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(71) Ansøger:
Stiesdal Offshore Technologies A/S, Vejlevej 270, 7323 Give, Danmark

(72) Opfinder:
Henrik Stiesdal, Nørrevoldgade 45, 5000 Odense C, Danmark

(74) Fuldmægtig:
Patrade A/S, Ceresbyen 75, 8000 Århus C, Danmark

(54) Titel: **STRUCTURE WITH GROUTED JOINTS AND A METHOD OF FORMING SUCH JOINT**

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Disclosed is a structure with at least two tubular braces joined at a node by a joint. The tubular braces may be made of steel. The joint is formed by means of concrete cast or grouted in a receiving joint volume in one or both of the braces. Also disclosed is an offshore structure e.g. a keel structure formed by braces and joints as outlined. Methods of forming such joints and structures are disclosed.

Fortsættes...

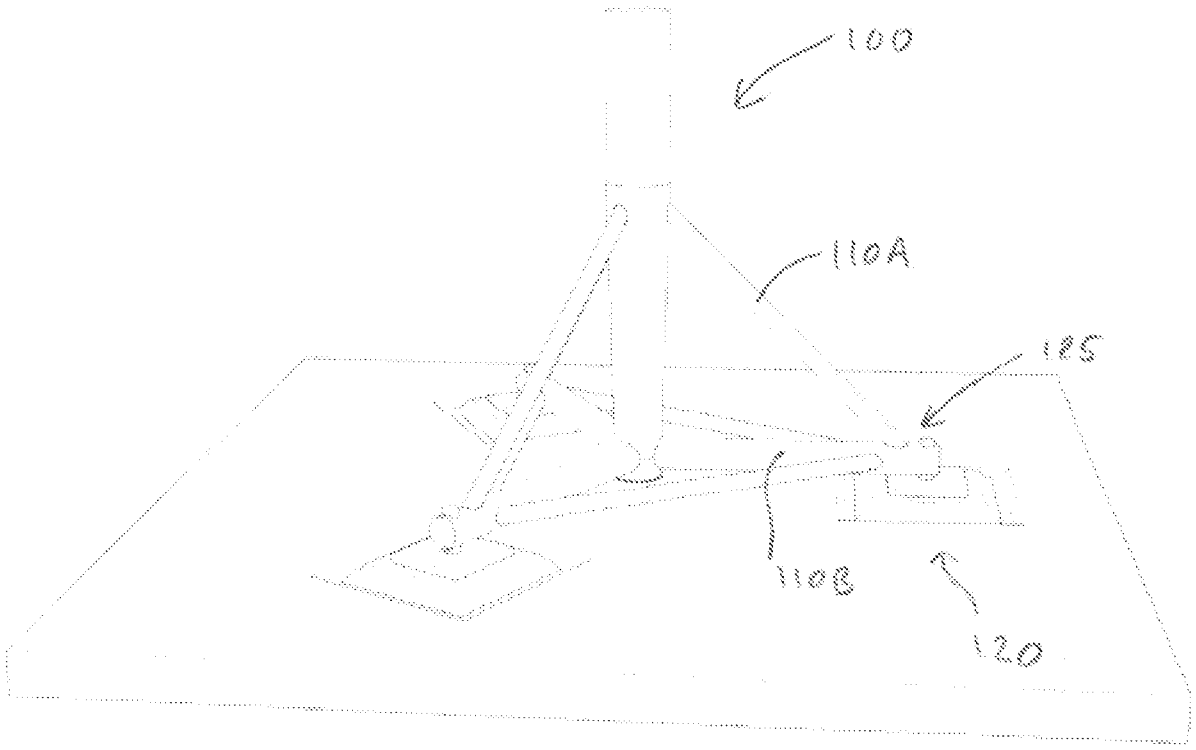

Fig. 1

Structure with Grouted Joints and a method of forming such Joints

Field of the Invention

The present invention relates to a structure comprising at least two tubular braces joined at a node by a joint. The tubular braces may be made of steel. The joint is formed by means of concrete cast or grouted in a receiving joint volume in one or both of the braces. Also disclosed is an offshore structure e.g. a keel structure formed by braces and joints as outlined. Methods of forming such joints and structures are disclosed.

Background of the Invention

Well designed and made joints for large scale structures or structures in general are of great importance.

In particular large scale structures and as an example offshore structures including keel structures demand lasting joints under harsh conditions and generally experience large dynamical forces.

Welding may or will pose hotspots and impose margins on dimensioning as well as increased inspection or control than otherwise required.

Object of the Invention

It is an objective to overcome issues with existing types of joints as well as structures formed with existing joints.

Description of the Invention

An objective may be achieved by a structure comprising at least two tubular braces joined at a node by a joint. The tubular braces may be made of steel. The joint is formed by means of concrete cast or grouted in a receiving joint volume in one or both of the braces.

It is understood that the receiving joint volume may comprise a gap formed in one of the braces. The gap may be formed as a volume or space caused by different sized in otherwise complementary end parts. One brace may have a male part complementary to a female part in another brace except for an excess volume between the male and the female part.

Thereby is provided a very strong and rigid connection between members such as braces.

A further advantage is that otherwise required levels of tolerances may be overcome or eliminated and thus easing the construction or assembly process.

An even further advantage is that the joint type outlined can be scaled easily basically without further complications. Should there be a gap between capacity and load then this type of joint allows for immediate increase in e.g. diameter of a brace and/or increase in strength class of concrete.

In fact the disclosed joint type spares a bushing or sleeve and leaves complications to casting or filling of concrete.

The structure may be an offshore structure. The nodes may be arranged and figured with a support or foot to be placed on ground or on the seabed.

Thereby is provided very strong and rigid joint connecting elongated members such as braces. The brace may be tubular shaped or have certain volumes with positive buoyancy. Thus the joint as formed may be adjusted in weight to further provide the required ballast or negative buoyancy.

In an aspect the joint comprises an end-part of a brace inserted into a receiving joint volume of another brace and the volume between is filled with concrete.

In an aspect the joint is formed of end-parts of two or more braces each configured with a receiving joint volume configured to receive a joint member. The volume between the end-parts and said member is filled with concrete.

The joint member may be a joint pipe being a solid member or a tubular member. Besides forming a strong and rigid joint, the joint member allows for substantially identical braces that are connected or joined by means of the joint member.

In an aspect the end-part of the brace or member that is inserted into a receiving joint volume in another brace is fitted with at least one L- or T-flange. There may be an alternative or variation of the L- or T-like flange. There may be a V-end where the legs form an arrow and serves as a hook.

Such end designs will make the joint even stronger. The flange may also be used for alignment during arrangement before and during filling of concrete.

In an aspect the end-part of the brace or member that is inserted into a receiving joint volume in another brace is internally and/or externally for part or its length surrounded by multiple reinforcement bars.

Reinforcement bars allows for a flexible design, adjustment during alignment in connection with filling of concrete. At the same time reinforcement allows for additional strength of the joint and may even form basis of reinforced concrete structure.

In an aspect multiple reinforcement bars project further than the end-part of the brace or member into the receiving joint volume in the other brace.

In an aspect the end-part of the brace or member that is inserted into a receiving joint volume in another brace is internally and/or externally for part or its length fitted with a pre-cast bushing and/or or sleeve comprising reinforced concrete.

In an aspect the receiving joint volume comprises a tubular steel or concrete section that is generally coaxial with the end-part of the brace or member that is inserted into the receiving joint volume in another brace.

In an aspect the end-part of the brace or member that is inserted into a receiving joint volume in another brace and/or the tubular steel or concrete section of the receiving joint volume is internally and/or externally for part or its length fitted with shear keys.

In an aspect the joint is formed as a grouted joint by means of grouting cement. Such cement may be e.g. what is sold under the trade name BASF MasterFlow which composition may form a starting point of grouting cement mixture.

In an aspect the joint is formed as a cast joint by means of concrete. That may be by mixing e.g. standard concrete based on Portland cement with suitable sea water admixtures.

An object is achieved by a method of forming a structure of tubular braces joined at a node as outlined. The method comprising an act of joining two braces at the node. There is an act of filling of grouting cement and/or concrete into at least one of the braces at the node.

This method provides a strong and rigid joint as outlined. The method is further advantageous since the acts can be performed on site and even subsea. The act of filling can be adjusted and controlled to provide a desired weight.

An object may be achieved by a keel structure with one or more nodes or joints formed as grouted joints as outlined. The keel structure may be formed by substantially identical and linear braces arranged to form a polygon; e.g. a triangle and wherein each brace has negative buoyancy.

An object is achieved by a method of forming a keel structure as outlined and according to the acts described. The act of filling or casting is performed to balance the buoyancy of the keel structure to predetermined balanced buoyancy.

In the following further objects and aspects of the outlined joints will be elaborated upon. In particular the outlined aspects relates to structure with multiple joints and where the structure is with overall properties such as rigidity as a single body. The structure may be for an offshore structure such as a keel structure for a floating offshore platform.

To form such single body, the structure may comprise at least two braces joined at a node by a joint. The joint may be as previously outlined or with one or more where the

joint is formed by means of concrete or cement grouted in a receiving joint volume in one of the braces.

It is understood that the receiving joint volume may comprise a gap formed in one of the braces. The gap may be formed as a volume or space caused by different sized in otherwise complementary end parts. One brace may have a male part complementary to a female part in another brace except for an excess volume between the male and the female part.

In an aspect the structure is an offshore structure. The structure may be a floating structure having positive buoyancy. The structure may be a sinking structure having negative buoyancy. The structure may be a keel for an offshore structure.

The braces may be longitudinal or linear in shape and the joints forming nodes. The brace may have end-parts or brace ends that are configured for establishing a joint. Between ends of a brace, the brace may be configured with tanks or structures to establish a predetermined level of buoyancy or even to adjust buoyancy.

Thus it is possible to establish an offshore structure with positive, negative, variable or adjustable buoyancy.

In an aspect the structure is formed by substantially identical and linear braces. The linear braces may be arranged to form a polygon such as a triangle. According to the desired shape, the end parts of braces may be adapted or pre-configured with required angles to form a single structure. For a triangle the angle between braces at a joint or node is 60 degrees.

The braces may be joined by means of grouting. Thereby is achieved a substantially rigid single body in a simple way. In particular the nodes may be particularly rigid and during operation the node points of the structure may behave identically whilst the braces may flex or deform between node points.

