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(54) **CONSTRUCTION NODE**

(57) System for composing a construction node (400, 500), comprising:
- a central body (100) comprising flat surfaces (101, 104, 103, 112) parallel to a direction Y;
- one or more holding elements (200, 300) of a first and second design,
wherein the system is adapted to compose different configurations of a construction node by releasably connecting holding elements (200, 300) to the flat surfaces, each of the connected holding elements (200, 300) adapted to hold an elongated element (600, 601), such that the central axis (607) of the elongated element (600, 601) defines a connection line (801, 802), and wherein:
- for a holding element (200) of the first design, the connection line (801) is perpendicular to the flat surface, and
- for a holding element (300) of the second design, the connection line (802) is inclined with respect to the flat surface.

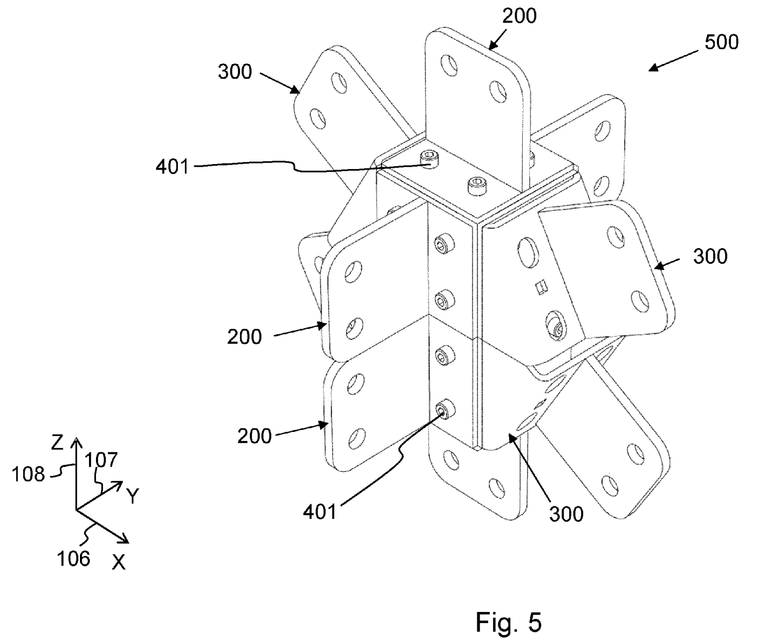

Fig. 5

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Description

Field of the Invention

[0001] The present invention generally relates to a system for composing a construction node. In particular, a construction node suitable for connecting elongated elements in a modular system is presented, that offers the standardisation of a grid-based node, while allowing for an increased flexibility and seamless integration into the skeleton of a house, accommodation, or other type of construction or structure.

Background of the Invention

[0002] Construction nodes are elements that allow to interconnect rods, bars or beams when building the skeleton of a temporary or permanent construction. The nodes, together with the elongated elements, e.g. rods, bars or beams, may serve as basic elements in a modular system. The modularity implies that prefabricated elements can be used, while still allowing to design spatial structures of various geometries. Such modular systems are widely used for building temporary constructions like scaffolds and stages. However, also for building the skeleton of houses and other accommodations, advantage can be taken of such a modular system comprising nodes and elongated elements. In particular, the use of modular, releasable elements allows to adapt the house skeleton according to the actual needs and to reuse elements elsewhere.

[0003] In the prior art, different types of construction nodes are known. Often, the provided solutions are grid-based, wherein the construction nodes serve as grid nodes, and the elongated elements follow the grid line directions of a regular grid, e.g. an orthogonal, hexagonal or octagonal grid. A system wherein bars are connected according to an octagonal grid, characterised by an angle of 45° between grid lines, is for example found in FR1554634, US3914063 and US005918998A. An example of a solution based on a hexagonal grid, characterised by a grid angle of 60°, is found in FR2350543. An advantage of working on a regular grid, is that the connection directions are fixed and thus the same type of node can be used at every connection point. Moreover, the system can be designed such that only a limited number of different bar lengths needs to be provided, thereby allowing for further standardisation. Finally, the aforementioned solutions make use of releasable connections, thereby enabling an easy assembly and disassembly of the construction.

[0004] These grid-based type of solutions, are typically used to connect metal bars in a temporary construction, wherein many bars are interconnected at the same node, and the variety in designs is relatively limited. However, when building a house or other accommodation, more flexibility in the design of the skeleton is required. For example, a regular hexagonal node only allows for two vertical and four angled connections in one plane, and does not allow to additionally connect a horizontal bar, while such a connection is frequently used in the skeleton of a house. On the other hand, a regular octagonal node does allow for vertical, horizontal and angled connections in one node, but requires an inclination angle of 45°, which may be too steep for e.g. a sloping roof. A second disadvantage of the known systems is that the node is merely designed as a point for connecting metal bars in all grid directions. The complexity of the node hereby causes a disruption in the obtained skeleton, and does not allow for a streamlined design when e.g. using wooden beams in the skeleton of a house.

[0005] Another type of solution, directed towards connecting wooden beams in the skeleton of a house, is presented in CN110306667A. The beam connector comprises a hollow sleeve, which is positioned around a vertical beam. Four angled fins are welded to the hollow sleeve, thereby allowing to mount beams according to two complementary angled directions. This type of solution merely concerns a connector, for connecting angled beams directly to a vertical beam. The connector does not serve as a construction node, the latter being a volume taking up space, and it does not make part of a modular reusable system. Finally, also here flexibility is limited, as no deviations from the directions determined by the welded fins are possible.

[0006] It is an objective of the present invention to disclose a system for composing a construction node, that resolves one or more of the above described shortcomings of the prior art solutions. More particularly, it is an objective to present a construction node suitable for connecting elongated elements in a modular system, that offers the standardisation of a grid-based node, while allowing for an increased flexibility and seamless integration into the skeleton of a house or other accommodation.

Summary of the Invention

[0007] According to a first aspect of the present invention, the above identified objectives are realized by a system for composing a construction node, defined by claim 1, the construction node being suitable for connecting elongated elements in a construction, and the system comprising:

- a central body, comprising flat surfaces parallel to a transverse direction Y, the transverse direction Y being orthogonal with respect to an XZ plane, and the XZ plane defined by a longitudinal direction X and an orthogonal vertical direction Z, wherein the flat surfaces together define a first polygonal cross section in the XZ plane;
- one or more holding elements of a first design, and one or more holding elements of a second design, the second design being different from the first design,

wherein the system is adapted to compose different configurations of a construction node by releasably connecting a selection of holding elements to the flat surfaces of the central body, each of the connected holding elements being adapted to hold an elongated element extending in the XZ plane, such that the central axis of the elongated element defines a connection line of the construction node in the XZ plane, and wherein the first and second design are such that:

- for a holding element of the first design, when being connected to a flat surface of the central body, the connection line is perpendicular to the flat surface, and
- for a holding element of the second design, when being connected to a flat surface of the central body, the connection line is inclined with respect to the flat surface, with an inclination angle different from 90 degrees.

[0008] Thus, the invention concerns a system for composing a construction node. A construction node is a component for connecting elongated elements in a construction, thereby forming for example the skeleton of the construction. An elongated element is an element extending in one direction, for example having a length dimension being much larger than the dimensions of the cross section perpendicular to the length direction. Various types of cross sections are possible, e.g. circular, rectangular or square. An elongated element may e.g. be referred to as a beam, rod, or bar. Typically, the construction node is a volume taking space; it is positioned between two elongated elements, such that these two elongated elements are not connected directly, but with the node in between them. The system comprises at least one central body, and holding elements. The holding elements and central body are such that a holding element may be connected to the central body. By connecting at least two holding elements to the central body, a construction node is formed, of which different configurations can be obtained by means of the system.

[0009] The central body extends in a longitudinal direction X, a transverse direction Y and a vertical direction or height direction Z, wherein the X, Y and Z direction are orthogonal with respect to each other. The central body comprises flat surfaces parallel to the transverse direction Y. The flat surfaces are the surfaces of the central body on which holding elements can be connected. The flat surfaces together define a first polygonal cross section in the XZ plane. This means that the cross sections of the flat surfaces according to an XZ plane, together define or delimit a polygon. Typically, the first polygonal cross section has a convex polygonal shape. In an embodiment, each of the flat surfaces is in contact with an adjacent flat surface, such that a cross section of the central body in an XZ plane corresponds to the aforementioned polygon. For example, the central body has a rectangular, hexagonal or octagonal cross section according to an XZ plane. In another embodiment, a flat surface is not in direct contact with an adjacent flat surface. For example, the cross section of the central body according to an XZ plane is composed of straight lines and rounded corners, e.g. a rectangle with rounded angles. In this case, the straight lines - corresponding to the cross section of the flat surfaces - merely define or delimit the polygonal shape, though the cross section of the central body is strictly spoken not a polygon due to the rounded corners.

[0010] The central body and holding elements are such that a holding element can be releasably connected to one of the flat surfaces of the central body. The connection between a holding element and central body is releasable, meaning that a holding element can be disconnected again without leaving permanent deformation or damage. Examples of releasable connections are: screw and bolted connections, connections employing keys and pins, clamp joints, etc. Typically, specific elements are present on the flat surfaces and/or holding elements, revealing that a releasable connection may be formed. For example, the flat surfaces may have apertures through which screws can be inserted and corresponding apertures may be present in a holding element. When two holding elements are releasably connected to the central body, a specific configuration of a node is obtained, suitable for joining two elongated elements in the skeleton. By selecting different holding elements, or by connecting them at another position of the central body, different configurations of a construction node can be formed, adapted for a specific connection point in the skeleton.

[0011] In composed condition of the node, according to a specific configuration, every holding element may hold an elongated element extending in the XZ plane. In this condition, the central axis of the elongated element defines a connection line of the construction node in the XZ plane. For example, an elongated element may be symmetrical around an axis, the latter defining the central axis. In general, the connection line may be any axis of the elongated element according to the direction in which the elongated element extends. In other words, a connection line defines a connection direction, namely the direction wherein an elongated element will extend when being attached to the node. The connection direction is fixed, meaning that a holding element determines a unique direction of the held elongated element, and this direction is not changeable or adaptable. In various embodiments, different means may be used for holding an elongated element. For example, a beam may be held by means of a fin on the holding element and a corresponding groove in the beam. In another embodiment, a holding element may comprise a sleeve suitable for inserting a beam. Preferably, a releasable connection is provided between the elongated element and the holding element.

[0012] Amongst the holding elements comprised in the system, one or more of them are of a first design, and one or more of them are of a second different design. This implies that a holding element of the first design has a different shape compared to a holding element of the second design. When a holding element of the first design is connected to a flat surface of the central body, the connection line is perpendicular to that flat surface. In other words: an elongated element may be held by a holding element of the first design, such that it extends according to a direction perpendicular to the corresponding flat surface of the central body. For a holding element of the second design, when being connected to a flat surface of the central body, the connection line is inclined with respect to the flat surface, with an inclination angle different from 90 degrees. In other words: an elongated element may be held by a holding element of the second design, such that it extends according to a direction not perpendicular to the corresponding flat surface of the central body.

[0013] The invented system has several advantages. First, the system allows to compose different configurations of construction nodes making use of only three different types of building blocks, namely a central body building block, a first holding element building block and a second holding element building block. The limited amount of building block types contributes to an increased modularity and standardisation. On the other hand, the three types of building blocks still allow for a large variety of composed construction nodes. In particular, the system allows to compose grid-based or regular type of nodes, for which the connection lines correspond to the grid line directions defined by a regular grid. For example, connecting holding elements of the first design on a central body with rectangular, hexagonal or octagonal cross section results in a grid-based node according to an orthogonal, hexagonal or octagonal grid respectively. In another embodiment, a hexagonal node may be formed by connecting holding elements of the first and second type on a central body with rectangular cross section. Moreover, the construction node may be designed as a volume of which the centre point serves as a true grid node, in which all connection lines intersect. Working on a regular grid further contributes to the modularity of the system and standardisation in the nodes and in the dimensions of the elongated elements.

[0014] Secondly, the system allows for an increased flexibility in the joints that may be formed between beams in a skeleton. Indeed, the system is not limited to composing grid-based nodes, but also allows to compose nodes wherein a connection line diverges from the aforementioned regular grid. For example, a holding element of the second design may be connected to the long side of a rectangular central body, and a holding element of the first design may be connected to the short side of the rectangular body, thereby defining an angled and vertical connection line respectively, both being according to a direction of a hexagonal grid. Additionally, a holding element of the first design may be connected to that long side of the central body, thereby defining a horizontal connection line deviating from the hexagonal grid. In this way, a vertical beam, an angled beam having an inclination of 30 degrees with respect to the horizontal direction, and a horizontal beam can be combined in the same node. Such a type of joint is often required in e.g. the skeleton of a house, and cannot be obtained when only using regular hexagonal nodes.

[0015] Finally, the system allows to compose a construction node having only those elements being actually required. Indeed, a holding element is only connected to the central body when it is needed for joining an elongated element in a specific direction; if no elongated element will be held in that direction, no corresponding holding element needs to be included in the node. In this way, the node does not contain any unnecessary elements, thereby avoiding any disruption in the skeleton due to unused connection elements. This contributes to a seamless integration of the construction node into the skeleton.

[0016] Optionally, as specified by claim 2, the system is adapted to compose different configurations of a construction node, wherein that different configurations comprise:

- configurations of a regular type, based on a regular grid defined by grid line directions in the XZ plane, the grid line directions having a mutual grid angle equal to the inclination angle, such that for any node of the regular type, every connection line in the XZ plane has a direction according to one of the grid line directions; and
- configurations of a semi-regular type, wherein for any node of the semi-regular type at least one connection line in the XZ plane has a direction according to one of the grid line directions of that same regular grid, and at least one connection line in the XZ plane has a direction different from any of that grid line directions.

[0017] A regular grid is defined by grid lines, according to different grid line directions. The points where grid lines intersect are defined as grid nodes. For a regular grid in the XZ plane, the grid line directions are different directions, all lying in the XZ plane. The regular grid is characterised by a specific, constant grid angle: the angle between every two different grid line directions is equal to the grid angle or a multiple thereof. In other words, for a specific regular grid, the grid angle is a fraction of 360°, i.e. 360° divided by a natural number. For example, the regular grid may be a hexagonal grid, with a grid angle of 60°. In other examples, the regular grid is an orthogonal grid with a grid angle of 90°, or an octagonal grid with a grid angle of 45°.

