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(54) **Title**: NODAL CONSTRUCTIVE SYSTEM OF RAPID ASSEMBLY FOR LOAD BEARING STRUCTURES, BUILDINGS AND ARTIFACTS OF MULTI-PURPOSE USE

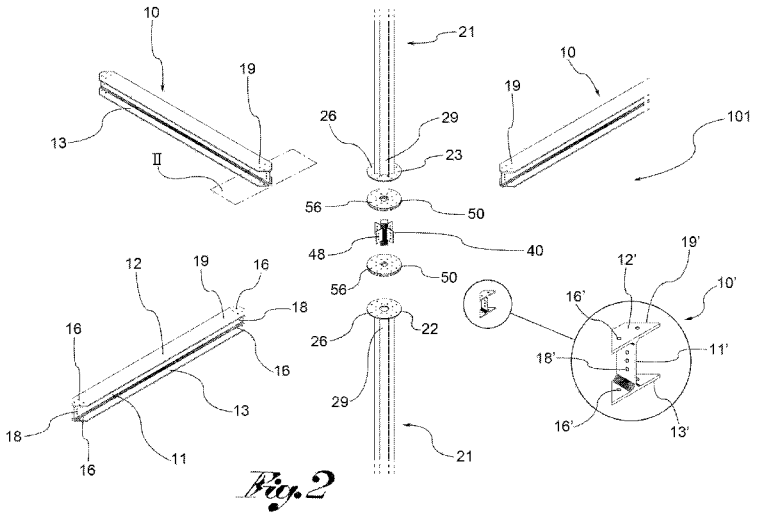

Fig. 2

(57) **Abstract**: A nodal system (30) for a load-bearing structure(100), comprising connection sections (19,19') of beams (10,10'), converging with each other towards a node (101) so as to form an interstitial space. The nodal system (30) also comprises a locking key (40) having an input configuration, wherein it is insertable in the interstitial space, and a locking configuration, rotated with respect to the input configuration, wherein it is suitable for making a mechanical connection between the connection sections (19,19') of the beams (10,10'). The nodal system (30) also has retention means (18, 18', 48, 108) for connecting the locking key (40) to, the connection sections (19,19') of the beams (10,10') so as to make them integral the one with the other.

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"Nodal constructive system of rapid assembly for load bearing structures, buildings and artifacts of multi-purpose use"

DESCRIPTION

[0001] The subject of the present invention is a nodal system for load bearing structures, of the permanent and semipermenent type. In particular, the invention concerns a nodal constructive system of rapid assembly and disassembly, for load-bearing structures, buildings and artifacts of multi-purpose use.

[0002] The load-bearing structure sector is undergoing considerable expansion because of the need to erect constructions that are quick to assemble and disassemble, and which can be easily adapted or reconfigured depending on the assigned intended use, e.g., commercial, residential, civil or social.

[0003] Said framework load-bearing structures are generally made of ferrous or other material, e.g., in wood, depending on the construction requirements. Such structures are particularly suitable for supporting buildings or artifacts of rapid assembly/disassembly, to erect buildings or constructions, if necessary compatible with anti-earthquake systems, for public and private users.

[0004] A load-bearing structure usually comprises a

plurality of elements, such as nodal systems, beams and pillars, joined by means of bolts, welding or other retention systems, to form a frame

[0005] Traditional systems for the assembly of such load-bearing structures are particularly retaining because the nodal system is made by welding the beams and/or the steel pillars or using L-shaped profile sections, called squares or linears, with subsequent assembly of the various component parts by means of bolts of different dimensions.

[0006] Because such traditional systems contemplate a welding phase, they do not allow recovering the structural components without the risk of damage and do not allow re-using them without further jobs and/or adaptations being made.

[0007] An example of load-bearing structure wherein the nodal system is made without welding is represented by patent document US6390719, wherein such nodal system is made by means of a box element and a series of L-shaped side elements, joined using bolts to the box element and suitable for supporting the beams, always fastened by means of bolts.

[0008] Such type of nodal system, comprising a large number of components, is particularly complicated to assemble/disassemble and very time consuming as regards

assembly.

[0009] The need perceived as regards frame load-bearing structures is to comprise a nodal system able to permit the rapid assembly/disassembly of the elements and, at the same time, to perfectly withstand static structural stresses.

[0010] The object of the present invention is to overcome the problems of prior art taking into account the needs of the sector.

[0011] The nodal system of the invention is particularly innovative in terms of speed of construction and strength,ease of use, ease of on-site transport and worksite movement and because it can be completely re-used after its removal, without incurring any serious damage to the elements of which it is made.

[0012] Such object is achieved by a nodal system, and assembly method and a locking key according to the claims 1, 15 and 20 and following claims. The dependent claims describe preferred or advantageous embodiments of the nodal system.

[0013] The characteristics and the advantages of the nodal system according to the present invention are clear from the description provided below by way of example only and without being limitative, in agreement with the attached illustrations, wherein:

[0014] - the figure 1 shows an axonometric view of a nodal system for a load-bearing structure, according to the present invention;

[0015] - the figure 2 shows an exploded view of a nodal system, according to the present invention;

[0016] - the figure 3 shows an axonometric view of a locking key of a nodal system, according to the present invention;

[0017] - the figures 4a and 4b show a flat view of a locking key, in input configuration and in locking configuration respectively, of a nodal system according to the present invention;

[0018] - the figure 5 shows a detail of the nodal system of figure 1;

[0019] - the figures 6a and 6b show an axonometric view, of the output face and of the input face respectively, of a vertical locking element of a nodal system, according to the present invention;

[0020] - the figure 7 shows an axonometric view of a load-bearing structure comprising a plurality of nodal systems, according to the present invention;

[0021] - the figures from 8a to 8l show the phases of a method of assembly of a nodal system, according to the present invention;

[0022] - the figure 9a shows a section of a beam of the

nodal system of figure 2 according to a section plane II-II;

[0023] - the figure 9b shows a section of a beam of the nodal system of figure 2 according to an alternative embodiment.

[0024] With reference to the attached illustrations, and in particular to the figure 7, a load-bearing structure 100 is shown.

[0025] The load-bearing structure 100 comprises a plurality of elements, such as beams 10,10' and pillars 20. The beam/beam and/or beam/pillar connection, called node 101, is made by means of a nodal system 30.

[0026] The figures 1, 2 and 5 show node 101 made by means of the nodal system 30.

[0027] The beam 10 has a substantially I-shaped section and comprises a vertical wall 11, positioned between a lower base 13 and an upper base 12.

[0028] At least one extremity of the beam 10 comprises a connection section 19 suitable for being connected to the node 101 by means of the nodal system 30.

[0029] At least one extremity of the lower base 13 and of the upper base 12, preferably in the connection section 19, have oblique cuts 14 suitable for giving the extremity itself a substantially trapezoidal shape.

[0030] At least one extremity of the lower base 13 and of

the upper base 12, preferably in the connection section 19, have holes 16, for housing screws and bolts.

[0031] At least one extremity of the vertical wall 11, preferably in the connection section 19, has holes 18, for housing screws and bolts.

[0032] The beam 10', or truncated beam 10', comprises a vertical wall 11', placed between a lower base 13' and an upper base 12'. Preferably, the lower base 13' and the upper base 12' having a substantially trapezoidal shape with oblique cuts 14'. Preferably, the lower base 13' and the upper base 12' having holes 16', for housing screws and bolts. Furthermore, the vertical wall 11' has holes 18' for housing screws and bolts.

[0033] At least one extremity of the truncated beam 10' comprises a connection section 19' suitable for connecting to a node 101 by means of the nodal system 30. Preferably, the entire truncated beam 10' is a connection section 19'.

[0034] The truncated beam 10' is an element of completion of the load-bearing structure 100, used to replace the beam 10. Normally, the beam 10' is positioned in the proximity of corners or edges of the load-bearing structure 100, e.g., in each node 101 comprising less than four beams 10. The truncated beam 10' is a closing point of the node 101, but not necessarily a closing

point of the load-bearing structure 100, inasmuch as in correspondence to a truncated beam 10' could be connected a further element of extension of the load-bearing structure 100, or any other load-bearing or non load-bearing element, such as, for example, a lean-to roof.

[0035] Preferably, the beam 10 and the truncated beam 10' are monobloc elements.

[0036] The connection sections 19,19' of the beams 10,10' converge towards the node 101 until an interstitial space is created, shown in the figures 4a and 4b. Preferably, the interstitial space is defined by the extremities of the beams 10,10' and oblique sections 14,14'.

[0037] The oblique cuts 14,14' can have different angles depending on use requirements, in particular, as shown in the figures 9a and 9b, such oblique cuts 14,14' are asymmetric with respect to the vertical wall 11,11' or to the core of the beam 10,10'. Preferably, a first oblique cut 14a,14'a is positioned at a greater distance A with respect to the vertical wall 11,11', and a second oblique cut 14b,14'b is positioned at a smaller distance B with respect to the vertical wall 11,11'.

[0038] Preferably, the first oblique cut 14a,14'a is shorter than the second oblique cut 14b,14'b. The greater length of the second oblique cut 14b,14'b is represented by the section W, defined as the distance between the

points of encounter of each oblique cut 14'a,14b,14'b with the respective side of the lower base 13,13'.

[0039] The pillar 20 comprises a central body 21 having, at least at one extremity, a connection section 29 suitable for being connected to a node 101 by means of the nodal system 30.

[0040] The pillar 20 also comprises, preferably in the connection section 29, a vertical locking element 22,23 having holes 26 for housing screws and bolts. Preferably, the vertical locking element 22,23 is a pedestal 22,23. Even more preferably, the pedestal 22,23 is all one piece with the pillar 20.

[0041] Preferably, the pillar 20 comprises a lower pedestal 23 and an upper pedestal 22. Preferably, the pillar 20 is a monobloc element.

[0042] The nodal system 30 also comprises a locking key 40, suitable for operating in rotation to make the connection of the node 101, i.e., the beam/beam and/or beam/pillar and/or pillar/pillar mechanical connection.

[0043] Preferably, as shown in the figures 4a and 4b, the locking key 40, with axis Z, is suitable for switching from

[0044] - an input configuration (figure 4a), wherein the locking key 40 can be inserted in the interstitial space defined by the connection sections 19,19' of the beams

10,10', to

[0045] - a locking configuration (figure 4b), rotated around the axis Z with respect to the input configuration, wherein the locking key 40 is suitable for making a mechanical connection between the connection sections 19,19' of the beams 10,10'.

[0046] Preferably, in the locking configuration, the locking key 40 is rotated by 45° with respect to the input configuration.

[0047] The direction of rotation of the locking key 40 is defined in relation to the greater distance A. Preferably, the locking key 40 is rotated in the direction of the first oblique cut 14a,14'a, and therefore in the direction of the greater distance A. In the configuration shown in figure 9a, the locking key 40 is rotated in a counterclockwise direction. In the variation shown in figure 9b, the locking key 40 is rotated in clockwise direction.

