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

(11) **EP 3 527 735 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
21.08.2019 Bulletin 2019/34

(51) Int Cl.:
E04B 1/19 *(2006.01)* *E04B 1/32* *(2006.01)*

(21) Application number: **19156527.4**

(22) Date of filing: **11.02.2019**

(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

(30) Priority: **16.02.2018 IT 201800002745**

(71) Applicant: **Università di Pisa**
56126 Pisa (IT)

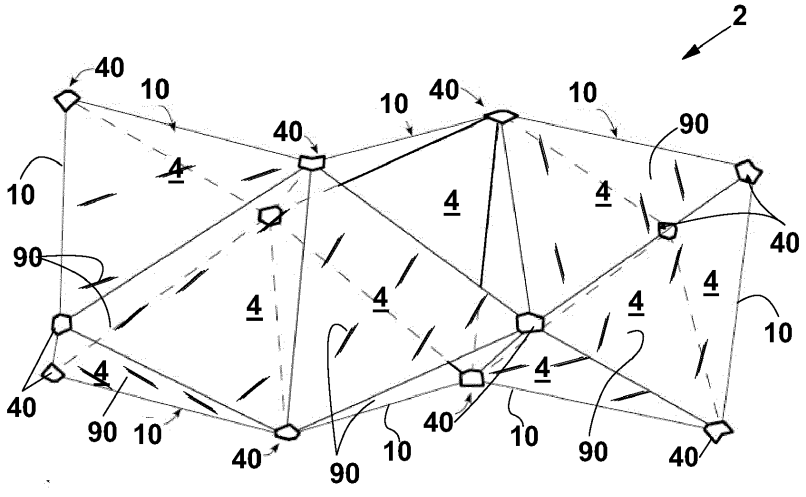
(72) Inventor: **FROLI, Maurizio**
I-56011 CALCI (IT)

(74) Representative: **Celestino, Marco**
ABM Agenzia Brevetti & Marchi
Viale Giovanni Pisano 31
56123 Pisa (IT)

(54) STRUCTURAL NODE FOR CONNECTING BUILDING ENVELOPE ELEMENTS, AND RETICULAR STRUCTURE COMPRISING SAID NODE

(57) A reticular structure (2) comprising rods (10) arranged to form polygonal meshes (4) and comprising polygonal panels (90) that generally close the meshes (4), the rods (10) and the panels (90) connected by own end portions (11) and by own flat vertex portions (91), respectively, within locking seats (45) and within support sectors (41), respectively, of nodes (40), the seats (45) and the sectors (41) crown-like arranged about a central space (3). The support sectors (41) are two by two rotatably connected about axes (46) of the rods, which are arranged in the locking seats (45), and each of them comprises a first half and a second half (43,44) that are rotatably connected to each other by hinges (50) having rotation axes (58) orthogonal to the planes on which the vertex portions (91) lie. According to the invention, the hinges (50) comprise front surfaces (51,52) having respective protrusions (53,54) and recesses (55,56), as well as a lock device (57) for relatively moving said front surfaces (51,52), in order to insert the protrusions (53,54) of each front surface (51,52) into the recesses (56,55), i.e. between the protrusions (54,53) of the other front surface (52,51), thus preventing any relative rotation of said front surfaces (51,52). This way, the node connections of the structure (2) can be stabilized, while allowing panel support angles of any amplitude; it is therefore possible to mount polygonal panels having any vertex angles, even if all identical nodes are used (Figs. 3 and 8).

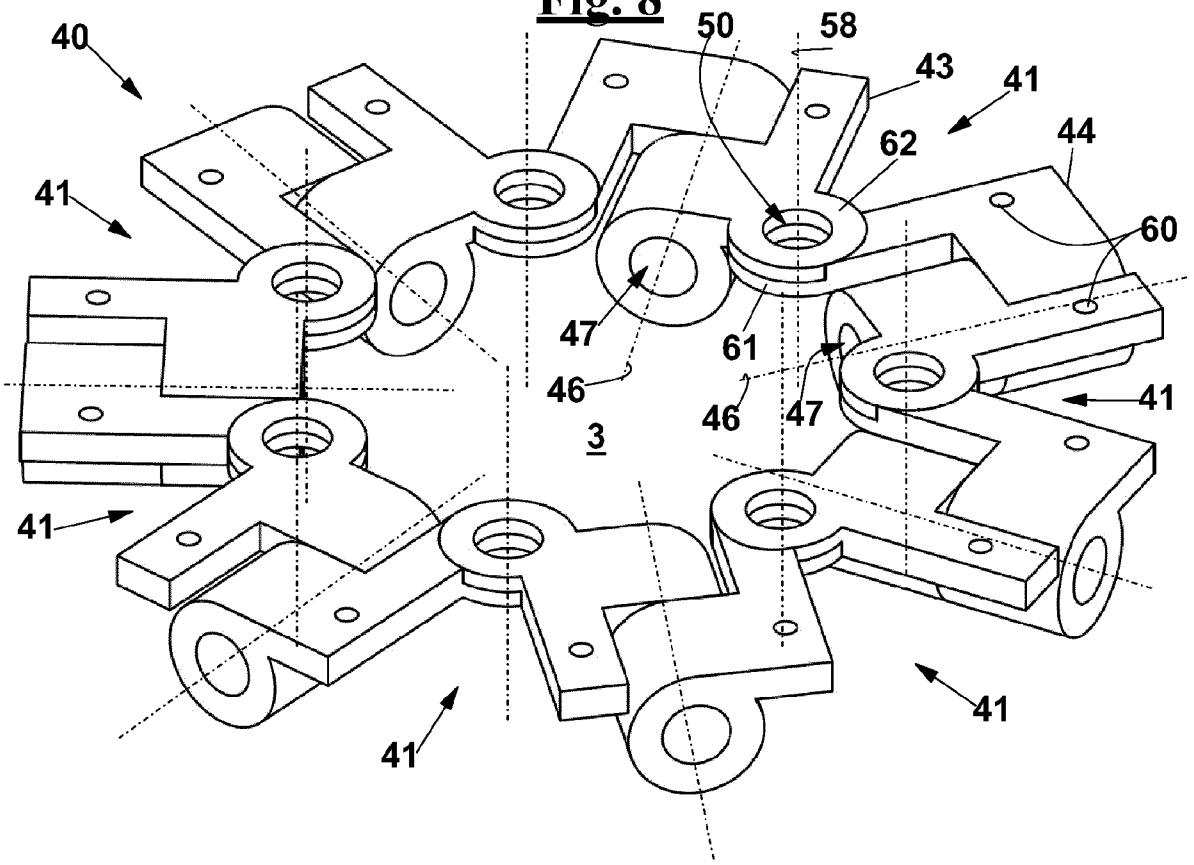
Fig. 3



EP 3 527 735 A1

(Cont. next page)

Fig. 8



Description

Field of the invention

[0001] The present invention relates to an improved structural node for connecting building envelope elements or, more in general, structure elements, such as opaque or transparent polygonal panels, in particular glass polygonal panels.

Description of the prior art and of the technical problem

[0002] As well known, systems have been developed in the last decades to simplify the construction of hybrid shell structures for manned spaces and/or artistic shell structures, consisting of metal rods and preferably polygonal panels, in particular glass panels. In particular, the nodes for connecting the panel and the rods to one another have been extensively studied, so that the designers can be as free as possible to design three-dimensional shells having the most various shapes, such as the shape shown in Fig. 3, or even more complex shapes.