[0018] The system allows to - by connecting selected holding elements to the central body - compose a node having a regular configuration in the XZ plane. This implies that the obtained node is based on a specific regular grid, namely a regular grid having a grid angle equal to the inclination angle as determined by the second design of holding elements. In other words, a grid-based node can be composed, by connecting selected holding elements to the central body according to a specific configuration. Different node configurations are possible that correspond to a regular node. For a composed node in a regular configuration, the connection lines in the XZ plane are such that they are parallel to the grid line directions defined by the regular grid in the XZ plane. This implies that any connection line of the regular node intersects any other connection line at an angle which is equal to the grid angle or a multiple thereof. In other words, for a regular type of node, any elongated element that is connected to the node extends in a direction which is parallel to one of the grid line directions. For example, the inclination angle as defined by the second design of holding elements may be 60°, defining a grid angle of 60°, such that regular type of nodes are based on a hexagonal grid. In this case, every central axis of a held elongated element will intersect with any other central axis at an angle being 60°, 120°, 180°, 240° or 300°. In other embodiments, a different grid angle may apply, e.g. 90° or 45° or 30°. In a preferred embodiment, for a node of the regular type, the centre point of the first polygonal cross section of the central body corresponds to a grid node, implying that every connection line of a regular node intersects the centre point of the first polygonal cross section of the central body.

[0019] On the other hand, the system also allows to compose a node having a semi-regular configuration in the XZ plane. This means that the obtained node has at least one connection line that corresponds to a grid line direction of the regular grid, the latter being the same regular grid in the XZ plane as defined by the regular type of nodes. Additionally, the node of the semi-regular type has a connection line which is according to a direction not parallel to any of the grid line directions. Thus, the semi-regular node is such that an elongated element can be connected that extends in a direction deviating from the grid line directions defined by the regular grid in the XZ plane. In other words, for a node of the semi-regular type, a pair of connection lines in the XZ plane is present for which the mutual angle does not correspond to the grid angle or a multiple thereof. A node of the semi-regular type can be obtained by providing a node of the regular type, and subsequently replacing a holding element of the first design by a holding element of the second design, or vice versa.

[0020] For example, the inclination angle as determined by holding elements of the second design may be 60°, defining a grid angle of 60°, such that regular type of nodes are based on a hexagonal grid in the XZ plane. The regular node may be composed of a central body with rectangular cross section, holding elements of a first design adapted to hold an elongated element in a direction perpendicular to a flat surface of the central body, and holding elements of a second design adapted to hold an elongated element at an angle of 60° with respect to flat surfaces of the central body. The central body may be adapted to connect two vertical beams and four angled beams in the XZ plane, every beam extending according to a grid line direction defined by the hexagonal grid. By replacing a holding element of the second design with one of the first design, an angled beam can be replaced by a horizontal beam, the horizontal direction not making part of the grid line directions of the hexagonal grid. In this way, the regular node based on the hexagonal grid is transformed into a node of the semi-regular type.

[0021] Similar configurations as in the previous example can be obtained by using a central body with hexagonal cross section; connecting holding elements of the first type results in a regular node based on a hexagonal grid, while replacing one of the holding elements with a holding element of the second design results in a semi-regular type of node. In other embodiments, other shapes of the first polygonal cross section, or another grid angle, may be used. In a preferred embodiment, every connection line in the XZ plane of a regular type of node intersects the centre point of the first polygonal cross section of the central body, while for a node of the semi-regular type at least one connection line intersects the centre point of the first cross section, and at least one connection line does not intersect the centre point of the first cross section.

[0022] Optionally, as specified by claim 3, the inclination angle is 60 degrees and the regular grid is a hexagonal grid. This implies that a holding element of the second design defines a connection line with an inclination angle of 60 degrees with respect to the flat surface of the central body. Accordingly, the grid angle of the regular grid is 60 degrees, the regular grid thus being a hexagonal grid. Thus, for a regular type of node, every connection line in the XZ plane is on the hexagonal grid, while for a semi-regular type of node at least one connection line is on the hexagonal grid and at least one connection line is not on the hexagonal grid. In an embodiment, the first polygonal cross section of the central body may be rectangular, and a hexagonal node may be obtained by connecting holding elements of the first design to the short sides of the rectangle and holding elements of the second design to the long sides of the rectangle. Replacing a holding element of the second design with one of the first design, results in a semi-regular type of node having a connection line deviating from the hexagonal grid. In another embodiment, the first polygonal cross section of the central body is hexagonal, and a hexagonal node may be composed by connecting holding elements of the first design to the sides of the hexagonal central body. In this case, replacing a first design holding element with a second design holding element, the latter defining the inclination angle of 60°, allows to connect a beam in a direction deviating from the hexagonal grid, thereby resulting in a semi-regular type of node.

[0023] Optionally, one of the line directions of the regular grid in the XZ plane corresponds to the vertical direction Z, and none of the grid line directions corresponds to the longitudinal direction X, and for a node of the semi-regular type at least one connection line has a direction according to the longitudinal direction X. For example, the regular grid is a hexagonal grid, having three different grid directions in the XZ plane: a grid direction according to the Z direction, a grid direction angled at 60° with respect to the Z direction, and a grid direction angled at 120° with respect to the Z direction. The X direction does not correspond to one of the grid directions of the hexagonal grid. In this case, for a regular type of node, every connection line in the XZ plane has a direction corresponding to one of the grid directions of the hexagonal grid, while for a semi-regular type of node at least one of the connection lines extends in X direction, thereby deviating from the hexagonal grid.

[0024] Optionally, as specified by claim 4, the holding elements of the first and second design both comprise a holding surface, wherein, when the holding element is connected to a flat surface of the central body:

- the holding surface is parallel to the transverse direction Y, and
- for a holding element of the first design, the holding surface is parallel to the flat surface of said central body, and
- for a holding element of the second design, the holding surface is inclined with respect to the flat surface of the central body, at an angle equal to the complement of the inclination angle,

such that, when the holding element is connected to a flat surface of the central body, the normal to the holding surface corresponds to the direction of the connection line in the XZ-plane.

[0025] This implies that each of the holding elements comprises a physical surface corresponding to the holding surface, being a flat surface which, when the holding element is connected to the central body, is parallel to the transverse direction and is perpendicular to the connection line. Thus, the normal to the holding surface defines the connection line: when an elongated element is held by the holding element, its central axis extends in a direction parallel to the normal, i.e. perpendicular to the holding surface. Typically, a component is fixed to the holding surface, that component being adapted to hold the elongated element. Typically, that component extends in a direction according to the normal to the holding surface. For example, a fin or sleeve is fixed to the holding surface, the fin or sleeve extending in a direction perpendicular to the holding surface and adapted to hold an elongated element extending in a direction perpendicular to the holding surface. For example, the elongated element may be a beam having a flat front face with a groove, and the holding element may comprise a fin secured to the holding surface of the holding element. When the beam is held by the holding element, the fin is inside the groove of the beam, and the front face of the beam is parallel to the holding surface. In an embodiment, the holding surface may be a contact surface, meaning that it is adapted to hold an elongated element, comprising a flat front face perpendicular to the central axis, such that this flat front face is at least partly in contact with the contact surface. In another embodiment, the front face of the beam is not in contact with the holding surface when being held by the holding element; e.g. there is a gap between the flat front face of the beam and the holding surface of the holding element.

[0026] Optionally, as specified by claims 5, for any node of the regular type, the distance from the centre point of the first polygonal cross section to the holding surface, measured along the connection line in the XZ-plane, is a constant value for each of the holding elements. This implies that for a regular type of node, the holding surfaces are at constant distance from the centre point of the first polygonal cross section of the central body. Thus, the holding surfaces together define or delimit a regular polygon. This has the advantage that the construction node may serve as a true grid node, and an increased standardisation in the length dimension of the elongated elements is obtained.

[0027] In an embodiment, two to six holding elements, adapted to hold an elongated element extending in the XZ plane, are connected to the central body in composed condition of the construction node.

[0028] Optionally, as specified by claim 6, the flat surfaces consist of a top surface, a bottom surface, a first side surface and a second side surface, the top and bottom surface being parallel to the XY plane, and the first and second side surface being parallel to the YZ plane. This implies that the central body has two pairs of parallel flat surfaces: a bottom surface parallel to a top surface, and a first side surface parallel to a second side surface. These flat surfaces may delimit the first polygonal cross section, the latter thus having a rectangular shape. This shape of central body further contributes to a seamless integration of the node in the skeleton, as a side surface of the central body, where no elongated element is attached to, may perfectly align with the elongated elements connected to the top and bottom surface of the central body.

[0029] Optionally, in composed condition of the construction node, at most one holding element is connected to the top surface, at most one holding element is connected to the bottom surface, at most two holding elements are connected to the first side surface, and at most two holding elements are connected to the second side surface.

[0030] Optionally, as specified by claim 7, the first polygonal cross section defined by the flat surfaces has a rectangular shape, of which the long sides are parallel to the Z direction and the short sides are parallel to the X direction, and the length of a long side is double of the length of a short side. In an embodiment the central body has a rectangular cross section. In another embodiment, the flat surfaces merely define or delimit a rectangle, e. g. when the cross section of the central body has rounded corners.

[0031] Optionally, as specified by claim 8, each of the flat surfaces comprises one or more apertures, adapted to receive fasteners for releasably connecting a holding element. For example, the fasteners may be screws, pins, or striking pens.

[0032] Optionally, as specified by claim 9, a holding element of the first or second design comprises a mounting plate, adapted to be releasably connected to the central body, such that the mounting plate is in contact with the flat surface of the central body. In an embodiment, the mounting plate may comprise one or more apertures, adapted to receive fasteners for releasably connecting the mounting plate to the central body.

[0033] Optionally, as specified by claim 10, a holding element of the first design comprises a fin extending in a direction perpendicular to the mounting plate.

[0034] Optionally, for a holding element of the first design, the top surface of the mounting plate corresponds to the holding surface of the holding element. This implies that for a holding element of the first design, when holding an elongated element comprising a flat front face perpendicular to the central axis, the flat front face of the elongated element is parallel to the mounting plate. In an embodiment, the flat front face of the elongated element may at least partly be in contact with the top surface of the mounting plate.

[0035] Optionally, as specified by claim 11, a holding element of the second design comprises a fin extending in an angled direction with respect to the mounting plate, with an angle relative to the mounting plate equal to the inclination angle.

[0036] Optionally, as specified by claim 12, a holding element of the second design comprises a holding plate, and a fin secured to the holding plate, wherein the direction in which the fin extends is perpendicular to the holding plate. Moreover, as specified by claim 13, the holding plate is secured to the mounting plate, at an angle with respect to the mounting plate being equal to the complement of the inclination angle.

[0037] Optionally, for a holding element of the second design, the top surface of the holding plate corresponds to the holding surface of the holding element. The holding surface is inclined with respect to a flat surface of the central body, at a second inclination angle different from 90 degrees. The second inclination angle corresponds to the complement of the inclination angle. This implies that, for a holding element of the second design, when holding an elongated element comprising a flat front face perpendicular to the central axis, the flat front face of the elongated element is parallel to the holding surface. In an embodiment, the flat front face may at least be partly in contact with the top surface of the holding plate.

[0038] Optionally, the fin, comprised in a holding element of the first or second design, comprises holes, the holes being adapted to releasably connect an elongated element by means of fasteners through the holes and corresponding holes provided in the elongated element. For example, the fasteners may be screws, pins, or striking pens.

[0039] Optionally, as specified by claim 13, the central body comprises a second set of flat surfaces parallel to the longitudinal direction X, wherein the second set of flat surfaces together define a second polygonal cross section in an YZ plane, and the system is adapted to compose different configurations of a construction node by releasably connecting a selection of the holding elements to the flat surfaces of the second set, each of the connected holding elements being adapted to hold an elongated element extending in the YZ plane, such that the central axis of an elongated element defines a connection line in the YZ plane. The YZ plane is orthogonal with respect to the longitudinal X direction. This implies that, additionally to the flat surfaces parallel to the transverse direction, the central body also comprises flat surfaces parallel to the longitudinal direction. The cross sections in an YZ plane of the latter flat surfaces together define a second polygonal shape. For example, the central body comprises a flat top and bottom surface parallel to the XY plane and a flat front and back surface parallel to the XZ plane. These flat surfaces are adapted to connect the holding elements of the first and second design. For a holding element of the first design, when being connected to a flat surface of the second set, the connection line in the YZ plane is perpendicular to that flat surface. For a holding element of the second design, when being connected to a flat surface of the second set, the connection line in the YZ plane is inclined with respect to that flat surface, with an inclination angle different from 90 degrees.

[0040] In this way, besides the different configurations of the construction node that can be obtained in the XZ plane, also different configurations can be obtained in the YZ plane. In an embodiment, the system allows to compose configurations in the YZ plane, comprising:

- configurations of a regular type, based on a regular grid defined by grid line directions in the YZ plane, the grid line directions having a mutual grid angle equal to the inclination angle, such that for any node of the regular type, every connection line in the YZ plane has a direction according to one of the grid line directions; and
- configurations of a semi-regular type, wherein for any node of the semi-regular type at least one connection line in the YZ plane has a direction according to one of the grid line directions, and at least one connection line in the YZ plane has a direction different from any of the grid line directions.

[0041] In this case, a construction node may be composed that has a regular configuration in both the XZ and YZ plane, or has a regular configuration in the XZ plane and a semi-regular configuration in the YZ plane, etc.

[0042] According to a second aspect of the present invention, defined by claim 14, the above identified objectives are realized by a construction system, the construction system comprising:

- a system for composing a construction node according to the first aspect of the invention;
- at least one elongated element having a central axis and two opposing outer ends, the outer ends adapted to be connected to the holding element of the first design and adapted to be connected to the holding element of said second design, thereby being held by the holding element of the first respectively second design,

such that:

- for a holding element of the first design, when being connected to a flat surface of the central body and holding the elongated element, the central axis is perpendicular to the flat surface, and
- for a holding element of the second design, when being connected to a flat surface of the central body and holding the elongated element, the central axis is inclined with respect to the flat surface, with an inclination angle different from 90 degrees.

