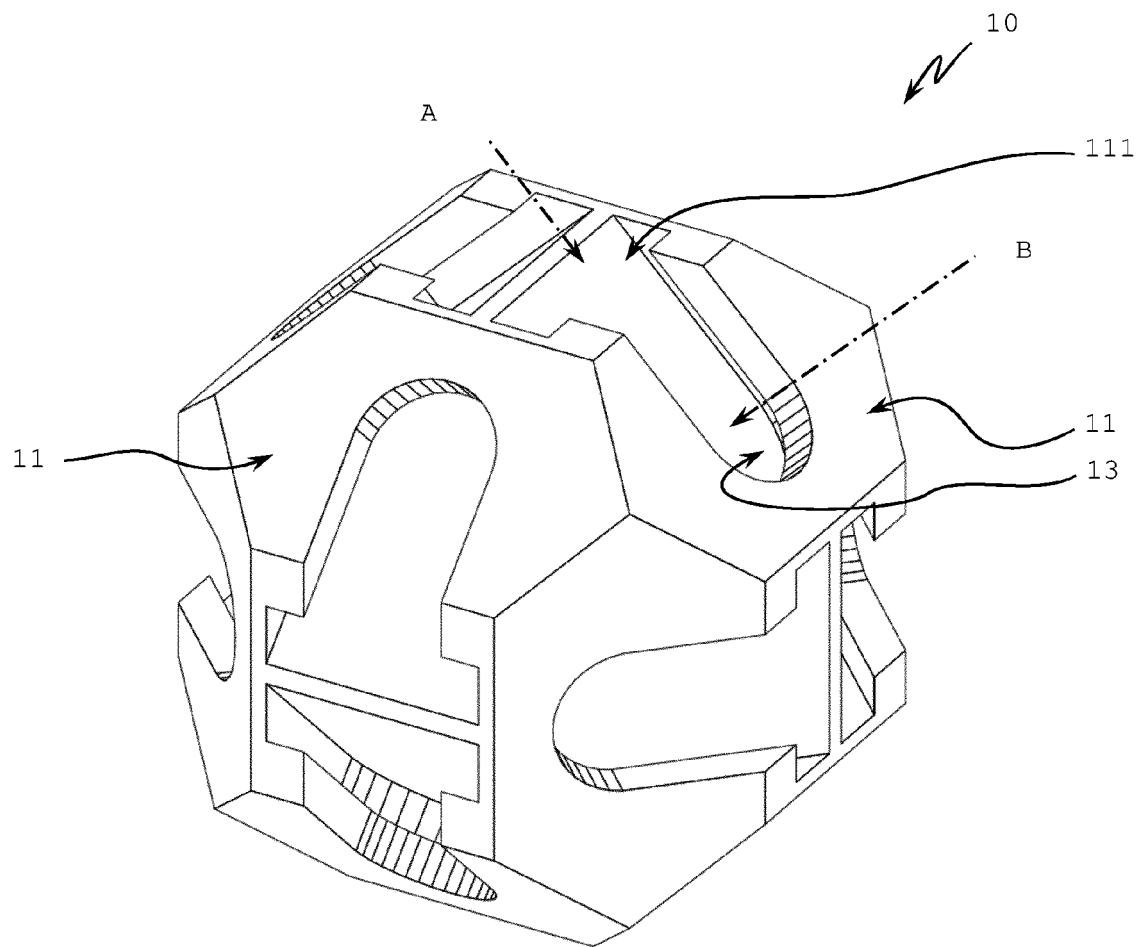


Fig. 3

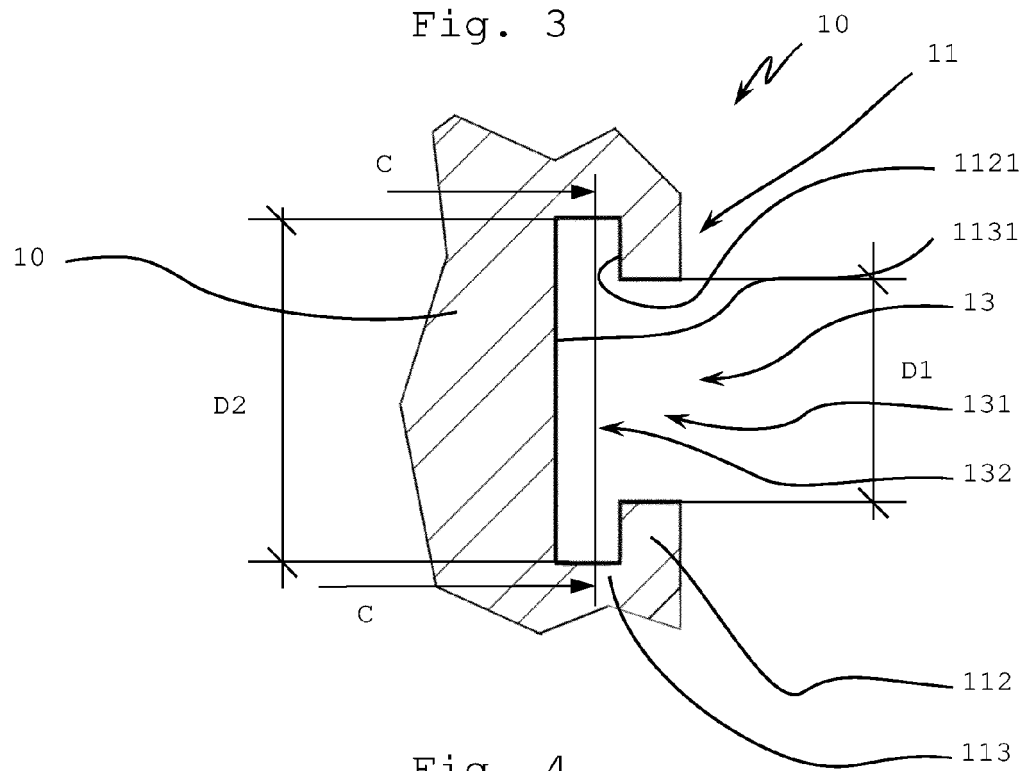


Fig. 4

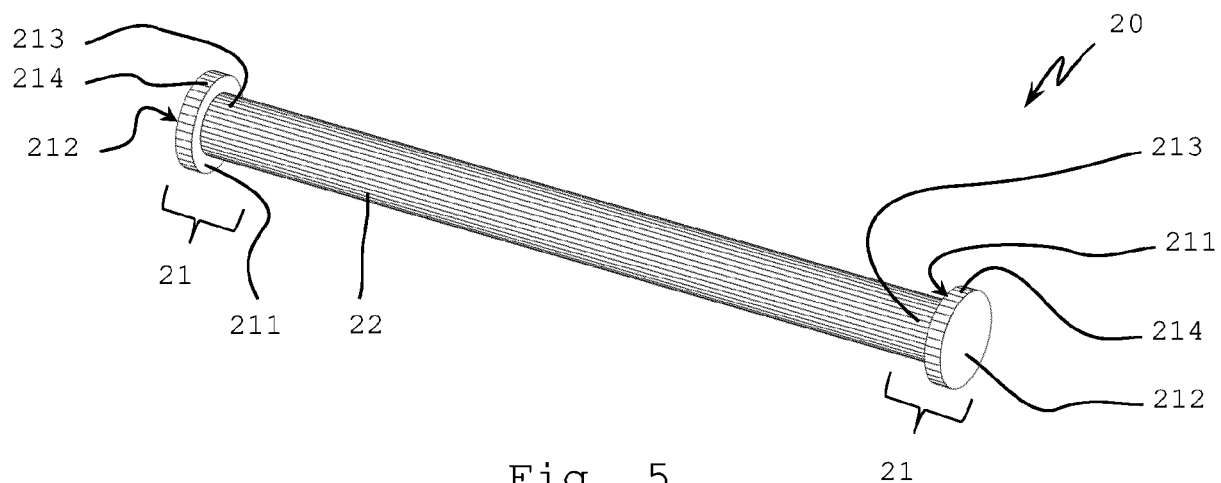