[0048] As shown in figure 3, the locking key 40 comprises a central body 41, substantially cylindrical, elongated along the axis Z.

[0049] The locking key 40 comprises at least a protrusion or wing 42, which protrudes from the central body 41 and extends radially to this. The wing 42, for example, is fitted by welding, die casting or other fastening

systems, along the central body 41 of the locking key 40.

[0050] Preferably, the locking key 40 comprises a plurality of wings 42, angularly equisdistant around the central body 41. The number of wings 42 depends on the structural requirements of the node 101, and in general, on the load-bearing structure 100. Preferably, the locking key 40 comprises four wings 42.

[0051] Preferably, the wings 42 are out of axis with respect to the axis Z of the central body 41.

[0052] Preferably, the wing 42 is substantially rectangular, even more preferably trapezoidal. The trapezoidal shape of the wings 42 facilitates the rotation of the locking key 40 from the input configuration to the locking configuration. In fact, the presence of oblique sides due to the trapezoidal shape, with longer base along the central body 41, prevents the rotation of the wings 42 from being hindered by any protuberances or protrusions on the beams 10,10', such as screws and bolts for example.

[0053] Preferably, the wing 42 comprises holes 48 for housing the screws and bolts, arranged longitudinally.

[0054] Preferably, the wings 42 of the locking key 40 ensure the horizontal fitting of the beams 10,10' to form the node 101. Even more preferably, the wings 42 of the locking key 40 also ensure a second alignment of the

beams 10,10' and consequently, the static check of the beams themselves. By changing the shape of the wings 42 and the position of the holes 48, the oblique fitting can also be made of the beams 10,10'.

[0055] The locking key 40 also comprises a shape element 43,44 positioned at one axial extremity of the central body 41.

[0056] Preferably, the shape element 43,44 is polygonal, e.g., rectangular, square, preferably star shaped.

[0057] Preferably, the shape element 43,44 comprises protrusions or edges 45, which protrude radially with respect to the central body 41. The edges 45 protrude radially from the central body 41 in correspondence to the wings 42. Preferably, the shape element 43,44 comprises four protrusions 45 angularly equidistant.

[0058] Preferably, the shape element 43,44 is inscribable in a square, wherein the edges 45 are placed substantially in correspondence to the diagonals of the square.

[0059] Preferably, the locking key 40 comprises two shape elements, an upper shape element 43 and a lower shape element 44.

[0060] Preferably, the locking key 40 is all one piece or monobloc.

[0061] During the assembly of the locking key 40 in the

node 101, as shown in the figures 4a and 4b, the locking key 40 is inserted, in an input configuration, in the interstitial space between the beams 10, 10'. The interstitial space must be such as to allow the transit of the wings 42 and of the shape element 43,44. In particular, the amplitude of the interstitial space is regulated by adjusting the different length of the oblique cuts 14a,14'a and 14b,14'b, and therefore by means of the section W.

[0062] Once inserted, the locking key 40 is rotated in a locking configuration, configuration rotated around the axis Z with respect to the input configuration, wherein the wings 42 are between the lower base 13,13' and the upper base 12,12' of each beam 10, 10', in such a way that the locking key 40 cannot be extracted from the interstitial space between the beams 10,10'.

[0063] In the locking configuration, the wings 42 abut against the vertical wall 11,11' of the connection sections 19,19' of each beam 10, 10'. The out-of-axis position of the wings 42 with respect to the central body 41 permits achieving a correct alignment of the wings 42 abutted against the vertical wall 11,11' of each beam 10,10'. Furthermore, the wing 42 is abutted against the vertical wall 11,11' on the side of the greater distance A, distance that permits adequately accommodating the

thickness of the wing itself.

[0064] Once the wings 42 are abutted against the vertical wall 11,11' of each beam 10, 10', the holes 48 of the wings 42 are aligned with the holes 18,18' of the vertical wall 11,11', so as to permit the transit of screws and bolts. Preferably, on the vertical locking element 22,23,50 or on a different supporting element of the node 101, an end stop element is provided which facilitates the aligning the holes 48 of the wings 42 with the holes 18,18' of the vertical wall 11,11'.

[0065] Preferably, the locking key 40 is ensured in locking configuration by means of the coupling of the wings 42 to the vertical walls 11,11' of the beams 10, 10', coupling achieved by means of screws and bolts 108 inserted at the same time in a hole 48 and in a hole 18,18', so as to prevent any rotation of the locking key 40 in the opposite direction with respect to the rotation of the locking configuration.

[0066] In one preferred embodiment of the invention, the nodal system 30 comprises:

[0067] - connection sections 19,19' of beams 10,10', converging on one another towards a node 101 until an interstitial space is created;

[0068] - a locking key 40, with axis Z, having an input configuration, wherein the locking key 40 is insertable

in the interstitial space, and a locking configuration, rotated around the axis Z with respect to the input configuration, wherein the locking key 40 is suitable for making a mechanical connection between the connection sections 19,19' of the beams 10,10';

[0069] - retention means 18,18',48,108 suitable for connecting the locking key 40 to the connection sections 19,19' of the beams 10,10' so as to make them integral the one with the other.

[0070] Preferably, the retention means 18,18',48,108 comprise the holes 48 made on the wings 42, the holes 18,18' made on the beams 10,10', screws and bolts 108.

[0071] Preferably, the nodal system 30 also comprises at least a vertical locking element 22,23,50 suitable for mechanically collaborating with the locking key 40 to make the connection of the node 101, i.e., the beam/beam and/or beam/pillar and/or the pillar/pillar connection.

[0072] The vertical locking element 22,23,50 can be of any shape, preferably square, rectangular, and still more preferably substantially round.

[0073] Preferably, the vertical locking element is a plate 50. Preferably, the nodal system 30 comprises two plates 50, each suitable for mechanically cooperating with one of the shape elements 43,44 of the locking key 40 to make the connection of the node 101, i.e., the beam/beam

and/or beam/pillar and/or pillar/pillar connection.

[0074] In an embodiment variation, the vertical locking element 22,23 is all one piece with the pillar 20. Preferably the vertical locking element is the pedestal 22,23 of a pillar 20.

[0075] The vertical locking element 22,23,50 comprises holes 56 for housing the screws and bolts suitable for achieving the mechanical fastening of the vertical locking element 22,23,50 and the pillar 20 and/or of the vertical locking element 22,23,50 and one or more beams 10, 10'. Furthermore, the holes 56 can house screws and bolts suitable for achieving the mechanical fastening of the vertical locking element 22,23,50 to other constructive elements.

[0076] The vertical locking element 22,23,50 also comprises an aperture 51. Preferably, the aperture 51 is arranged centrally on the vertical locking element 22,23,50.

[0077] Preferably, the aperture 51 has a polygonal shape, e.g., rectangular, square, preferably star shaped.

[0078] The aperture 51 comprises:

[0079] - walls suitable for permitting the input of the shape element 43,44, in input configuration, and

[0080] - an abutment 52 suitable for creating an axial restraint to the extraction of the shape element 43,44, in locking configuration.

[0081] The shape element 43,44 of the locking key 40 is in fact insertable, in the input configuration, in the aperture 51, and is suitable for realizing a shaped coupling realizing an axial restraint with the vertical locking element 22,23,50 in the locking configuration.

[0082] To make a correct shaped coupling, the shape element 43,44 of the locking key 40 has a shape inscribable in the aperture 51 and which can be coupled with the shape of such aperture 51 in a slot-in system.

[0083] Preferably, the aperture 51 of the vertical locking element 22,23,50 is a through aperture. Said aperture 51 presents itself, on each face of the vertical locking element 22,23,50, with a different shape or with the same shape but rotated.

[0084] The nodal system 30 also comprises fastening means 16,16',56,106 suitable for mechanically connecting the vertical locking element 22,23,50 to the connection sections 19,19' of the beams 10,10' to make them integral the one with the other.

[0085] Preferably, the fastening means 16,16',56,106 comprise the holes 56 made on the vertical locking element 22,23,50 and/or the holes 16,16' made on the beams 10,10', screws and bolts 106.

[0086] Preferably the holes 16,18,26,48,56 of the nodal system 30 are already threaded to allow locking without

nuts and/or accommodating other retention means inherent at origin.

[0087] In one embodiment of the invention, a load-bearing structure 100 comprises a plurality of beams 10,10' and pillars 20, and the beam/beam and/or beam/pillar and/or pillar/pillar connection is made by means of a nodal system 30 in agreement with the invention.

[0088] The figures from 8c to 8e show a method of assembly of node 101 of a load-bearing structure 100.

[0089] The method of assembly of a nodal system 30 for a load-bearing structure 100, comprises the phases of:

[0090] - preparing connection sections 19,19' of beams 10,10', a locking key 40 and retention means 18,18',48,108 between said connection sections 19,19' and said locking key 40;

[0091] - preparing said connection sections 19,19' of beams 10,10' converging towards a node 101 until an interstitial space is realized (figure 8c);

[0092] - inserting the locking key 40, in an input configuration, in said interstitial space (figure 8d);

[0093] - turning the locking key 40 in a locking configuration, turned with respect to the input configuration (figure 8d);

[0094] - fastening the locking key 40, in locking configuration, to said connection sections 19,19' of

beams 10,10' by means of said retention means 18,18',58,108 so as to make them intergral with one another (figure 8d).

[0095] The assembly method also comprises, before the locking key 40 insertion phase, the following phases:

[0096] - preparing a lower vertical locking element 22,50 having an aperture 51 and fastening means 16,16',56,106 (figure 8b);

[0097] - fastening said connection sections 19,19' of beams 10,10' to the lower vertical locking element 22,50 by means of said fastening means 16,16',56,106 so as to make them integral the one with the other (figure 8b).

[0098] The assembly method also comprises, after the locking key 40 fastening phase, the following phases:

[0099] - preparing an upper vertical locking element 23,50 having an aperture 51 suitable for the transit of said shape element 43;

[00100] - fitting said upper vertical locking element 23,50 over the shape element 43 of the locking key 40 (figure 8e);

[00101] - turning said upper vertical locking element 23,50 above the locking key 40 so as to realize a shaped coupling creating an axial restraint with said locking key 40 (figure 8e);

[00102] - fastening said connection sections 19,19' of

beams 10,10' to said upper vertical locking element 23,50 by means of said fastening means 16,16',56,106 so as to make them integral the one with the other (figure 8e).

[00103] Preferably, for the correct assembly of the nodal system 30, it is essential to follow a precise assembly sequence, summarized in the subsequent phases.