[0003] As Figs. 1a/b show, IT1420093 describes a node 30 comprising support sectors 31 for panels 20, typically six sectors, every two adjacent support sectors hinged about a same respective relative rotation axis 20a that is parallel to adjacent edges 21 of two panels 20 connected to the two adjacent support sectors. In an exemplary embodiment, rotation axes 20a are defined by hinges 33 comprising pins 33a integral to the rods, which can be pre-tensioned, so that compression forces arise acting on panels 20 adjacent to the rods and to support sectors 31 by which the panels are supported. When a structure is erected, the relative rotation of support sectors 31 makes it possible to arrange the panels 20 so that any desired local tridimensional conformation can be obtained.

[0004] Such nodes allows a great freedom in the choice of the mutual orientation of adjacent panels, but they can connect only panels having a predetermined vertex angle. More in detail only panels having the shape of an equilateral triangle can be to connect, if all identical nodes are advantageously used in the same structure, typically as shown in Fig. 1a.

[0005] The node or support device 23 of Fig. 2, which is described in DE 10 2011 117 184 A1, overcomes this limitation. In fact, node 23 comprises sectors 25 consisting of two halves 27,28 that are mutually articulated at a rotatable screw-threaded joint 29, or even at a different rotatable joint, whose rotation axis 29' is orthogonal to the plane defined by the relative rotation axes with respect to adjacent sectors 25, i.e. with respect to the rods housed therein, not shown. Therefore, each sector 25, when it is mounted, can be adjusted for connection with a polygonal panel 20 of any vertex angle. Therefore, by using nodes all identical to equal to node 23 of Fig. 2, structures cam be obtained that contains panels 20 having the shape of an equilateral triangle or any triangular shape, as well as polygonal panels of any shape, as disclosed in the cited document, paragraph [0030].

[0006] Even if a greater freedom is allowed to the designer in the choice of the shape of the panels and in the design of the shell surface, the node of DE 10 2011 117 184 A1 still has some drawbacks. Firstly, the stability of the connection with the panels can only be assured if the locking forces steadily maintain the value they have when the panel is mounted by tightening the screw means 29.

[0007] Moreover, the nodes of both Figs. 1a/b and Fig. 2 allow arranging the panels substantially on the same plane where the rods lie, therefore the rods are unaesthetically visible from outside the structure, and break the glass look of the structure. Moreover, the connections as described above make it difficult to obtain a waterproof structure, since in that case a sealing means must be arranged between such heterogeneous items as the polygonal panels and the rods.

Summary of the invention

[0008] It is therefore a feature of the present invention to provide a reticular structure and a node thereof to which panels can be mounted, in particular glass panels having any desired polygonal shape, by using all identical nodes.

[0009] It is also a feature of the invention to provide a reticular structure in which the panels can be laid out on planes different from the planes defined by the rods, so that structure, once erected, shows the panel surfaces only.

[0010] These and other objects are achieved by a reticular structure as defined by independent claim 1. Exemplary specific embodiments of the invention are defined by the dependent claims.

[0011] According to the invention, a reticular structure comprises:

- a plurality of rods;
- a plurality of nodes connecting end portions of the rods, wherein the rods and the nodes define a plurality of polygonal meshes;
- a plurality of polygonal panels having flat vertex portions, the polygonal panels closing at least one part of the polygonal meshes;

wherein each of said nodes comprises:

- support sectors for respective panels converging to said each node, the support sectors crown-like arranged about a central space of said each node, the support sectors configured for housing and locking the flat vertex portions on respective planes;
- locking seats for respective rods converging to said each node, arranged alternately with respect to the support sectors, the locking seats configured for slidingly housing and locking the end portions along respective sliding axes;

wherein every two adjacent support sectors are rotatably connected about the sliding axes of a respective one of the converging rods,
wherein each support sector comprises a first half and a second half rotatably connected to each other by hinges having respective rotation axes orthogonal to respective planes of respective flat vertex portions,
wherein the main feature is that the hinges comprise:

- respective front surfaces having respective pluralities of protrusions and recesses;
- a lock device for relatively moving the front surfaces between:
    - a spaced-apart position, in which a free space is present between the top of the protrusions of the one and the other front surfaces, allowing a relative rotation about a corresponding rotation axis of the two front surfaces facing each other, and
    - a closed position, in which the protrusions of each front surface are inserted within the recesses, i.e. they are inserted between the protrusions of the other front surface, thus preventing a relative rotation of the front surfaces, unless the protrusions and/or the recesses are removed by plastic collapse.

[0012] This makes it possible to stabilize the node connections of the reticular structure, while allowing panel support angles of any amplitude; it is therefore possible to mount polygonal panels having any vertex angles, even if all identical nodes are used.
[0013] Preferably, the recesses have a depth set between 1 and 5 mm.
[0014] The protrusions and the recesses can be made by a plastic deformation technique or by machining, in particular, by a technique selected from the group consisting of:

- milling;
- arc-air gouging;
- casting;
- compression moulding.

[0015] In particular, each hinge comprises two annular disc portions of the first half and of the second half, respectively, of a support sector, wherein the front surfaces comprise mutually-facing ring surfaces of the annular disc portions.
[0016] For example, the protrusions and the recesses have a linear shape and are arranged transversally to a relative displacement direction of the front surfaces, so as to hinder a relative rotation movement of the ring surfaces. In particular, the linear protrusions and the linear recesses are arranged radially with respect to the axes of the respective hinges.
[0017] As an alternative, in another different exemplary embodiment, the protrusions and the recesses can have the shape of small pyramids. Advantageously, each locking seat is defined by two cylindrical hinge elements belonging to respective adjacent support sectors and aligned along respective sliding axes.
[0018] In an exemplary embodiment, the support sectors comprise respective retaining members that define recesses configured for receiving the vertex portions of respective polygonal panels extending along respective planes that are arranged at a predetermined distance from the two rods housed within respective locking seats adjacent to the support sectors.
[0019] This way, the polygonal panels can be arranged to cover respective polygonal meshes converging to the node, and can be positioned at a predetermined height above the adjacent rods that are arranged within the adjacent through holes. This allows a side-by-side arrangement of the edges of contiguous polygonal panels, above the rods, and makes it possible to substantially hide the rods and the nodes to an observer looking at the reticular structure from the outside, i.e. from a position opposite to the rods and to the nodes with respect to the polygonal panels itself. Moreover, the side-by-side arrangement of the edges of the polygonal panel makes it easier to provide a sealing means between mutually adjacent polygonal panels, which is a common practice to obtain a waterproof structure. In facts, this step can be carried out by sealing the adjacent edges of the polygonal panels, without involving the nodes and the rods.
[0020] Preferably, each retaining member comprises a base portion that is connected to a respective support sector, and a cover portion that is removably connected to the base portion.
[0021] Advantageously, the polygonal panels are glass panels.