Fig. 5

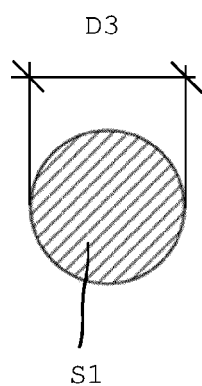


Fig. 6A

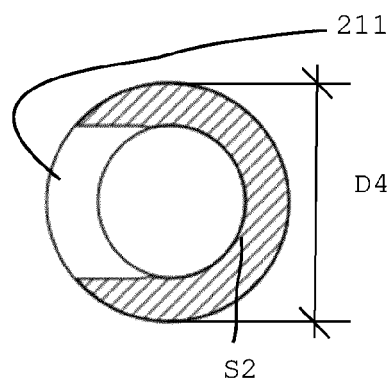


Fig. 6B

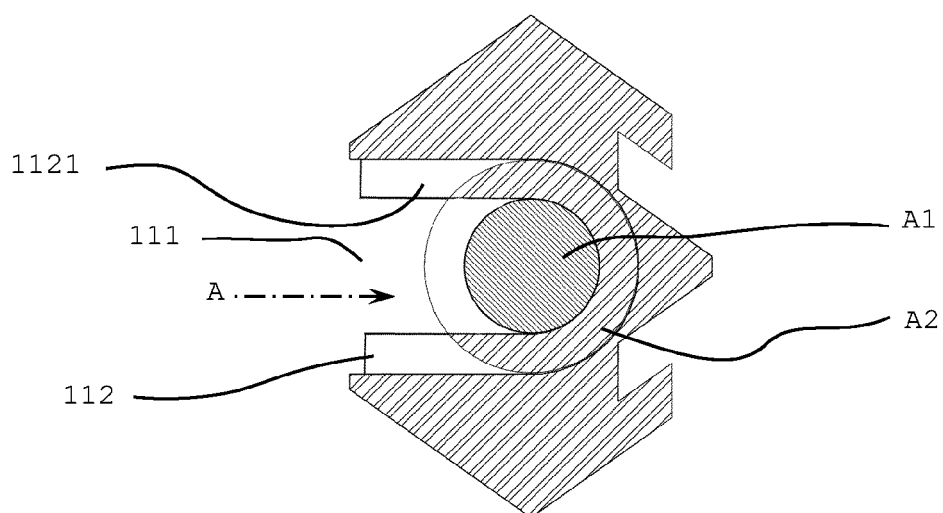


Fig. 7

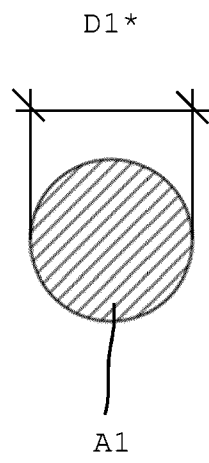


Fig. 8A

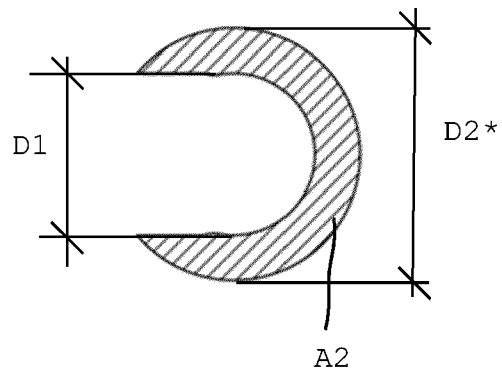


Fig. 8B