[00104] Phase A: install a vertical locking element 22,50 having an aperture 51; arrange the beams 10,10' so the holes 16,16' of the lower base 13,13' coincide with the holes 56,26 prepared on the vertical locking element 22,50 and so the connection sections 19,19' realize an interstitial space; proceed to fasten (vertical locking element - beams) by means of the suitable fastening systems 106; insert the locking key 40 in the interstitial space realized between the connection sections 19,19' of the beams 10,10', making sure of having penetrated the aperture 51 of the vertical locking element 22,50 with the shape element 44 of the locking key 40.

[00105] Phase B: turn the locking key 40 by 45° (or other degree according to the need of the nodal system 30) so as to obtain the locking of the locking key 40 and the alignment of the holes 48 of the wings 42 with the holes 18,18' of the vertical wall 11,11' of the beams 10,10'; proceed to fasten (locking key - beams) by means

of the suitable retention means 108.

[00106] Phase C: close the nodal system 30 inserting a further vertical locking element 23,50, having an aperture 51, on the locking key 40, so the shape element 43 of the locking key 40 penetrates the aperture 51 of the further vertical locking element 23,50; turn the further vertical locking element 23,50 by 45° (or other degree according to the need of the nodal system 30) so as to obtain the locking of the further vertical locking element 23,50 and the alignment of the holes 56,26, provided on the further vertical locking element 22,50, with the holes 16,16' of the upper base 12,12' of the beams 10,10'; proceed to fasten (further vertical locking element - beams) by means of suitable retention systems 106.

[00107] Each node 101 can have various horizontal extension configurations, depending on the use of more or less truncated beams 10' (which preferably realize a closing point of the structure) of more or less beams 10 (which preferably realize an extension point of the structure). Some of the possible configurations of the node 101, shown in figure 7, are, for example:

[00108] - single node 101a, made up of three truncated beams 10' and one beam 10;

[00109] - double node 101b, consisting of two truncated

beams 10' and two beams 10;

[00110] - triple node 101c, consisting of one truncated beam 10' and three beams 10;

[00111] - quadruple node 101d, consisting of four beams 10.

[00112] The figures from 8b to 8l show a method of assembly of a module 120 of a load-bearing structure 100.

[00113] The method of assembly of a module 120 of the load-bearing structure 100 comprises the following phases:

[00114] - realizing a lower base 121 of the module 120 by means of beams 10,10': connecting each beam 10, to both the extremities, with another beam 10 by means of a first nodal system 30 (figures from 8c to 8e);

[00115] - realizing the height 122 of the module 120 by means of pillars 20: fastening, by means of fastening means 16,16',56,106, each pillar 20 to the upper vertical locking element 23,50 of the first nodal system 30 (figure 8f);

[00116] - realizing the upper base 123 of the module 120 by means of the beams 10,10': connecting each beam 10, to both the extremities, with another beam 10 by means of a second nodal system 30, and fastening, by means of the fastening means 16,16',56,106, each pillar 20 to the lower vertical locking element 22,50 of the

second nodal system 30 (figures from 8g to 8l).

[00117] The figures from 8a to 8l show a method for assembling a load-bearing structure 100.

[00118] The method of assembly of a load-bearing structure 100 comprises the phases of realizing a plurality of modules 120 (figures from 8b to 8l).

[00119] Preferably, the method of assembly of a load-bearing structure 100 also comprises, before the phase of realizing a plurality of modules 120, the following phases:

[00120] - preparing support plinths 60 (figure 8a);

[00121] - fastening any anti-earthquake devices 70, preferably a seismic isolation device, on support plinths 60 by means of retention means (figure 8a);

[00122] The parts making up the nodal system (locking key and locking element) can be made in any metal alloy, preferably iron or steel, in wood and by-products, in composite metal and wood material, in plastic material, in glass. Preferably, such elements are made from sustainable material and recyclable using traditional industrial processes.

[00123] Preferably, the elements making up the nodal system (locking key and locking element) have special finishes against atmospheric agents and time wear, or anything else invasive or deteriorating in relation to

the type of use and to the chosen material.

[00124] The nodal system can also present itself in different forms, but it is essential that the technical locking solution be realized by the compound presence of two different forms (locking key shape element - opening of locking element) perfectly penetratable in an input solutions and subsequently rotatable in an output solution which determines its locking. Such locking is further stiffened by a retention system of various kind and form (e.g., screws and bolts), including deriving from a traditional lock preferably fitted on the locking key, so as to ensure greater protective safety against tampering by third parties or access to the central system, besides acting as a further stiffening of the structure. The lock could comprise one or more mobile components, preferably flexible, and thus have the task of permitting or preventing the oscillation of the nodal system.

[00125] Preferably, for a correct assembly and fitting of the node, it is essential that the drilling of the various component elements (beams, pillars, locking key, locking element) be dimensionally constant so as to allow a perfect alignment of the holes for fitting the various elements, and a simplification of the relative types of retention means.

[00126] Innovatively, a nodal system for load-bearing structures according to the present invention permits the fast assembly and disassembly of the components and, at the same time, provides excellent resistance to the static stresses of the structure.

[00127] Advantageously, a nodal system for load-bearing structures according to the present invention permits a reconfiguration and a different directionality of the beam/pillar components according to the requirements in question.

[00128] Advantageously, a nodal system for load-bearing structures according to the present invention permits extensions/retentions of the single modules of the load-bearing structure without necessarily intervening with changes to the entire structure as a whole.

[00129] Advantageously, a nodal system for load-bearing structures according to the present invention ensures simplicity of construction and rapidity of assembly.

[00130] Advantageously, a nodal system for load-bearing structures according to the present invention implies less construction effort and less movement of weights.

[00131] Advantageously, a nodal system according to the present invention does not require on-site machining operations but only the sequential assembly of the components, and allows using non-qualified personnel,

with consequent cost cutting.

[00132] Advantageously, a nodal system according to the present invention, consisting as it does of just a few elements, identical, which can be coupled or stacked, permits the optimization of the packaging and transport spaces of the elements themselves, as well as the removal of such elements without incurring damage to the materials making it up, such as to force them to be replaced.

[00133] Advantageously, a nodal system according to the present invention permits simplifying current worksite transport and storage logistic systems and/or completely eliminating storage areas, inasmuch as the structure can be assembled a little at a time as the means of transport used is gradually emptied.

[00134] Advantageously, a nodal system according to the present invention, being modularly implementable and easy to transport, is also particularly suitable for marketing through "type" structure assembly kits and/or their predefined implementations. Such a marketing system can help simplify the management phases of the production warehouse and automated shipment, providing a large saving in terms of time, costs and organization, with consequent reduction of environmental impact and direct and indirect pollution.

[00135] Advantageously, a nodal system according to the present invention, being repeatable in the load-bearing structure and immediately assemblable, can be immediately used on site without large storage spaces being required.

[00136] Advantageously, a nodal system according to the present invention permits a considerable reduction in environmental impact and direct and indirect pollution.

[00137] Advantageously, a nodal system according to the present invention is suitable for the realization of: commercial buildings, dwelling houses; public buildings and spaces; frameworks for fire-escape ladders, for lifts; gangways for bicycle-pedestrian use, for railway/road use, for lean-to roofs, for structural car-parks; gazebos; bridges; grandstands; stands; stages; platforms; greenhouses; metal roofs; containment structures for excavation works; accessory structures for industry in general, for telecommunications, for renewable energies, for serving a non-invasive building system adaptable to risk contexts, for laminated beam systems for roofs, more in general, to replace traditional construction systems without any limits as regards use, fruition, extension and intended use.

[00138] Advantageously, a nodal system according to the present invention is suitable for being combined with traditional structural systems and compatible materials,

such as tensile structures or the like and/or a consequence of a pre-existing structure, e.g., being used in the realization of added storeys, extensions and internal, external and underground structural consolidations of traditional buildings.

[00139] A technician in the sector could clearly make changes to the device described above, all falling within the protection scope defined by the following claims.

CLAIMS

1. Nodal system (30) for a load-bearing structure (100), comprising:

- connection sections (19,19') of beams (10,10'), converging with each other towards a node (101) so as to form an interstitial space;

- a locking key (40), with axis Z, having an input configuration, wherein said locking key (40) is insertable in said interstitial space, and a locking configuration, rotated around the axis Z with respect to the input configuration, wherein said locking key (40) is suitable for making a mechanical connection between said connection sections (19, 19') of beams (10, 10');

- retention means (18,18',48,108) suitable for connecting said locking key (40) with said connection sections (19,19') of beams (10,10') so as to make them integral the one with the other.

2. Nodal system (30), according to claim 1, wherein said locking key (40) comprises a central body (41) and wings (42), which project from the central body (41) and extend radially to it, and wherein said retention means (18,18',48,108) comprise holes (48) made on the wings (42).

3. Nodal system (30), according to claim 1 or 2, comprising four wings (42) angularly equidistant around

the central body (41) and having a substantially trapezoidal shape.

4. Nodal system (30), according to claim 2 or 3, wherein, in the locking configuration, the wings (42) abut against a vertical wall (11,11') of said connection sections (19,19') of the beams (10,10') in such a way that the holes (48) of the wings (42) are aligned with the holes (18,18') provided on said vertical wall (11,11').

5. Nodal system (30), according to any of the previous claims, further comprising at least one vertical locking element (22,33,50) having an aperture (51) provided with an abutment (52), and wherein said locking key (40) comprises a respective shape element (43,44) insertable, in the input configuration, in the aperture (51), and suitable for realising a shaped coupling which forms an axial constraint with said vertical locking element (22,30,50), in the locking configuration.

6. Nodal system (30), according to claim 5, wherein the walls delimiting said aperture (51) are suitable for permitting the entrance of said shape element (43,44), in input configuration, and the abutment (52) is suitable for forming an axial constraint to the extraction of said shape element (43,44), in the locking configuration,

and/or wherein said shape element (43,44) is positioned at the axial extremity of the central body (41) and

comprises edges (45) which project radially in relation to the central body (41).

7. Nodal system (30), according to claim 5 or 6, further comprising attachment means (16,16',56,106) suitable for mechanically connecting said at least one vertical locking element (22,23,50) to said connection sections (19,19') of beams (10,10') so as to make them integral the one with the other, and wherein said attachment means (16,16',56,106) comprise holes (56) made on said at least one vertical locking element (22,23,50).

8. Nodal system (30), according to any of the claims from 5 to 7, wherein the nodal system (30) comprises at least one connection section (29) of a pillar (20), and wherein at least one vertical locking element (22,23,50) is all one piece with said pillar (20),

and/or wherein at least one vertical locking element (22,23,50) is a plate (50).

9. Nodal system (30), according to claim 8, further comprising:

- at least one connection section (29) of a pillar (20), and
- attachment means (16,16',56,106) suitable for mechanically connecting said plate (50) to said connection sections (29) of a pillar (20) so as to make them integral the one with the other, wherein said

attachment means (16,16',56,106) comprise holes (56) made on the plate (50).