Brief description of the drawings

[0022] The invention will be now shown with the description of some exemplary embodiments, exemplifying but not limitative, with reference to the attached drawings, in which like reference characters designate the same or similar parts, throughout the figures of which:

- Fig. 1a is an elevation side view of a node of a reticular structure comprising rods and polygonal panels, according to a prior art;
- Fig. 1b is a view of three support sectors of the node of Fig. 1a, connected to one another;
- Fig. 2 is a perspective view of a node of a reticular structure comprising rods and polygonal panels, according to another prior art;
- Fig. 3 diagrammatically shows a structure according to the invention;
- Fig. 4 is a diagrammatical elevation side view of a node of a structure according to the invention, in a flat conformation;
- Fig. 5 is an exploded perspective view of a node

portion in a structure according to the invention, in which the node portion includes a support sector comprising two mutually articulated halves, and also includes two halves of respective adjacent nodes that are articulated with said node;

- Figs. 6 and 7 are cross sectional views of details of the first half and of the second half of a same support sector of a node;
- Figs. 8-11 are perspective views of nodes of structures according to the invention, shown in a flat conformation, and comprising seven, six, four and three dismantled support sectors, respectively;
- Fig. 12 is a perspective view of a detail of a reticular structure according to the invention, in which one node is shown in a convex conformation along with the rods and the panels connected by such node.

Description of a preferred exemplary embodiment.

[0023] With reference to Fig. 3, a reticular structure 2 is described, wherein a plurality of rods 10 are connected to each other by a plurality of node elements 40 and define a plurality of polygonal meshes 4, in this case triangular meshes 4. Structure 2 is configured as a hybrid structure, since it comprises panels 90 that close at least one part of polygonal meshes 4, and since panels 90, preferably glass panel or in any case panels made of a material different from the metal material of rods 10, cooperate to bear the loads acting on structure 2, as described hereinafter.

[0024] As shown in Fig. 4, each node element 40 comprises a plurality of support sectors 41 (one of which is shown in black) that are crown-like arranged about a central space 3, the support sectors configured to support corresponding panels 90 converging to node element 40.

[0025] Between each support sector 41 and a neighbouring supporting sector 41, node 40 also comprises one locking seat 45 for each rod 10 converging to node 40, in such a way that support sectors 41 and locking seats 45 alternate about the crown. As shown in Fig. 5, each locking seat 45 has a hole 47 for housing an end portion 11 of rod 10, and for preventing the latter from sliding along its own axis 46. Moreover, adjacent support sectors 41 are rotatably connected to one another about sliding axis 46 of one of converging rods 10.

[0026] As shown more in detail, still in Fig. 5 and, for instance, in Fig. 8, each support sector 41 comprises a first half 43 and a second half 44, the halves pivotally articulated to each other by a hinge 50 having a rotation axis 58.

[0027] Panels 90 have flat vertex portions 91, shown more in detail in Fig. 12, but can comprise portions, not shown, that deviate from planarity, at own central regions, i.e. at a distance from vertices 91. Support sectors 41 are configured for housing and locking flat vertex portions 91 so that the latter lie on respective planes, to which rotation axes 58 of hinges 50 are orthogonal.

[0028] According to the invention, and still with reference to Fig. 5, hinges 50 comprise front surfaces 51,52 having respective pluralities of protrusions 53,54 and of recesses 55,56, and also comprise lock devices 57 (Fig. 12) that are housed within central holes 59 of hinges 50. This makes it possible to move front surfaces 51,52 with respect to each other, between a spaced-apart position D, in which a free space S is present between the top of protrusions 53,54 of front surfaces 51,52, and a closed position R, as shown in Figs. 6 and 7. Moreover, still according to the invention, protrusions 53,54 and recesses 55,56 are arranged in such a way that, when moving from spaced-apart position D (Fig. 6) to closed position R (Fig. 7), protrusions 53 of each front surface 51 are introduced into recesses 56 of the other front surface 52, i.e. between protrusions 54 of the other front surface 52 and, similarly, protrusions 54 of each front surface 52 are introduced into recesses 55 of front surface 51, i.e. between protrusions 53 of front surface 51. This prevents any relative rotation of front surfaces 51,52. Such a relative rotation could be possible only by deforming and/or removing protrusions 53,54 and recesses 55,56. This would require a plastic collapse of front surfaces 51,52, to avoid which recesses 55,56 preferably have a depth set between 1 and 5 mm, and protrusions 53,54 have a height comprised in the same range of values.

[0029] Fig. 5 relates to an exemplary embodiment in which protrusions 53,54 and recesses 55,56 have a transverse orientation with respect to the relative displacement direction of front surfaces 51,52, in particular they comprise radial linear protrusions 53,54 and radial linear recesses 55,56 that are alternately arranged with respect to each other. In the exemplary embodiment of Fig. 5, each hinge 50 comprises two annular disc portions 61,62 made respectively in first half 43 and in second half 44 of support sector 41, and front surfaces 51,52 comprise mutually-facing ring surfaces of annular disc portions 61,62. In this case, transverse protrusions 53,54 and recesses 55,56 are respectively radial protrusions 53,54 and radial recesses 55,56. However, in other exemplary embodiments, not shown, the protrusions and the recesses can have the shape of small pyramids, or any other form of roughness obtained by machining the contact surfaces.

[0030] Recesses 55,56, as well as protrusions 53,54, can be made by machining or by cold or hot plastic deformation, in particular by such a technique as milling, or arc-air gouging, or casting, or compression moulding.

[0031] Still with reference to Figs. 5 and 8, locking seats 45 for rods 10 can be defined by respective cylindrical hinge elements 48,49 of respective adjacent support sectors 41, said hinge elements aligned along respective sliding axes 46.

[0032] In order to support panels 90, support sectors 41 preferably comprise respective retaining members 80, as shown in Fig. 12. Retaining members 80 define recess 84 that are configured for receiving flat vertex portions 91 of panels 90, said vertex portions lying on planes at a predetermined distance L from two rods 10 housed

within locking seats 45, arranged adjacent to respective support sectors 41.

[0033] As shown in Fig. 13, in an exemplary embodiment, each retaining member 80 can comprise a base portion 85 that is connected to a respective support sector 41, and a cover portion 86 that is removably mounted to base portion 85, for instance, by a screws means 87 housed within holes 60, as shown in Figs. 5 and 8-11.

[0034] As Figs. 9, 10 and 11 show, the node elements of the reticular structure according to the invention can comprise any number of support sectors 41, and can therefore connect a same number of panels 90; these node elements are different from the node element of Fig. 8 in that they comprise six, four and three support sectors 41, respectively, instead of seven support sectors.

[0035] The foregoing description of specific embodiments will so fully reveal the invention according to the conceptual point of view, so that others, by applying current knowledge, will be able to modify and/or adapt in various applications these specific embodiments without any further research and without parting from the invention, and, accordingly, it is meant that such adaptations and modifications will have to be considered as equivalent to the exemplified specific embodiment. The means and the materials to put into practice the different functions described herein could have a different nature without, for this reason, departing from the field of the invention. It is to be understood that the phraseology or terminology that is employed herein is for the purpose of description, and not of limitation.