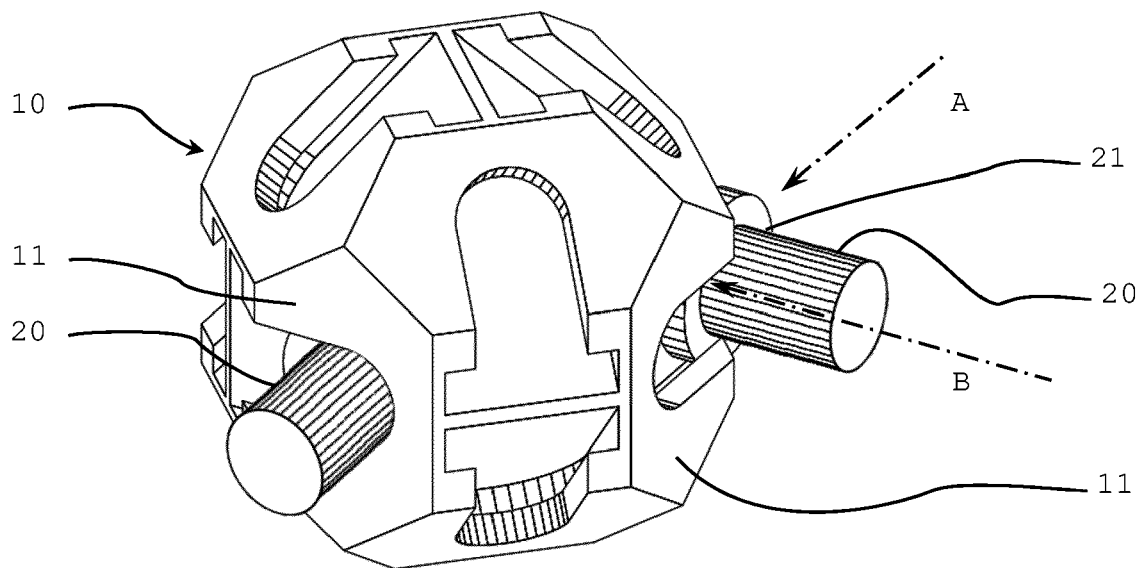


Fig. 9

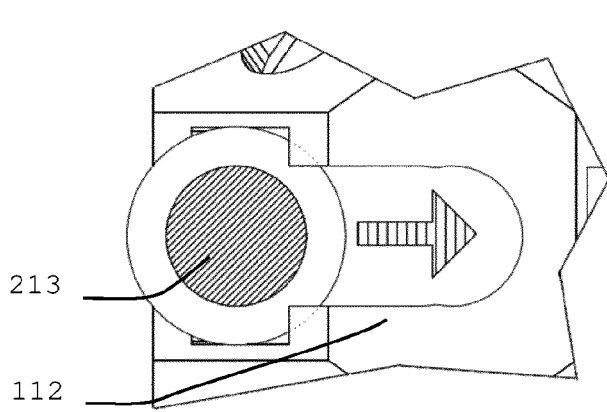


Fig. 10A

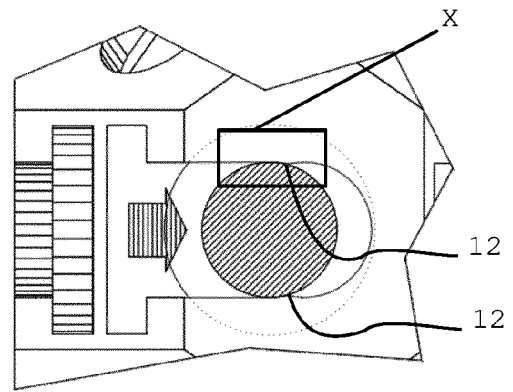