10. Load-bearing structure (100), comprising a plurality of beams (10,10') and pillars (20), wherein the beam/beam and/or beam/pillar and/or pillar/pillar connection is made by means of a nodal system (30), according to any of the previous claims.

11. Method of assembly of a nodal system (30) for a load-bearing structure (100), comprising the steps of:

- preparing connection sections (19,19') of beams (10,10'), a locking key (40) and retention means (18,18',48,108) between said connection sections (19,19') and said locking key (40);
- positioning said connection sections (19,19') of beams (10,10'), converging towards a node (101) so as to form an interstitial space;
- inserting the locking key (40), in an input configuration, in said interstitial space;
- rotating the locking key (40) to a locking configuration, rotated in relation to the input configuration;
- fastening the locking key (40), in locking configuration, to said connection sections (19,19') of beams (10,10') by means of said retention means (18,18',48,108) so as to make them integral the one with

the other.

12. Assembly method, according to claim 11, wherein said locking key (40) comprises a respective shape element (44) insertable, in the input configuration, in said aperture (51), and suitable for realizing a shaped coupling which forms an axial constraint with said vertical locking element (22,50), in the locking configuration, and further comprising, before the step of inserting the locking key (40), the steps of:

- preparing a vertical locking element (22,50) having an aperture (51) and attachment means (16, 16',56,106);
- fastening said connection sections (19,19') of beams (10,10') to the vertical locking element (22,50) by means of said attachment means (16,16',56,106) so as to make them integral the one with the other.

13. Assembly method, according to claim 11 or 12, wherein said locking key (40) comprises a shape element (43), and further comprising, after the step of fastening the locking key (40), the steps of:

- preparing a vertical locking element (23,50) having an aperture (51) suitable for the transit of said shape element (43);
- fitting said vertical locking element (23,50) over the shape element (43) of the locking key (40);
- rotating said vertical locking element (23,50) over the

locking key (40) so as to form a shaped coupling which forms an axial constraint with said locking key (40);

- fastening said connection sections (19,19') of beams (10,10') to said vertical locking element (23,50) by means of said attachment means (16,16',56,106) so as to make the integral the one with the other.

14. Method of assembly of a module (120) for a load-bearing structure (100), comprising the steps of:

- making a lower base (121) of the module (120) by means of beams (10,10'): connecting each beam (10), at both extremities, to another beam (10) by means of a first nodal system (30) according to the method in accordance with claim 18;

- forming the height (122) of the module (120) by means of pillars (20): fastening, by means of attachment means (16,16',56,106), each pillar (20) to the further vertical locking element (22,33,50) of the first nodal system (30);

- making the upper base (123) of the module (120) by means of beams (10,10'): connecting each beam (10), at both extremities, to another beam (10) by means of a second nodal system (30) according to the method in accordance with any of the claims from 15 to 18, and fastening, by means of attachment means (16,16',56,106), each pillar (20) to the vertical locking element

(22,33,50) of the second nodal system (30).

15. Locking key (40), suitable for forming a mechanical connection between components, comprising:

- a central body (41) with axis Z;
- wings (42) which protrude from the central body (41), extend radially from it, and comprise holes (48);
- two shape elements (43,44) positioned at the extremities of the central body (41) and comprising edges (45) which project radially in relation to the central body (41);

wherein said locking key (40), is suitable for switching from an input configuration, wherein said locking key (40) is suitable for being inserted between components to be mechanically connected, to a locking configuration, rotated around the axis Z with respect to to the input configuration, wherein said locking key (40) is suitable for forming a mechanical connection between the components to be connected by means of the wings (42) and the shape elements (43,44).

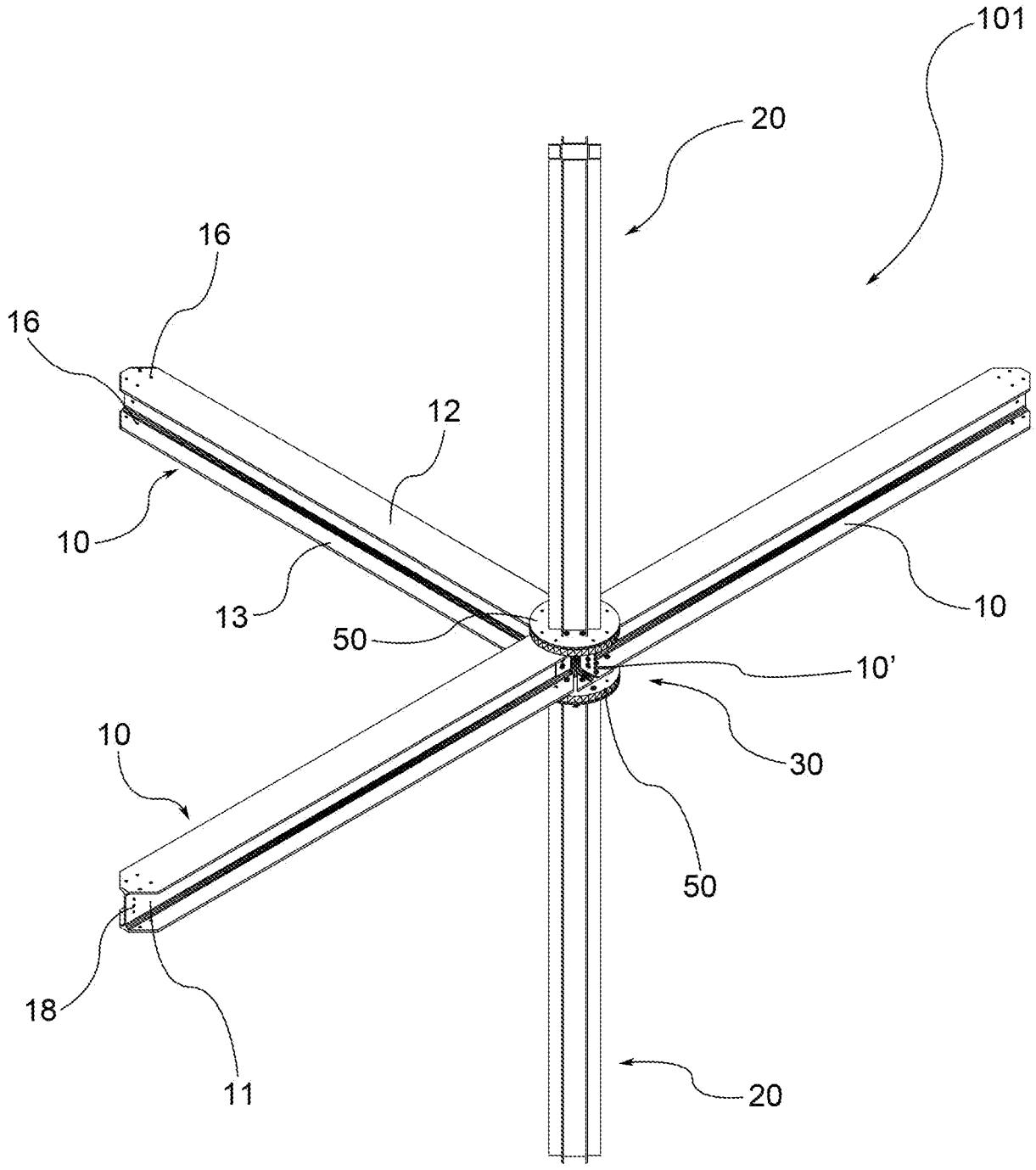

Fig.1

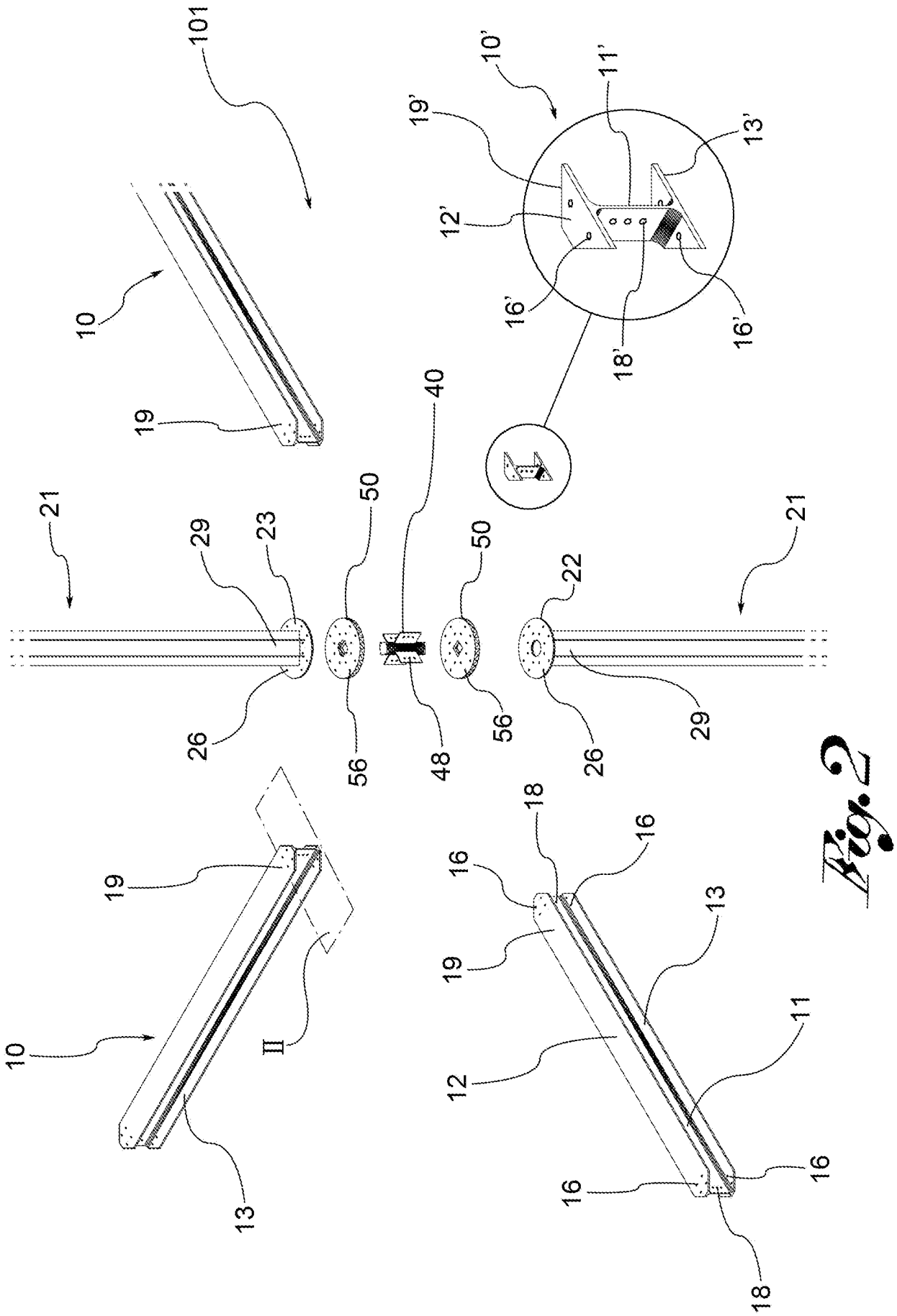
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Fig. 2