The braces may be of steel and the joints formed by grouting concrete to make the bond between braces.

As an example a keel structure may be suspended at node points and with weight of 100 to several hundred tons the keel structure.

Furthermore the grunting may be part of the ballasting of the structure. In example a keel structure for a floating structure. The joints may be formed onshore and the keel structure may have buoyancy suitable for transport or even a positive buoyancy enabling a floating structure. The braces may be configured to receive a concrete mixture to completely adjust the level of ballast.

In example such keel structure may be formed by braces having a diameter of about 2,000 mm. Brace ends may be joined in areas where the length or extend of the receiving volume is about 3,000 to 5,000 mm. In the case of 3,000 mm the forces to be transferred are about 3,000kN radially and axially.

Such structure will have a surface area of about 6,000,000 mm2 radially and 20,000,000 mm2 axially. The resulting tensions are in the order of 0,5 MPa radially and 0.15 MPa axially. As an example standard concrete 35M (35Mpa) may transfer 20MPa radially and 5MPa axially.

In an aspect the joint comprises a thin end-part of a brace inserted into a receiving joint volume of another brace having a thick end-part and a through end part of the another brace and the receiving joint volume between is filled with the concrete.

In another example a keel structure may be formed by three braces with a diameter of about 4,000 mm and a length of 65,000 mm.

In an aspect a joint in the offshore structure or keel structure is formed of brace end-parts of two braces each configured with a receiving joint volume. The thicker part or through part of a brace is configured to receive a joint pipe or joint member and the receiving joint volumes between is filled with the concrete.

The offshore structure or keel structure may have the respective brace end-parts formed complementary to interface against each other.

In an aspect the joint pipe or joint member is a bent joint pipe and with joint ends inserted into the receiving joint volume at the very end of respective braces.

The bent joint pipe may be U-shaped or V-shaped otherwise angled according to the shape of the structure. The bent joint pipe may be shaped as a piecewise linear type. The shape might be boomerang shaped.

In an aspect a single piece, e.g. monolith, pipe or cylindrically shaped joint material is heated, maybe piecewise or under temperature control during bending. The angles may be from 0 to 180 degrees and of diameters or variable diameters between say 10 to 100-200 cm.

The reinforcement bars may be steel reinforcements that extend fully or partially into another brace.

In an aspect the brace end of one brace inserted into a receiving joint volume of another brace comprises multiple reinforcement bars that at least partially enters the receiving joint volume.

In an embodiment an end of the brace is a thin end-part of the brace that is extended with reinforcement bars that extends into a receiving joint volume of a thick end-part of another brace.

The reinforcement bars may be arranged in the periphery of the thin end-part of the brace. There may be more layers or arrays of reinforcement bars.

As such the offshore structure or keel structure may have one or more joints formed as grouted joint.

An object may be achieved of forming a structure being an offshore structure of keel structure comprising braces joined at one or more nodes as outlined. There is an act of joining two braces at a node. There is an act of filling of concrete into a receiving joint volume of least one of the braces at the node.

The forming may be of multiple braces and multiple nodes and the act of filling or casting is performed to balance the buoyancy of the structure. The filling may be performed onshore to provide a structure with suitable ballast for transportation also at sea.

Description of the Drawing

Embodiments of the invention will be described in the figures, whereon:

Fig. 1 illustrates a structure with a grouted joint at a node;

Fig. 2 illustrates a brace inserted into a receiving volume of another brace;

Fig. 3 illustrates a member inserted into a receiving volume of respective braces;

Fig. 4 illustrated aspects of brace end fittings;

Fig. 5 illustrates aspects of a brace fitted with reinforcement bars;

Fig. 6 illustrates further aspects of a brace fitted with reinforcement bars;

Fig. 7 illustrates a joint with two braces fitted with reinforcement bars;

Fig. 8 illustrates further aspects of a brace fitted with reinforcement bars;

Fig. 9 illustrates a coaxial arrangement of a brace end and a receiving volume;

Fig. 10 illustrates a section with shear keys;

Fig. 11 illustrates a keel structure with grouted joints formed by a thin end-part of one brace inserted into a thick end-part of another brace;

Fig. 12 illustrates a keel structure with grouted joints formed by a joint pipe inserted into complimentary brace ends;

Fig. 13 illustrates a keel structure with grouted joints formed by a joint pipe inserted into brace ends; and

Fig. 14 illustrates a keel structure with grouted joints formed by a bent joint pipe inserted into the very end of braces.

5

Detailed Description of the Invention

Item	**No**
100	Structure
110	Brace
111	Member
112	Brace end /end-part of brace
115	Thin end-part of brace / male part
116	Thick end-part of brace / female part
117	Through part
120	Node
125	Joint
130	Joint pipe
132	Bent joint pipe or joint member
135	Joint end
136	Flange
137	L-Flange
138	T-Flange
140	Reinforcement bars
142	Bolts
150	Receiving joint volume
152	Separator
155	Tubular section
160	Pre-cast bushing
165	Pre-cast sleeve
190	Concrete
191	Grouting cement
192	Reinforced concrete

195	Grouted joint
196	Concrete section
197	Sheer keys
200	Offshore structure
300	Keel Structure

Figure 1 illustrates a structure 100 comprising at least two tubular braces 110A, 110B joined at a node 120 by a joint 125. The braces are tubular braces 110A, 110B and made of steel. The joint (125) is formed by means of concrete 190 cast or grouted in a receiving joint volume 150 in one or both of the braces 110A, 110B.

The structure 100 is illustrated as a supporting structure with feet at respective nodes 120.

Figure 2 illustrates a brace 110A inserted into a receiving volume 150 of another brace 110B. The receiving volume is filled with concrete 190. In this case the receiving volume 150 is defined by the tubular shape of the brace 110B and separators 152 being divider walls or plates. The separators 152 may be placed or located according to the need of structural strength, weight or both.

Here the joint 125 comprises an end-part 112A of the brace 110A inserted into the receiving joint volume 150 of the other brace 110B.

Figure 3 illustrates a member 110 inserted into receiving volumes 150A, 150B of respective braces 110A, 110B.

The joint 125 is formed of end parts 112A, 112B of respective two braces 110A, 110B each configured with a receiving joint volume 150A,150B configured to receive a joint member 111. The volume 150A, 150B between the end parts and said member 111 is filled with concrete 190. The member 111 is angled according to the angle required of the respective braces 110A, 110B.

Figure 4 A and B illustrates aspects of joints 125 end fittings. The end-part 112A of the brace 110A that is inserted into a receiving joint volume 150 in another brace

110B is fitted with one L-flange 137 (B) or T-flange 138 (A). The end-part 112A of the inserted brace 110A is hollow and with an opening at the very end so that the hollow part forms a receiving volume 150 to be filled with concrete 190 with the volume of the other brace 110B.

Figure 5 illustrates aspects of a brace 110A fitted with reinforcement bars 140 forming a reinforced concrete 192 joint. The end-part 112A of the brace 110A that is inserted into a receiving joint volume 150 in another brace 110B has a cross-section, which is surrounded by multiple reinforcement bars 140 to extend into the receiving volume 150.

The multiple reinforcement bars 140 projects at least further than the end-part 112A of the brace 110A and into the receiving joint volume (150) in the other brace (110B). The reinforcement bars 140 are shown to be supported by a flange 137 and to be embedded in the receiving volume 150.

Fig. 6 illustrates further aspects of a brace 110A fitted with reinforcement bars 140.

Here the end-part 112A of the brace 110A that is inserted into the receiving joint volume 150 in another brace 110B is internally and externally for part of its length fitted with a pre-cast bushing 160 and sleeve 165 comprising reinforced concrete 192.

Here the end-part 112A of the inserted brace 110A has a separator 152A at the very end of the brace 110A.

Fig. 7 illustrates a joint 125 with two braces 110AI, 110AII each fitted with respective reinforcement bars 140I, 140II extending into a receiving volume 150 of a receiving brace 110B. The reinforcement bars 140 are fitted in respective flanges internally in the braces 110AI, 110AII. The reinforcement bars 140 are adjusted according to the geometry and arranged to provide as forces as symmetric as possible.

Figure 8 illustrates further aspects of a brace 110A fitted with reinforcement bars 140 in what might be considered a hybrid version of a grouted joint 125. Bolts 142 are used in combination with concrete. In this case an inner and outer tube is arranged and

fixed on the inside and outside of the receiving brace 110B being thicker than the brace 110A to be inserted and to fit in between the inner and outer tube. Holes in the receiving brace 110B for the reinforcement bars 140 to penetrate are provided at an angle. The thinner brace 110A to be inserted is fitted with a flange and there is a corresponding loose flange on inside of the receiving brace 110B in the receiving volume 150. The reinforcement bars 140 and one or both of the flanges may be fixed or adjusted by means of bolts 142.

Figure 9 illustrates a coaxial arrangement of a brace 110A end 112A to be inserted into and a receiving volume 150 formed in a receiving brace 110B. The receiving joint volume 150 is formed by a tubular section 155, e.g. formed by steel or concrete that is generally coaxial with the end-part 112A of the brace 110A that is inserted into the receiving joint volume 150 in the receiving brace 110B.

In continuation of figure 9, figure 10 illustrates a concrete section 196 with shear keys 197. That is: the brace end-part 112A of the brace 110A to be inserted is fitted with shear keys 197.

Figures 11, 12, 13 and 14 illustrate a structure 100 comprising three braces 110A, B, and C that are numbered according to being joined at respective nodes 120I, I,III by joints 125I,II,III. The joints 125I,II,III are formed by means of concrete 190 grouted (not shown) in respective receiving joint volumes 150I, II, III in the braces 110A, 110B, 110C.

The structure 100 shown is intended to be a keel structure 300 for a floating off-shore structure 200 and to have negative buoyancy. The form of the keel 300 structure is a triangle. The structure is here formed by identical braces 100 and identical joints 125 at respective nodes 120. Thus the keel structure is here formed as a triangle and of three identical braces 110A, B, C where the first brace 110A extends between node 120I and node 120II, brace 110B between node 120II, and node 120III, and brace 110C between node 120III and node 120I. This nomenclature is used in the variants of keel structures illustrated in figures 12, 14 and features relating to an element A at a node II will have a suffix AII etc.