Fig. 10B

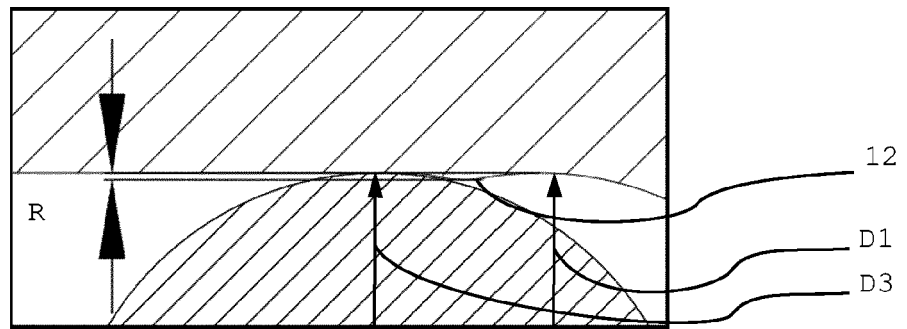


Fig. 11

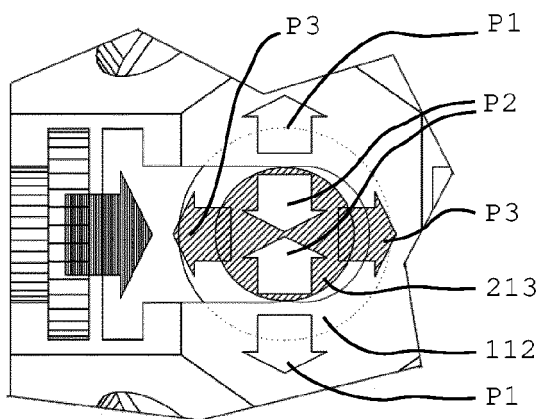


Fig. 10C