[0043] Thus, the construction system comprises at least one central body, one or more holding elements of the first design, one or more holding elements of the second design, and at least one elongated element. The elongated element has outer ends being specifically adapted to connect to a holding element. Typically, a pair of connection elements is present, of which one element is comprised in the holding element, and one element is comprised in the elongated element. For example, the holding element comprises a fin, and the elongated element comprises a corresponding groove. Additionally, the fin may comprise holes, and the elongated element comprises corresponding holes through which fasteners may be inserted. In a preferred embodiment, a releasable type of connection is formed between the elongated element and the holding element. Typically, the construction system comprises multiple beams, all of them having a similar design at their outer ends.

[0044] According to a third aspect of the present invention, the above identified objectives are realized by a set of construction nodes, defined by claim 15, wherein each of the construction nodes is suitable for connecting elongated elements in a construction, and each of the construction nodes comprises:

- a central body, comprising flat surfaces parallel to a transverse direction Y, the transverse direction Y being orthogonal with respect to an XZ plane, and the XZ plane defined by a longitudinal direction X and an orthogonal vertical direction Z, wherein the flat surfaces together define a first polygonal cross section in the XZ plane;
- at least two holding elements, connected to the flat surfaces of the central body, each of the connected holding elements being adapted to hold an elongated element extending in the XZ plane, such that the central axis of the elongated element defines a connection line of the construction node in the XZ plane, and

wherein the set comprises one or more holding elements of a first design and one or more holding elements of a second design, the second design being different from the first design, wherein:

- for a holding element of the first design, the connection line is perpendicular to the flat surface, and
- for a holding element of the second design, the connection line is inclined with respect to the flat surface, with an inclination angle different from 90 degrees,

and wherein the set comprises different configurations of construction nodes, comprising:

- at least one configuration of a regular type, based on a regular grid defined by grid line directions in the XZ plane, the grid line directions having a mutual grid angle equal to the inclination angle, such that for any node of the regular type, every connection line in the XZ plane has a direction according to one of the grid line directions, and
- at least one configuration of a semi-regular type, for which at least one connection line in the XZ plane has a direction according to one of the grid line directions, and at least one connection line in the XZ plane has a direction different from any of the grid line directions.

[0045] In an embodiment, the construction nodes comprised in the set of construction nodes may be obtained by composing nodes using the system according to the first aspect of the invention. In this case, each construction node comprises holding elements releasably connected to the central body. In another embodiment, the holding elements are secured to the central body in a non-releasable way. For example, two or more holding elements are welded to flat surfaces of a central body to obtain a construction node. The construction nodes comprised in the set do not all have the same configuration. In particular, at least one node of the set has a regular configuration, and at least one node of the set has a semi-regular configuration.

[0046] The construction nodes may make part of a construction system for constructing a building, the construction system comprising:

- a set of construction nodes according to the third aspect of the invention;
- elongated elements, each of the elongated elements having two opposing outer ends adapted to connect to the holding elements,

wherein the construction system is adapted to join the elongated elements by means of the construction nodes.

Brief Description of the Drawings

[0047]

Fig. 1 shows a central body, according to an embodiment of the invention.

Fig. 2 shows a holding element of a first design, according to an embodiment of the invention.

Fig. 3 shows a holding element of a second design, according to an embodiment of the invention.

Fig. 4 shows a composed construction node, according to an embodiment of the invention, the construction node being an orthogonal node.

Fig. 5 shows a composed construction node, according to an embodiment of the invention, the construction node being a hexagonal node in the XZ plane and an orthogonal node in the YZ plane.

Fig. 6 and 7 illustrate how elongated elements can be connected to a construction node, according to an embodiment of the invention.

Fig. 8 gives a cross section according to an XZ plane of the construction node of Fig. 5.

Fig. 9 illustrates the different connection line directions that may be obtained with a construction node according to an embodiment of the invention, and their relation to a regular hexagonal grid.

Fig. 10 to 13 illustrate different configurations of construction nodes, for different types of joints in a skeleton, according to an embodiment of the invention.

Fig. 14 shows a skeleton of a house, making use of construction nodes according to an embodiment of the invention.

Detailed Description of Embodiment(s)

[0048] Fig. 1 shows a central body 100, according to an embodiment of the invention. The central body 100 extends in a longitudinal X direction 106, a transverse Y direction 107 and a vertical or height direction Z 108. The central body comprises flat surfaces 101, 104, 103, 112 parallel to the Y direction. In the shown embodiment, these flat surfaces consist of a top surface 101, a bottom surface 104, a first side surface 103 and a second side surface 112. The bottom 104 and top surface 101 are parallel to the XY plane, and both side surfaces 103, 112 are parallel to the YZ plane. In an XZ plane, the flat surfaces 101, 104, 103, 112 define a first polygonal cross section 812. In the shown embodiment, the central body 100 comprises a rectangular cross section according to an XZ plane, this rectangular cross section corresponding to the first polygonal cross section 812. As is visible on Fig. 8, the first polygonal cross section 812 is a rectangle, of which the sides correspond to the cross sections of the flat surfaces 101, 103, 104, 112. In the shown embodiment, the height 108 of the central body 100 is double of the width 110, such that for the rectangular cross section the long side 902 is double of the short side 901. In another embodiment, the cross section of the central body 100 may be a rectangle with rounded corners, such that the top flat surface 101 is not in direct contact with the side flat surface 103, the side flat surface 103 is not in direct contact with the bottom flat surface 104, etc.

[0049] In the embodiment shown in Fig. 1, the central body 100 further comprises a flat front surface 111 and a flat back surface 113, both parallel to the XZ plane. The front and back surface 111, 113, together with the top flat surface 101 and the bottom flat surface 104, form a second set of flat surfaces, the latter all being parallel to the X direction. In an YZ plane, the flat surfaces 101, 104, 111, 113 define a second polygonal cross section, being a rectangle in the YZ plane. In the shown embodiment, the height 108 of the central body 100 is double of the depth 109, the depth 109 thus being equal to the width 110. The shown central body 100 is a volume having a shape similar to a cuboid, having rounded edges where the front face 100 respectively back face 113 is connected to the side faces 112, 103.

[0050] Fig. 1 shows that the front surface 111, the first side surface 103, and the top surface 101 comprise apertures 105. Similarly, although not visible on the figure, the back surface 113, the bottom surface 104 and the second side surface 112 comprise apertures. The apertures the central body 100 allow holding elements 200, 300 to be releasably connected to the flat surfaces of the central body 100, as is further illustrated in Fig. 4 and 5.

[0051] Fig. 2 shows a holding element 200 of a first design, according to an embodiment of the invention. The holding element 200 comprises a mounting plate 203. The mounting plate 203 comprises apertures 204, adapted to receive fasteners for releasably connecting the mounting plate 203 to one of the flat surfaces 101, 103, 104, 111, 112, 113 of the central body 100, as is illustrated in Fig. 4 and 5. When being connected to the central body 100, the bottom side of the mounting plate 203 is in contact with the corresponding flat surface of the central body 100. The holding element 200 of the first design further comprises a fin 201, being a plate extending in a direction perpendicular to the mounting plate 203. The fin 201 allows an elongated element 600, 601 to be releasably connected to the holding element 200, as is further illustrated in Fig. 6. For this purpose, the fin 201 comprises holes 202. Finally, the holding element 200 of the first design comprises a holding surface 205, corresponding to the top surface of the mounting plate 203. In the shown embodiment, the top surface of the mounting plate 203 is parallel to the bottom surface of the mounting plate 203.

[0052] Fig. 3 shows a holding element 300 of a second design, according to an embodiment of the invention. The holding element 300 comprises a mounting plate 303. The mounting plate 303 comprises apertures, not visible on Fig. 3, adapted to receive fasteners for releasably connecting the mounting plate 303 to one of the flat surfaces 101, 103, 104, 111, 112, 113 of the central body 100, as is further illustrated in Fig. 5. When being connected to the central body 100, the bottom side of the mounting plate 303 is in contact with the corresponding flat surface of the central body 100. The holding element 300 of the second design further comprises a holding plate 305 and a fin 301 secured to the holding plate 305. The fin 305 is a plate extending in a direction perpendicular to the holding plate 305. Apart from the position of the fin 301 as shown in Fig. 3, the fin 301 may also have a position rotated by 90 degrees, as indicated by the square notches 307. The fin 301 allows an elongated element 600 to be releasably connected to the holding element 300, as is further illustrated in Fig. 7. For this purpose, the fin comprises holes 302. The holding plate 305 is secured to the mounting plate 303, and is inclined with respect to the mounting plate 303. As a result, the fin 301 extends in an angled direction with respect to the mounting plate 303, with an angle relative to the mounting plate 303 equal to the inclination angle 810. The inclination angle 810, as determined by the second design of holding element 300, is further illustrated in Fig. 8. In the shown embodiment, the inclination angle 810 is 60 degrees. The angle between the holding plate 305 and the mounting plate 303 defines a second inclination angle 814, different from 90 degrees. The second inclination angle 814 is equal to the complement of the first inclination angle 810, thus 30 degrees in the shown embodiment. The holding plate 305 comprises holes 304, allowing for an easy access to the apertures in the mounting plate 303, when connecting a holding element 300 to the central body 100 or when disconnecting it. Finally, the holding element 300 of the second design comprises a holding surface 306, corresponding to the top surface of the holding plate 305.

[0053] Fig. 4 shows a composed construction node 400, wherein holding elements 200 of the first design are connected to the central body 100. The front flat surface 111, back flat surface 113, and two side flat surfaces 103, 112, each allow to connect at most two holding elements 200, these two holding elements 200 being positioned underneath one another. The top flat surface 101 and bottom flat surface 104 each allow to connect at most one holding element 200. Thus, in the XZ plane and YZ plane respectively, at most six holding elements 200 are connected to the central body 100. In total, at most ten holding elements may be connected to the central body 100. For releasably connecting a holding element 200 to a flat surface of the central body, screws 401 or striking pens 401 are inserted through the apertures 204 of the mounting plate 203 and through corresponding apertures 105 of the central body 100. In connected condition, the bottom side of the mounting plate 203 is parallel to and in contact with the corresponding flat surface 101, 103, 104, 111, 112, 113. The construction node 400 shown in Fig. 4 is an orthogonal node, meaning that elongated elements 600, 601 may be joined according to orthogonal directions, as is further illustrated in Fig. 6.

[0054] Fig. 5 shows a composed construction node 500, wherein holding elements 200 of the first design and holding elements 300 of the second design are connected to the central body 100. The front flat surface 111, back flat surface 113, and two side flat surfaces 103, 112, each allow to connect at most two holding elements 200, 300, either of the first or second design, these two holding elements 200, 300 being positioned underneath one another. In the XZ plane and YZ plane respectively, at most six holding elements 200, 300 may be connected to the central body 100. In total, at most ten holding elements 200, 300 may be connected to the central body 100. For releasably connecting a holding element 300 to a flat surface of the central body, screws 401 or striking pens 401 are inserted through the apertures of the mounting plate 303 and through corresponding apertures 105 of the central body 100. In connected condition, the bottom side of the mounting plate 303 is parallel to and in contact with the corresponding flat surface 101, 103, 104, 111, 112, 113. The construction node 500 shown in Fig. 5 is an orthogonal node in the YZ plane, meaning that elongated elements 600, 601 may be joined according to orthogonal directions. In the XZ plane, the node 500 represents a hexagonal node, meaning that elongated elements 600, 601 may be joined according to a hexagonal grid, as is further illustrated in Fig. 7 and 8.

[0055] Fig. 6 and Fig. 7 illustrate how elongated elements 600, 601 may be connected to the construction node 400 and 500 respectively. In the shown embodiment, the elongated elements 600, 601 are wooden beams having a rectangular cross section. Every beam 600, 601 comprises a straight groove 604, extending in the length direction of the beam 600, 601, adapted for receiving a fin 201, 301 of a holding element 200, 300. A beam 600, 601 is releasably connected to the node 400, 500 by inserting the fin 201, 301 into the groove 604, and by fixing the beam by means of screws 609. The screws 609 are inserted through holes 603 in the beam 600, 601 and the corresponding holes 202, 302 in the fin 201, 301. A pair of corresponding connection elements is thus present, comprising on the one hand the fin 201, 301 with holes 202, 302 and on the other hand the groove 604 and holes 603. In the shown embodiment, two types of beams are provided: beams 600 with a square cross section and two holes 603, and beams 601 with a rectangular cross section and four holes 603. The height of the latter type of beam 601 is double compared to the height of the first type of beam 600. For a beam 601 the height is such that two fins 201, positioned underneath each other, may be inserted into the groove 604. A beam 600, 601 comprises a flat front face 602, which does not cover the complete cross section, because of a recess 608. When a beam 600, 601 is connected to a holding element 200 of the first design, the flat front face 602 is parallel to the holding surface 205. In the shown embodiment, the flat front face 602 is in contact with the top surface of the mounting plate 203, or only a small gap due to clearance or tolerances is present between the flat front face 602 and the top surface of the mounting plate 203. When a beam 600, 601 is connected to a holding element 300 of the second design, the flat front face 602 is parallel to the holding surface 306. In the shown embodiment, the flat front face 602 is in contact with the top surface of the holding plate 305, or only a small gap due to clearance or tolerances is present between the flat front face 602 and the top surface of the holding plate 305. The recess 608 in the front face of a beam 600, 601 provides space for the fasteners 401 used to connect a holding element 200 to the central body 100.

[0056] Fig. 6 and 7 show that an elongated element 600, 601 has a central axis 607, being the symmetrical axis of the beam 600, 601. When a beam 600, 601 is held by a holding element 200, 300, the central axis 607 defines a connection line, corresponding to the direction in which the elongated element 600, 601 extends when being held by the node. For a holding element 200 of the first design, the connection line is perpendicular to the flat surface 101, 103, 104, 111, 112, 113 of the central body 100. For a holding element 300 of the second design, the connection line is angled with respect to the flat surface 101, 103, 104, 111, 112, 113 of the central body 100, at an angle equal to the inclination angle 810.

