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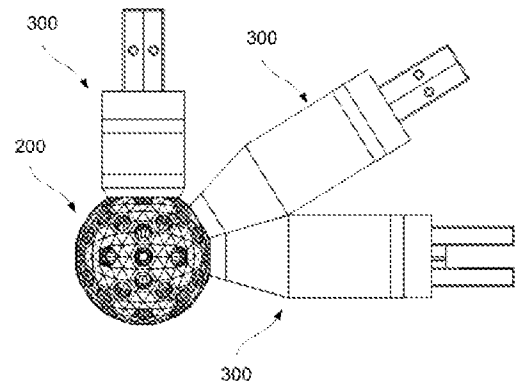
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(71)	Applicant	PRODUKTIF NORWAY AS, c/o Total Innovation AS /Atle Dyrli, Bygning 100, Raufoss Industripark, 2830 RAUFOSS, Norge		
(72)	Inventor	Rune Kongshaug, Nasvikveien 16, 6532 AVERØY, Norge		
(74)	Agent or Attorney	CURO AS, Vestre Rosten 81, 7075 TILLER, Norge		

(54)	Title	Construction system for assembly of a structural construction.
(57)	Abstract	

Construction system (100) for assembly of structural construction, wherein the joint assembly (100) comprises hollow spherical joints (200) and connection assemblies (300) for structure elements (400) or joints, wherein the hollow spherical joint (200) is assembled by multiple identical interlocking joint members (210) or sets of corresponding identical interlocking joint members (210a-b), wherein the hollow spherical joint (200) is provided with multiple connection points (220), wherein the connection assembly (300) is adapted for detachable attachment to the connection points (220) and comprises a locking assembly (500) for locking and unlocking of the connection assembly (300) to the hollow spherical joint (200).



Construction system for assembly of a structural construction

The present invention is related to a construction system for assembly of a structural construction, according to the preamble of claim 1.

The present invention is especially related to a construction system for assembly of a structural construction that makes use of universal and mass-customizable parts.

Background

Tomorrow's demands on the construction sector will require systemic and sustainable resource management with fully integrated production and distribution.

It further demands a lower environmental footprint for each construction. It is thus a requirement of construction systems to reduce the pollution and waste, preferably to facilitate a zero-waste circular economy.

There have over the years been made several attempts to provide a construction system with the attempt of simplifying the assembly of a structural construction, which will be discussed below.

In US3921360A is described a connector having a shape defining an irregular polyhedron having twelve surface portions of a regular hexagonal configuration and six surface portions of square configuration coupled elongated struts of equal length to provide a structurally stable framework or lattice type support structure. The connector and coupled struts provide for fluid and/or electrical distribution throughout the framework.

From US3982841A is known an improved connector for removably interconnecting elongate structural members, comprising a sleeve member adapted to be removably fitted to an end of the structural member and holding an internally threaded nut apparatus, a connector bolt one end of which is threaded in the nut apparatus and having a T-head at the other end, and a tapered cylindrical collar having a concentric bore, through which the bolt extends. The T-head is adapted to non-rotatably engage an appropriately sized aperture. Intermediate the collar and sleeve, and located about the bolt, is a bias spring which biases the collar towards the T-head to hold the bolt in engaging relation with the aperture in which the T-head is inserted. The connection between the aperture and bolt may be secured by rotating the nut apparatus in a predetermined direction. A

hollow connector ball, having a plurality of apertures adapted to receive and be engaged by the T-head of the bolt, is also provided to allow the structural members to be interconnected at various angles.

US4129975A discloses a construction set comprised of a plurality of hollow 26 faceted joint elements with the facets being arranged in a selected orientation and having an opening, located in each facet, which is configured for receiving an elongate strut for interconnecting a plurality of the joint elements to form a three-dimensional framework. The struts have clip fasteners at each end adapted for snap fitting engagement within the openings such that they are not separable merely by application of tensile force to the struts; and locking means are provided for preventing inadvertent disengagement of the struts from the joints.

From FR 2513736B is known an assembly node made of two hemispherical shells assembled along a diametric plane to form a closed ball. The solution further comprises assembly bars having an expanding end that enters a node perforation and expands so that the tip of the bar lodges inside the ball and the end shaft of the bar bears solidly against the walls of the perforations. The shells have some projections and some correspondingly shaped notches along their assembly edges so that each notch of one shell receives the projection arranged aligned with that of the other shell.

In US4640572A is described a connecting mechanism for structural building system components for supporting radial, compression and tension loads by use of a captive, expanding/contracting jaw assembly which is caused to extended from an opening in the end of the connecting member into a connecting port located in the attaching component. The jaw assembly is then caused to expanded outward and to lock into the connecting port of the attaching component. Operation of the connecting mechanism is performed by causing an operating sleeve, which is located on the outside diameter of the connecting member, to be moved. This causes a structural bond to be made which firmly joins the connecting member and the attaching component. The procedure is reversed for simple removal of structural components or disassembly of the structure whenever desired.

DE3620619A1 discloses a set of structural elements comprising a number of framework bars, a number of hollow junction bodies approximately in the form of spheres and a number of coupling bodies. The junction bodies exhibit a number of plug-in holes that are distributed in a specific pattern over the circumferential surface of the junction body. The framework bars are further provided with plug-in-holes at ends thereof. The coupling bodies are at each end thereof provided with a coupling head for connection to the plug-in holes on the framework bars and the junction bodies.

US4763459A describes a similar solution by a lock joint for a space station truss has a plurality of struts joined together in a predetermined configuration by node point fittings. The fittings have removable inserts therein. The lock joint has an elongated housing connected at one end to a strut. A split-fingered collet is mounted within the housing for movement reciprocally therein. A handle on the housing is connected to the collet for moving the collet into the insert where the fingers of the collet expand to lock the joint to the fitting.

In US5074700A is described a coupling wherein a spherical or ring-shaped female coupling member has sockets for pins at the ends of rod-shaped male coupling members. Each pin has a conical displacing portion in front of a cylindrical peripheral surface which is formed with a pair of recesses, and the female coupling member contains a pair of movable retaining elements for each socket and springs, rubber pads or like parts which bias the retaining elements into the recesses of a pin in the respective socket. The conical displacing portion serves to spread the retaining elements apart during introduction of the pin into a selected socket, and the pin is thereupon secured in inserted position by an internally threaded sleeve which surrounds the end of the rod and can be moved into abutment with the external surface of the female coupling member in order to urge undercut portion of surfaces in the recesses of the inserted pin against the respective retaining elements. The pin can be extracted from its socket upon retraction of the sleeve and rotation of the rod-shaped coupling member relative to the female coupling member so that the peripheral surface of the pin spreads the respective retaining elements apart and dislodges them from the recesses.