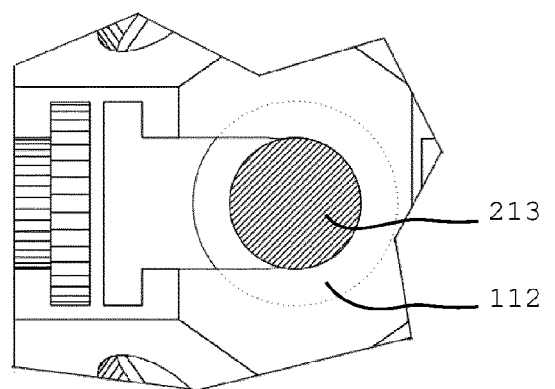


Fig. 10D

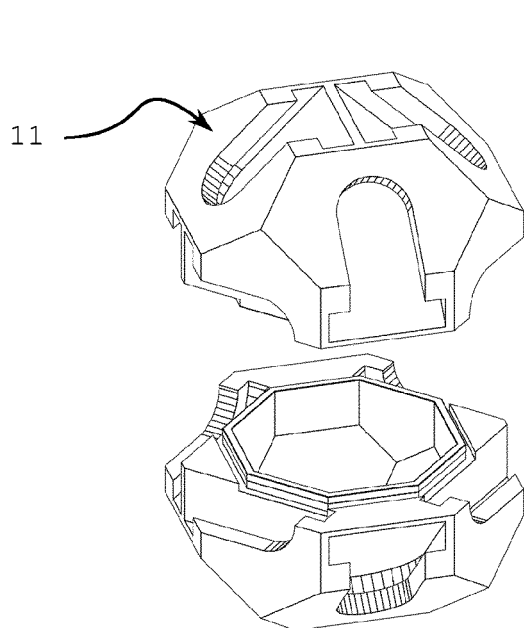


Fig. 12A

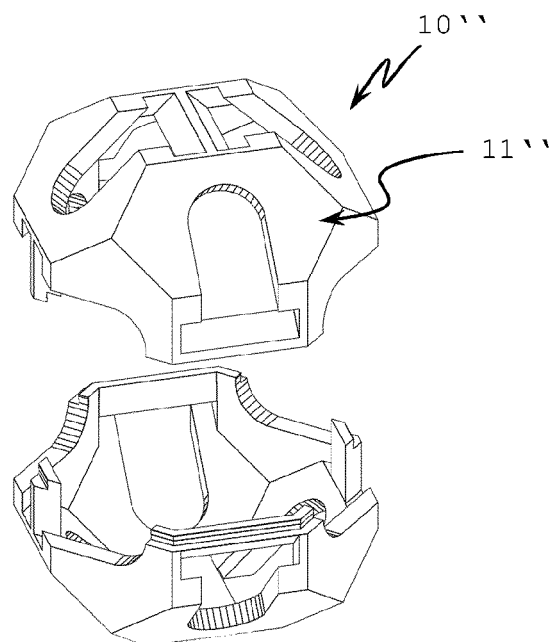