Figure 11 illustrates, A a top view and B a perspective view, a structure 100, for an offshore structure 200 e.g. keel structure 300 formed with braces 110A, B, C joined at nodes 120I, II, III as grouted joints 125 formed by a thin end-part 115 of a brace 110A to be inserted into a thick end-part 116 of another brace 110C.

The thin end-part 115A of the brace 110A is inserted into the receiving joint volume 150, the other brace 110C having a through end part 117 at the thick end part 116 also having the receiving joint volume 150 which is filled with the concrete 190.

Figures 12 and 13 illustrate a structure 100 as shown and with an exemplary as a joint 125 formed of brace end-parts 112A, 112B of respective two braces 110A, 110B each configured with a receiving joint volume 150A, 150B. In this case the thicker part or through part of a brace is configured to receive a joint pipe 130 or a member 111 and the receiving joint volumes 150A, 150B between is filled with concrete 190.

Figure 12 specifically illustrates nodes 120I, II, III formed where the respective brace end-parts 112A, 112B are formed complementary to interface against each other and a joint pipe 130 or member 111 inserted and joined by grouting as outlined. The grouted joints 125I, II, III, are formed by a joint pipe 130 or member 111 inserted into complimentary brace ends.

Fig. 13 specifically illustrates nodes 120I, II, III formed as a structure with grouted joints formed by a joint pipe 130 inserted into brace ends 112A, 112B.

Figure 14 illustrates a structure with grouted joints formed at respective nodes 120I, II, III and formed by a bent joint pipe 132 inserted into the very end of braces 110.

The joint pipe 130 or member is a bent joint pipe 132 and with joint ends 135A, 135B inserted into the receiving joint volume 150 at the very end 112 of respective braces 110A, 110B as illustrated.

The bent joint pipe 132 is shown as a “V-shaped” angled according to the triangular shape of the structure 100. The bent joint pipe 132 is shaped as a piecewise linear type. The shape may be said to be a boomerang shape.

CLAIMS

1. A structure (100) comprising at least two tubular braces (110A, 110B) joined at a node (120) by a joint (125), wherein the tubular braces (110A, 110B) are made of steel, and wherein the joint (125) is formed by means of concrete (190) cast or grouted in a receiving joint volume (150) in one or both of the braces (110A,110B).

2. The structure (100) according to claim 1, wherein the structure (100) is an offshore structure.

3. The structure (100) according to any one or more of the preceding claims, wherein the joint (125) comprises an end-part (112A) of a brace (110A) inserted into a receiving joint volume (150) of another brace (110B), and where the volume (150) between is filled with concrete (190).

4. The structure (100) according to any one or more of the preceding claims, wherein the joint (125) is formed of end parts (112A, 112B) of two or more braces (110A, 110B) each configured with a receiving joint volume (150A, 150B) configured to receive a joint member (111), and where the volume (150A, 150B) between said end parts and said member is filled with concrete (190).

5. The structure (100) according to any one or more of the preceding claims, wherein the end-part (112) of the brace (110A) or member (111) that is inserted into a receiving joint volume (150) in another brace (110B) is fitted with at least one L- or T-flange (137,138).

6. The structure (100) according to any one or more of the preceding claims, wherein the end-part (112A) of the brace (110A) or member (111) that is inserted into a receiving joint volume (150) in another brace (110B) is internally and/or externally for part or its length surrounded by multiple reinforcement bars (140).

7. The structure (100) according to claim 6, wherein the multiple reinforcement bars (140) project further than the end-part of the brace (110A) or member (111) into the receiving joint volume (150) in the other brace (110B).

8. The structure (100) according to any one or more of the preceding claims, wherein the end-part (112A) of the brace (110A) or member (111A) that is inserted into a receiving joint volume (150) in another brace (110B) is internally and/or externally for part or its length fitted with a pre-cast bushing (160) and/or sleeve (165) comprising reinforced concrete (192).

9. The structure (100) according to any one or more of the preceding claims, wherein the receiving joint volume (150) comprises a tubular steel or concrete section that is generally coaxial with the end-part (112A) of the brace (110A) or member (111) that is inserted into the receiving joint volume (150) in another brace (110B).

10. The structure (1) according to any one or more of the preceding claims, wherein the end-part (112A) of the brace (110A) or member (111A) that is inserted into a receiving joint volume (150) in another brace (110B) and/or the tubular steel or concrete section (196) of the receiving joint volume (150) is internally and/or externally for part or its length fitted with shear keys (197).

11. The structure (100) according to any one or more of the preceding claims, wherein the joint (125) is formed as a grouted joint (195) by means of grouting cement (191), e.g. BASF MasterFlow.

12. The structure (100) according to any one or more of the preceding claims, wherein the joint (125) is formed as a cast joint (22) by means of concrete (190), e.g. standard concrete based on Portland cement with suitable sea water admixtures.

13. Method of forming a structure (100) of tubular braces (110) joined at a node (120) according to any one or more of claims 1 to 12, the method comprising acts of
- joining two braces (110A, 110B) at the node (120);
- filling of grouting cement (191) and/or concrete (190) into at least one of the braces (110A, 110B) at the node (120).

14. A keel structure (100) according to any one or more of claims 1 to 12, wherein the keel structure (100) is formed by substantially identical and linear braces (110) ar-

ranged to form a polygon; e.g. a triangle and wherein each brace (110) has negative buoyancy.

15. A method of forming a keel structure (100) according to claim 14 and according to the method of claim 13 and wherein the act of filling is performed to balance the buoyancy of the keel structure (100) to predetermined balanced buoyancy.