In US5839248A is described a frame assembly which can be converted to various shapes to hold different articles. Inner and outer frame members are utilized with the inner frame member serving to hold a panel or flat plate thus forming an enclosure. The frame members are connected to joints to form the frame assembly. With each joint having a U-shaped plate housing a fastening element which attaches to each outer frame member in a snap fit relationship. A screw rod and adjusting bolt enable a detachable connection between the U-shaped plate and the fastening element. Dual fins of the fastening element behind corresponding protruded blocks lying within the outer frame to allow for connection between frame the fastening element.

From US20020110411A1 is known a self-assembled spherical joint structure is mainly designed as a structure of a multi-angular spheroid with multiple tangent planes of six cubical quadrilaterals and twelve beveled hexagons, and with mounting holes disposed respectively at the centers of the quadrilateral and the beveled hexagonal tangent planes to make each spherical joint have eighteen mounting holes with included angles pointing at different directions so as to increase the application of a single spherical joint and to make all the spherical joint have the identical structure for

exchangeable connection to not only fully comply with the needs of specific application, but also to be able to make various applications by using the supporting rods pointing at different mounting angles to directly fulfil the specific need of the assembly.

A disadvantage of the mentioned prior art solutions is that they are not designed to handle the structural loads required for permanent or long-term structures.

A further disadvantage for many of the prior art inventions is that they require many parts for connection or special tools for assembly and disassembly.

A further disadvantage of the mentioned prior art solutions is that they are not scalable in a simple manner.

A further disadvantage of many items in the mentioned prior art is that they rely on threaded connections which can be cross-threaded, and thus damage the part and undermine the integrity of the joint.

A further disadvantage of the mentioned prior art is that most solutions have fixed dimensions of beams or struts which limit the ability to create unique or custom designs. The final shape of the structure is limited to a few basic configurations such as a cube, pyramid, or rectangle of fixed size.

A further disadvantage is that many of the inventions in the prior art do not have the capability to carry services such as water, power, or data signals through the beams/struts and joints.

There is accordingly a need for a construction system addressing these issues of the prior art.

Object

The main object of the present invention is to provide a construction system partly or entirely solving the drawbacks of prior art solutions.

An object of the present invention is to provide a construction system consisting of mass-produced standard parts that are ready-to-assemble onsite.

It is an object to provide a construction system enabling manual assembly onsite that is tool-less or requires minimal tools at assembly.

An object of the present invention is to provide a construction system enabling mass-customization without changing the parts.

It is an object of the present invention to provide a construction system enabling both assembly and disassembly in a simple manner.

An object of the present invention is to provide a construction system designed for effective packaging and shipment.

It is an object of the present invention to provide a construction system resulting in a minimal environmental footprint.

An object of the present invention is to provide a construction system that is modular and scalable.

It is an object of the present invention to provide a construction system that may be disassembled and re-used in another construction.

An additional object of the construction system to provide conduit paths for services such as water, power and data signal transmission within the structural elements

A further additional object of the construction system to create structures that can withstand the loads and moments exerted on permanent structures by natural and manmade forces and usage.

Further objects of the present invention will appear from the following description, claims and attached drawings.

The invention

A construction system for assembly of a structural construction according to the present invention is defined by the technical features of claim 1. Preferable features of the construction system are disclosed in the dependent claims.

A construction system according to the present invention makes use of high-precision connectors in the form of multidirectional hollow spherical joints based on universal spherical polyhedron geometries.

The term spherical is herein used to define that the joint exhibits an exterior mainly/overall spherical shape. However, as will be discussed further herein, exterior surfaces or sides of the hollow spherical

joint will deviate from the shape of an ideal sphere and form connecting interfaces for other construction elements.

The construction system according to the present invention further comprises connection assemblies enabling structural elements to be attached to the hollow spherical joint according to the present invention.

The hollow spherical joint is according to the present invention designed to facilitate triangulation in structures such as foundations, roofs, trusses, bridges and a full range of constructions at various scales. These triangular structures operate on compression forces, which are directed through the center of the hollow spherical joint. As an embodiment of the present invention, the triangle is an omnipresent geometry.

According to the present invention, the hollow spherical joint is formed by multiple identical interlocking joint members or sets of corresponding identical interlocking joint members enabling the assembly of the multiple interlocking joint members to form a complete hollow spherical joint, a hemisphere or a section of a sphere. An individual joint member may also be considered or referred to as a plate, which is shaped to interlock with other plates, and with receptor(s) for one or several structural members, further described below.

Two non-limiting examples of geometrical shapes the present invention is suitable to make use of are icosahedron and rhombicuboctahedron, which are examples of a sphere of polyhedron patterns, providing a full range and versatility of the hollow spherical joint providing different half- or full-domed geometrical shapes and connection interfaces and/or points around the same.

In the case of identical interlocking joint members (or plates), these will according to one embodiment of the present invention be formed as interlocking triangle joint members. In the case of sets of corresponding identical interlocking joint members, these will according to one embodiment of the present invention, be formed by a set of identical interlocking square joint members and a set of identical interlocking triangle joint members.

For the first mentioned case with identical interlocking joint members, the triangle joint member is according to one embodiment of the present invention manufactured based on a unique design of an icosahedron projected onto an ideal sphere, according to any number n of vectors.

According to one embodiment of the present invention, triangular geometry is found both inside the hollow spherical joint as the mentioned triangle joint members, and is also found between hollow spherical joints connected with structural elements.

According to one embodiment of the present invention, the hollow spherical joint design is created from an equilateral triangle that is one side in a spherical polyhedron, such as an icosahedron. These equilateral triangles are then subdivided into smaller triangles by segmenting each of its sides by a number (" n ") of vectors. An icosahedron is a polyhedron in its simplest form with only one vector. Regardless of scale, a larger number of vectors will correspond with a higher number of straight segments that will approximate a sphere. These spheres or hemispheres are also known as geodesic domes.

The vectors are counted from center to center of a pentagon located at each of the icosahedron's corners. As an embodiment of a hollow spherical joint according to the present invention, a unique shape is a triangle joint member created from projection of an icosahedron divided into six or more vectors.

According to the present invention, these triangle subdivisions are projected onto the circumsphere of an ideal sphere to create an ordered- n tessellation of a polygon. That is the first step to create multiple identical joint members with a number of vector n subdivisions.

At this stage a unique "triangle joint member" (or "plate") is created.