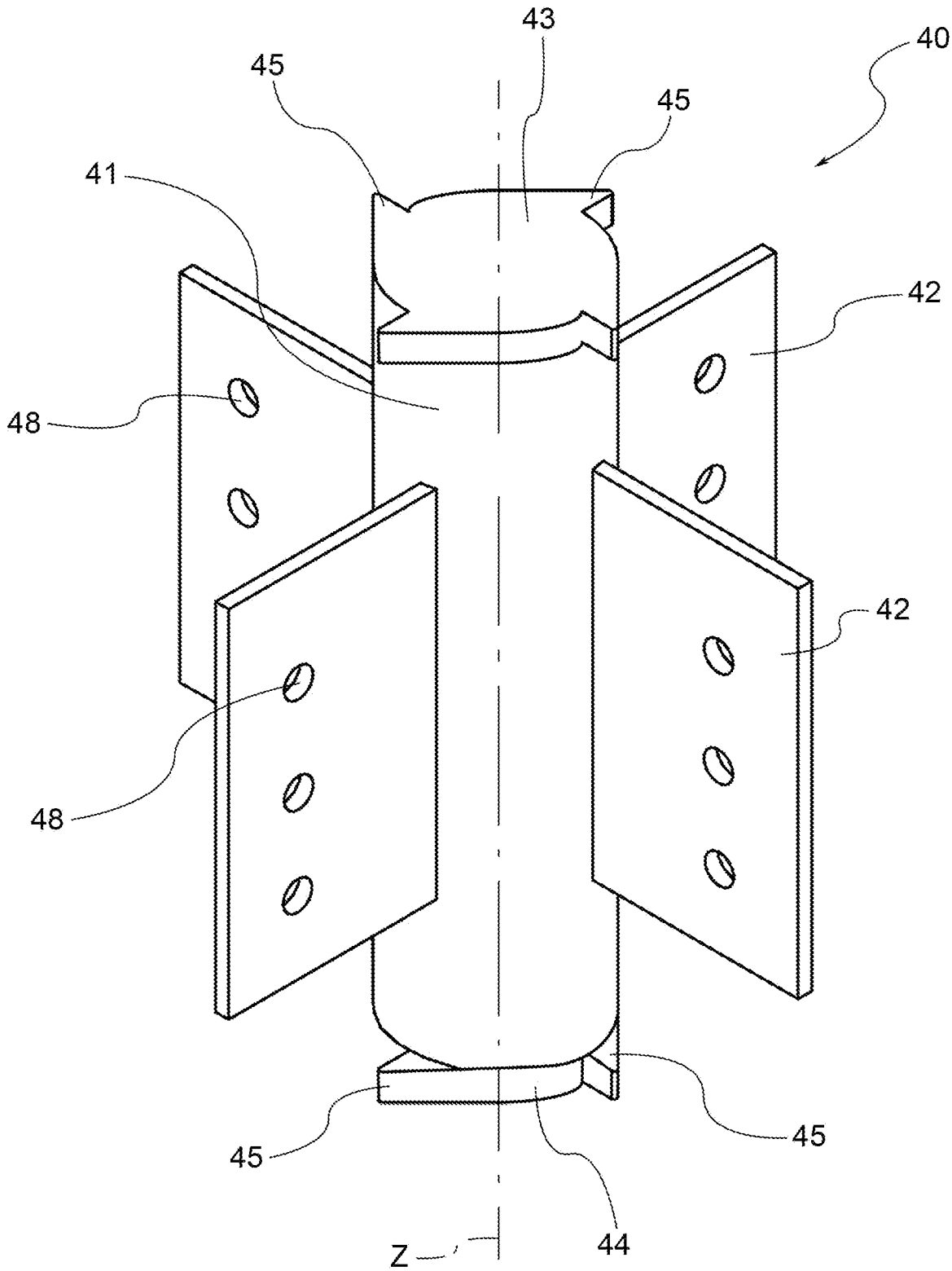

Fig.3

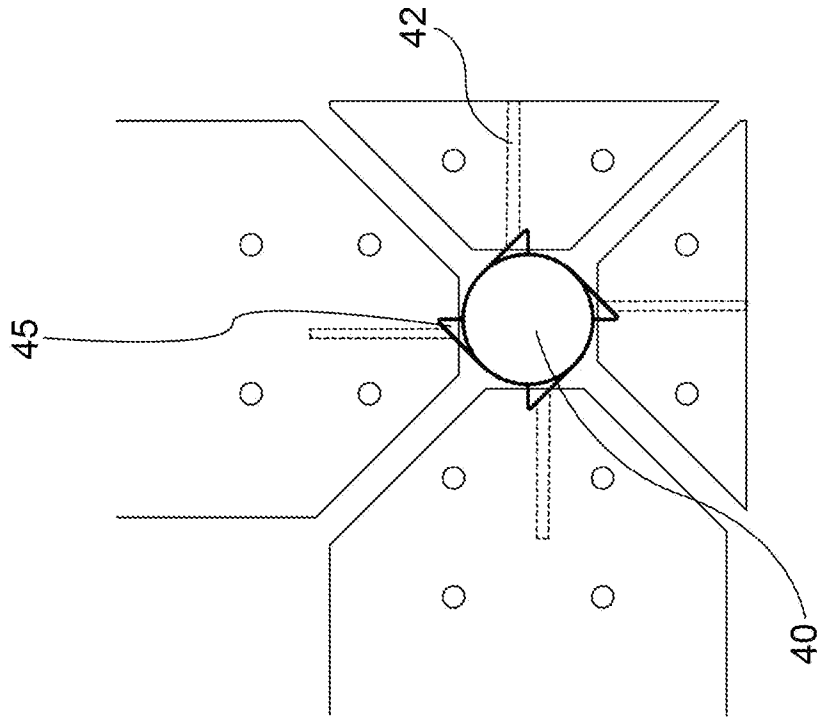

Fig. 1b

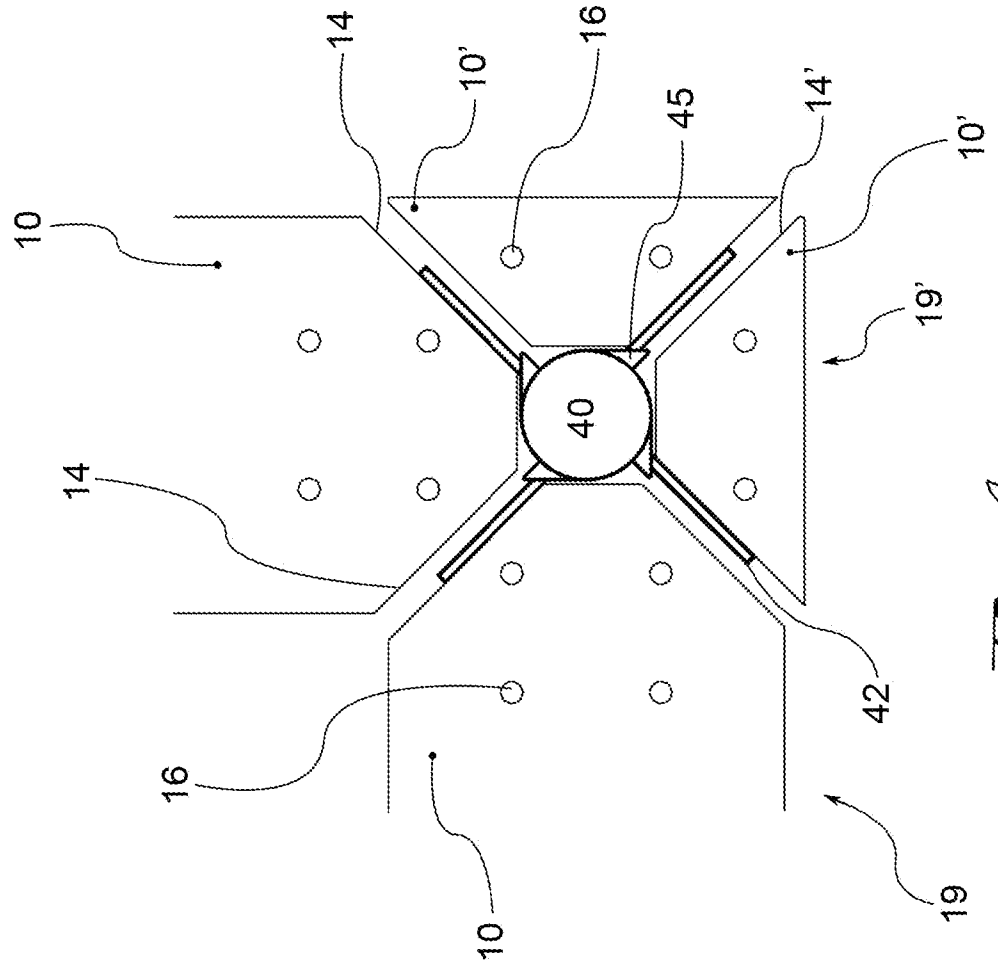

Fig. 1a

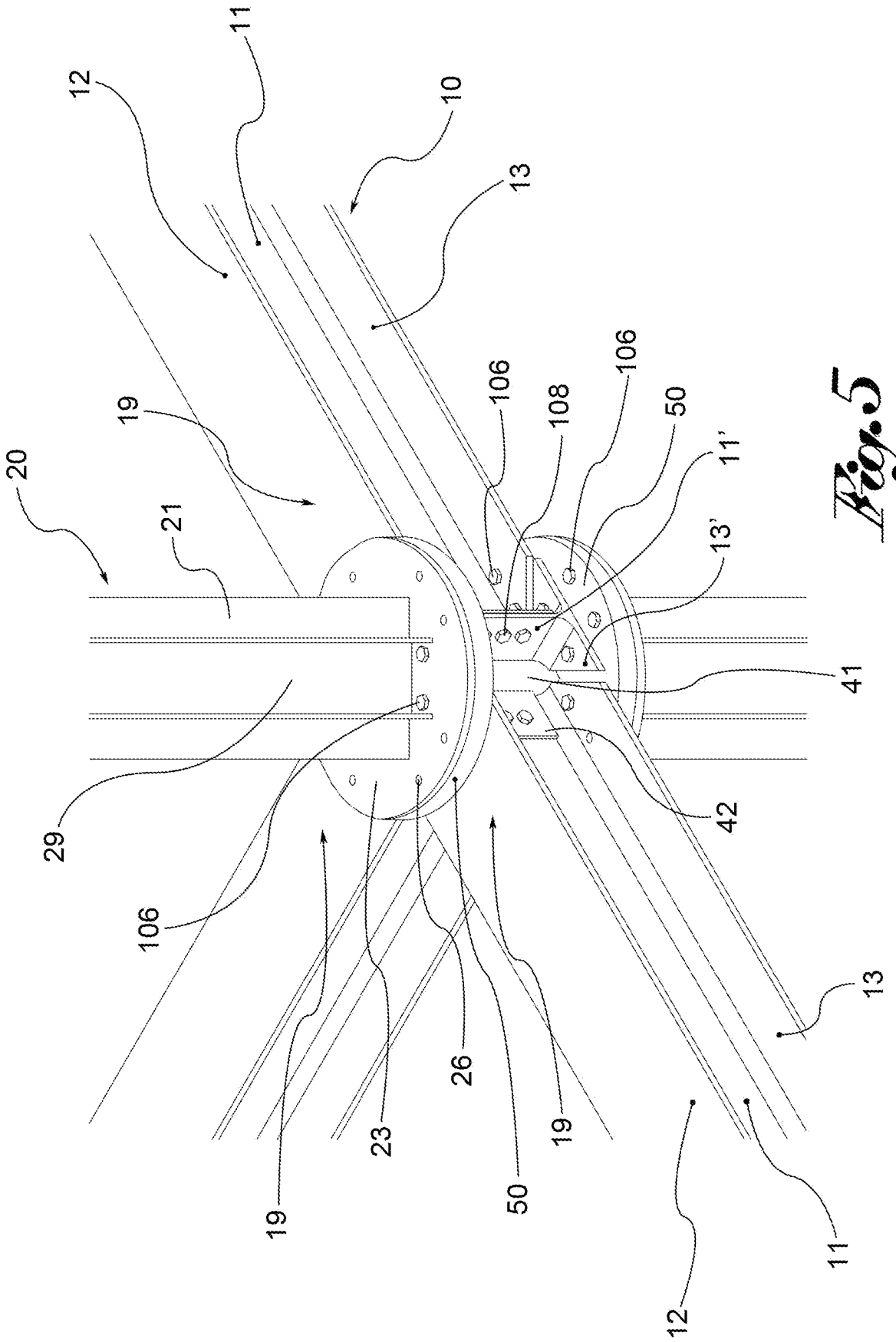
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Fig.5