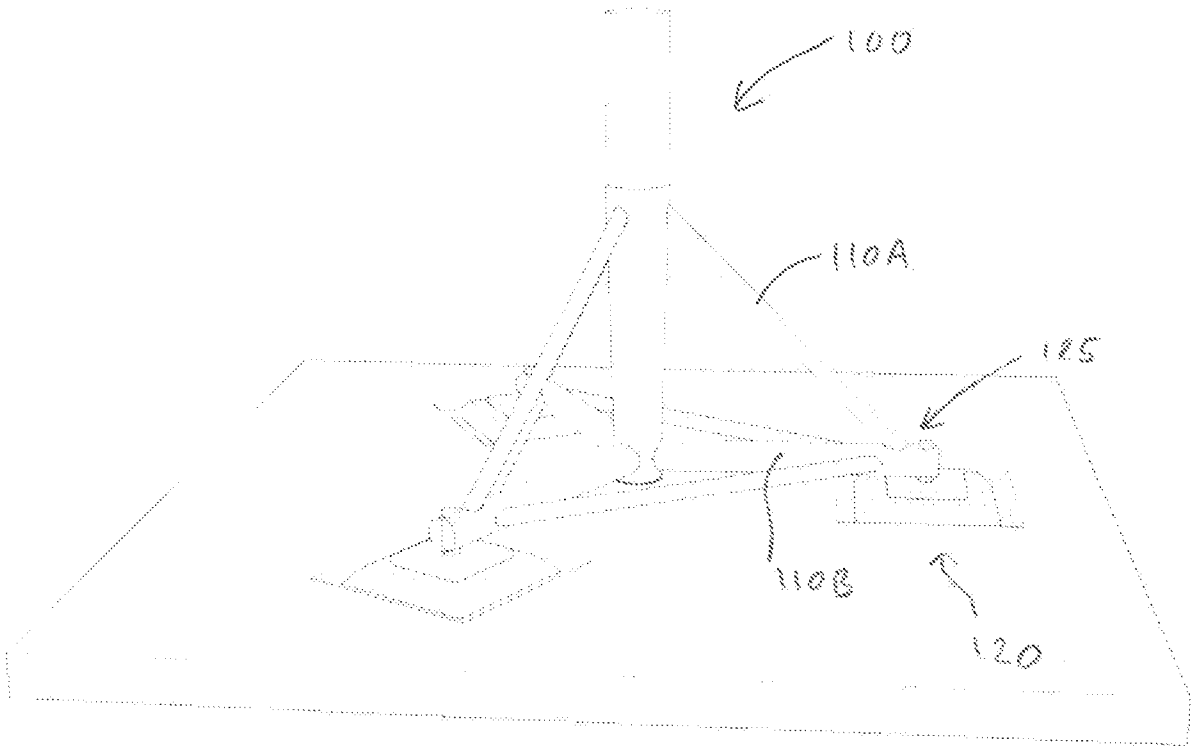

Fig. 1

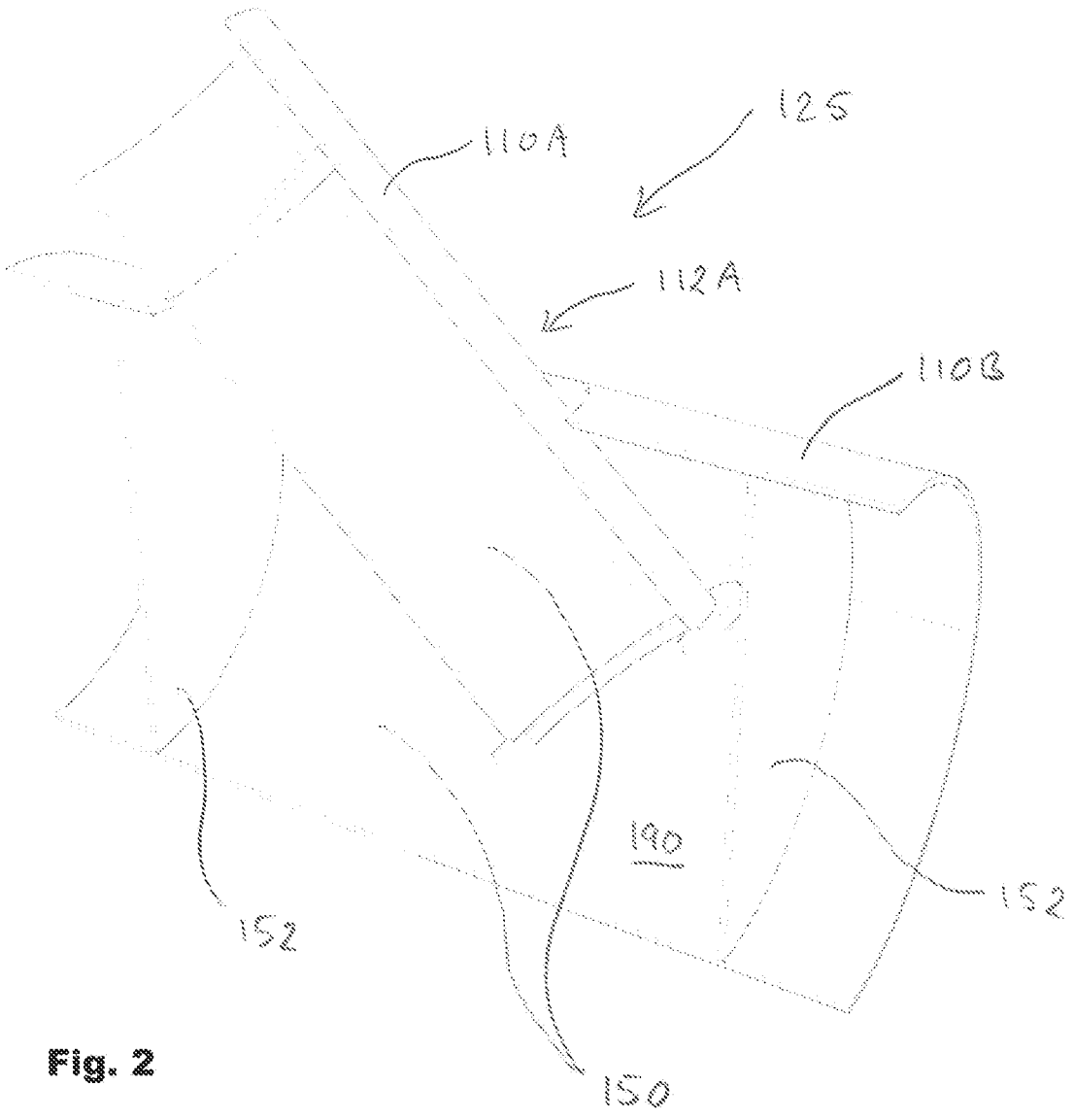

Fig. 2

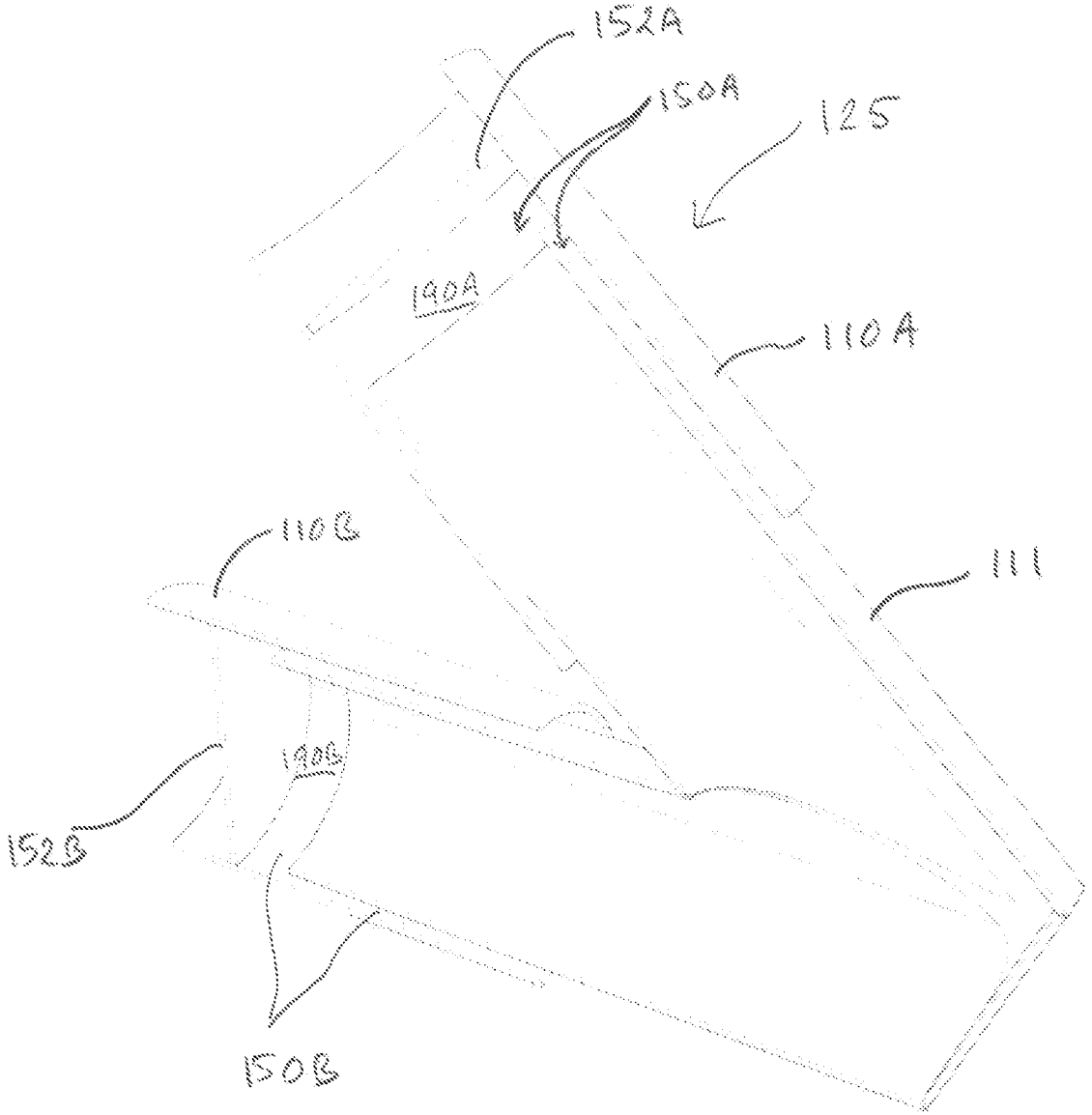

Fig. 3

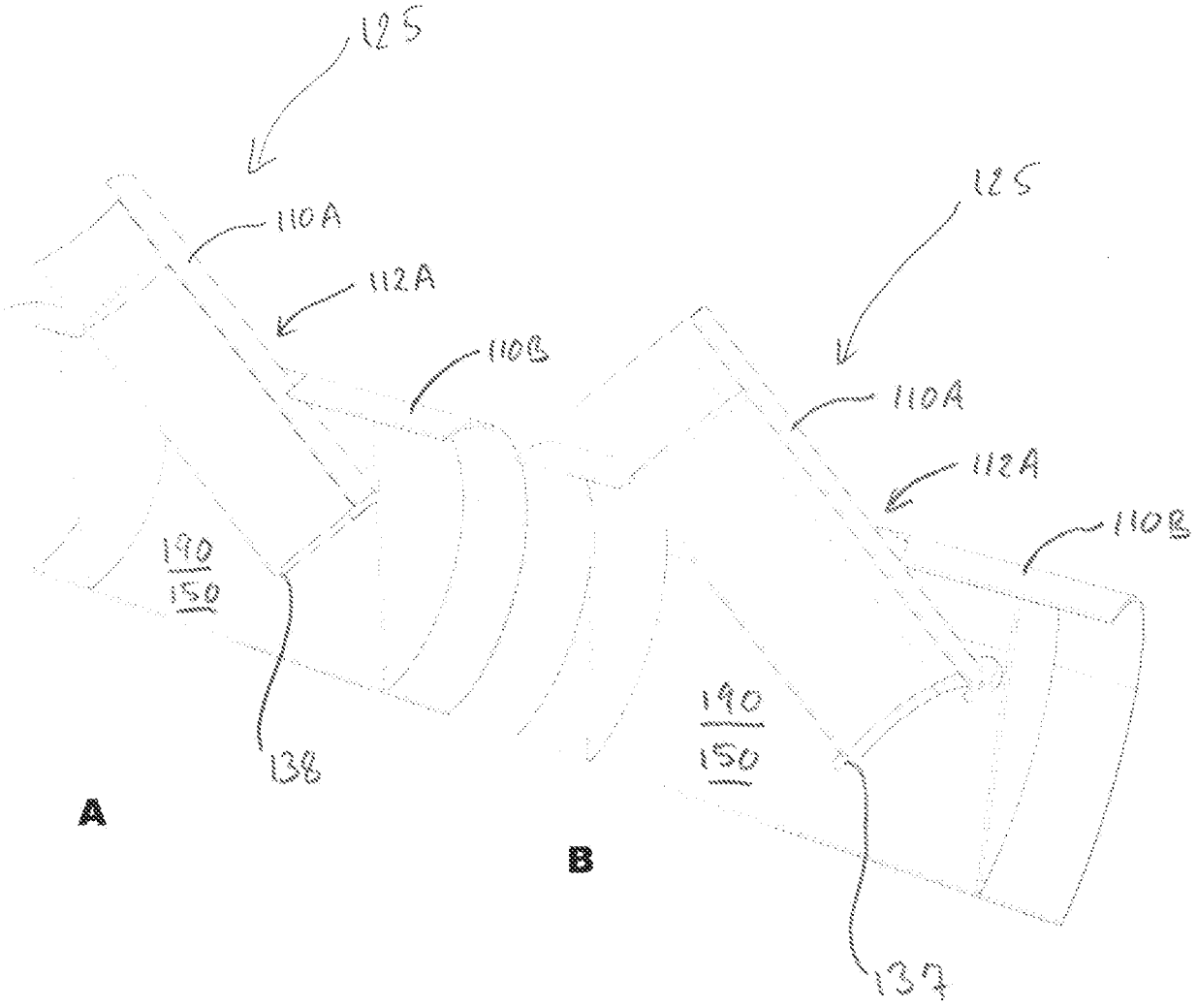
125
110A
112A
110B
190
150
138
A
125
110A
112A
110B
190
150
137
B