A virtual 3D representation of a polyhedron is created by projecting the resulting triangular subdivisions onto inner, middle and outer geometrical surfaces. The innermost and outermost projection define the thickness of the hollow spherical joint wall.

According to one embodiment of the present invention the thickness of this wall is found by an iterative process that can be easily adjusted based on two single variables: the ratio of the wall thickness to the hollow spherical joint diameter.

Since the hollow spherical joint is created using pure geometry, these variables may be adjusted at different scales and the geometry of the hollow spherical joint can be scaled parametrically by changing only these two variables: thickness ratio as a function of diameter.

The factors that influence the wall thickness of the hollow spherical joint are material selection and the desired compression strength at various scales.

By using the middle geometry, and by manipulating the triangle vectors, the geometry of the geodesic dome is altered into a unique interlocking shape, defining a “triangle joint member” according to the present invention.

According to one embodiment of the present invention, for purposes of manufacturing, twenty identical triangle joint members are assembled to form the hollow spherical joint according to the present invention.

According to one embodiment of the present invention, the intersecting points of the two-dimensional (2D) representation of an icosahedron subdivided into six or more vectors and projected onto a sphere provides a precise geometrical three-dimensional (3D) representation of the triangle joint member with the exact location of vertices that define the hollow geodesic dome of the hollow spherical joint according to the present invention.

According to the present invention, these vertices are used to define an interlocking shape so that the multiple identical triangle joint members become unique triangle joint members that can grip onto/into each other in such a way that symmetry is preserved, and so that the overall multi-part structure maintains its integrity eliminating stress points (that would otherwise risk creating fissures in the structure).

According to one embodiment of the present invention, the hollow spherical joint is given a wall thickness that is driven by a global variable based on material density.

In accordance with one embodiment of the present invention, the exterior and interior surfaces are concentric with the origin of the hollow spherical joint.

According to one embodiment of the present invention a middle surface is projected between the mentioned inner and outer surfaces. These surfaces are perfect projections of each other at three different scales.

At the design stage, this 3D geometry occupies the triangle joint member’s initial boundary-space before defining its interlocking mechanism.

According to the present invention, the triangle joint member’s side-planes convert at the origin of the hollow spherical joint. These side planes are coincidental with the triangle joint member’s sides at the early design stage.

According to one embodiment of the present invention, each triangle joint member side is divided into four quadrants mirrored around the middle surface and the symmetry axis. The middle surface divides the triangle joint member side into outer and inner surfaces. The middle surface does not need to be in the middle. The symmetry axis is perpendicular to the projected icosahedron's midpoint ("M") as shown in Figs. 1b-d. The axis is coincident with a triangle joint member's side plane, and mirrors the triangle joint member side in left and right surfaces.

According to one embodiment of the present invention, a unique joint member triangle shape is created by two steps:

(a) adding and subtracting material mirrored around the middle's surface midpoint M. In other words, if material is removed from outer-left, a scaled equivalent amount is added to the inner-right, etc. Thus an interlocking upper lip with a symmetric lower groove is created, which forms an interlocking profile.

(b) this interlocking profile is replicated at each triangle side by mirroring it around the triangle joint member's central axis. This central axis passes through the origin of the hollow spherical joint and the C vertex, the projected center of the icosahedron triangle, as shown in Figs. 1b-d.

According to one embodiment of the present invention, the corner segments are preserved at their initial boundary-space position, and will not be added or subtracted. In other words, in a 6-vector polyhedron, vector 1 and 6 would remain untouched. At other scales, at the minimum the first and last vectors will remain untouched.

In the illustration in Fig. 1a-d vector 2, 3 on top and vector 4, 5 on bottom have been removed and vector 2, 3 on bottom and 4, 5 on top have been added so that symmetry around point M is preserved. The resulting shape is the result of a hexagon removed between top and middle surface, and of hexagon being added between middle and inner surface. This design action creates a lip-groove alternating pattern: lip on top-left, groove on bottom-right.

To summarize, the three stages of using a triangle in a hollow spherical joint: number n of vector triangles (design stage), multiple triangle joint members (manufacturing stage) and any number of triangle structure elements (assembly). According to the present invention, there will be a different number of joint members depending on the polyhedron shape to be formed. For the example of icosahedron, there will e.g. be twenty triangle joint members.

It should be mentioned that other polyhedron geometries will result in a different number of joint members that can either be triangles, squares or any polyhedron shape.

The hollow spherical joint according to the present invention is intrinsically related to triangulation resulting from triangulation at various scales, which ties back to vector triangles and the manipulation of these to create a unique interlocking multi-part (twenty-part) polyhedron projected hollow geodesic dome.

According to one embodiment of the present invention, the hollow spherical joints are made of multiple such triangle members, and the hollow spherical joints according to the present invention enable triangular constructions that result from these triangle joint members.

Accordingly, the hollow spherical joint according to the present invention provides a purely geometrical shape that is scalable to any dimension and construction need. As such, the resulting geometry has structure elements extending from hollow spherical joint to hollow spherical joint along the intersecting planes of an icosahedron or along the intersecting planes of rectangles dimensioned to golden ratio proportions.

No discrete number exists to exactly dimension these triangles or rectangles, but perfectly scalable precision is achieved by pure geometry (not requiring any particular number), which makes the model infinitely scalable.

According to the present invention, the hollow spherical joint is provided with multiple vertices, which vertices are oriented according to a structural construction reference grid to be assembled to accomplish a desired construction outcome. The desired construction outcome determines the choice of a specific polyhedron geometry, which in turn determines the orientation and choice of directional vertices. All choices of polyhedrons are scalable, however it is the choice of polyhedron geometries and the manipulation of resulting plate geometries, which make the construction system infinitely configurable (mass-customizable).

According to one embodiment of the present invention, the hollow spherical joint is configured in the structural construction reference grid whereby an initial decision is made to orient the hollow spherical joint vertices according to the structural construction reference grid to accomplish a desired construction outcome. For the specific example of a plate made from a polyhedron shaped as icosahedron, at each corner of each triangle joint member are located pentagons, and at each pentagon's center is a vertex suited for connections with structure elements along the axis defined diagonal directions in the triangular construction by means of the connection assembly according

to the present invention. For other embodiments, the joint member may be any triangle, rectangle, square or polyhedron shape.

For sake of clarity, the triangle joint members will now be discussed, however the same principles are also applicable for square and rectangular or other polyhedron shape. The dimensioning of the resulting triangles form a structure according to golden ratio geometric principles. These points are referred to as triangle joint member vertices ("T"), as shown in Fig. 1b-d. At the center of each triangle block is a center vertex ("C") as shown in Fig. 1b-d. Along the sides of the triangles are vertices M, M1 and M2 giving three additional directions. As such, each hollow spherical joint configuration is based on picking vertices to form a unique geometry, all of which are geometrically stable and flexible.