[0057] This is further illustrated in Fig. 8, wherein a cross section according to an XZ plane is given for the node 700 of Fig. 7. In the XZ plane, the central body 100 has a rectangular cross section 812, corresponding to the first polygonal cross section 812. A holding element 200 of the first design is connected to the top flat surface 101, thereby defining a connection line 801 and connection direction 807. The connection direction 807 corresponds to the direction in which an elongated element 600, 601 will extend when being held by the holding element 200. The connection line 801 corresponds to the central axis 607 of such a held elongated element 600, 601. For the holding element 200 connected to the top surface 101, the connection line 801 and connection direction 807 are perpendicular to the top surface 101, and perpendicular to the short sides 901 of the rectangular cross section 812. The holding surface 205 of the holding element 200 is perpendicular to the connection line 801 and is parallel to the flat top surface 101 of the central body 100. In other words, the normal to the holding surface 205 corresponds to the direction of the connection line 801 and corresponds to the connection direction 807. In the shown embodiment, the connection line 801 intersects the centre point 811 of the rectangular cross section 812. Another holding element 200 of the first design is connected to the bottom flat surface 104 of the central body 100, thereby defining a connection line 804 perpendicular to the flat surface 104 and intersecting the centre point 811.

[0058] Holding elements 300 of the second design are connected to the side flat surface 103, thereby defining connection lines 802 and 803, and connection directions 808 and 809. The connection direction 808, 809 corresponds to the direction in which an elongated element 600, 601 will extend when being held by the holding element 300. The connection line 802, 803 corresponds to the central axis 607 of such a held elongated element 600, 601. For the holding elements 300 connected to the side surface 103, the connection line 802, 803 and connection direction 808, 809 are angled with respect to the side surface 103, and angled with respect to the long sides 902 of the rectangular cross section 812. The angle between the connection line 802, 803 and the flat surface 103 is the inclination angle 810. In the shown embodiment, the inclination angle 810 is 60 degrees. The holding surface 306 of the holding element 300 is perpendicular to the connection line 802, 803 and is inclined with respect to the flat side surface 103 of the central body 100, at a second inclination angle 814 different from 90 degrees. The second inclination angle 814 is the complement of the inclination angle 810. In the shown embodiment, the second inclination angle 814 is 30 degrees. In other words, the normal to the holding surface 306 corresponds to the direction of the connection line 802 and corresponds to the connection direction 808. In the shown embodiment, the connection lines 802, 803 intersect the centre point 811 of the rectangular cross section 812. Additional holding element 300 of the second design are connected to the side flat surface 112 of the central body 100, thereby defining connection lines 805, 806 angled with respect to the flat surface 112 and intersecting the centre point 811.

[0059] The node configuration shown in Fig. 8 is a configuration of a regular type, meaning that all connection lines 801-806 have a direction according to a regular grid, in this case a hexagonal grid. This is further illustrated in Fig. 9. Fig. 9 again shows the rectangular cross section 812 of the central body 100, having short sides 901 and long sides 902. Moreover, it shows a hexagonal grid, wherein the centre point 811 of the rectangle 812 serves as a grid node 911. The hexagonal grid is defined by three grid line directions 907, 908 and 909, and a constant grid angle 910. In the shown embodiment, the grid line directions correspond to the vertical direction 907, a first angled direction 908 and a second angled direction 909. The first and second angled direction 908, 909 each are at an angle of 60 degrees with the vertical direction Z and at an angle of 30 degrees with the horizontal direction X. The grid is characterised by a constant grid angle 910 of 60 degrees, being the angle between two adjacent grid line directions. As such, the mutual angle between two grid line directions 907, 908, 909 is always 60 degrees or a multiple thereof. For example, the angle between grid line direction 807 and 908 is 60 degrees, and the angle between grid line direction 907 and 909 is 120 degrees.

[0060] From Fig. 8 and 9 it is clear that the inclination angle 810, as determined by the second design holding elements 300, is equal to the grid angle 910 of the hexagonal grid. In other words, the regular grid corresponding to the inclination angle 810 of 60 degrees is the hexagonal grid. The node configuration as shown in Fig. 8 is of the regular type, meaning that every connection line 801-806 is on the hexagonal grid. This implies that any of the connection directions 807-809 corresponds to one of the grid line directions 907-909. The node shown in Fig. 8 makes use of two holding elements 200 of the first design, having a connection line corresponding to the vertical grid line direction 907, and four holding elements 300 of the second design, having a connection line corresponding to the angled grid line directions 908 and 909. In the node configuration shown in Fig. 8, six holding elements 200, 300 are connected in the XZ plane, such that a connection line 801-806 is present according to any of the grid line directions 907-909.

[0061] However, other node configurations of the regular type are possible wherein less than six holding elements 200, 300 are connected to the central body 100. Indeed, every node configuration wherein any of the connection lines is on the regular hexagonal grid, is considered to be of the regular type. For example, a node configuration wherein only a holding element 200 of the first design is connected to the top surface 101 and a holding element 300 of the second design is connected to the side surface 103, is of the regular type, as the corresponding connection lines 801 and 803 are on the regular grid with grid angle equal to the inclination angle of 60 degrees. Remark that an orthogonal node, for example the node of Fig. 4, with orthogonal connection lines, may also be considered as a grid-based node, as each of the connection lines intersect each other at a constant grid angle of 90 degrees. However, this grid angle does not correspond to the inclination angle of 60 degrees as defined by the second design of holding elements 300. In this context, a regular type of node is a node having connection lines according to the hexagonal grid, corresponding to the inclination angle of 60 degrees, such that the orthogonal node does not correspond to a regular type of configuration.

[0062] Fig. 8 further shows that for a regular type of node, in the shown embodiment, the distance 813 is a constant value for every of the connected holding elements 200, 300. The distance 813 is measured along the connection line 806, from the centre point 811 to the holding surface 205, 306 of the holding element 200, 300. For a holding element 200 of the first design, the holding surface 205 corresponds to the top surface of the mounting plate 203. For a holding element 300 of the second design, the holding surface 306 corresponds to the top surface of the holding plate 305. Thus, the holding surfaces 205, 306 of the connected holding elements 200, 300 together define a regular polygon, in this case a hexagon.

[0063] Apart from composing nodes having a regular type of configuration, the system also allows to compose nodes having a semi-regular type of configuration. For a node with semi-regular configuration, at least one connection line is on the regular grid, in this case the hexagonal grid, and at least one connection line is not on that regular grid. A node with semi-regular configuration may e.g. be obtained by starting from a node with regular configuration, having connection lines according to the grid characterised by the inclination angle, and replacing a holding element 300 of the second design with a holding element 200 of the first design. For example, in the node configuration shown in Fig. 8, the holding element 300 of the second design, defining an angled connection line 803, may be replaced by a holding element 200 of the first design. Doing so, the holding element 200 will define a connection line perpendicular to the long side 902, in this case a connection line parallel to the X-direction. The obtained connection line corresponds to the line in horizontal direction 904 as indicated in Fig. 9. Fig. 9 further indicates a line 903 in horizontal direction: replacing in Fig. 8 the holding element 300 with angled connection line 802 by a holding element 200 of the first design, results in a horizontal connection line according to direction 903. The connection lines 903 and 904 are not on the hexagonal grid as defined by the regular type of node, as the horizontal direction does not correspond to one of the grid line directions 907, 908, 909 of the hexagonal grid. On the other hand, the other connection lines of the node are still on the hexagonal grid. The obtained node configuration is thus of the semi-regular type.

[0064] For the shown embodiment, a node may be composed having a specific configuration in the XZ plane, and having a specific configuration in the YZ plane. A node may have a regular type of configuration in both the XZ plane and YZ plane, may have a semi-regular type of configuration in both the XZ plane and YZ plane, may have a semi-regular type of configuration in the XZ plane and a regular type of configuration in the YZ plane, etc. Remark that for the orthogonal node 400 as presented in Fig. 4, the connection lines in Z direction are on the hexagonal grid, while the connection lines in X and Y direction are not on the hexagonal grid. In this context, the orthogonal node 400 of Fig. 4 thus has a semi-regular type of configuration, both in the XZ and YZ plane. The node 500 as presented in Fig. 5 is a hexagonal node in the XZ plane, and thus has a configuration of the regular type in the XZ plane. According to the YZ plane, the node 500 is orthogonal, thus having a configuration of the semi-regular type in the YZ plane.

[0065] Fig. 10 to 13 illustrate different node configurations, which can be composed using the invented system. Each of the presented nodes is directed to a specific function within the skeleton 1400 of a house or other building. Fig. 14 illustrates such a skeleton 1400, wherein nodes of different configurations are used to join elongated elements 600, 601. In the embodiment of Fig. 14, the holding elements 200, 300 are releasably connected to the central body 100. In another embodiment, holding elements may be secured to a central body in a non-releasable way, to obtain a set of construction nodes according to various configurations.

[0066] The node 1000 as presented in Fig. 10 may be used to join beams 600 in the ridge of a roof, see also Fig. 14. In the XZ plane, three holding elements 200, 300 are connected to the central body 100: a holding element 200 of the first design, defining a connection line 1002 according to the Z direction, and two holding elements 300 of the second design, defining a connection line 1001 and 1003 respectively. The connection lines 1001 and 1003 are at an angle of 30 degrees with respect to the X-direction and 60 degrees with respect to the Z-direction. Each of the connection lines 1001, 1002 and 1003 have a direction corresponding to one of the grid line directions 907, 908, 909 of the hexagonal grid. The node thus has a regular type of configuration in the XZ plane.

[0067] The node 1100 as presented in Fig. 11 may be used to create a ring beam at the corner of the skeleton, see also Fig. 14. In the XZ plane, three holding elements 200, 300 are connected to the central body 100: a first holding element 200 of the first design, defining a connection line 1103 according to the Z direction, a second holding element 200 of the first design, defining a connection line 1102 according to the X direction, and a holding element 300 of the second design, defining a connection line 1101 at an angle of 30 degrees with respect to the X direction. The connection lines 1101 and 1103 intersect the centre point 811, and have a direction corresponding to one of the grid line directions 907, 908 of the hexagonal grid. The connection line 1102 does not intersect the centre point 811, and has a direction not corresponding to one of the grid line directions 907-909 of the hexagonal grid. The node 1100 thus has a semi-regular configuration in the XZ plane. As is clear from Fig. 14, the node 1100 allows to join a vertical, horizontal and inclined beam 600 in one point. Such a connection would not be possible when using a regular hexagonal node. The inclined beam has an angle of 30° with respect to the horizontal, which is a preferred value for the inclination of a roof. Remark that using a regular octagonal node would allow for a vertical, horizontal and inclined beam joined in one point, but then would require an inclination angle of 45°.

[0068] The node 1200 as presented in Fig. 12 is suitable for connecting a purlin in a roof. The node 1300 as presented in Fig. 13 is suitable for constructing a ring beam.

[0069] Fig. 14 shows that in the skeleton 1400, the vertical and angled beams are all on a hexagonal grid. This, together with the fact that the nodes have a constant distance 813, see Fig. 8, results in vertical and angled beams all having a standardized length: the length of each of these beams is L1 or a multiple thereof. The beams used in horizontal direction all have a length based on a second standardized set: the length of each of these beams is L2 or a multiple thereof.

[0070] Fig. 14 illustrates that the composed construction nodes allow for a seamless integration into the skeleton 1400. Indeed, a node only comprises these holding elements 200, 300 that are actually needed; no unused holding elements 200, 300 are connected to the central body 100. As a result, the beams 600, 601 perfectly align with the flat sides of the central body 100, and no place is taken by unused holding elements. The system also allows for a simple design of the beams 600, 601: common wooden beams with a flat orthogonal front face may be used, in which only the holes 603 and grooves 604 need to be provided.

[0071] Finally, Fig. 14 illustrates that two beams 600, 601 may be joined together making use of only a holding element 200 of the first design. Indeed, by means of screws or pins through the apertures 204 of the mounting plate 203, the holding element 200 may be secured directly to a first beam 600, the screws or pins thereby piercing the beam. A second beam 600 may then be connected to the holding element 200 by means of the fin 201 and groove 604. The two beams are thus joined without making use of a complete construction node. This results in an additional flexibility concerning the connections that can be made.

[0072] The above shows that the system allows to compose various configurations of construction nodes, thereby obtaining construction nodes adapted for a specific function in the skeleton of a house or other building. The fact that regular as well as semi-regular type of nodes may be composed, results in an increased flexibility compared to existing systems making only use of grid-based nodes. On the other hand, the obtained skeleton is still largely based on a regular grid, thereby allowing for a large amount of standardization in the beam dimensions.

[0073] The nodes may be composed according to the specific actual needs, making use of only three different type of elements: the central body, the holding element of the first design, and the holding element of the second design. A modular system is thus obtained, allowing to make use of prefabricated standard elements, while still allowing for substantial flexibility in the design of the skeleton. When at a certain point in time the house needs to be adapted, according to the actual needs of the occupants, the beams and nodes may easily be disassembled, and reused at another location.

[0074] Although the present invention has been illustrated by reference to specific embodiments, it will be apparent to those skilled in the art that the invention is not limited to the details of the foregoing illustrative embodiments, and that the present invention may be embodied with various changes and modifications without departing from the scope thereof. The present embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein. In other words, it is contemplated to cover any and all modifications, variations or equivalents that fall within the scope of the basic underlying principles and whose essential attributes are claimed in this patent application. It will furthermore be understood by the reader of this patent application that the words "comprising" or "comprise" do not exclude other elements or steps, that the words "a" or "an" do not exclude a plurality, and that a single element, such as a computer system, a processor, or another integrated unit may fulfil the functions of several means recited in the claims. Any reference signs in the claims shall not be construed as limiting the respective claims concerned. The terms "first", "second", third", "a", "b", "c", and the like, when used in the description or in the claims are introduced to distinguish between similar elements or steps and are not necessarily describing a sequential or chronological order. Similarly, the terms "top", "bottom", "over", "under", and the like are introduced for descriptive purposes and not necessarily to denote relative positions. It is to be understood that the terms so used are interchangeable under appropriate circumstances and embodiments of the invention are capable of operating according to the present invention in other sequences, or in orientations different from the one(s) described or illustrated above.