Fig. 4

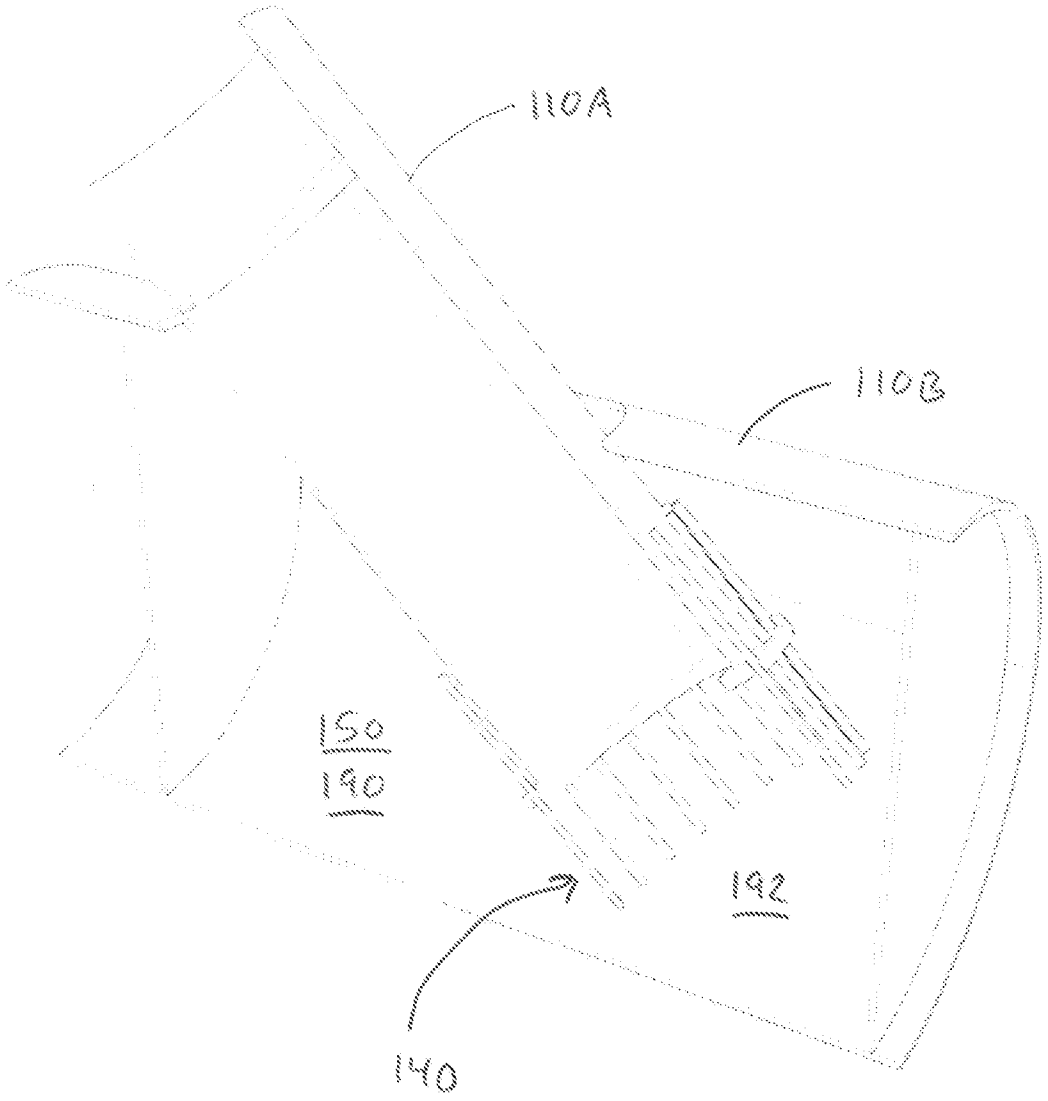

Fig. 5

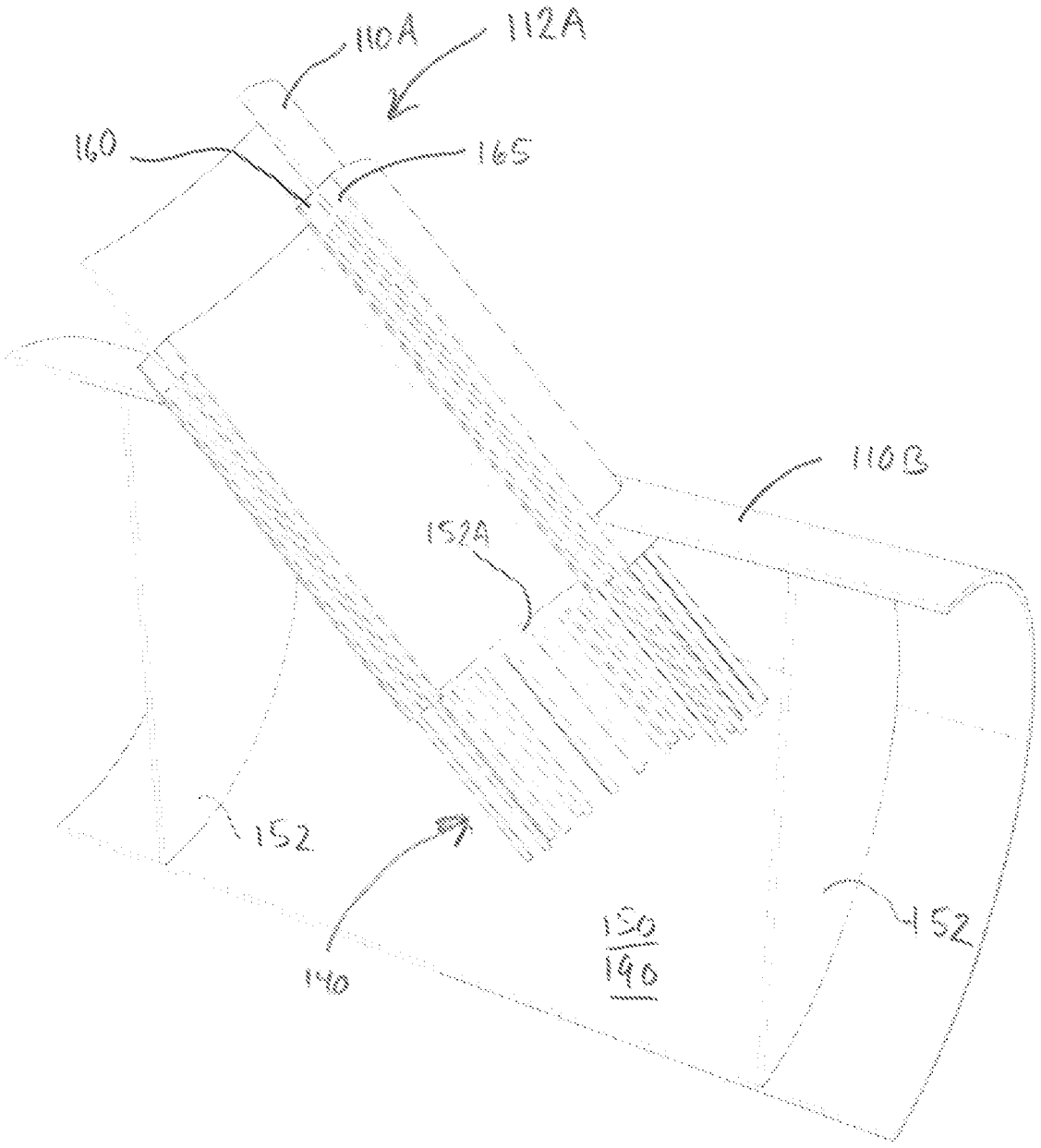

Fig. 6

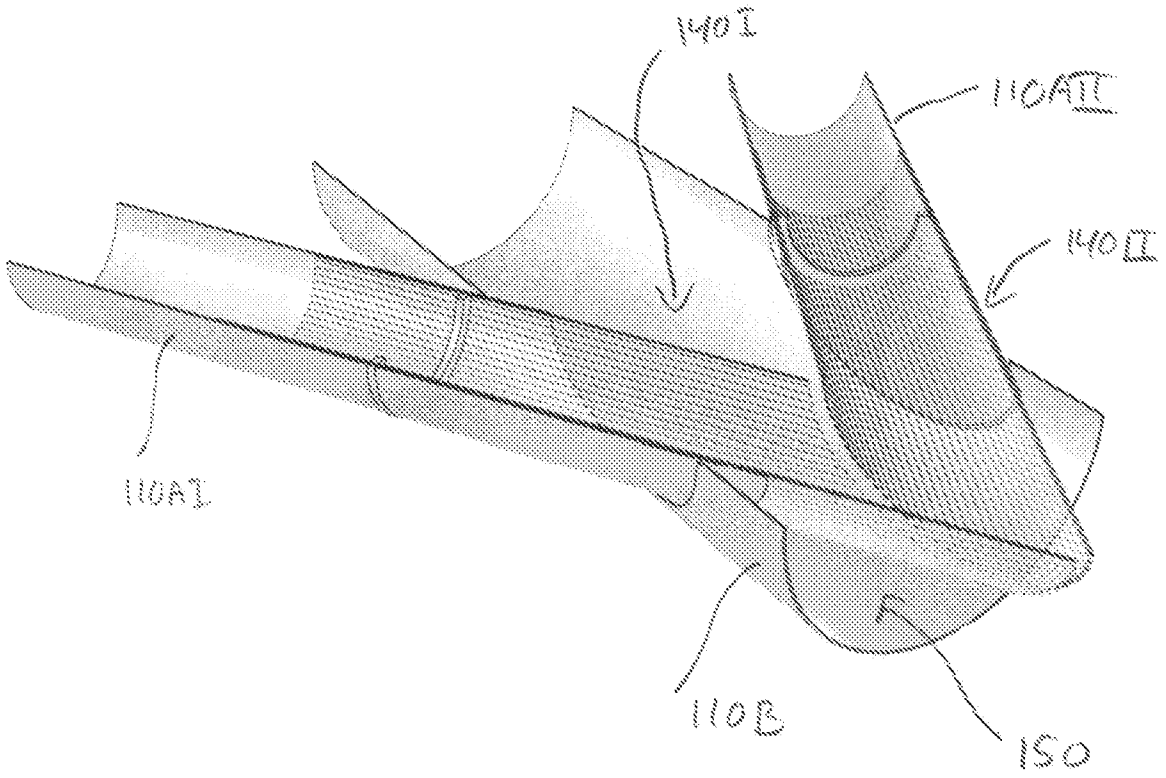

Fig. 7

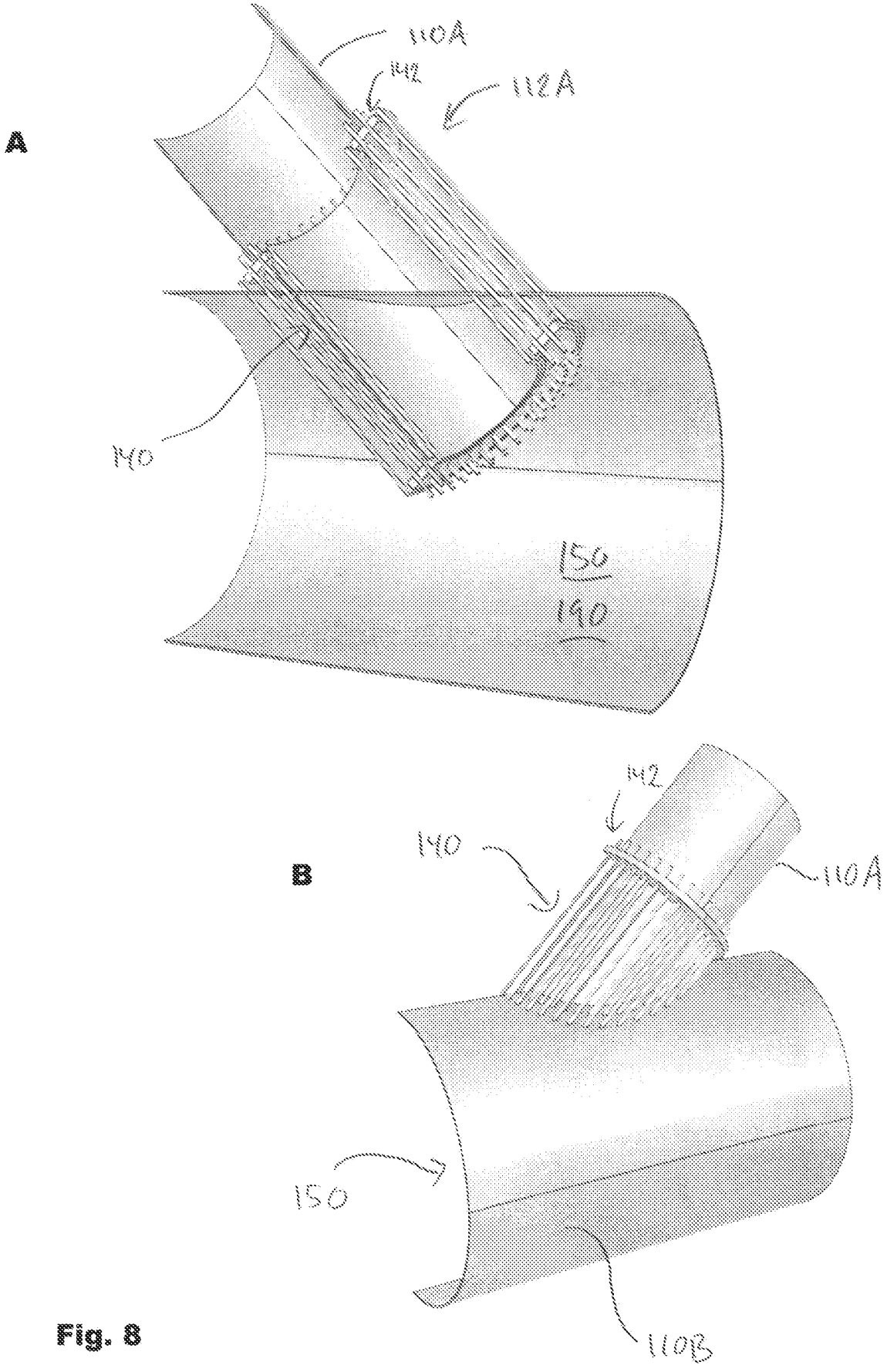

Fig. 8

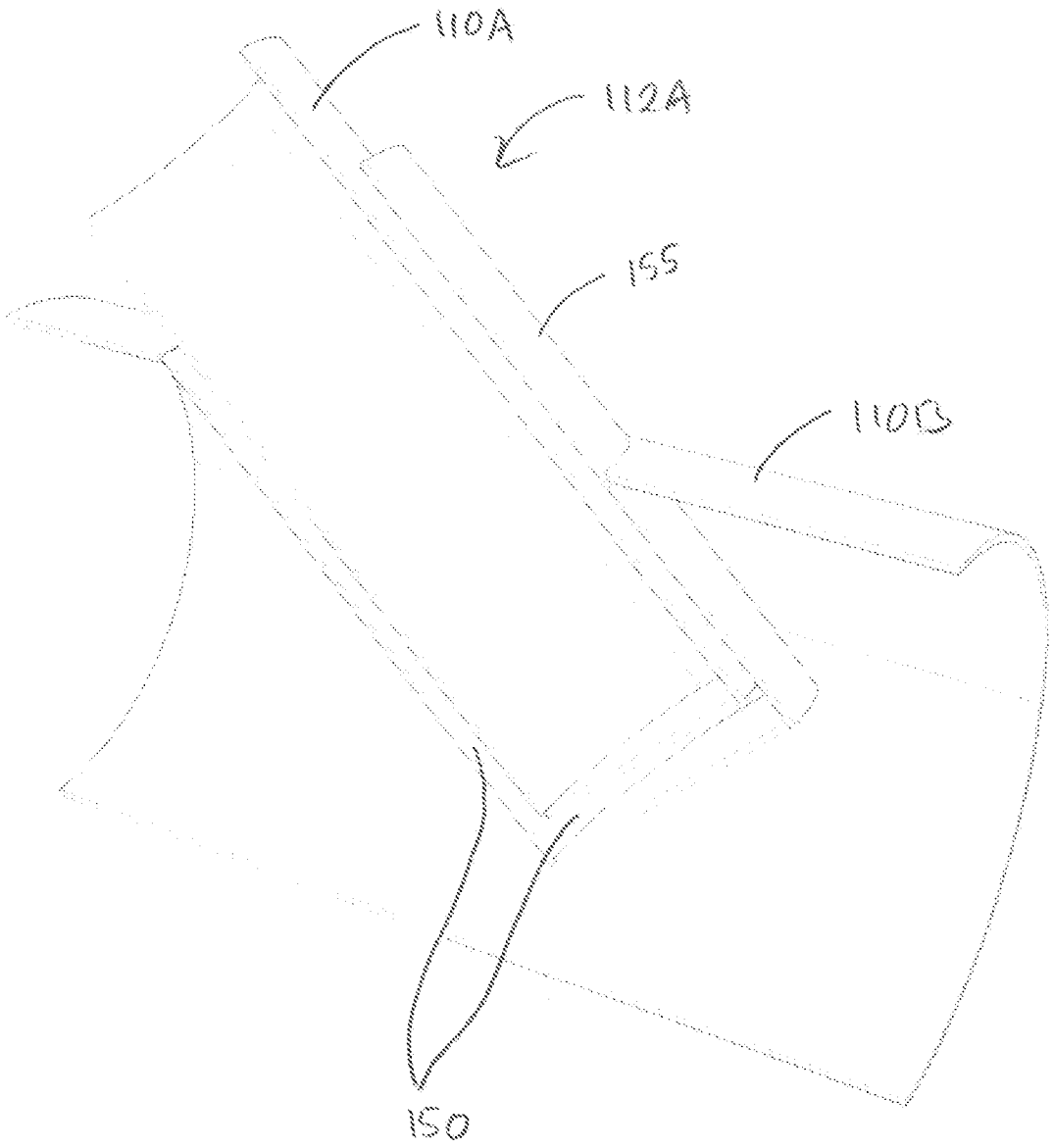