The flexibility accorded to directing structure elements according to vertices give rise to various hollow spherical joint configurations that can accommodate traditional, conventional, modern as well as futuristic construction shapes not yet imagined by humankind, but most certainly already existing in our cosmos and biosphere, which, regardless of scale are based on the same geometries or laws of physics that are found in nature.

According to the vertices found in an ideal spherical geometry as defined above, an embodiment of the present invention is to identify all the possible combinations of vertices available for connecting the hollow spherical joint with any combination of structure elements.

According to one embodiment of the present invention, the hollow spherical joint geometry based on an icosahedron of twenty identical triangles, divided into six vectors and projected onto an ideal sphere, using a combination of pentagons centered on the vertex of each of the icosahedron's corners, and using the other naturally occurring hexagons as vertices for identifying additional connection points for any number between 0 and 92 possible connections. According to the present invention, the hollow spherical joint will be provided with at least two connection points for arrangement of structure elements by means of connection assemblies according to the present invention. In practice, there will be more than two connection points, as will be discussed further below.

Again using the icosahedron triangular joint member embodiment as one specific example of a polyhedron shape, and according to one embodiment of the present invention, the hollow spherical joint has nine potential hollow spherical joint to structural element configurations organized around the triangle joint member's sides (M or M1 and M2), corner (T) or center (C) vertices.

According to one embodiment of the present invention, the hollow spherical joint can be customized to any construction need with 12, 20, 30, 32, 42, 50, 60, 62 and/or 92 potential connection points for structure elements, each of which can be customized for unique needs as any number of connection points between 1 and 92 can be used alone or in combination with any other.

According to the present invention, each of these vertices is a potential connection point along the structural construction reference grid.

In accordance with a further embodiment of the present invention, the hollow spherical joint is based on a rhombicuboctahedron, which according to the present invention is formed by two different sets of identical interlocking joint members. According to this special case of the hollow spherical joint according to the present invention, the hollow spherical joint is formed by a set of five identical interlocking square joint members and a set of four identical interlocking triangular joint members that together form a half-sphere, which pattern is repeated to form a full sphere, i.e. a hollow spherical joint according to the present invention with a total of ten identical interlocking square joint members and eight identical interlocking triangular joint members. As for the prior embodiment, also this embodiment may be provided with a desired number of connections points formed by vertices in a similar manner as described for the prior embodiment.

In an alternative configuration of the latter embodiment, the hollow spherical joint is formed by eight identical interlocking joint members, where each identical interlocking joint member exhibits a shape that is a combination of the mentioned triangle and square joint members, such that four identical joint members when assembled together form a half-sphere corresponding to the mentioned five identical square pieces and four identical triangular joint members, and wherein eight identical joint members form a full-sphere.

The discussed embodiments of the hollow spherical joint based on the rhombicuboctahedron and icosahedron geometrical shapes are only two examples of a sphere of polyhedron patterns, providing a full range and versatility of the hollow spherical joint providing different half- or full-domed geometrical shapes and connection interfaces and/or points around the same.

Accordingly, the hollow spherical joint according to the present invention is thus based on identical interlocking joint members or sets of identical interlocking joint members around vertices and axes that allow symmetry and mirroring of interlocking joint members that can be mass-produced for intuitive assembly.

By the hollow spherical joint according to the present invention, any shape or angle or number of connections is possible by the principles of forming a unique interlocking shape according to the present invention.

The construction system according to the present invention further comprises connection assemblies enabling connection of structure elements to the hollow spherical joint according to the present invention, i.e. the connection points provided by the vertices.

According to the present invention the hollow spherical joint connection points forms a receptor and connection interface for the connection assembly, further described below.

In accordance with the present invention, the receptor has a polygonal shape (likeness of a sphere shape), or an ideal spherical shape formed as a cylinder or a cone.

According to one embodiment of the hollow spherical joint according to the present invention especially suitable for the icocahedron example, the receptor has the shape of a DECAGON (10 sides) thus forming a decagon receptor, which preserves symmetry with both PENTAGON (5 sides) shapes at T vertices, and preserves symmetry of HEXAGON (6 sides) shapes at M, M1, M2 and C vertices.

According to one embodiment of the present invention, the polygonal or decagon receptor shape follows a cone or lofted shape to the center of the hollow spherical joint.

According to one embodiment of the present invention, the thickness of the hollow spherical joint wall is geometrically optimized to the size of the polygon shape to receive a connector of corresponding shape of the connection assembly.

According to the present invention, the receptor and connection assembly are provided with mutual locking means for detachable attachment of the connection assembly to the hollow spherical joint.

In accordance with one embodiment of the present invention, the receptor and connection assembly are adapted to form a dual tenon fork locking mechanism. The dual tenon fork locking mechanism has no moving mechanical parts and a wider head so that the bending of the two tenon forks allows for narrowing of the head when entering the receptor and a widening when it clears passage. The wider head grips onto the inner surface of the hollow sphere. The cone-shaped receptor is in this case lofted to allow for a coned portion and a straight portion of the passage. The straight portion is to preserve material thickness in the neck that links tenon to its wider head.

In accordance with one embodiment of the present invention, the receptor and connection assembly are adapted to form a ball- or cylinder-based locking mechanism.

According to the present invention, the receptor is provided with multiple recesses or holes distributed in circumferential direction thereof, wherein at least one recess or hole is arranged at each polygon face, which recesses or holes are adapted for receiving corresponding locking balls or cylinders of the connection assembly, so as to maximize the surface area between receptor and connection assembly.

According to the present invention, the receptor and connection assembly may be adapted to use any number of locking balls or cylinders that serve to lock the connection assembly in place to the hollow spherical joint.

In accordance with the present invention, the connection assembly comprises an activation and deactivation member for attachment and detachment of the connection assembly to the hollow spherical joint.

The connection assembly is according to the present invention formed for enabling three functions: (1) accommodation of the locking means at one end; (2) accommodation of the activation and deactivation member, and (3) provided with a connection device at the other end for connection to structure elements, such as beams or joints.

Accordingly, the connection assembly is at one end provided with a connector adapted to the connection points of the hollow spherical joint for insertion therein and detachable attachment thereto, and at the other end is provided with a connection device for connection of structure elements to the hollow spherical joint.

According to one embodiment of the connection assembly it is further provided with a ring adapted the exterior surface of the hollow spherical joint for maximal engagement therewith, which ring is adapted for expansion compressing providing a tight seal that allows for material, manufacturing or assembly tolerance.