Claims

1. System for composing a construction node (400, 500), said construction node (400, 500) being suitable for connecting elongated elements (600, 601) in a construction, wherein said system comprises:

- a central body (100), comprising flat surfaces (101, 104, 103, 112) parallel to a transverse direction Y, said transverse direction Y being orthogonal with respect to an XZ plane, and said XZ plane defined by a longitudinal direction X and an orthogonal vertical direction Z, wherein said flat surfaces (101, 104, 103, 112) together define a first polygonal cross section (812) in said XZ plane;
- one or more holding elements (200) of a first design, and one or more holding elements (300) of a second design, said second design being different from said first design,

wherein said system is adapted to compose different configurations of a construction node by releasably connecting a selection of said holding elements (200, 300) to said flat surfaces (101, 104, 103, 112) of said central body (100), each of said connected holding elements (200, 300) being adapted to hold an elongated element (600, 601) extending in said XZ plane, such that the central axis (607) of said elongated element (600, 601) defines a connection line (801, 802) of said construction node in said XZ plane, and wherein said first and second design are such that:

- for a holding element (200) of said first design, when being connected to a flat surface (101, 104, 103, 112) of said central body (100), said connection line (801) is perpendicular to said flat surface (101, 104, 103, 112), and
- for a holding element (300) of said second design, when being connected to a flat surface (101, 104, 103, 112) of said central body (100), said connection line (802) is inclined with respect to said flat surface (101, 104, 103, 112), with an inclination angle (810) different from 90 degrees.

2. System according to claim 1, wherein said different configurations of a construction node, comprise:

- configurations of a regular type (1000), based on a regular grid defined by grid line directions (907, 908, 909) in said XZ plane, said grid line directions (907, 908, 909) having a mutual grid angle (910) equal to said inclination angle (810), such that for any node of said regular type, every connection line (1001, 1002, 1003) in said XZ plane has a direction according to one of said grid line directions (907, 908, 909); and
- configurations of a semi-regular type (1100), wherein for any node of said semi-regular type at least one connection line (1101, 1103) in said XZ plane has a direction according to one of said grid line directions (907, 908, 909), and at least one connection line (1102) in said XZ plane has a direction different from any of said grid line directions (907, 908, 909).

3. System according to claim 2, wherein said inclination angle (810) is 60 degrees and said regular grid is a hexagonal grid.

4. System according to any of the preceding claims, wherein said holding elements of said first (200) and second design (300) comprise a holding surface (205, 306), wherein, when said holding element (200, 300) is connected to a flat surface (101, 104, 103, 112) of said central body (100):

- said holding surface (205, 306) is parallel to the transverse direction Y, and
- for a holding element of said first design (200), said holding surface (205) is parallel to said flat surface (101, 104, 103, 112) of said central body (100), and
- for a holding element of said second design

(300), said holding surface (306) is inclined with respect to said flat surface (101, 104, 103, 112) of said central body (100), at an angle (814) equal to the complement of said inclination angle (810),

such that, when said holding element (200, 300) is connected to a flat surface (101, 104, 103, 112) of said central body (100), the normal to said holding surface (205, 306) corresponds to the direction of said connection line (801, 802) in said XZ-plane.

5. System according to claim 2 and 4, and wherein for any node of said regular type, the distance (813) from the centre point (811) of said first polygonal cross section (812) to said holding surface (205, 306), measured along said connection line (805) in said XZ-plane, is a constant value for each of said holding elements (200, 300).

6. System according to any of the preceding claims, wherein said flat surfaces (101, 104, 103, 112) consist of a top surface (101), a bottom surface (104), a first side surface (103) and a second side surface (112), said top (101) and bottom surface (104) being parallel to the XY plane, and said first (103) and second side surface (112) being parallel to the YZ plane.

7. System according to claim 6, wherein said first polygonal cross section (812) has a rectangular shape, of which the long sides (902) are parallel to the Z direction and the short sides (901) are parallel to the X direction, and the length of a long side (902) is double of the length of a short side (901).

8. System according to any of the preceding claims, wherein each of said flat surfaces (101, 104, 103, 112) comprises one or more apertures (105), adapted to receive fasteners (401) for releasably connecting a holding element (200, 300).

9. System according to any of the preceding claims, wherein a holding element (200, 300) of said first or second design comprises a mounting plate (203, 303), adapted to be releasably connected to said central body (100), such that said mounting plate (203, 303) is in contact with said flat surface (101, 104, 103, 112) of said central body (100).

10. System according to claim 9, wherein a holding element (200) of said first design comprises a fin (201) extending in a direction perpendicular to said mounting plate (203).

11. System according to claim 9, wherein a holding element (300) of said second design comprises a fin (301) extending in an angled direction with respect to said mounting plate (303), with an angle relative to said mounting plate (303) equal to said inclination angle (810).

12. System according to claim 11, wherein a holding element (300) of said second design comprises a holding plate (305), and wherein

- said fin (301) is secured to said holding plate (305), the direction in which said fin (301) extends being perpendicular to said holding plate (305), and
- said holding plate (305) is secured to said mounting plate (303), at an angle with respect to said mounting plate (303) being equal to the complement (814) of said inclination angle (810).

13. System according to any of the preceding claims,

wherein said central body (100) comprises a second set of flat surfaces (101, 104, 111, 113) parallel to said longitudinal direction X, wherein said second set of flat surfaces (101, 104, 111, 113) together define a second polygonal cross section in an YZ plane,
and said system is adapted to compose different configurations of a construction node by releasably connecting a selection of said holding elements (200, 300) to said flat surfaces (101, 104, 111, 113) of said second set, each of said connected holding elements (200, 300) being adapted to hold an elongated element (600, 601) extending in said YZ plane, such that the central axis (607) of said elongated element (600, 601) defines a connection line of said construction node in said YZ plane.

14. Construction system comprising:

- a system for composing a construction node according to claim 1 to 13;
- at least one elongated element (600, 601) having a central axis (607) and two opposing outer ends, said outer ends adapted to be connected to said holding element (200) of said first design and adapted to be connected to said holding element (300) of said second design, thereby being held by said holding element (200, 300) of said first respectively second design,

such that:

- for a holding element of said first design (200), when being connected to a flat surface (101, 104, 103, 112) of said central body (100) and holding said elongated element (600, 601), said central axis (607) is perpendicular to said flat

surface (101, 104, 103, 112), and
- for a holding element of said second design (300), when being connected to a flat surface (101, 104, 103, 112) of said central body (100) and holding said elongated element (600, 601), said central axis (607) is inclined with respect to said flat surface (101, 104, 103, 112), with an inclination angle (810) different from 90 degrees.

15. A set of construction nodes,

each of said construction nodes (1000, 1100, 1200, 1300) suitable for connecting elongated elements (600, 601) in a construction,
and each of said construction nodes (1000, 1100, 1200, 1300) comprising:

- a central body (100), comprising flat surfaces (101, 104, 103, 112) parallel to a transverse direction Y, said transverse direction Y being orthogonal with respect to an XZ plane, and said XZ plane defined by a longitudinal direction X and an orthogonal vertical direction Z, wherein said flat surfaces (101, 104, 103, 112) together define a first polygonal cross section (812) in said XZ plane
- at least two holding elements (200, 300), connected to said flat surfaces (101, 104, 103, 112) of said central body (100), each of said connected holding elements (200, 300) being adapted to hold an elongated element (600, 601) extending in said XZ plane, such that the central axis (607) of said elongated element (600, 601) defines a connection line (801, 802) of said construction node in said XZ plane, and

wherein said set comprises one or more holding elements (200) of a first design and one or more holding elements (300) of a second design, said second design being different from said first design, wherein:

- for a holding element (200) of said first design, said connection line (801) is perpendicular to said flat surface (101, 104, 103, 112), and
- for a holding element (300) of said second design, said connection line (802) is inclined with respect to said flat surface (101, 104, 103, 112), with an inclination angle (810) different from 90 degrees,

and wherein said set comprises different configurations of construction nodes, comprising:

- at least one configuration of a regular type (1000), based on a regular grid defined by grid line directions (907, 908, 909) in said XZ plane, said grid line directions (907, 908, 909) having a mutual grid angle (910) equal to said inclination angle (810), such that for any node of said regular type, every connection line (1001, 1002, 1003) in said XZ plane has a direction according to one of said grid line directions (907, 908, 909), and
- at least one configuration of a semi-regular type (1100), for which at least one connection line (1101, 1103) in said XZ plane has a direction according to one of said grid line directions (907, 908, 909), and at least one connection line (1102) in said XZ plane has a direction different from any of said grid line directions (907, 908, 909).