Claims

1. A reticular structure (2) comprising:

- a plurality of rods (10);
- a plurality of nodes (40) connecting end portions (11) of said rods (10),
  wherein said rods (10) and said nodes (40) define a plurality of polygonal meshes (4);
- a plurality of polygonal panels (90) having flat vertex portions (91), said polygonal panels (90) closing at least one part of said polygonal meshes (4);

wherein each of said nodes (40) comprises:

- support sectors (41) for respective panels (90) converging to said each node (40), said support sectors (41) crown-like arranged about a central space (3) of said each node (10), said support sectors (41) configured for housing and locking said flat vertex portions (91) on respective planes;
- locking seats (45) for respective rods (10) converging to said each node (40), arranged alternately with respect to said support sectors (41), said locking seats (45) configured for slidingly housing and locking said end portions (11) along respective sliding axes (46);

wherein every two adjacent support sectors (41) are rotatably connected about one of said sliding axes (46) of said converging rods (10), wherein each of said support sectors (41) comprises a first half and a second half (43,44) rotatably connected to each other by hinges (50) having respective rotation axes (58) orthogonal to respective said planes of respective flat vertex portions (91),

characterized in that said hinges (50) comprise:

- respective front surfaces (51,52) having respective pluralities of protrusions (53,54) and recesses (55,56);
- a lock device (57) for relatively moving said front surfaces (51,52) between

  - a spaced-apart position (D), in which a free space (S) is present between the top of said protrusions (53,54) of the one and the other front surfaces (51,52), allowing a relative rotation about a corresponding rotation axis (58) of said front surfaces (51,52) facing each other, and
  - a closed position (R), in which said protrusion (53,54) of each front surface (51,52) are inserted within said recesses (56,55) i. e. between said protrusion (54,53) of the other front surface (52,51) preventing a relative rotation of said front surfaces (51,52), unless said protrusions (53,54) and/or said recesses (55,56) are removed by plastic collapse.

2. A reticular structure (2) according to claim 1, wherein said recesses (55,56) have a depth set between 1 mm and 5 mm, and/or said protrusion (53,54) have a height set between 1 mm and 5 mm.

3. A reticular structure (2) according to claim 1, wherein said protrusions (53,54) and said recesses (55,56) are made with a technique selected from the group consisting of:

- milling;
- arc-air gouging;
- casting;
- compression moulding.

4. A reticular structure (2) according to claim 1, wherein each of said hinges (50) comprises two annular disc portions (61,62) of said first half (43) and of said second half (44), respectively, wherein said front surfaces (51,52) comprise mutually-facing ring surfaces

of said annular disc portions (61,62).

5. A reticular structure (2) according to claim 1, wherein said protrusions (53,54) and said recesses (55,56) have a linear shape and are arranged transversally to a relative displacement direction of said front surfaces (51,52), so as to hinder a relative rotation movement of said ring front surfaces (51,52).

6. A reticular structure (2) according to claim 5, wherein said protrusions (53,54) and said recesses (55,56) have a linear shape and are arranged radially with respect to said axes (58) of said hinges (50), so as to hinder a relative rotation movement of said ring front surfaces (51,52).

7. A reticular structure (2) according to claim 1, wherein said protrusions (53,54) and said recesses (55,56) have the shape of small pyramids.

8. A reticular structure (2) according to claim 1, wherein each of said locking seats (45) is defined by two cylindrical hinge elements (48,49) belonging to respective adjacent support sectors (41) and aligned along respective sliding axes (46).

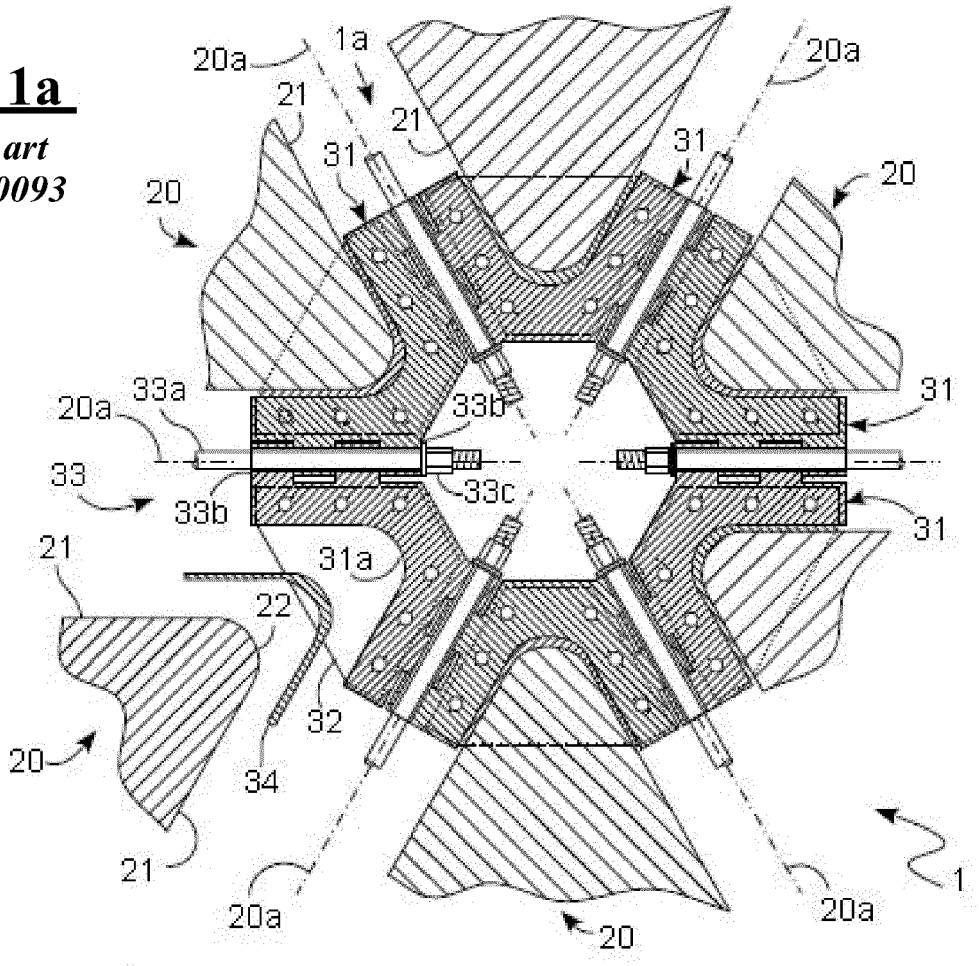
9. A reticular structure (2) according to claim 1, wherein each support sector of said support sectors (41) comprises a retaining member (80) that defines a recess (84) configured for receiving a flat vertex portions (91) of a respective polygonal panel (90) of said polygonal panels, said polygonal panel extending along a respective plane of said planes that is arranged at a predetermined distance (L) from two rods (10) housed within respective locking seats (45) adjacent to said support sector (41).

10. A reticular structure (2) according to claim 9, wherein each of said retaining members (80) comprises a base portion (85) that is connected to a respective support sector (41) and a cover portion (86) that is removably connected to said base portion (85).