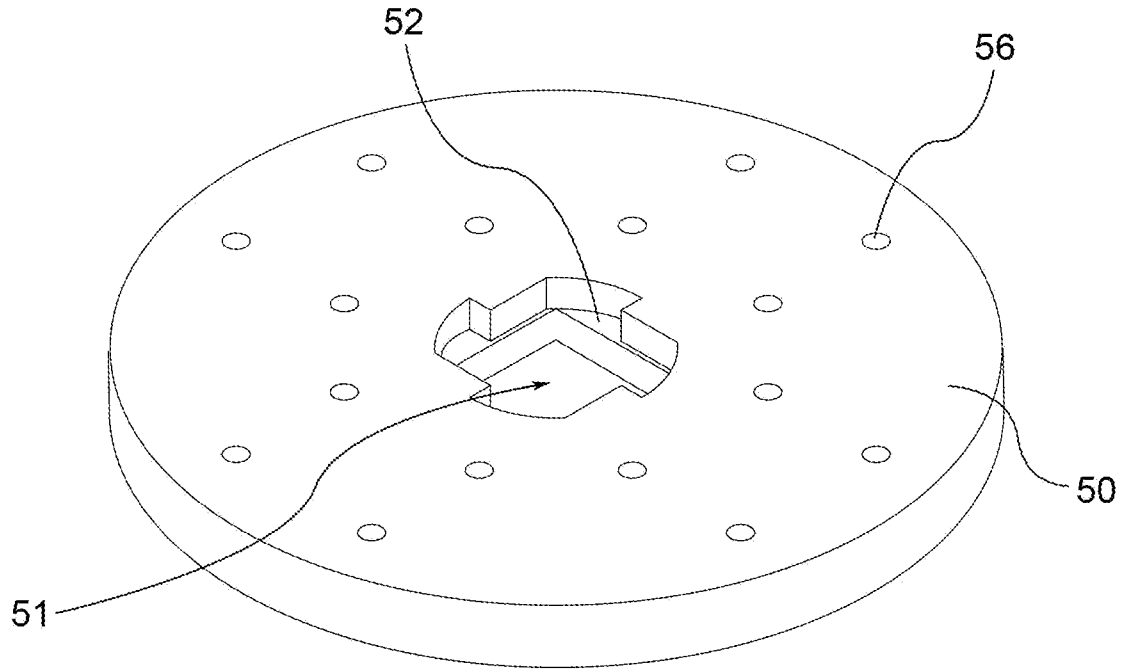

Fig.6a

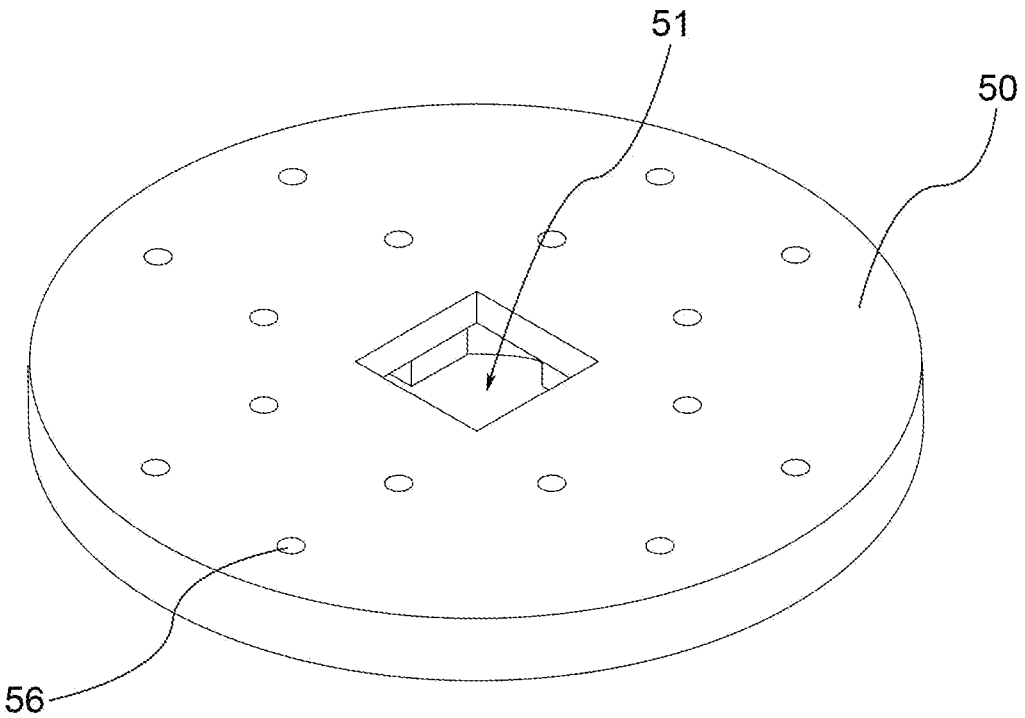

Fig.6b

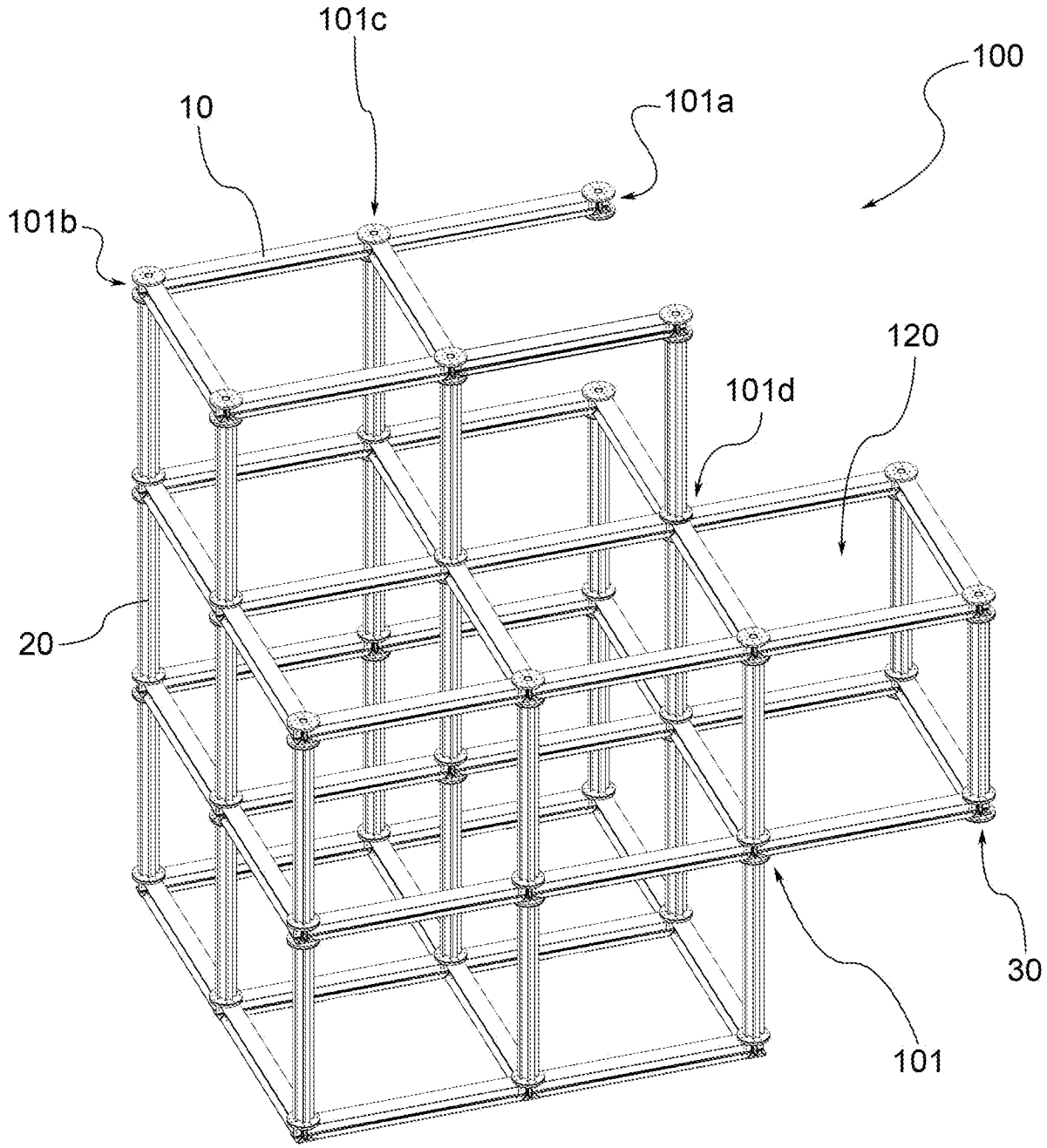

Fig.7

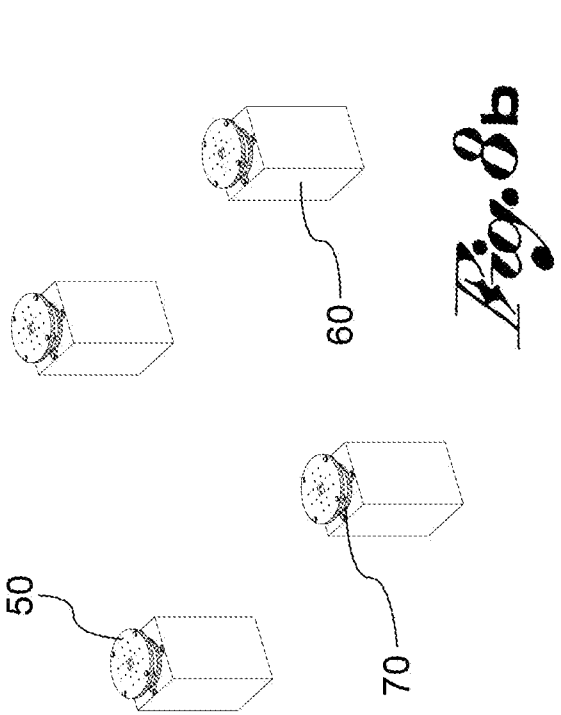

Fig.8b

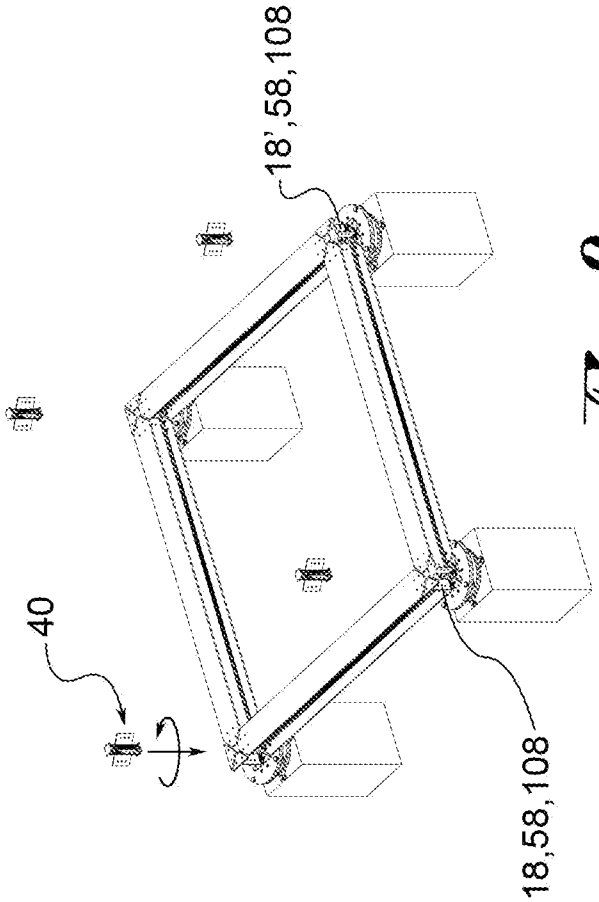

Fig.8d

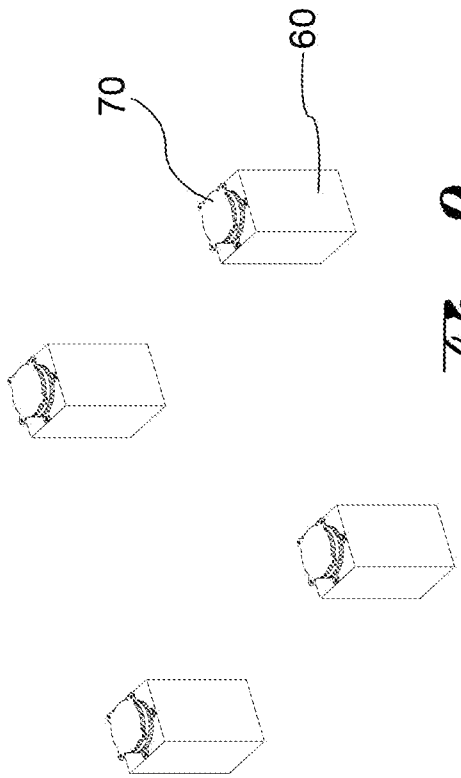

Fig.8a

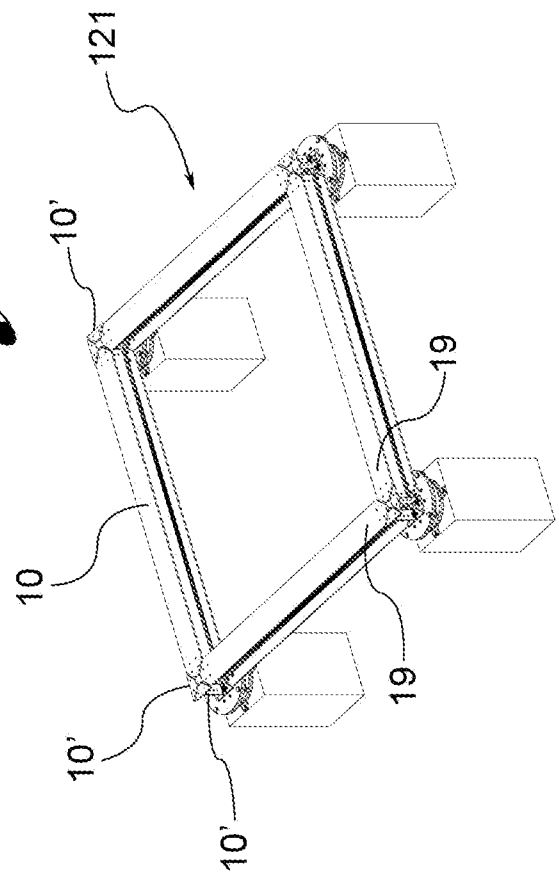

Fig.8c

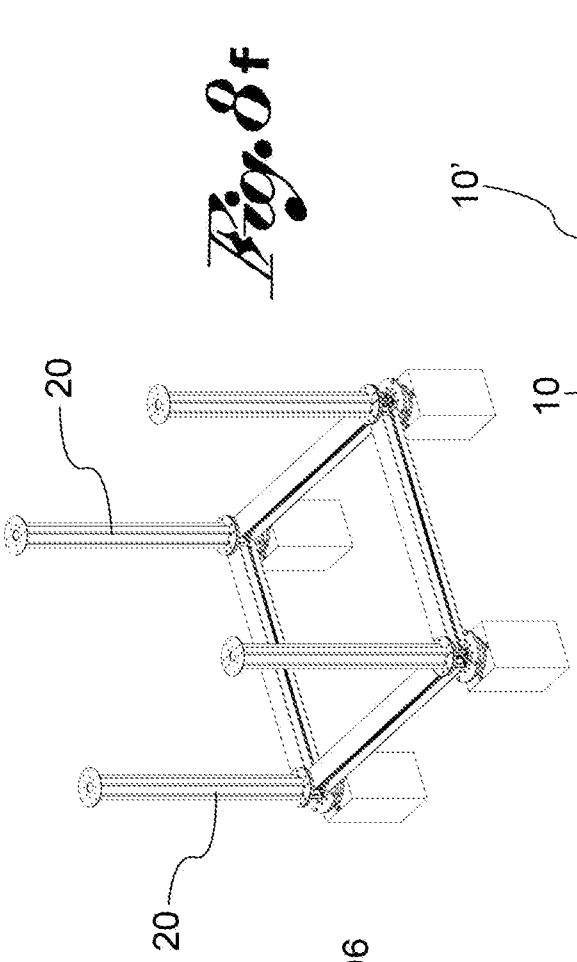

Fig.8f

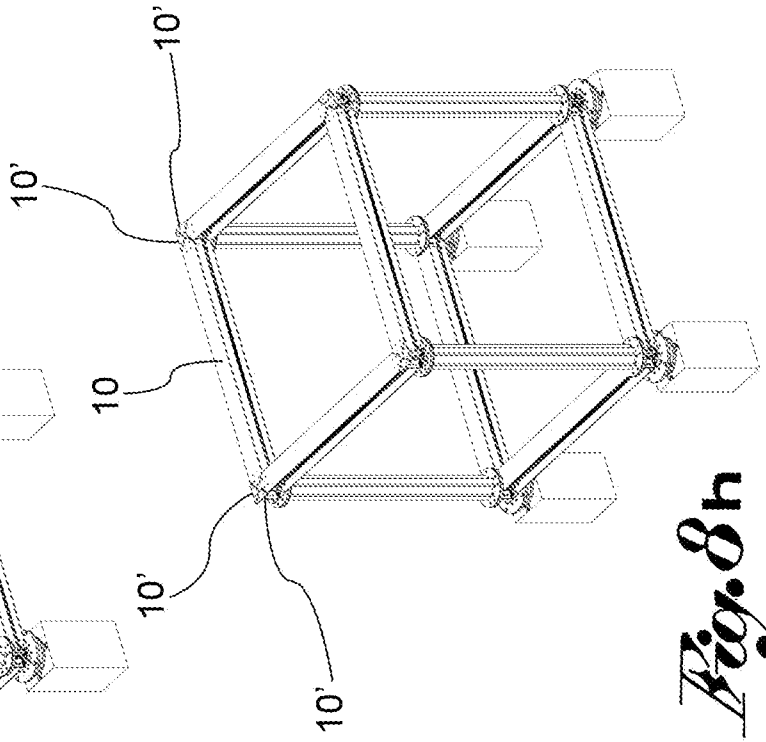

Fig.8h

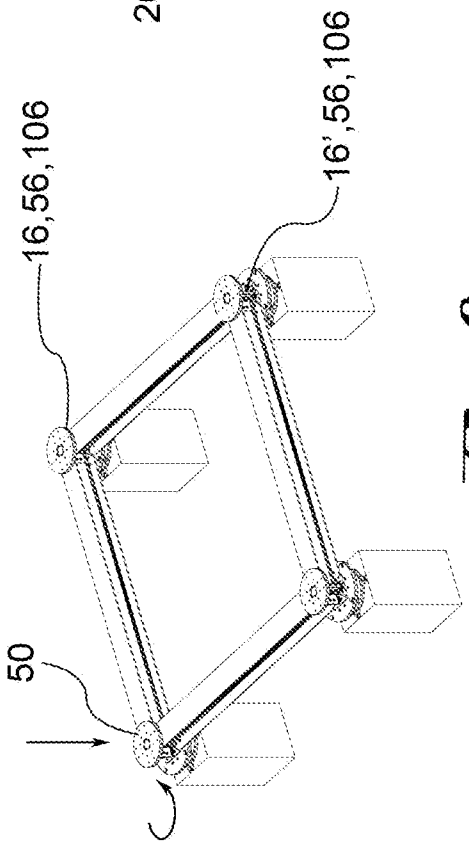

Fig.8e

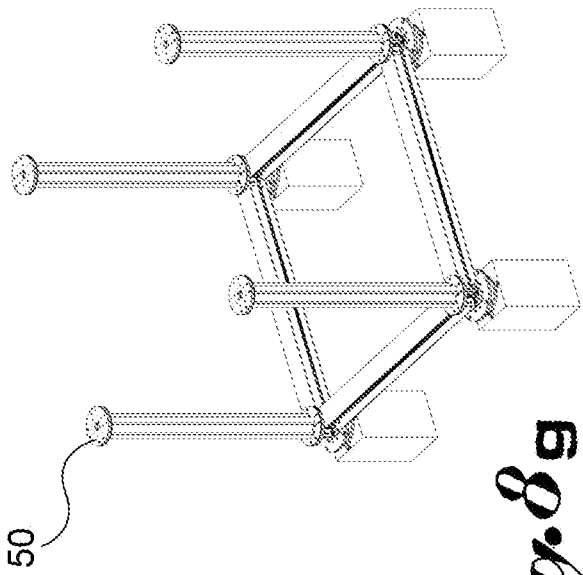

Fig.8g

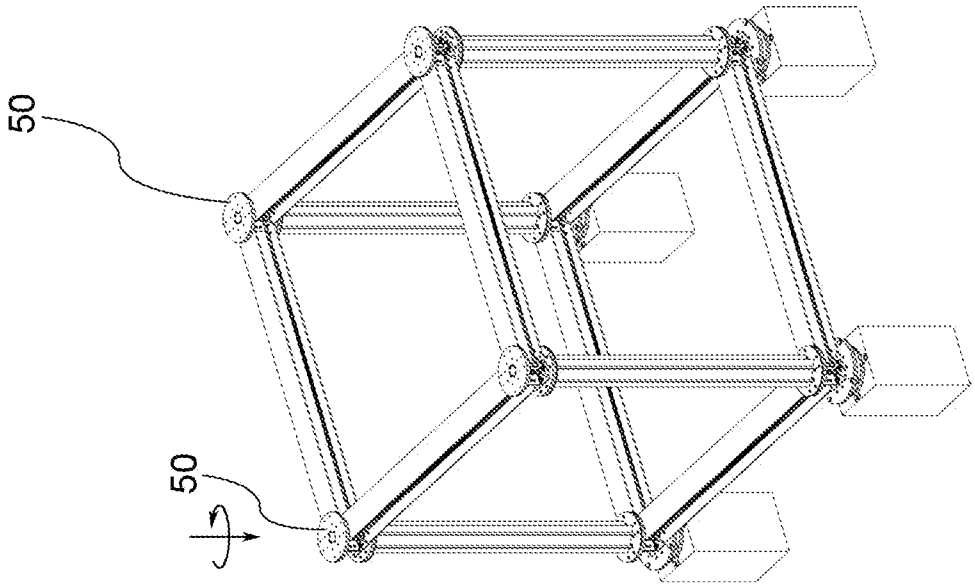

Fig.8l

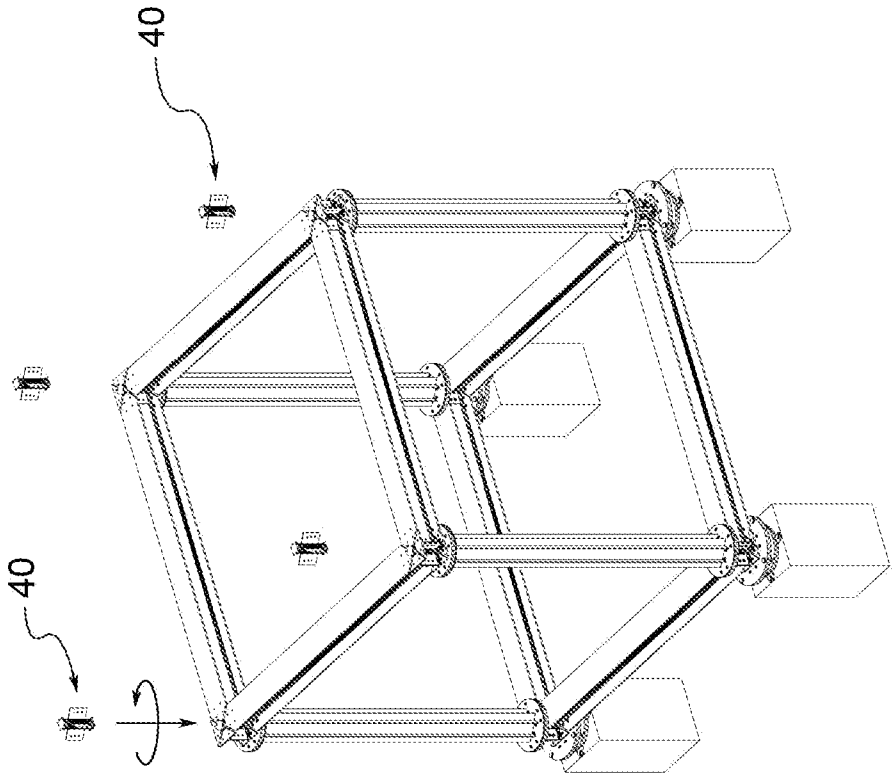

Fig.8i

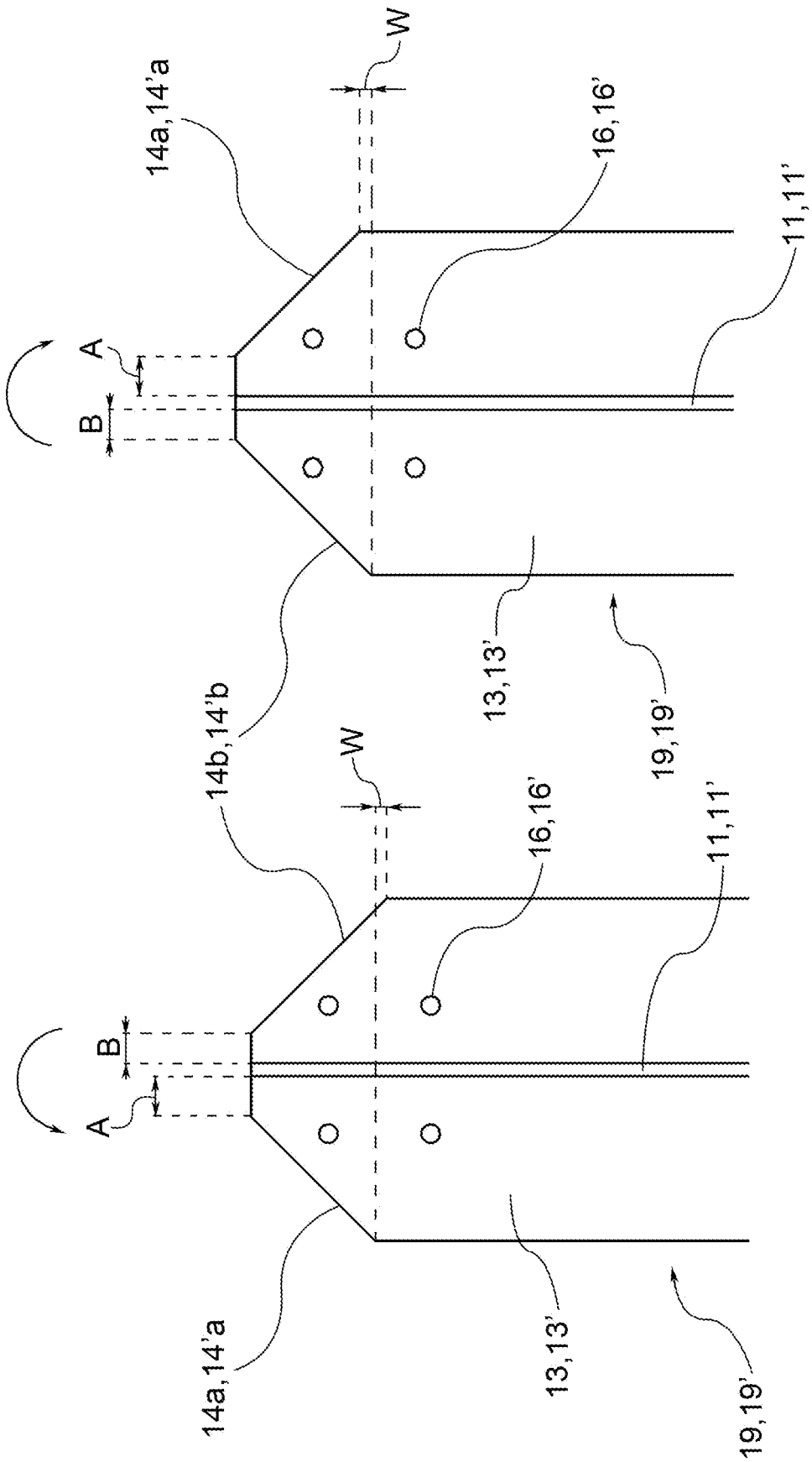
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Fig.9b

Fig.9a

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2013/055450

A. CLASSIFICATION OF SUBJECT MATTER
INV. E04B1/19 E04B1/24 F16B7/18 F16B7/20
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
E04B F16B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 10 2007 055479 A1 (AUDI NSU AUTO UNION AG [DE]) 28 May 2009 (2009-05-28) paragraph [0016] - paragraph [0019]; figures 1-3	1-12,15
X	WO 2005/111343 A1 (UNIV SINGAPORE [SG]; LIEW JAT YUEN RICHARD [SG]; KRISHNAPILLAI ANANDAS) 24 November 2005 (2005-11-24) page 6, line 14 - page 8, line 26; figures 1a,1b	1-15
X	US 4 122 646 A (SAPP DENNIS H) 31 October 1978 (1978-10-31) column 3, line 17 - column 5, line 49; figures 1-7	1,11,15

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

☒ See patent family annex.

* Special categories of cited documents :

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"E" earlier application or patent but published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"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

"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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
24 October 2013	04/11/2013

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Couprie, Brice

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2013/055450

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 102007055479 A1	28-05-2009	NONE	
WO 2005111343 A1	24-11-2005	NONE	
US 4122646 A	31-10-1978	NONE	