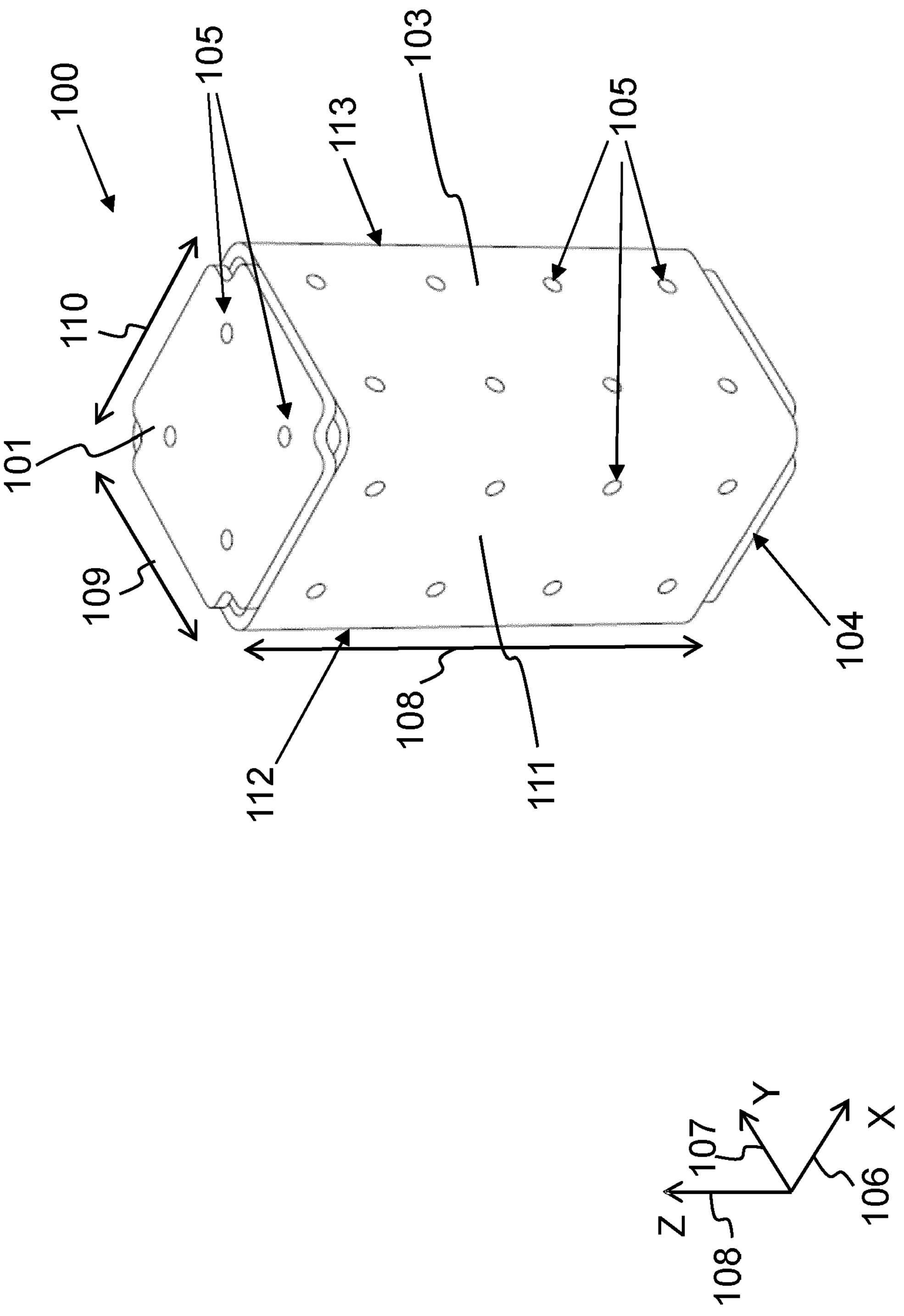

Fig. 1

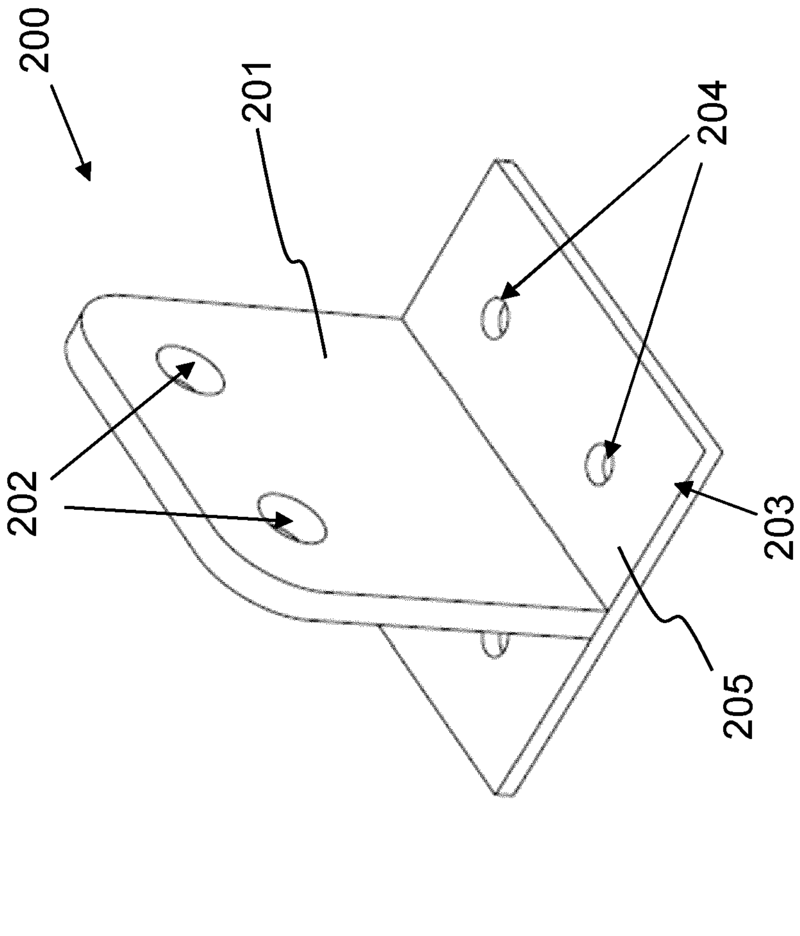

Fig. 2

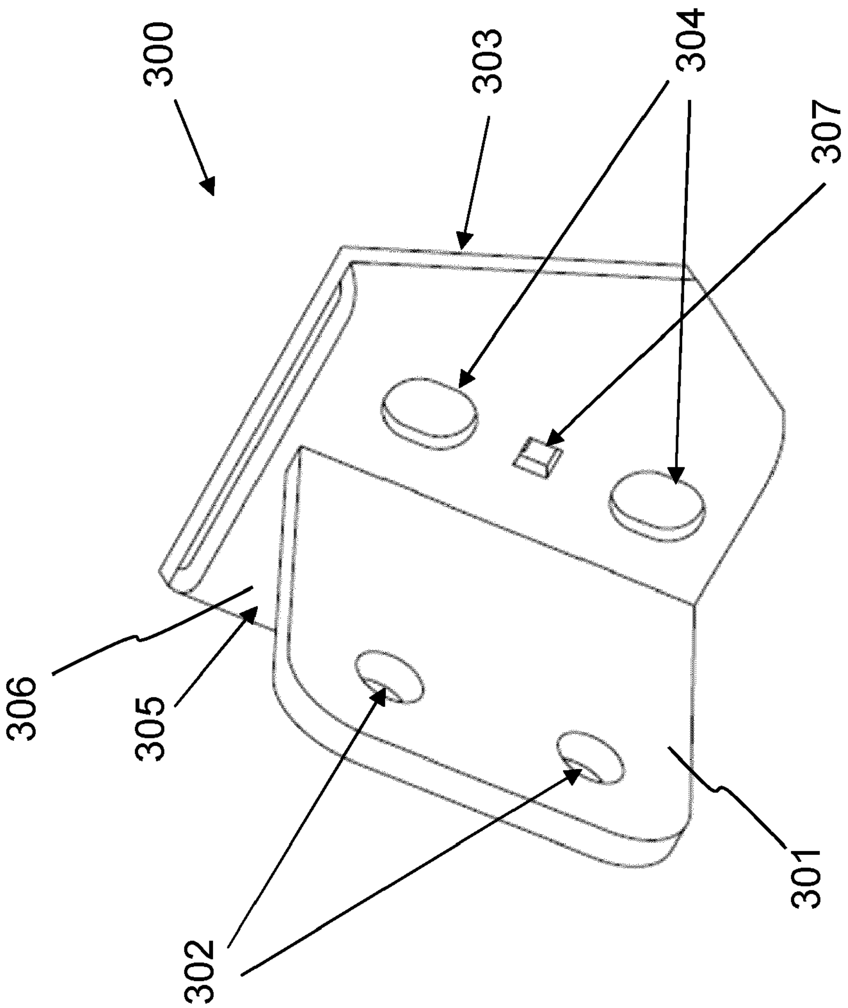

Fig. 3

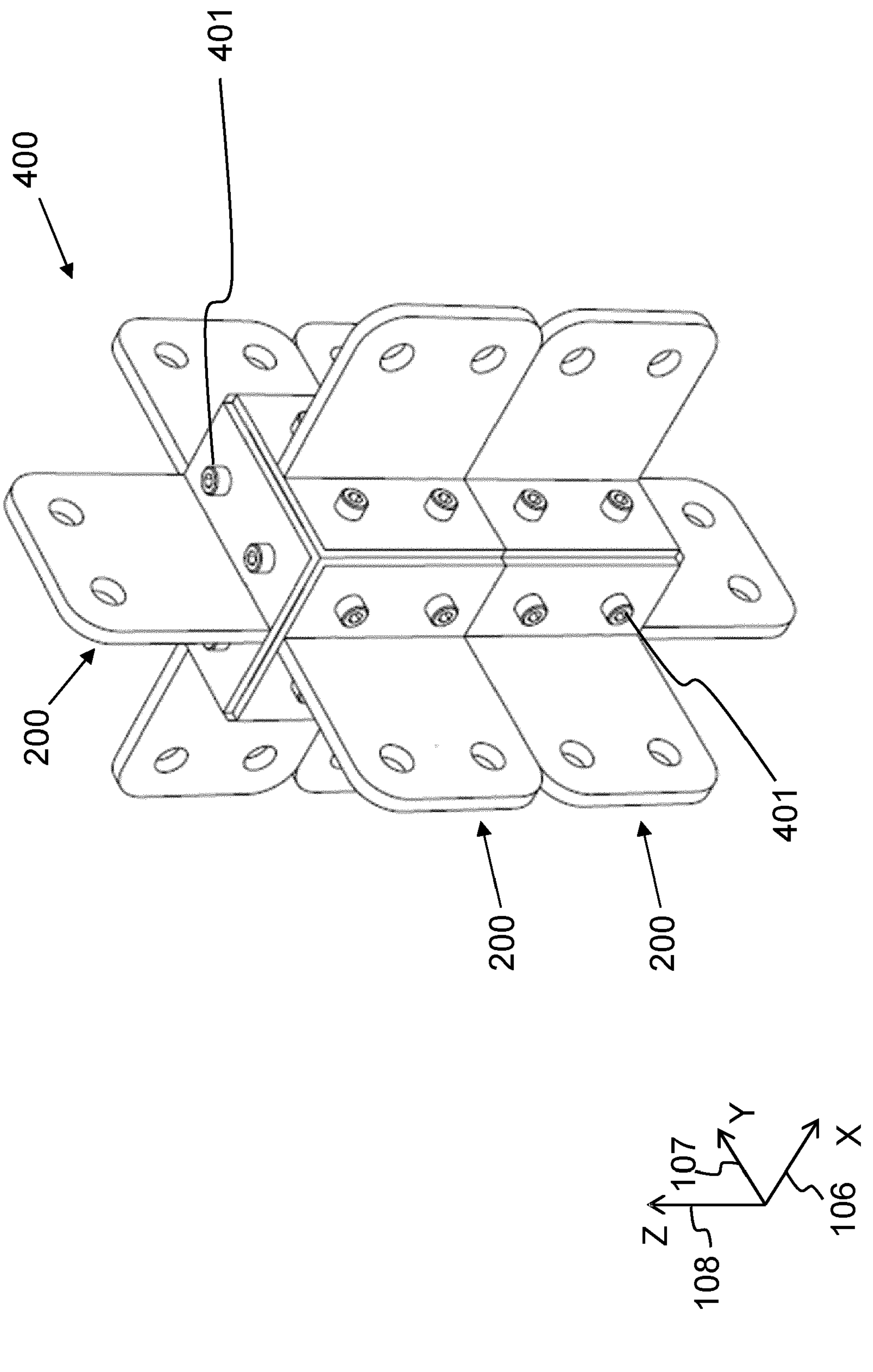

Fig. 4

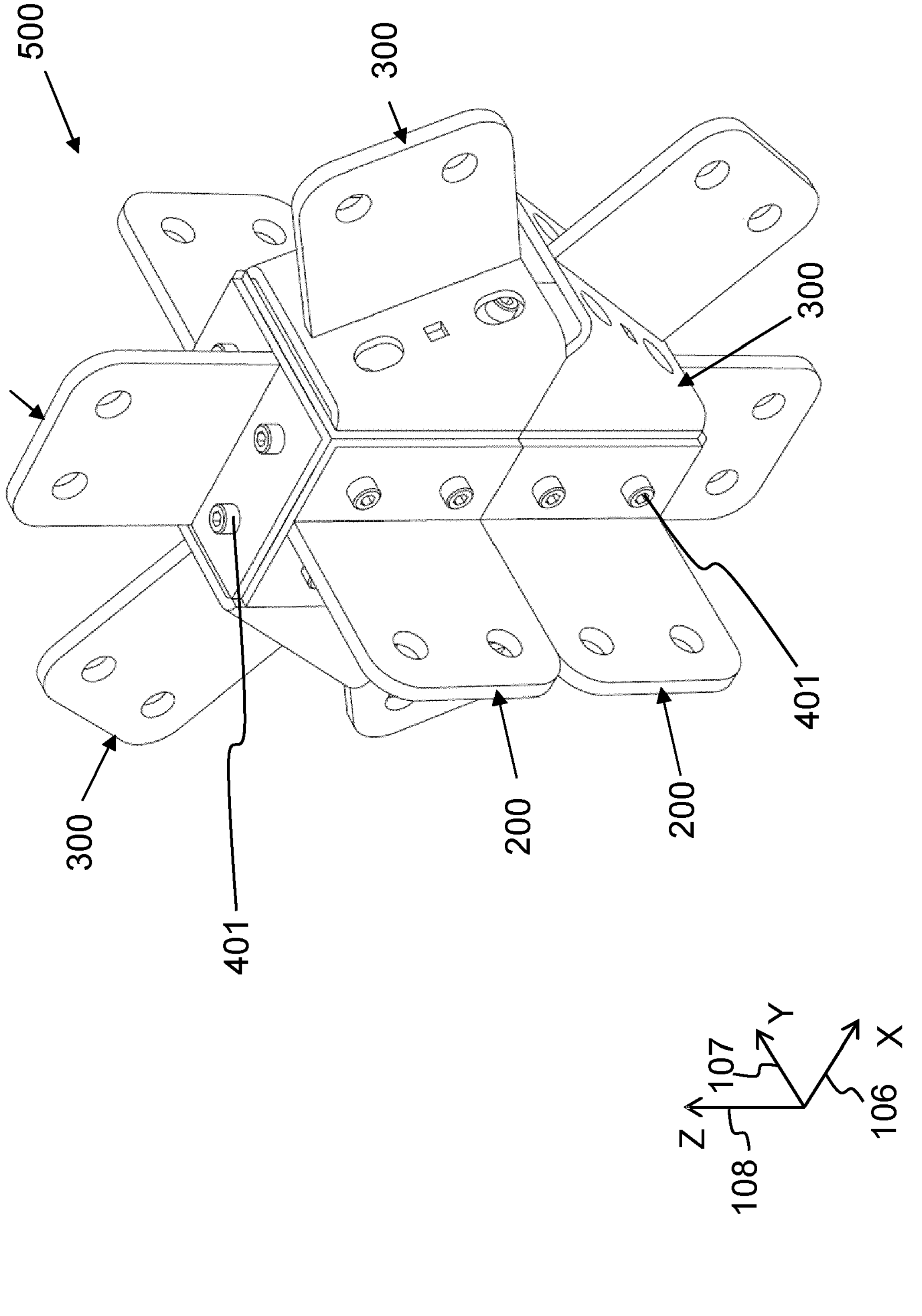

Fig. 5

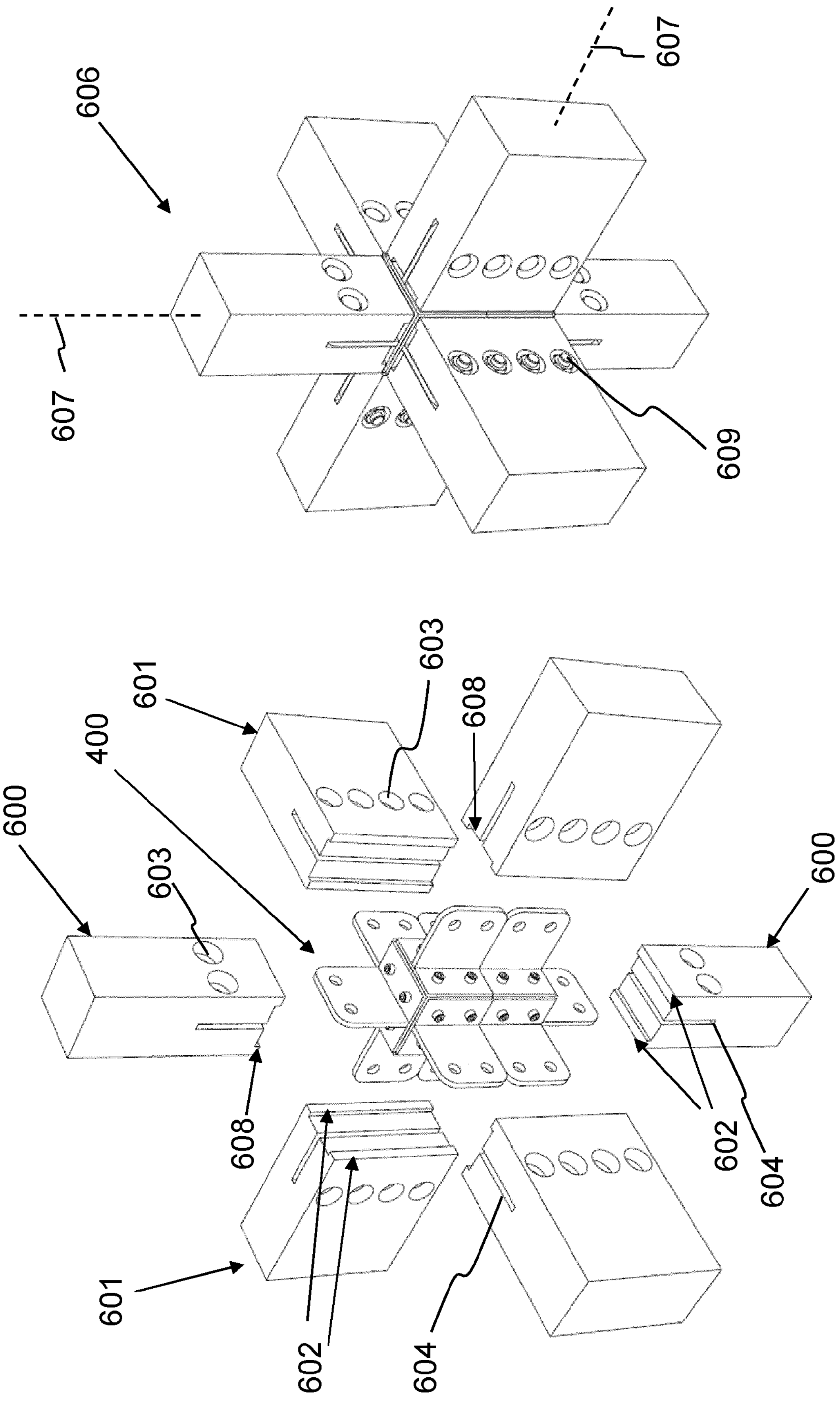
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Fig. 6