In accordance with a further embodiment of the connection assembly according to the present invention, it further comprises a main body.

The mentioned ring and main body is adapted for receiving the connector with a tight fit for precise orientation of the connection assembly to the hollow spherical joint.

According to the present invention the ring and main body exhibit different exterior shapes depending on if the connection assembly is a standalone connection assembly or if it is to be arranged adjacent another connection assembly.

According to the present invention, the activation and deactivation member has several functions. It activates and deactivates the locking mechanism. It is designed for retaining the parts of the connection assembly axially in the connection assembly. To accomplish this, the activation and deactivation member has an adapted length and is provided with lock pins or teeth. These are adapted to be received in a key lock member accommodated in the connection assembly. Accordingly, the activation and deactivation member will compress the parts of the connection assembly together, enhancing the compressive strength of the connection device and structure element or joint as well as the locking mechanism.

According to a further embodiment of the present invention, the mentioned activation and deactivation member also is provided with a third state in the form of a standby position allowing for transport between activated and deactivated positions. The standby position is for retention of ball- or cylinder-based locking element during different phases of the construction supply-chain, for example between a 3D modular offsite factory location and the construction site where onsite final assembly, when structural members are locked into the joint, will take place.

According to one embodiment of the present invention, the structure element or joint arranged to the connection device of the connection assembly is arranged to lock the activation and deactivation member in the locking position once assembled. This multifunction purpose of individual parts constitute an essential quality of the embodiment of this construction system.

The connection assembly according to the present invention is made of standard manufactured parts that can be customized and scaled for different construction multifunction purposes.

According to the present invention any structure from a child's toy, light tent or model set, to buildings with multiple floors, as well as bridges, or even offshore platforms or similar is possible to build by using the principles of the present invention. As such, and as an embodiment of the present invention, scaling occurs according to need and according to the geometry and laws of physics, seeking to mimic phenomena uncovered in nature. The present invention thus seeks to replicate relationships of strength found in nature at all scales.

The parts of the connection assembly may according to a further embodiment be provided with polygonal recesses and/or flanges for stacking into each other for directional stability.

The connection assembly further provides protection of the components of the locking mechanism.

By that the connection assembly, at least partly, has a shape that is coincidental with the shape of adjacent connection assemblies, multiple adjacent connection assemblies can support each other or come in the shape of trusses where custom connection assemblies provide additional stability to the hollow spherical connection assembly connection.

The parts of the connection assembly can be mass-produced due to its simple shapes and pointed use, they lend themselves for both custom and mass production, allowing for both standardization and custom packaging enabling ready-to-use assembly onsite. The present invention in this manner also reduces the energy use and waste.

The connection assembly according to the present invention enables manual (tool-less) assembly. During the hollow spherical joint to structure element assembly, it provides a flexible and small component that allows for manual connection of structure elements to the hollow spherical joint. Additionally, the connection assembly provides for an expansion joint, or can support anchors for post-tensioning cables, or the highly customizable connection assembly can provide a snap-on connection device that can tighten and secure the hollow spherical joint to structure element connection to complete the assembly, especially as the last link after multiple systems have been assembled in order to fit a last piece.

The connection assembly according to the present invention is thus a flexible, mass-customizable component that can be adjusted to scale and function of a given connection, such as hollow spherical joint to hollow spherical joint, hollow spherical joint to structure element or hollow spherical joint to another joint. As an embodiment of this invention, the connection assembly comes in short, medium and long lengths, and can come in any length depending on length of custom parts thereof.

As an embodiment of the present invention, the shape of the connection assembly depends on the proximity of other connection assemblies and the connection points on the hollow spherical joint surface, which are identified as hollow spherical vertices M, M1, M2, C or T, as discussed above. The angle from the hollow spherical joint origin "O" to (M1/M2, T) forms the sharpest angle. According to one embodiment of the present invention, the connection assembly comprises a main body with a cone-shaped part of medium length that has been defined to satisfy the sharpest angle. The cone-shaped part is adapted to encapsulate and maximize surface contact area with the hollow spherical joint. Thus, all custom lengths and cone-shaped part length classes are geometrically defined to

maximize the strength properties of one or multiple structural members interfacing with the hollow sphere and with each other.

According to one embodiment of the present invention the hollowness of the hollow spherical joint is used for the exchange of services such as data, power, and water (or other gases or fluids). The void in the hollow spherical joint may thus act as nodes to exchange and route services.

According to one embodiment of the present invention, the mentioned void has its continuation in the connection assembly and structure elements connected thereto who are equipped with a conduit for services.

Accordingly, the present invention provides a solution where it both works as a load-bearing structure and in addition provides a network (conduits and nodes) for the distribution of services. The same geometry that in nature provides optimal strength also provides for the most efficient network of service distribution.

The present invention thus provides a solution that meets the demands on the construction sector to provide systemic and sustainable resource management with fully integrated production and distribution.

The construction system according to the present invention further provides a new value-chain that can be replicated and scaled to transform the construction industry from one that pollutes and wastes, into one that supports a zero-waste circular economy.

When employing engineered wood, the construction system according to the present invention is designed as a solution that can fix massive amounts of atmospheric carbon through global sourcing (procurement) practices.

The construction system according to the present invention enables the use of wood, steel, aluminium, concrete and/or composite material.

The hollow spherical joint geometry of the construction system according to the present invention provides unprecedented flexibility and gives rise to different construction types and scales with infinite variation and flexibility.

The constructions system according to the present invention is in practice tool-less as no screws, nails or cutting required for assembly of the joint members to the hollow spherical joint, for

connection of connection assemblies to the hollow spherical joint and structural elements to the connection device of the connection assembly.

Further preferable features and advantageous details of the present invention will be described in the following example description, claims and attached drawings.

Example

The present invention will below be described in further detail with references to the attached drawings, where:

Fig. 1a-d are principle drawings of a joint members for a hollow spherical joint according to an embodiment of the present invention,

Fig. 2a-m are principle drawings a different embodiments of a hollow spherical joint according to the present invention,

Fig. 3a-l are principle drawings of a connection assembly according to the present invention,

Fig. 4 is a principle drawing of a connector according to the present invention,

Fig. 5a-b are principle drawings of a ring according to the present invention,

Fig. 6a-b are principle drawings of a main body according to the present invention,

Fig. 7a-b are principle drawings of an adaptor according to the present invention,

Fig. 8a-d are principle drawings of a connection device according to the present invention,

Fig. 9a-c are principle drawings of a locking assembly according to the present invention, and

Fig. 10a-d are principle drawings of different embodiments of use of the present invention.