11. A reticular structure (2) according to claim 1, wherein said polygonal panels (90) are glass panels.

Fig. 1a

prior art
IT1420093



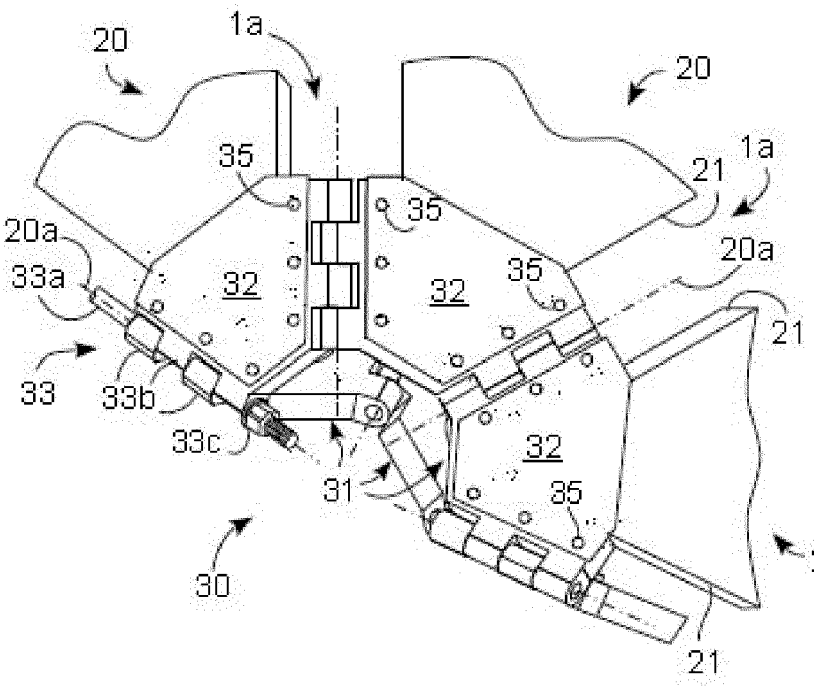


Fig. 1b

prior art
IT1420093

Fig. 2

prior art
DE 10 2011 117 184

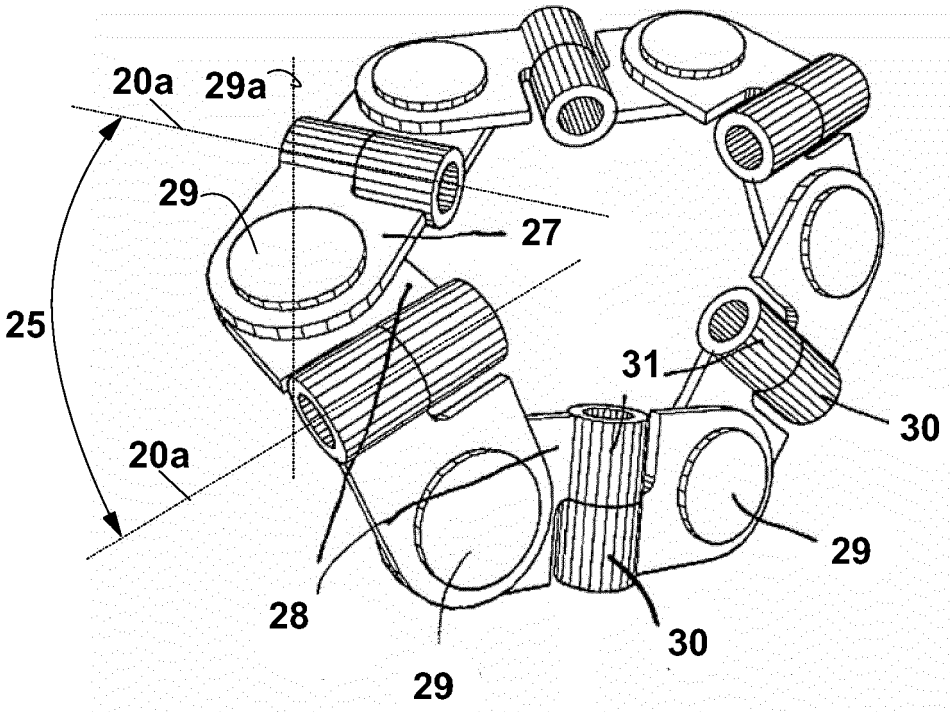


Fig. 3

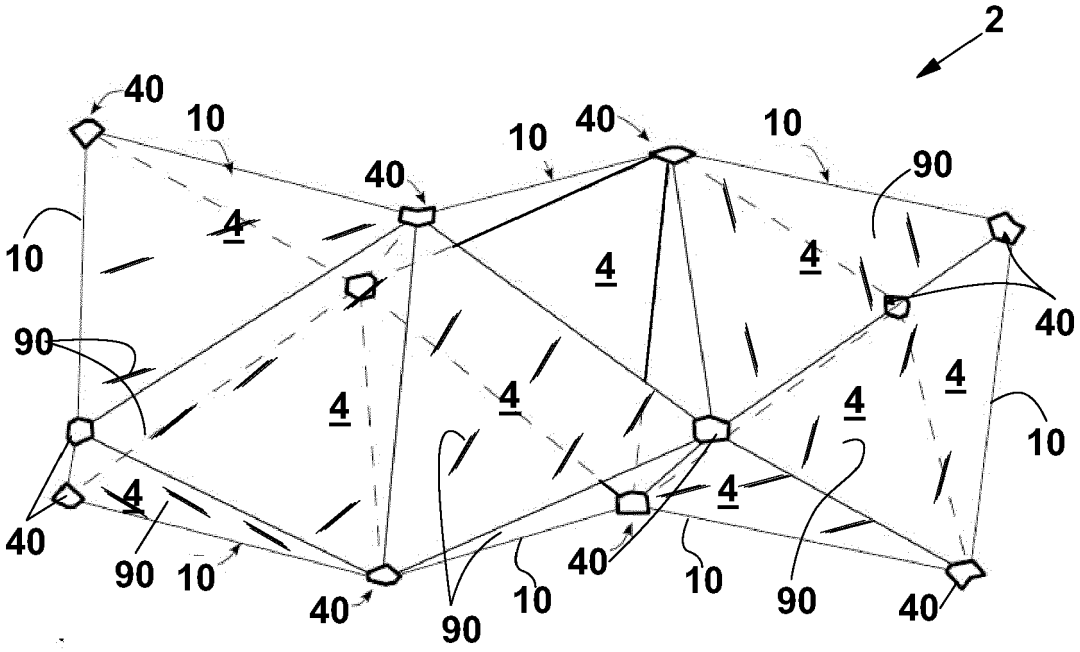


Fig. 5

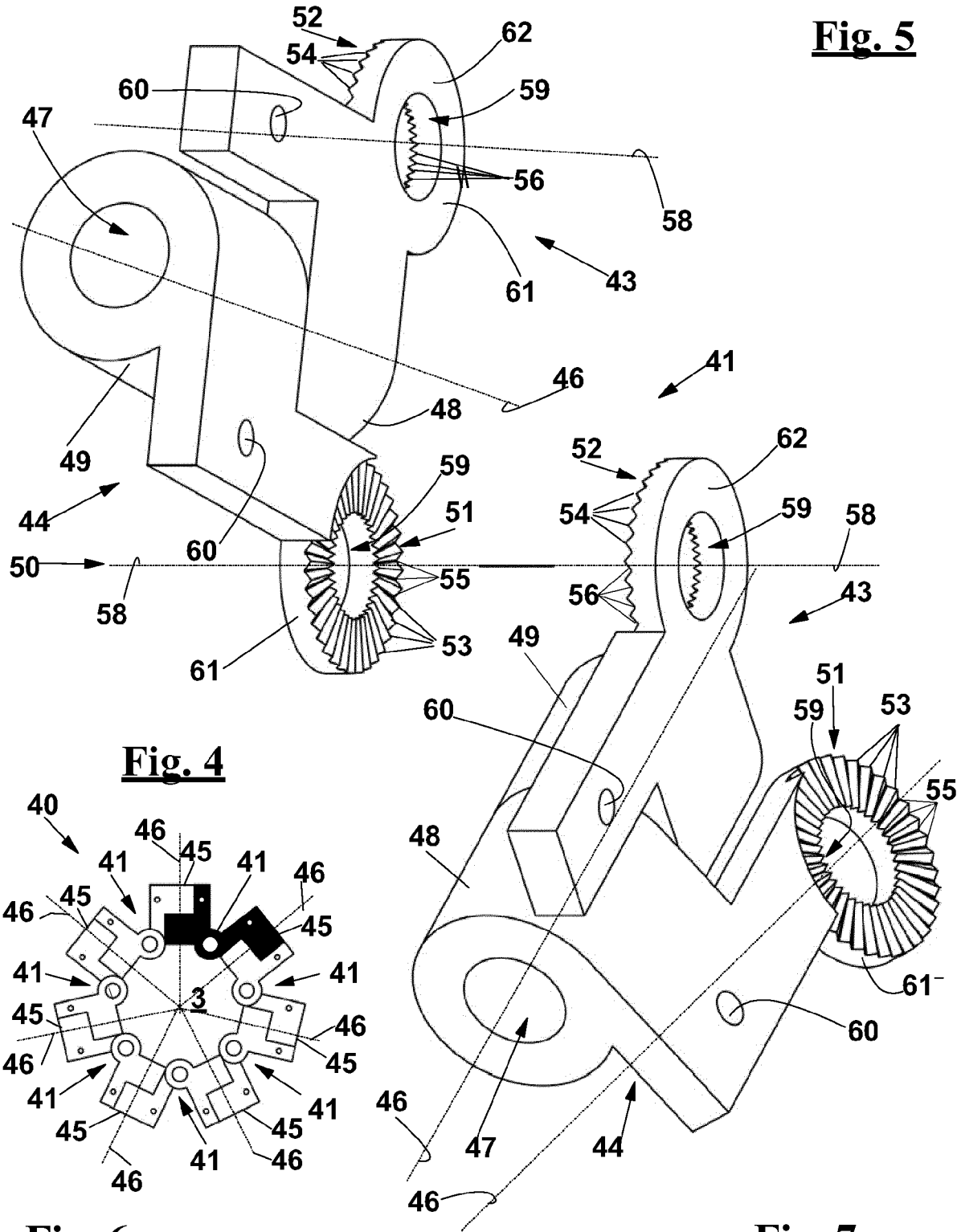


Fig. 4

Fig. 6
(D)

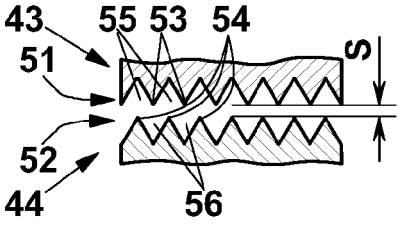


Fig. 7
(R)