Fig. 9

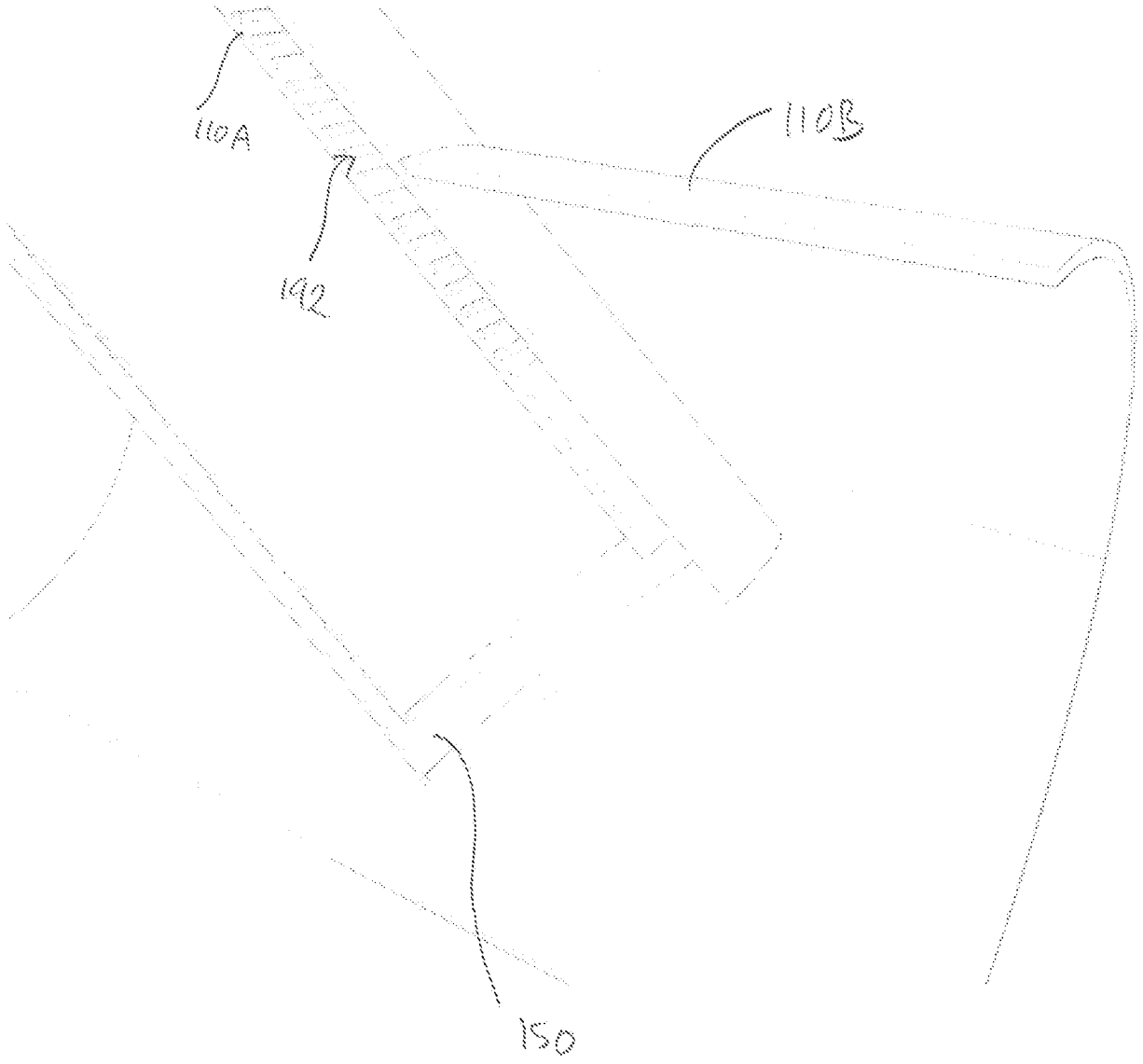

Fig. 10

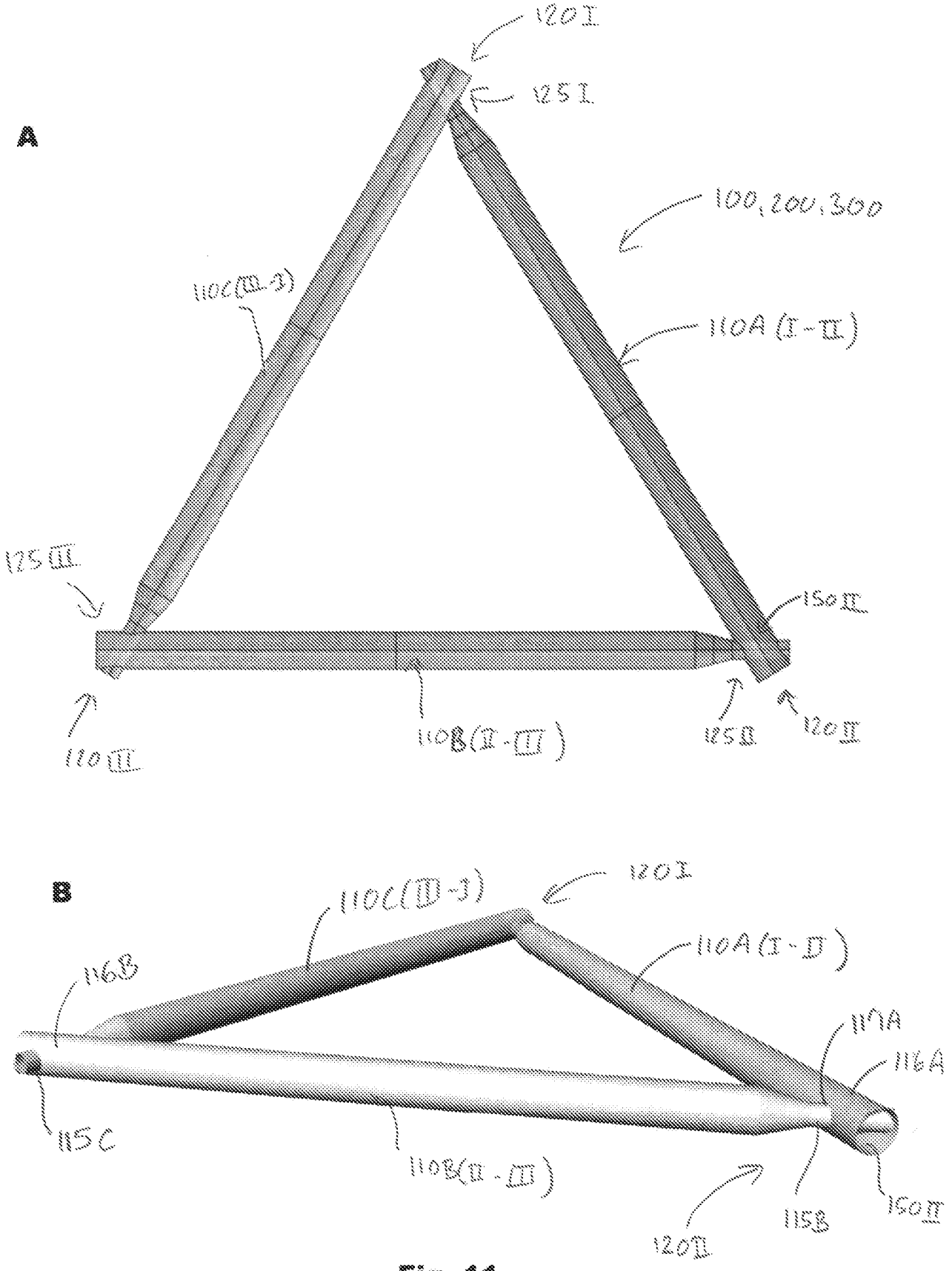
A
120 I
125 I
100, 200, 300
110C (II-3)
110A (I-II)
125 III
150 II
110 III
110B (II-III)
125 II
120 II
B
110C (II-3)
120 I
110A (I-II)
116B
117A
116A
115C