Fig. 12B

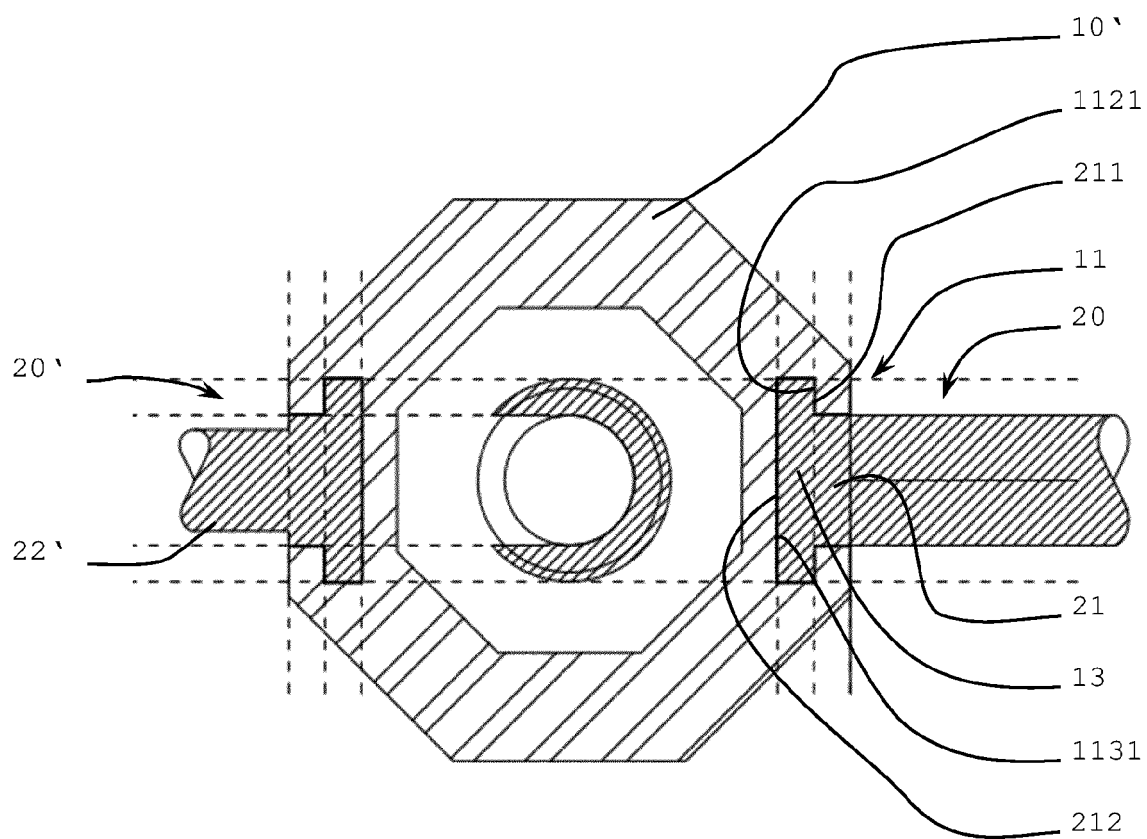
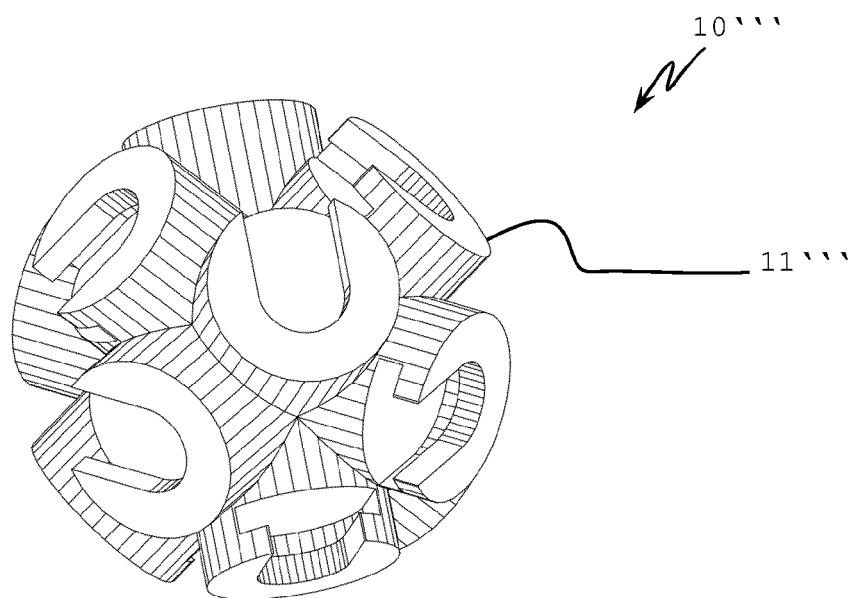
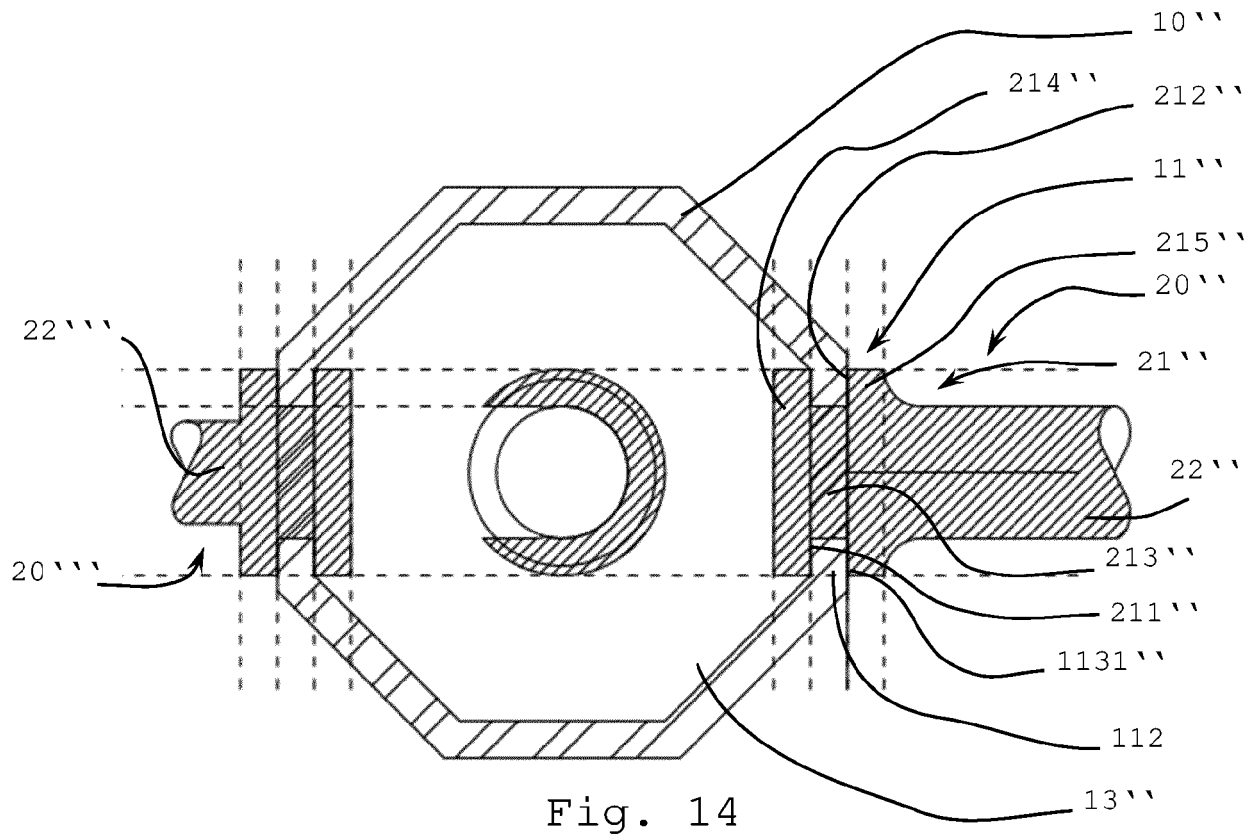