Reference is made to Fig. 2a-i showing principles drawings of a hollow spherical joint 200 formed by multiple identical joint members 210, as shown in Fig. 1a-d. The multiple identical joint members 210 are designed so that when they are assembled together they form a complete hollow spherical joint 200.

According to a one embodiment of the present invention, the hollow spherical joint 200 is assembled by twenty identical joint members 210 exhibiting a triangle shape.

In accordance with one embodiment of the present invention the hollow spherical joint 200 geometry is based on an icosahedron of twenty identical triangle shaped joint members 210, divided into six vectors and projected onto an ideal sphere, using a combination of pentagons centered on the vertex of each of the icosahedron's corners.

Each joint member 210 has a unique geometry around each triangle's "center axis", coincidental with each triangle midpoint M.

According to the present invention, the multiple joint members 210 are designed with an interlocking profile at engaging sides for attachment to adjoining joint members 210.

In accordance with one embodiment of the present invention, as shown in Fig. 1a, the interlocking profile is formed by an interlocking upper lip 211 and a symmetric lower groove 212 at each triangle side, enabling the adjacent joint members 210 to be interlocked.

For additional attachment and structural integrity of the hollow spherical joint 200, glue and/or heat treatment may be performed to ensure that the joint members 210 are firmly fixed to each other.

According to the present invention, the multiple joint members 210 are designed for maximum density and compression.

According to the present invention the joint members 210 may be mass-produced, manufactured by, e.g., but not limited to, reinforced ceramic, composite material or similar.

According to the present invention, the hollow spherical joint 200 is provided with multiple connection points 220, i.e. at least two, for attachment of structure elements 400 by means of connection assemblies 300, see Fig. 3a-l, according to the present invention, further described below.

In accordance with the present invention, the naturally occurring hexagons of the triangle joint members 210 are used as vertices for forming the connection points 220 in the hollow spherical joint 200, enabling a creation of any number between 2 and 92 connection points 220. As shown in Fig. 1d there are nine potential hollow spherical joint to structural element configurations organized around the triangle joint member's sides (M or M1 and M2), corner (T) or center (C) vertices.

The midline of the triangle is split into two additional vertices M1 and M2, and they can be oriented vertically according to T, C, M1 and M2 vertices. All other configurations can be oriented according to M, C or T orientations.

Each of these vertices is a potential connection point 220 along master grid of a structure to be constructed. The connection points 220 thus enables connections for structure elements 400, such as beams or joints, as well as hollow spherical joint to hollow spherical joint.

This unprecedented flexibility of one single hollow spherical joint 200 geometry gives rise to different construction types and scales with infinite variation and flexibility from one joint member 210.

In Fig. 2a-h are shown different embodiments of the hollow spherical joint 200 according to the present invention comprising different number of connection points 220 distributed around the circumference of the hollow spherical joint 200 according to the present invention. Fig. 2a shows an embodiment with twelve connection points 220, Fig. 2b shows an embodiment with twenty connection points 220, Fig. 2c shows an embodiment with thirty connection points 220, Fig. 2d shows an embodiment with thirty-two connection points 220, Fig. 2e shows an embodiment with forty-two connection points 220, Fig. 2f shows an embodiment with fifty connection points 220, Fig. 2g shows an embodiment with sixty-two connection points 220 and Fig. 2h shows an embodiment ninety-two connection points 220. The more connection points 220 the hollow spherical joint 200 comprises, the more possible angles are provided that a structure element 400 can be arranged to the hollow spherical joint 200 with.

For e.g. the embodiment with sixty-two connection points 220, the center C vertices serve to connect structure elements along the vertical or horizontal planes in a construction. The embodiment further takes full advantage of both of the right angles found in conventional construction: vertical Z-axis and orthogonal X- and Y-axis in the horizontal plane, and also provides connection points 220 for triangulation.

The embodiment with sixty-two connection points 220 is organized around the mid-point ("M") serving as top of the hollow spherical joint 200 along the vertical z-axis. This initial position orients the hollow spherical joint 200 vertically. The M vertex is found at the center of one of thirty hexagons, which is located at the midpoint of any of the three sides of a triangle joint member 210. As an embodiment of this innovation, one M vertex out of $(20 \times 3 / 2 =) 30$ possible M vertices has been elected at random to orient the other triangle joint members 210, and this M-point remains fixed in relation to the hollow spherical joint's 200 origin, X- and Y-axis with the reference grid.

Reference is now made to Fig. 2i-k showing principle drawings of a second embodiment of the hollow spherical joint 200 according to the present invention that is formed based on the same principles as the first embodiment. In the second embodiment, the hollow spherical joint 200 is based on a rhombicuboctahedron. The hollow spherical joint 200 according to the second embodiment is formed by two sets of identical joint members, in the form of a set of identical square joint members 210a and a set of identical triangle joint members 210b, which according to the present invention is formed by two different sets of joint members.

Reference is now made to Fig. 2L showing principle drawing an alternative configuration of the second embodiment, wherein the hollow spherical joint 200 is formed by eight identical joint members 210. In this embodiment, the joint members 210 are provided with corresponding interlocking profiles 213, 214 at sides thereof enabling attachment to an adjoining joint member 210, as well as at lower side thereof provided with corresponding interlocking profiles 215 for attachment to adjoining joint members 210. In this embodiment each identical joint member 210 exhibits a shape that is a combination of the mentioned triangle and square joint members above, such that four identical joint members 210 when assembled together form a half-sphere corresponding to the mentioned five identical square pieces 210a and four identical triangular joint members 210b, and wherein two such half-spheres are arranged to together by the mentioned interlocking provides at lower side of the identical joint members 210 form a full-sphere.

As for the first embodiment, also the two latter embodiments may be provided with a desired number of connections points 220 formed by vertices in a similar manner as described for the first embodiment.

According to the present invention, the connection points 220 form a receptor and connection interface adapted for receiving and engagement with the connection assembly 300 according to the present invention.

According to one embodiment of the present invention the connection points 220 is formed by a receptor having a desired polygonal or decagon shape for receiving engaging part (connector 310) of the connection assembly 300 with a corresponding shape, further described below. In the shown embodiment, the receptor has the shape of a decagon and thus forming a decagon receptor, which preserves symmetry with both pentagon shapes at T vertices of the hollow spherical joint 200, and preserves symmetry of hexagon shapes at M, M1, M2 and C vertices of the hollow spherical joint 200.

In the shown embodiment, the connection point 220 is further cone-shaped and thus form a decagon cone-shape adapted to receive a corresponding engaging part (connector) of the connection assembly 300, further described below.