110B (II-III)
115B
160 II
120 II

Fig. 11

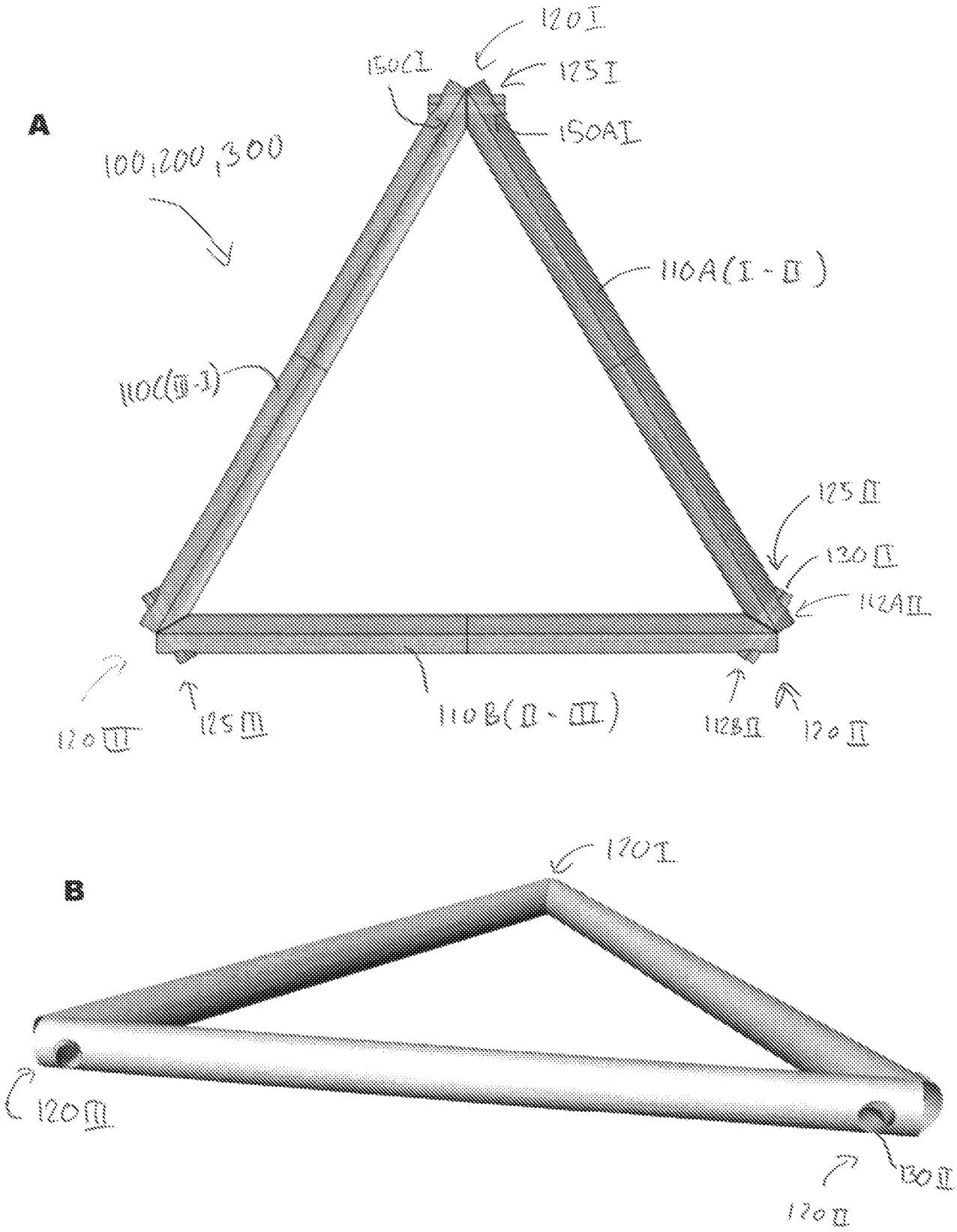
A
100,200,300
120 I
150 I
125 I
150A I
110A (I - II)
110 (III - I)
125 II
130 II
112A II
120 III
125 III
110B (II - III)
112B II
120 II
B
120 I
120 III
130 II
120 II