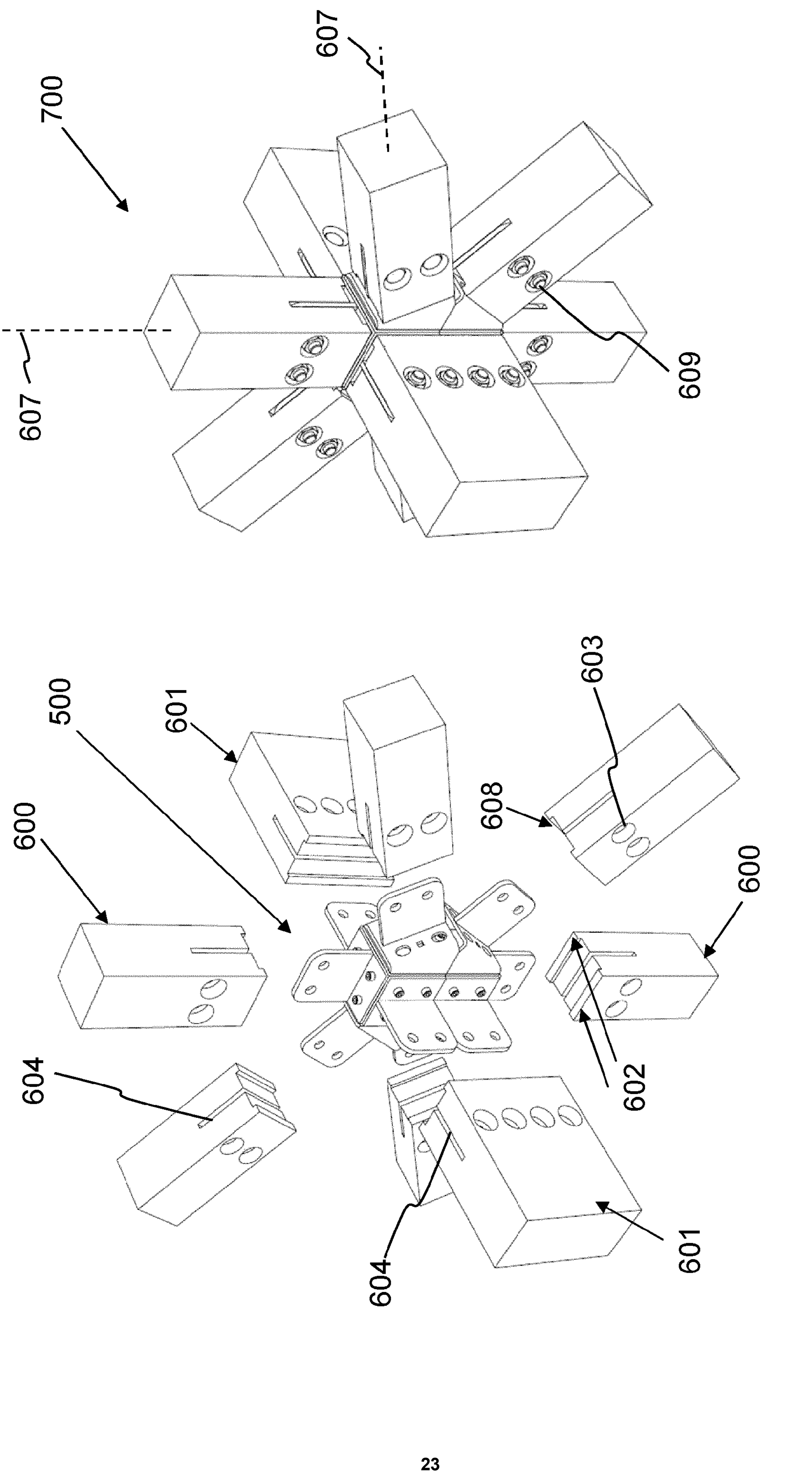

Fig. 7

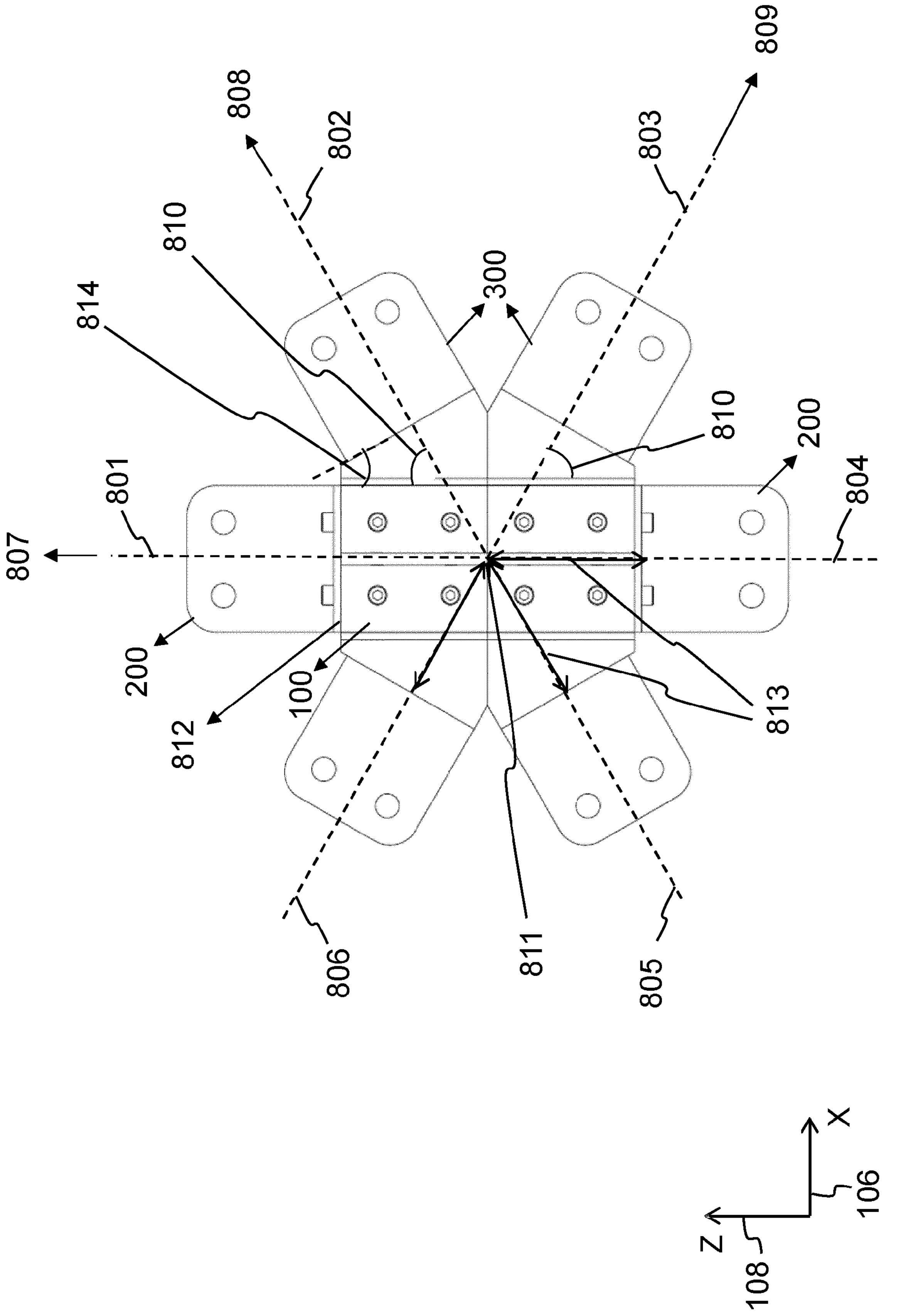
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Fig. 8