The connections points 220 are further provided with multiple locking ball receiving recesses or holes 520 for a locking assembly 500, further described below, for detachable attachment of the connection assembly 300 to connection points 220 of the hollow spherical joint 200.

Reference is now made to Fig. 3a-l showing principle drawings of different embodiments of a connection assembly 300 according to the present invention, and cross-sectional views thereof. The connection assembly 300 according to the present invention is assembled by several parts in longitudinal direction thereof to form the connection assembly 300. According to the present invention comprises a connector 310 forming the engaging part with the connection points 220, lower ring 320 forming engaging surface with the exterior surface of the hollow spherical joint 200, a main body 330, an adaptor 340, a connection device 350 for attachment of a structure elements 400 and a locking assembly 500 (see Fig. 9a-c) locking the mentioned parts together axially and to the hollow spherical joint 200.

The connector 310, as shown in detail in Fig. 4, is formed by an elongated polygonal- or decagon-shaped part 311 and a polygonal- or decagon cone-shaped part 312, wherein the polygonal or decagon cone-shaped part 312 is adapted the polygonal or decagon cone-shaped receptor of the connection point 220 for insertion therein. The connector 311 is further provided with a through hole 313 for receiving an activation and deactivation member 530 of the locking assembly 500, further described below.

The ring 320 and main body 330 are according to the present designed to exhibit different shapes and size for altering the properties of the connection assembly 300 depending on the use, i.e. if the connection assembly 330 is a standalone connection assembly 330 or if the connection assembly is to be arranged adjacent another connection assembly 330.

Reference is now made to Figs. 5a-b showing the mentioned ring 320 in more detail, wherein Fig. 5a shows an embodiment for a standalone connection assembly 300 and Fig. 5b shows an embodiment for use where connection assemblies 300 arranged adjacent each other. In the embodiment in Fig. 5a the ring 320 is formed by an upper mainly cylindrical part 321 and a cone-shaped lower part 322, wherein the end surface 323 of the lower part 322 is adapted the curvature of the hollow spherical joint 200 for engagement therewith. In the embodiment in Fig. 5b, the ring 320 is cone-shaped wherein the end surface 323 of the ring 320 is adapted the curvature of the

hollow spherical joint 200 for engagement therewith. In a standalone embodiment, it is preferable with a larger engagement surface towards the hollow spherical joint 200 surface.

The ring 320 is further provided with a polygonal or decagon-shaped through hole 324 in the center of the ring 320 adapted the elongated polygonal or decagon-shaped part 311 of the connector 310 for accommodation of the connector 310 and fixation to the connector 310.

At least the part of the ring 320 engaging the exterior surface of the hollow spherical joint 200 is preferably elastic or compressible for expansion compression providing a tight seal that allows for material, manufacturing or assembly tolerances. The ring 320 may e.g. be a gasket.

Reference is now in addition made to Figs. 6a-b showing further details of the main body 330. For a standalone embodiment, as shown in Figs. 3i-l and 10a-d, the mentioned main body 330 is mainly cylindrical, while for an embodiment where the connection assembly 300 is arranged adjacent another connection assembly 300, the main body 330 is formed by a cone-shaped part 331 facing the ring 320 and ending in a mainly cylindrical part 332 facing the keyhole disc 363. As shown in Figs. 3a-l the shape and length of both the cone-shaped part 331 and cylindrical part 332 may have different shape and length. The cone-shaped part 331 has at its narrow end a circumference adapted to the upper side of the mentioned ring 320. The main body 330 further provided with a polygonal- or decagon-shaped recess 333 of limited extension at lower side of the cone-shaped part 331, in the center thereof, adapted the elongated polygonal- or decagon-shaped part 311 of the connector 310 for accommodation of the connector 310 and fixation to the connector 310.

Accordingly, when the ring 320 and main body 330 are arranged to each other the polygonal- or decagon-shaped through hole 323 and polygonal- or decagon-shaped recess 333 coincides and together are adapted to receive and accommodate the connection 310 and assemble these parts together in a fixed manner.

The main body 330 is further provided with a centrally through hole 334 for receiving the activation and deactivation member of the locking assembly 500, further described below, which through hole 334 coincides with the through hole 313 of the connector 310 when arranged together.

Further, the inclination of the cone-shaped ring 320 coincides with the cone-shaped part of 331 of the main body 330.

The main body 330 is further at upper side provided with a polygonal recess 335 for engagement with the adaptor 340, further described below.

Reference now made to Figures 7a-b showing principle drawings of an adaptor 340 according to the present invention, seen from lower and upper side, respectively. The adaptor 340 is formed by a mainly circular disc 341, which at both sides thereof is provided with polygonal connection flanges 342a-b with an exterior diameter smaller than the exterior diameter of the adaptor 340. The polygonal connection flange 342a at lower side is adapted for being received and accommodated in the mentioned polygonal recess 335 at upper side of the main body 330, and at the polygonal connection flange 342b at upper side is adapted for being received in a polygonal recess 352 (see Fig. 8b-d) of a connection device 370 to be arranged thereon, further described below.

The adaptor 340 is further provided with a centered through hole 343 for receiving and accommodating the activation and deactivation member 530 of the locking assembly 500, which through hole 343 coincides with the through hole 334 of the main body 330 when the adaptor 340 is arranged to the main body 330.

The adaptor 340 is further at upper side provided with a centred polygonal recess 344 of limited extension adapted for receiving a key lock member 550 of the locking assembly 500, further described below.

In an alternative embodiment the technical features of the adapter 340 is integrated in upper part of the main body 330. Accordingly, the main body 330 may at upper end be provided with the polygonal connection flange 342b and polygonal recess 344, such that the adaptor 340 for some embodiments is not required.

Reference is now made to Figures 8a-d showing example embodiment of connection devices 350 according to the present invention, wherein Fig. 8a-b show a first embodiment in the form of a mortise connection, and Fig. 8c-d show a second embodiment in the form of a snap-in connection. The connection device 350 is formed by a main body 351, which in the embodiment of Fig. 8a-b is disc-shaped and in the embodiment of Fig. 8c-d is a massive cylinder.

The main body 351 is at lower side provided with a polygonal recess 352 adapted for receiving and accommodating the polygonal flange 342b at upper side of the adaptor 340 for connection thereto.

The main body 351 is further provided with a centered through hole 353 adapted for receiving the activation and deactivation member 530 of the locking assembly 500, further described below. In the wall of the through hole 353 is further arranged recesses 354 extending in longitudinal direction of the through hole 353, adapted for allowing lock pins or teeth 540 of the locking assembly 500 to pass, further described below.