Fig. 13



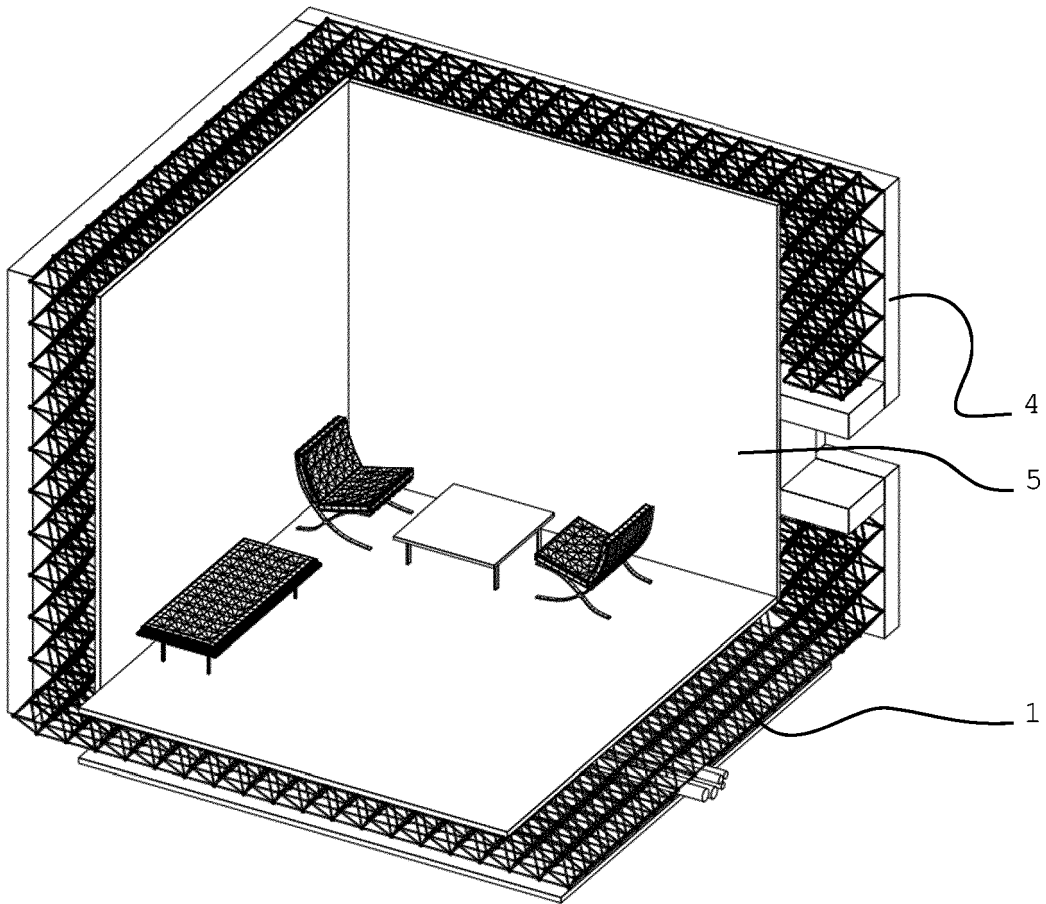


Fig. 16



EUROPEAN SEARCH REPORT

Application Number
EP 20 15 6423

5

10

15

20

25

30

35

40

45

50

55

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	WO 2006/123337 A2 (LAVI EREZ [IL]; INDYK GAL [IL]) 23 November 2006 (2006-11-23) * page 6, line 28 - page 10, line 20; figures 2-5 *	1-14	INV. E04B1/19
X	US 2 895 753 A (FENTIMAN ARTHUR E) 21 July 1959 (1959-07-21) * the whole document *	1-14	
X	US 6 378 265 B1 (KONSTANDT MATIAS [AR]) 30 April 2002 (2002-04-30) * abstract; figures 1-14 *	1-14	
			TECHNICAL FIELDS SEARCHED (IPC)
			E04B
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 22 July 2020	Examiner Galanti, Flavio
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			

 1
EPO FORM 1503 03/02 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 20 15 6423

5

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.

22-07-2020

10

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2006123337 A2	23-11-2006	EP 1893060 A2 US 2008224470 A1 WO 2006123337 A2	05-03-2008 18-09-2008 23-11-2006
US 2895753 A	21-07-1959	NONE	
US 6378265 B1	30-04-2002	NONE	

15

20

25

30

35

40

45

50

55

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

- GB 2132306 A [0003]