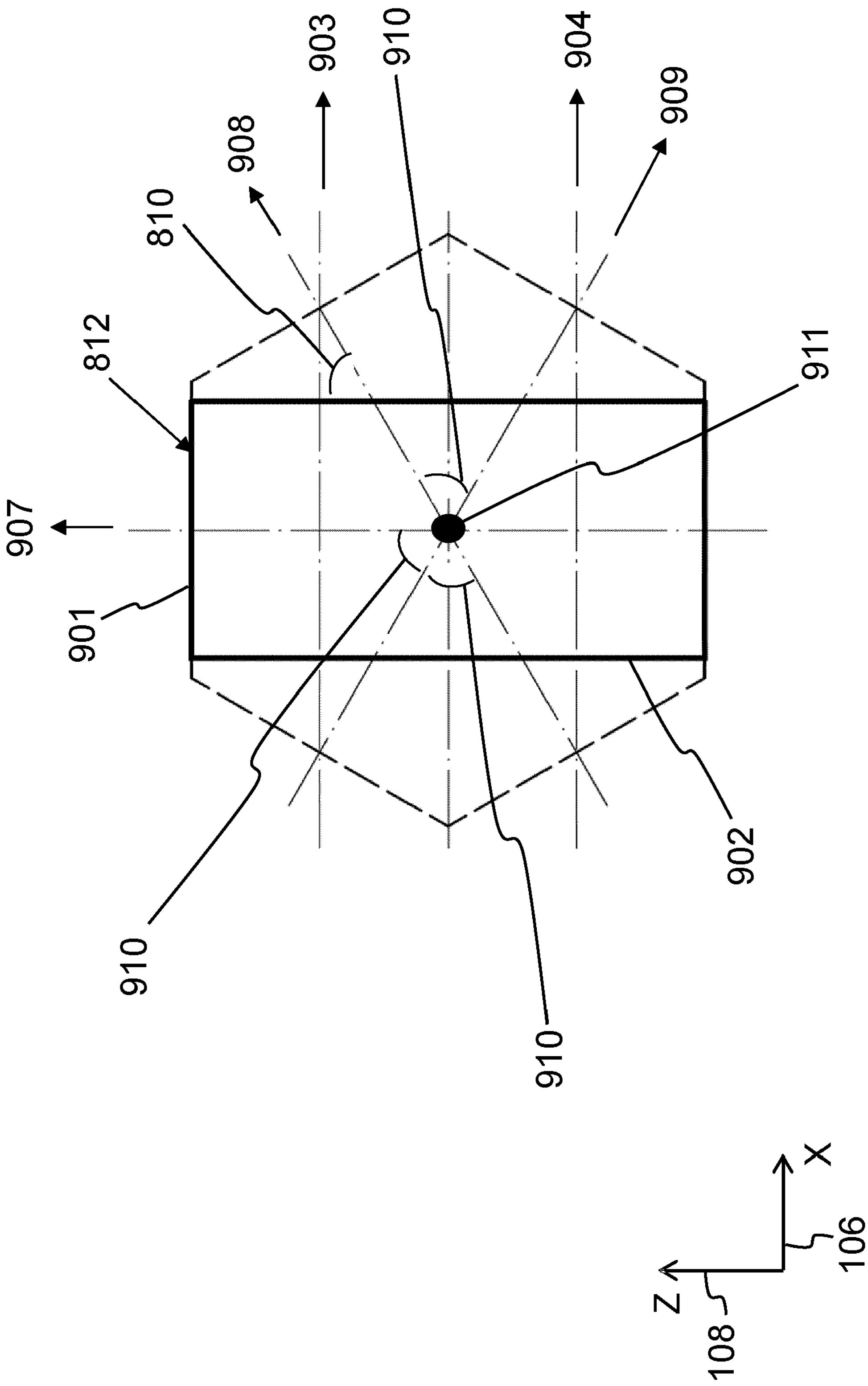

Fig. 9

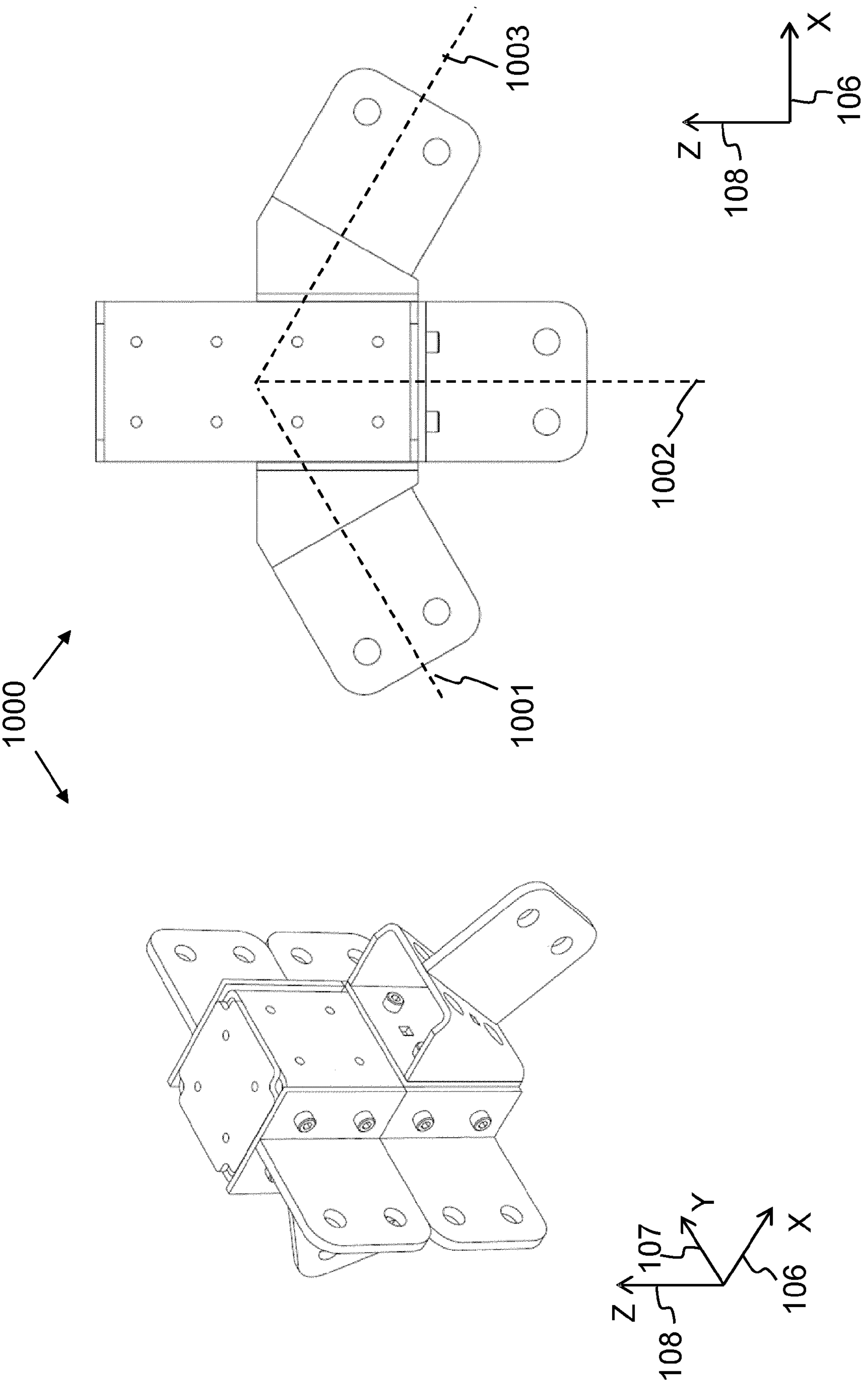

Fig. 10

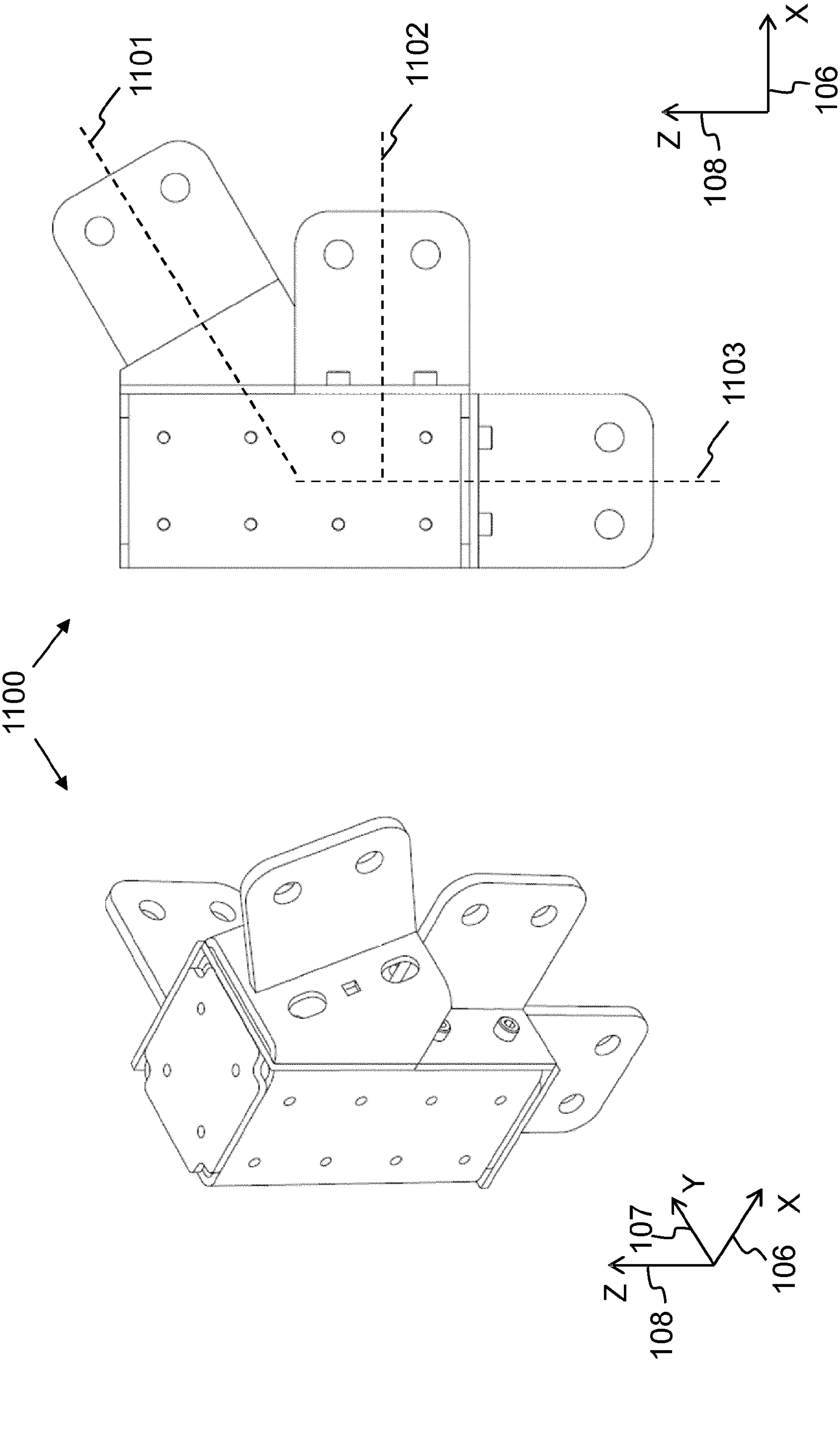

Fig. 11

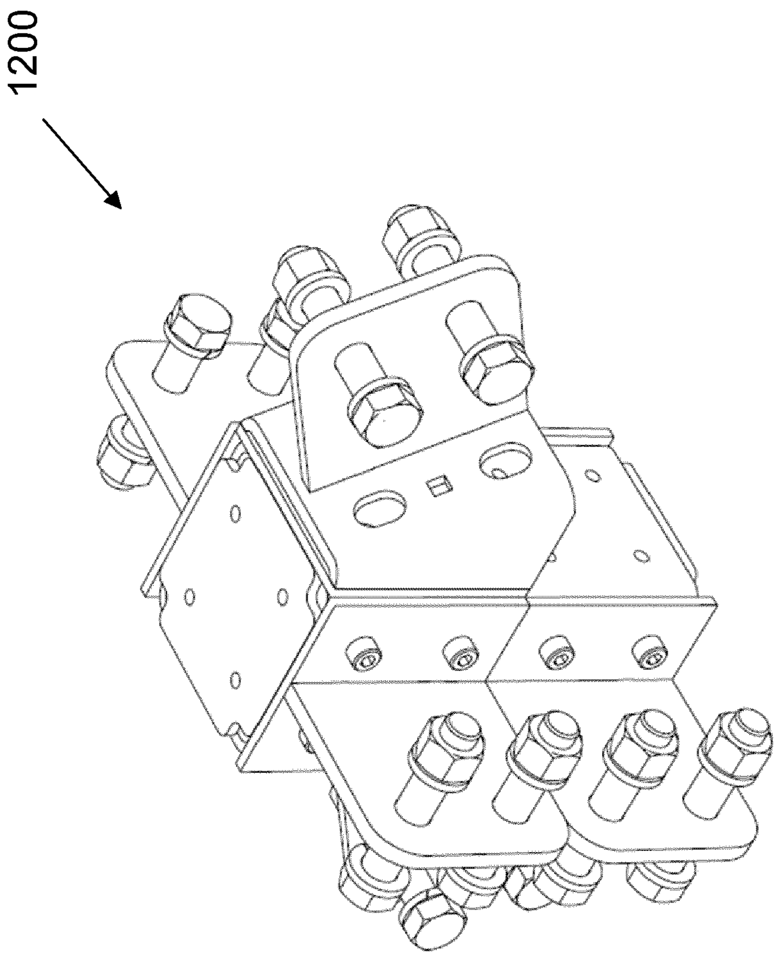

Fig. 12

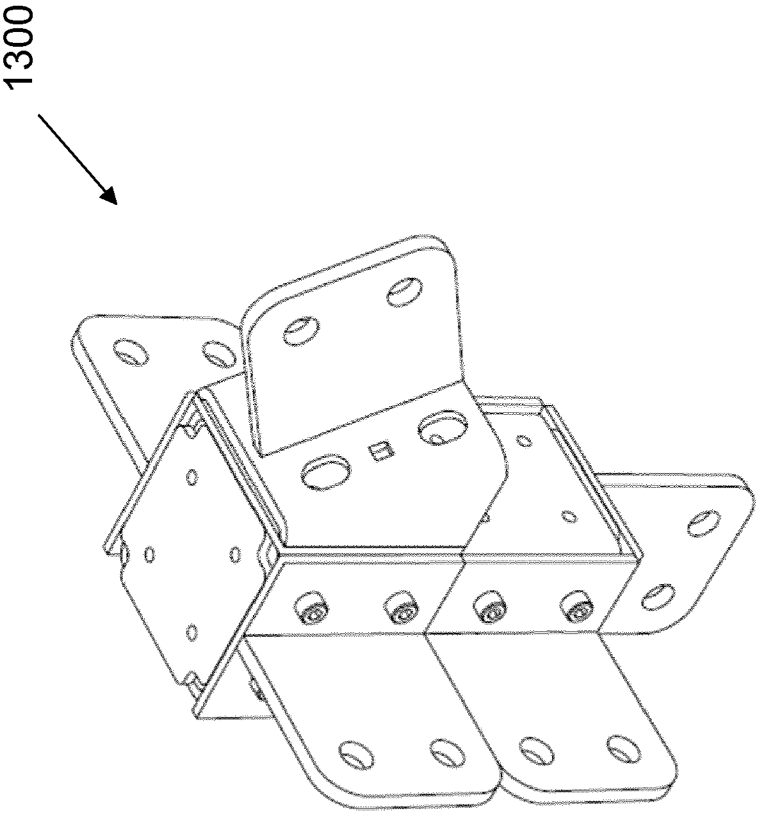

Fig. 13

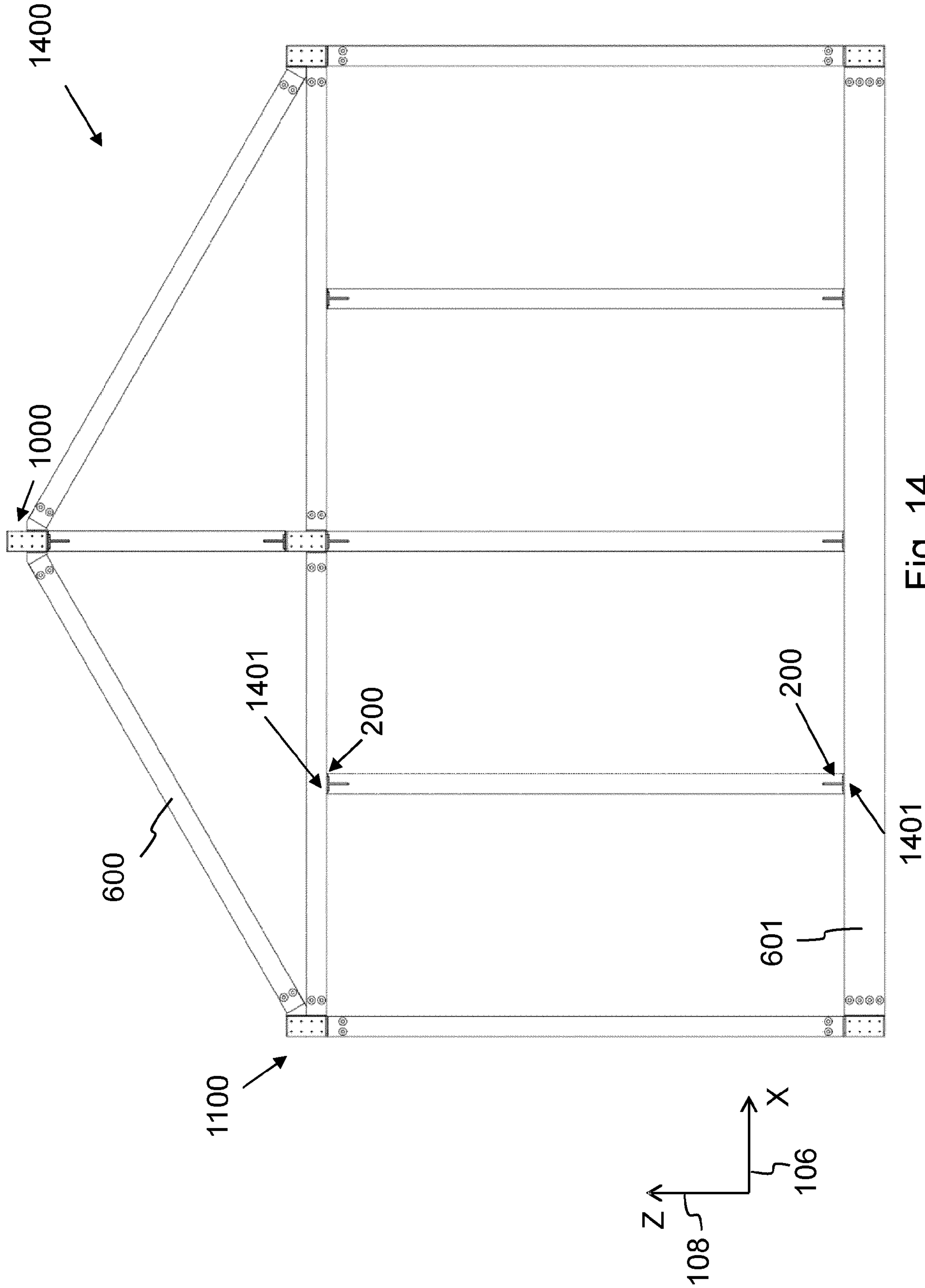

Fig. 14

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EUROPEAN SEARCH REPORT

Application Number
EP 22 17 1136

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	IT 2018 0000 3583 A1 (VIERO LAURA [IT]; VIERO CLAUDIO [IT]) 15 September 2019 (2019-09-15) * page 4, line 10 - page 8, line 14; figures 1-10 * -----	1-15	INV. E04B1/19 E04B1/26
X	US 2015/093184 A1 (HENRY DREW P [US]) 2 April 2015 (2015-04-02) * paragraph [0004] - paragraph [0043]; figures 1-3b * -----	1,4,6,7, 9-12,14	
			TECHNICAL FIELDS SEARCHED (IPC)
			E04B

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	17 October 2022	Dieterle, Sibille

CATEGORY OF CITED DOCUMENTS

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17-10-2022

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

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- CN 110306667 A **[0005]**