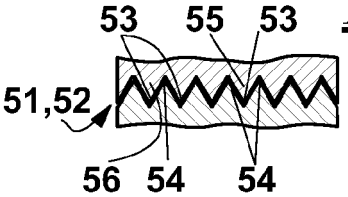


Fig. 8

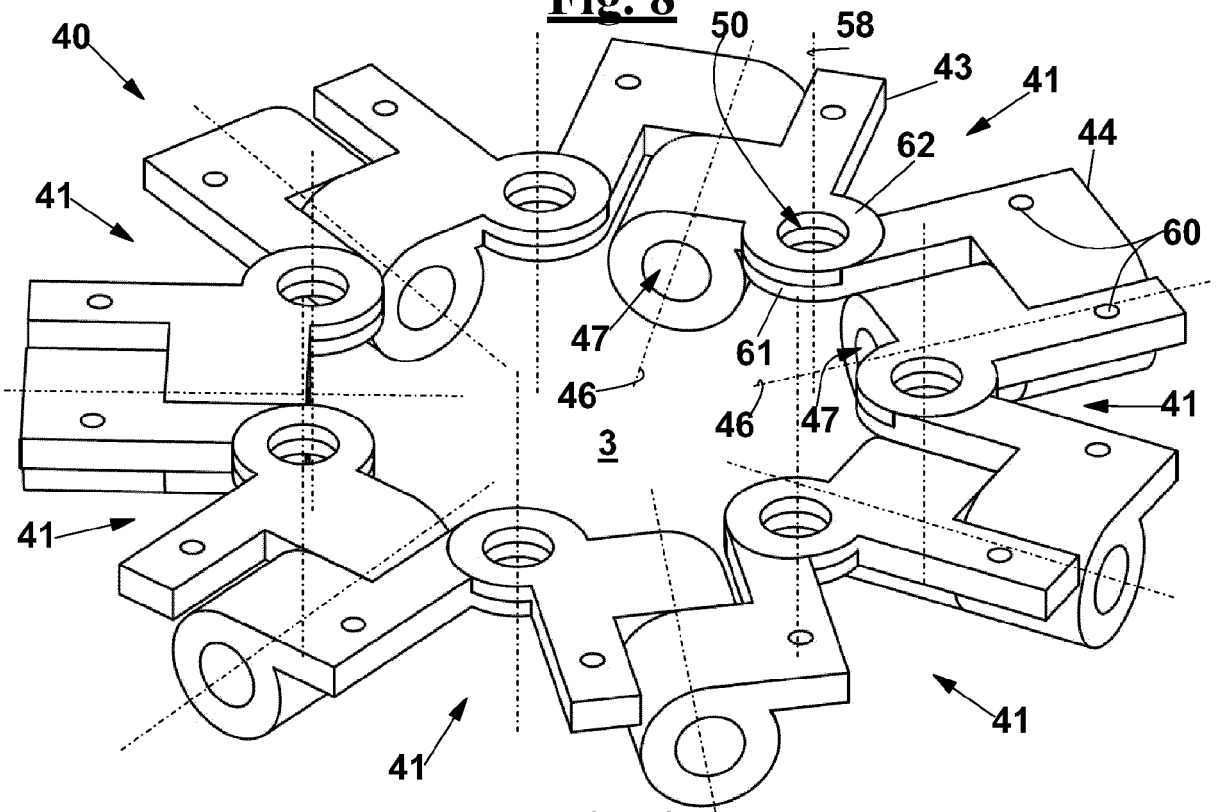

40
41
41
41
41
41
50
58
43
41
44
62
60
47
46
61
46
47
3

Fig. 9

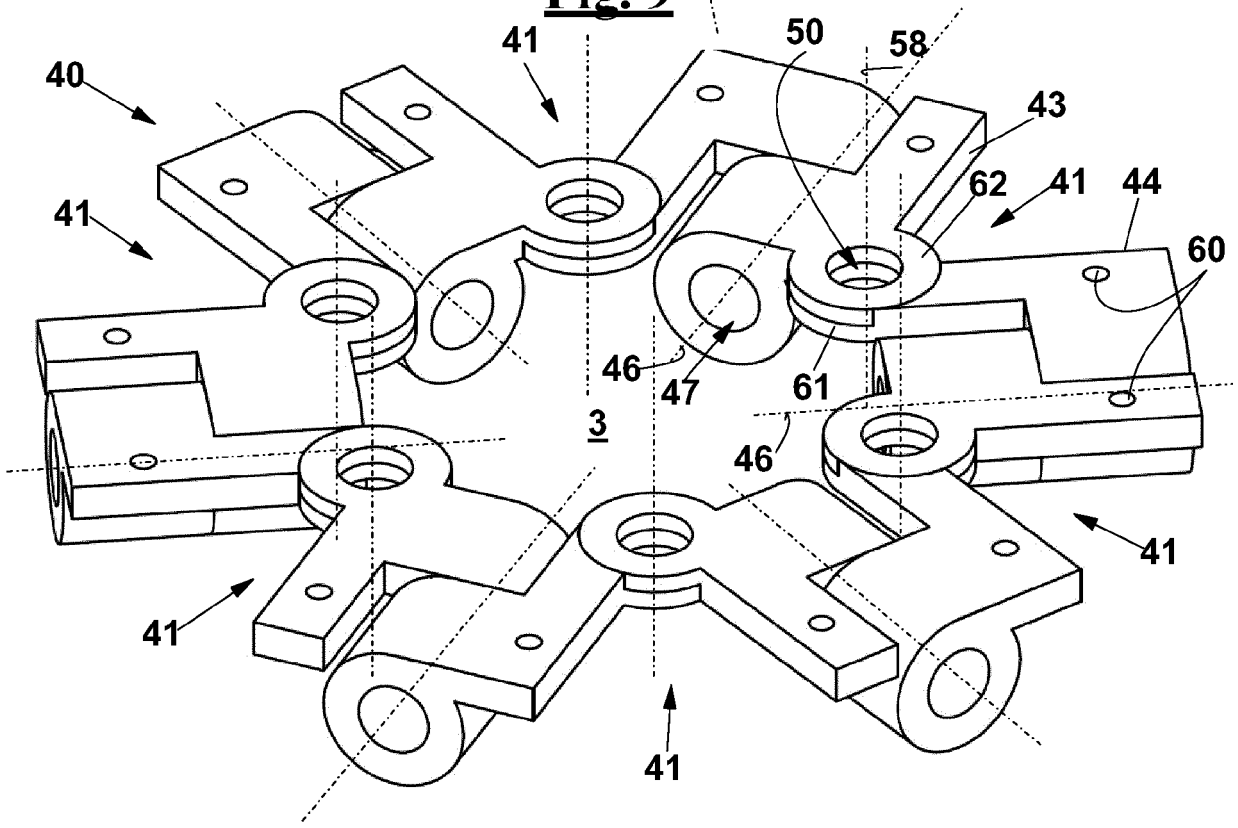

41
40
41
41
41
50
58
43
62
41
44
60
46
47
61
46
3

Fig. 10

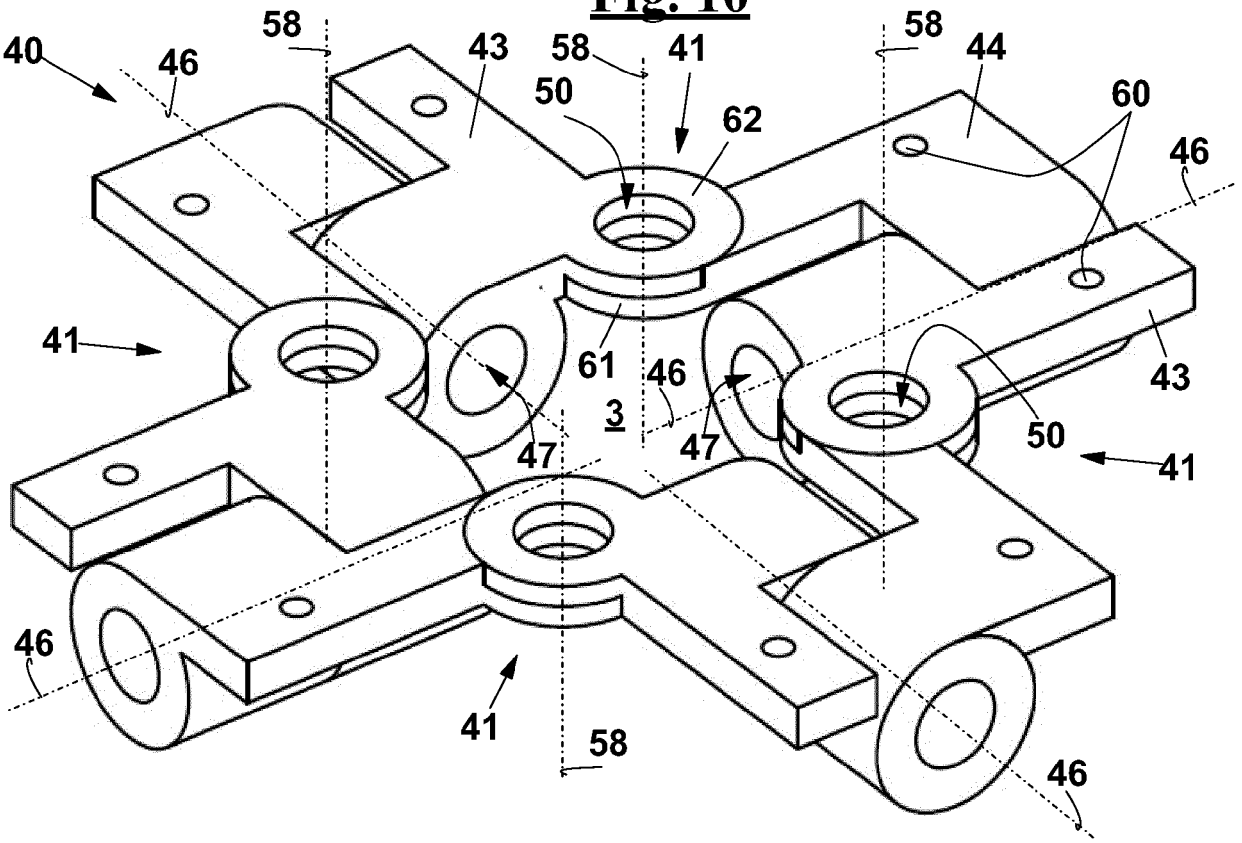

40
46
58
43
58
41
50
62
58
44
60
46
41
61
46
3
47
47
50
41
43
46
41
58
46

Fig. 11

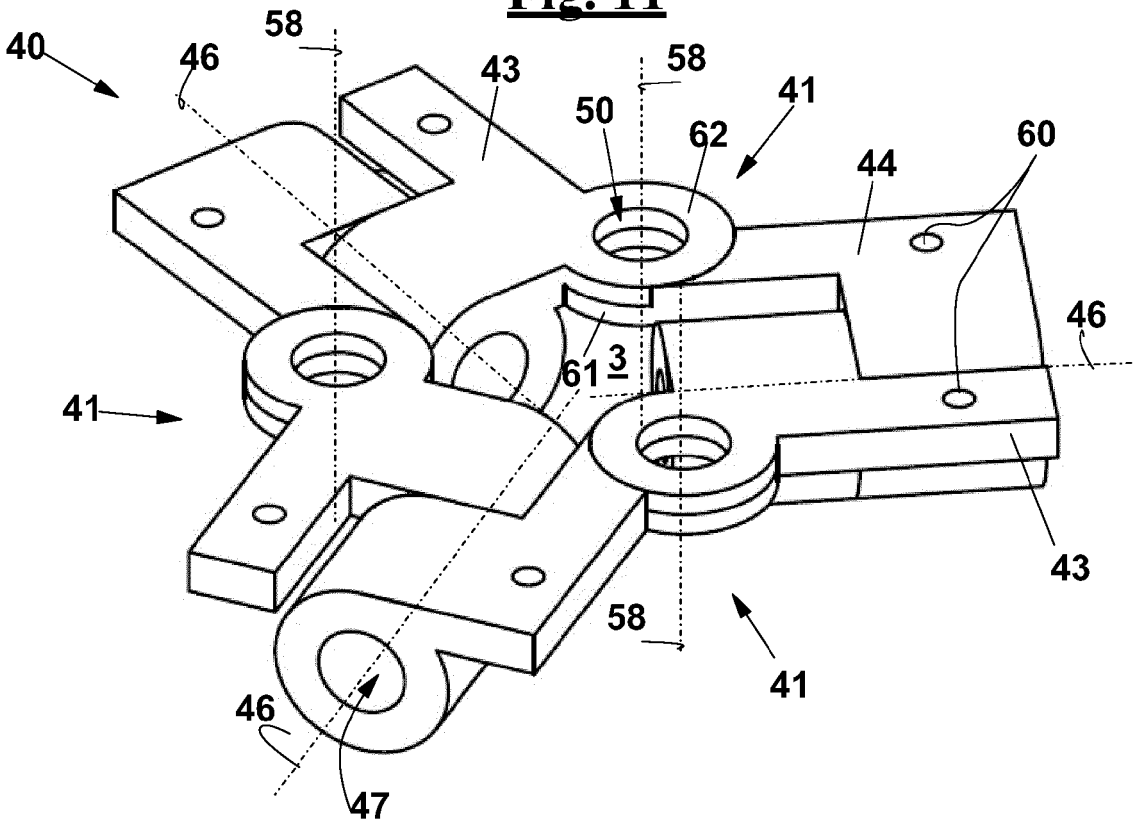

40
46
58
43
58
41
50
62
44
60
46
61
3
41
43
58
41
46
47

Fig. 12

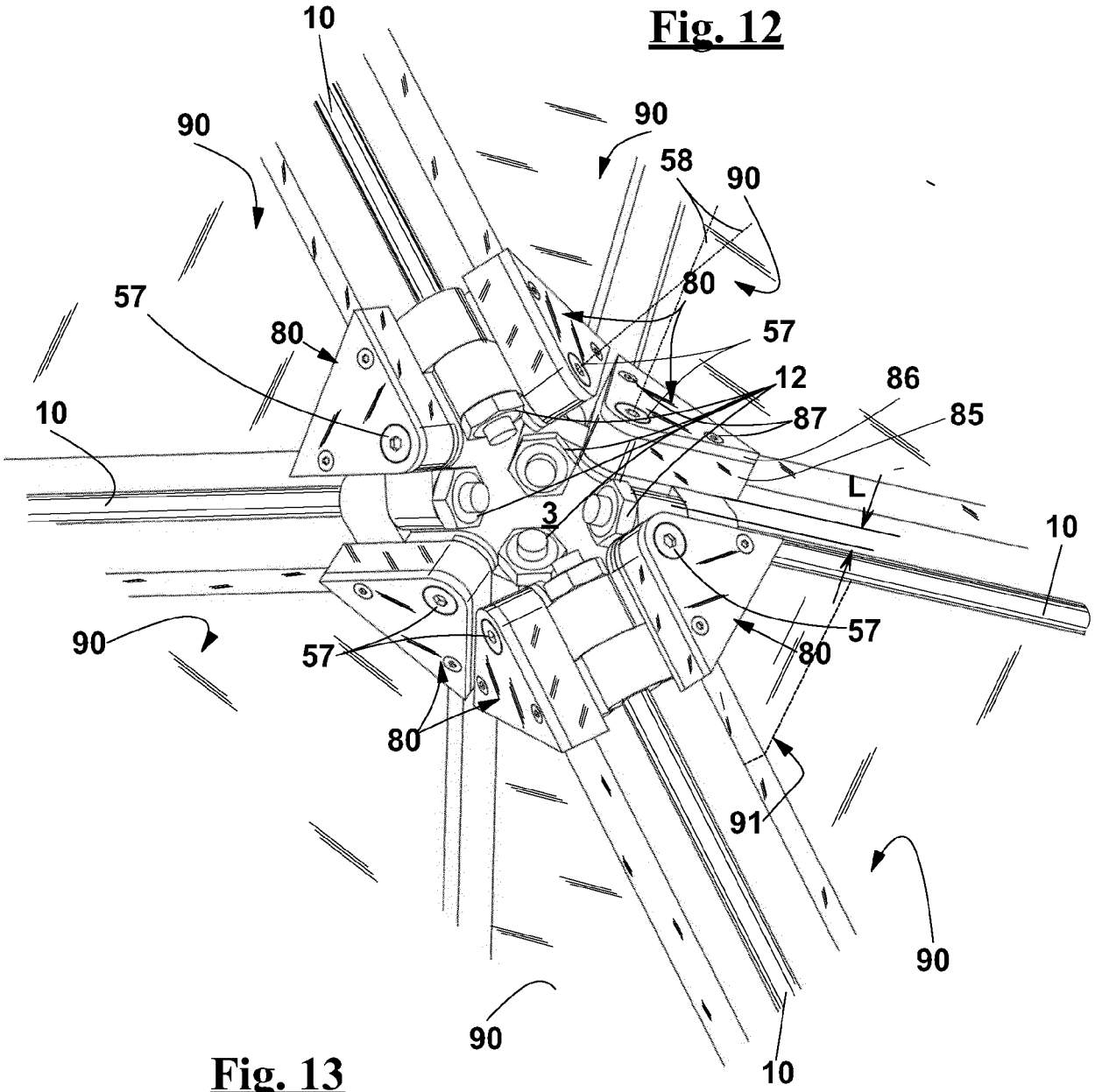
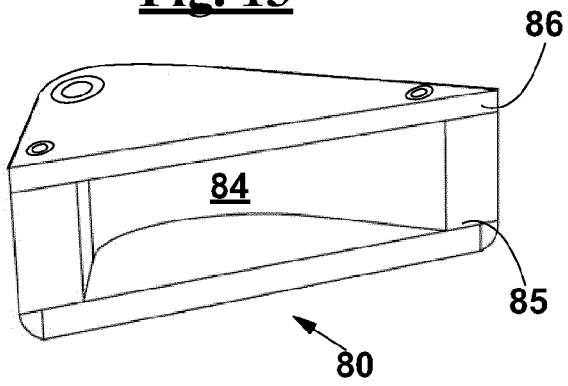

10
90
90
58
90
57
80
80
57
12
86
10
87
85
L
3
10
90
57
57
80
80
91
90
90
10

Fig. 13


86
84
85
80

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 19 15 6527

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	DE 10 2011 117184 A1 (LORENZ ALEXANDER [DE]) 2 May 2013 (2013-05-02) * paragraphs [0051] - [0055]; figures 13-16 * -----	1-11	INV. E04B1/19 ADD. E04B1/32
A,D	IT MI20 131 496 A1 (UNIV PISA) 11 March 2015 (2015-03-11) * the whole document * -----	1-11	
A	DE 101 12 313 A1 (BAUER SIMON [DE]) 20 September 2001 (2001-09-20) * the whole document * -----	1-11	

TECHNICAL FIELDS SEARCHED (IPC)

E04B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	10 April 2019	Couprie, Brice

CATEGORY OF CITED DOCUMENTS

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

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

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 19 15 6527

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.

10-04-2019

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 102011117184 A1	02-05-2013	DE 102011117184 A1	02-05-2013
		GB 2510532 A	06-08-2014
		WO 2013060470 A1	02-05-2013
IT MI20131496 A1	11-03-2015	---	
DE 10112313 A1	20-09-2001	NONE	

EPO FORM P0459

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

REFERENCES CITED IN THE DESCRIPTION

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

Patent documents cited in the description

- IT 1420093 **[0003]**
- DE 102011117184 A1 **[0005] [0006]**