Fig. 12

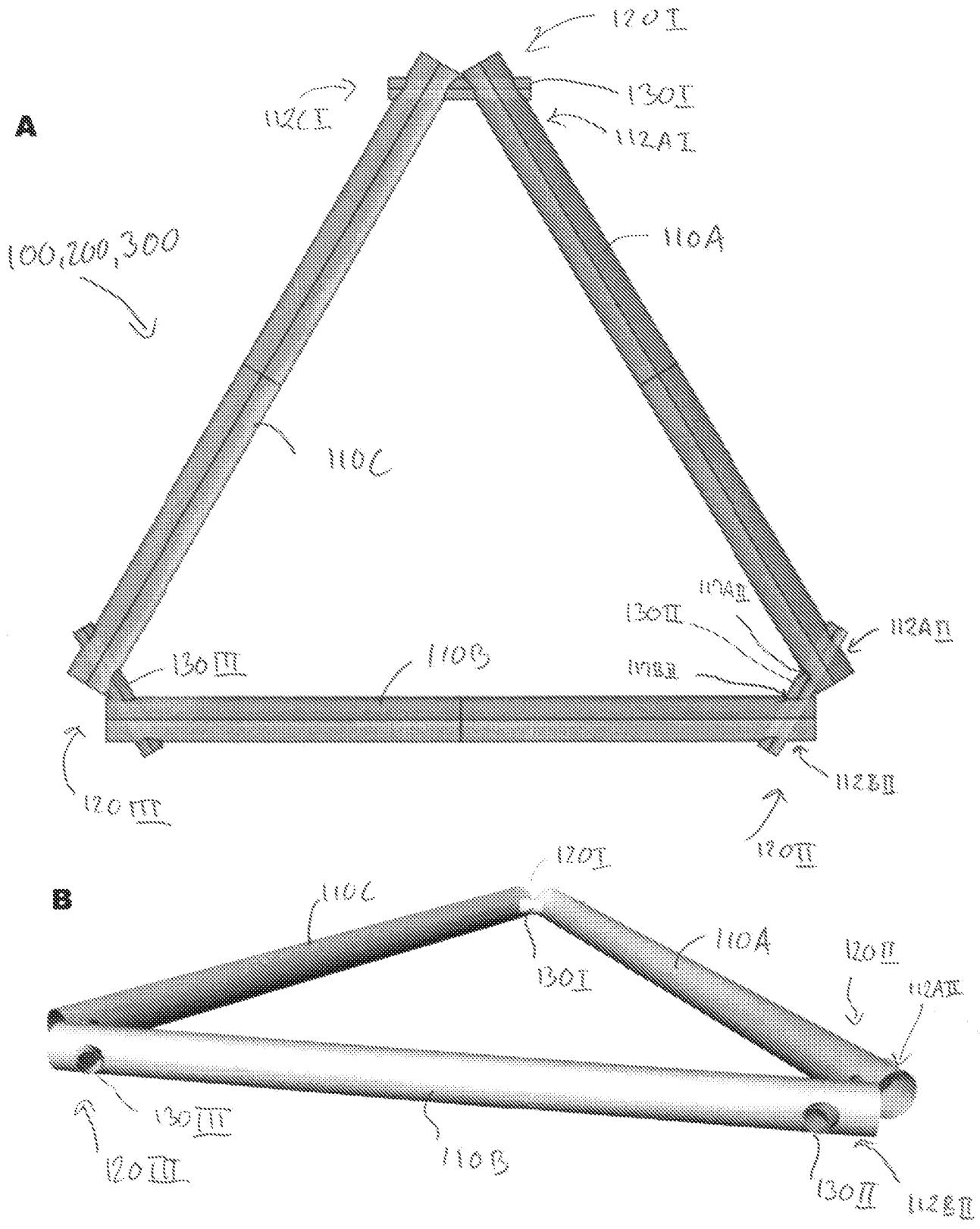
A
100,200,300
120 I
130 I
112A I
112C I
110A
110C
110B
130 III
120 III
130 II
112A II
112B II
120 II
B
110C
120 I
110A
130 I
120 II
112A II
130 III
120 III
110B
130 II
112B II

Fig. 13

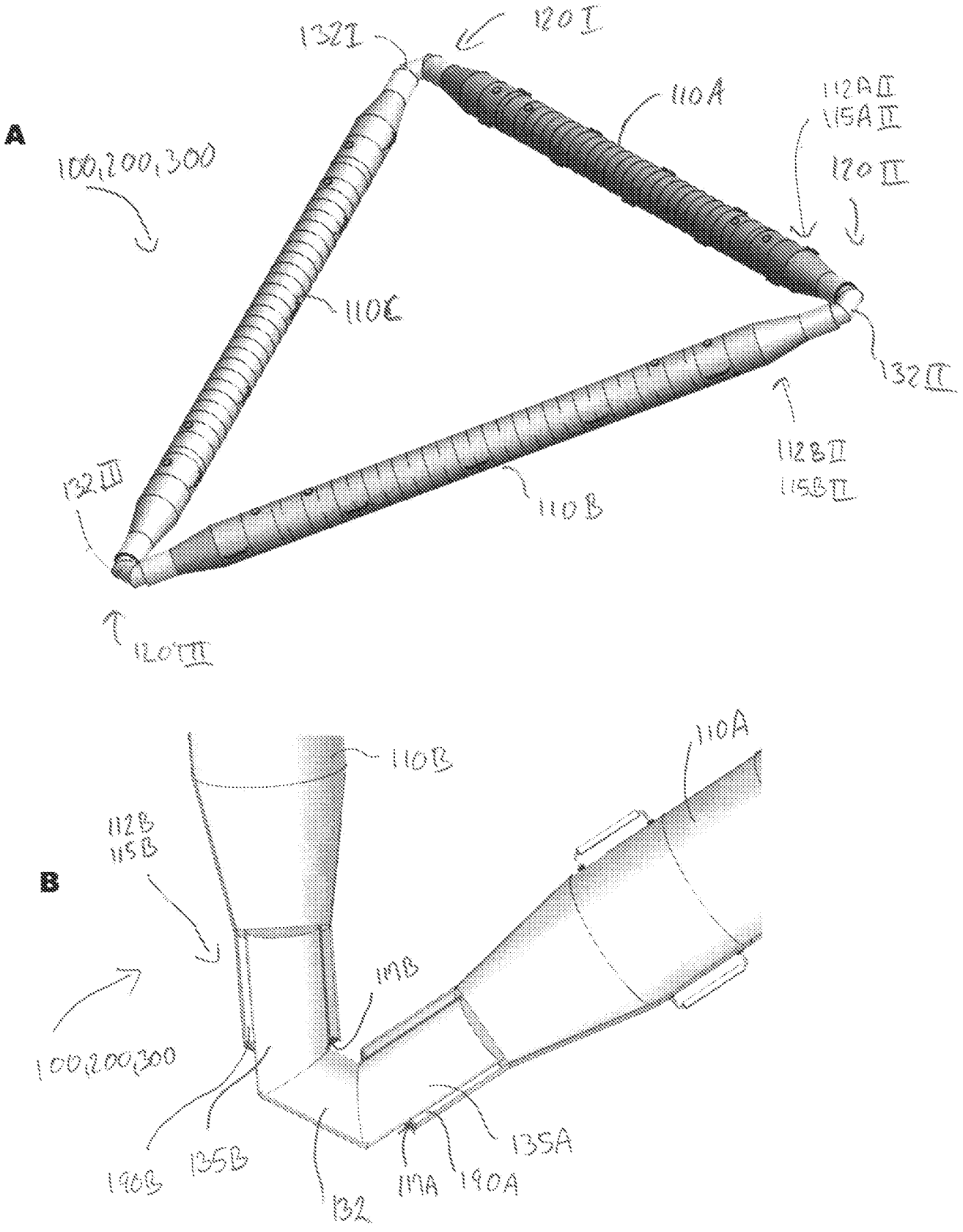
A
100,200,300
132I
120I
110A
112AII
115AII
120II
110C
132II
112BII
115BII
132III
110B
120III
B
110B
110A
112B
115B
117B
100,200,300
190B
135B
132
117A
190A
135A

Fig. 14

DANISH PATENT AND TRADEMARK OFFICE

SEARCH REPORT - PATENT	Application No. PA 2020 70470

1. ☐ Certain claims were found unsearchable (See Box No. I).

2. ☐ Unity of invention is lacking prior to search (See Box No. II).

A. CLASSIFICATION OF SUBJECT MATTER:
E02B 17/00 (2006.01); E04B 1/58 (2006.01)
According to International Patent Classification (IPC)

B. FIELDS SEARCHED

PCT-minimum documentation searched (classification system followed by classification symbols)
E02B; E04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
DK, NO, SE, FI: IPC-classes as above.

Electronic database consulted during the search (name of database and, where practicable, search terms used)
EPODOC, WPI, Fulltext: English

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant for claim No.
X Y	US 2015/0240442 A1 (JOSE M. GARCIA-VALDECASAS BERNAL et al.) 2015.08.27. See [0004], [0041], [0049], [0050], [0053], [0080] – [0084], Fig. 7, pos. 7, Fig. 8 & 9.	1 - 5, 7 - 15 5, 6
Y A	US 4722156 A (TAKANOR SATO) 1988.02.02. See Fig. 5, pos. 74 and Fig. 7, pos. 96.	5, 6 1 - 4, 7 - 15
X A	JP 2000087504 A (NIPPON STEEL CORP) 2000.03.28. See Fig. 1, 3, 4.	1, 13, 14, 15 2 - 12
X A	JP 2012077533 A (SHIMIZU CONSTRUCTION CO LTD) 2012.04.19. See Fig. 1 – 7.	1, 2, 13, 14, 15 3 - 12

☐ Further documents are listed in the continuation of Box C.

* Special categories of cited documents:	"P" Document published prior to the filing date but later than the priority date claimed.
"A" Document defining the general state of the art which is not considered to be of particular relevance.	"T" Document not in conflict with the application but cited to understand the principle or theory underlying the invention.
"D" Document cited in the application.	"X" Document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone.
"E" Earlier application or patent but published on or after the filing date.	"Y" Document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
"L" Document which may throw doubt on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified).	"&" Document member of the same patent family.
"O" Document referring to an oral disclosure, use, exhibition or other means.	

Danish Patent and Trademark Office
Helgeshøj Allé 81
DK-2630 Taastrup
Denmark

Telephone No. +45 4350 8000
Facsimile No. +45 4350 8001

Date of completion of the search report
12 January 2021

Authorized officer
Christian Ruegaard Hansen
Telephone No. +45 4350 8528

SEARCH REPORT - PATENT		Application No. PA 2020 70470
C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant for claim No.

SEARCH REPORT - PATENT	Application No. PA 2020 70470

Box No. I Observations where certain claims were found unsearchable

This search report has not been established in respect of certain claims for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched, namely:

2. ☐ Claims Nos.:
because they relate to parts of the patent application that do not comply with the prescribed requirements to such an extent that no meaningful search can be carried out, specifically:

3. ☐ Claims Nos.:
because of other matters.

Box No. II Observations where unity of invention is lacking prior to the search

The Danish Patent and Trademark Office found multiple inventions in this patent application, as follows:

SEARCH REPORT - PATENT	Application No. PA 2020 70470
SUPPLEMENTAL BOX	
Continuation of Box [.]	