The main body 351 is further at upper side provided with a recess 355 of limited extension adapted for receiving a head assembly 533 (see Fig. 9a-b) of the activation and deactivation member 530 of the locking assembly 500, further described below.

In the embodiment of Fig. 8a-b the connection device 350 is provided with two parallel protruding connection attachment members 356a-b enabling the attachment of a structure element 400 with corresponding connection members 410 (see Fig. 10c) thereto by means of suitable fixation means, such as e.g. holes 357 and pins (not shown).

In the embodiment of Fig. 8c-d the cylindrical main body 351 is provided with longitudinally extending slots 358 ending in transversal recesses 359 adapted for from receiving and accommodating a snap-in connection (not shown) of a structure element 400.

Reference is now made to Fig. 9a-c showing principle drawings of the components of the locking assembly 500 according to the present invention.

The locking assembly 500 according to one embodiment of the present invention is a ball-based locking-mechanism comprising multiple locking balls 510, multiple locking ball receiving recesses or holes 520 arranged in surfaces of the connection points 220 of the hollow spherical joint 200, a activation and deactivation member 530 with lock pins or teeth 540 and a key lock member 550.

According to the present invention, the multiple locking balls 501 are arranged movable in transversal direction of each side of the decagon cone-shaped part 312 of the connector 310, as shown in Fig. 4 and 9a. In the shown embodiment, each side of the decagon cone-shaped part comprises two movable locking balls 510 displaced in longitudinal direction of the mentioned sides of the decagon cone-shaped part 312. The number of locking balls 510 in longitudinal direction of each side of the decagon cone-shaped part 312 may be one or higher than two. The mentioned locking balls 510 are movable from an unlocked (retracted) position in the decagon cone-shaped part 312 and a locking position where the mentioned locking balls 510 protrude from the exterior surface of the decagon coned-shaped part 312. The mentioned locking balls 510 are such arranged that they can be activated and deactivated from interior of the decagon cone-shaped part 312 by the activation and deactivation member 530.

Accordingly, when the connector 510 with the locking balls 510 is received and accommodated in the connection points 220 of the hollow spherical joint 200, the recesses or holes 520 and locking balls 510 are aligned, due to the corresponding shape of the connection point 220 and connector

510, such that locking balls 510 upon activation can protrude from the connector 510 and be received and in engagement with the mentioned recesses or holes 520 in the connection points 220.

The ball-based locking assembly 500 further comprises the activation and deactivation member 530, as shown in detail in Fig. 9b, formed by an elongated body 531 designed to be received in the through holes of connection device 350, adaptor 340, main body 330 and connector 310, and exhibits a length that is adapted the lengths of these parts. Accordingly, the length of the activation and deactivation member 530 is adapted the total length of these components, which as described above may vary depending on use. The elongated body 531 is provided with a tapering lower end 532 adapted to be received in the decagon cone-shaped part 312 of the connector 310 with the mentioned locking balls 510 in retracted position by the shortest diameter of the tapering lower end 532.

The activation and deactivation member 530 is further at upper end provided with a head assembly 533 comprising a disc 534 arranged to the upper end of the elongated body 531, which disc 534 has a larger diameter than the diameter of the elongated body 531. The mentioned disc 534 has a shape and size adapted to be received in the mentioned recess 355 of the connection device 350. To the mentioned disc 534 is further arranged a handle 535 protruding from the disc 534, enabling rotational movement of the mentioned activation and deactivation member 530 when inserted into the connection device 300.

The elongated body 531 is further at provided with a number of protruding lock pins or teeth 540 extending perpendicularly from the elongated body 531 and distributed in circumferential direction thereof, which pins or teeth 540 are arranged at a distance from upper end of the elongated body 531 adapted to be received and accommodated in the key lock member 550, further described below.

The key lock member 550, as shown in detail in Fig. 9c, is adapted by size and shape to be received and accommodated in the mentioned recess 544 at upper end of the adaptor 340. In the shown embodiment the key lock member 550 is formed by a polygonal body 551 with a through hole 552 adapted to receive the mentioned elongated body 531 of the activation and deactivation member 530. The key lock member 550 is further provided with a number of curved tracks (keyholes) 553 exterior of the mentioned through hole 552, adapted for receiving and accommodating the mentioned lock pins or teeth 540 of the activation and deactivation member 530. The curved tracks 553 extend with an initial part in the vertical plane and curves to end in a horizontal part that is forming a locking position.

Accordingly, the key lock member 550 is accommodated and fixed in the adaptor 540 that is fixed to the main body 330 and the connection device 350.

The position of the lock pins or teeth 540 is adapted in longitudinal direction of elongated body 531 such that when the activation and deactivation member 530 is inserted into the connection device 300 the lock pins or teeth 540 come into engagement with the mentioned tracks 553 and is allowed to be moved axially in the connection device 300 in the mentioned tracks 553, and when in locking position, the disc 533 is in firm engagement with the connection device 350.

Accordingly, the present invention provides a modular connection device 300 that can be adapted depending on the use and requirement for structure element 400 to be arranged thereto.

The connection device 300 is assembled by arranging the desired ring 320 and desired main body 330 to the connector 310, that due to the decagon-shaped part 312 of the connector 310 and decagon-shaped through hole 324 and decagon-shaped lower recess 333 of the ring 320 and main body 330, respectively, retain these parts together. The adaptor 340 can then be arranged to the upper end of the main body 330 by means of the polygonal recess 335 of the main body 330 and lower polygonal flange 342a of the adaptor 340 retaining these parts together. Accordingly, the parts of the connection device are stacking into each other for directional stability.

The key lock member 550 can next be arranged in the upper polygonal recess 344 of the adaptor 340 and retained therein.

Next, a desired connection device 350 can be arranged to the adaptor 340 by means of the upper polygonal flange 342b and polygonal recess 352 of the connection device 350.

The connector 310, ring 320, main body 330, adaptor 340 and connection device 350 are now retained to each other as well as prevented from rotation in relation to each other, i.e. directionally stable.

The connection assembly 300 is now ready for being arranged to the hollow spherical joint 200 at a desired connection point 220 by insertion of the connector 310 into the connection point 220.

When the connector 310 is in place in the connection point 220 the activation and deactivation member 530 is inserted axially into the connection assembly 300 via the through holes 353, 334, 313 of the connection device 350, adaptor 340, main body 330 and connector 310, respectively, such that lower tapering end 532 is positioned at the mentioned locking balls 510 in the connector 310. During this axial movement of the activation and deactivation member 530, the lock pins or

teeth 540 are allowed to pass through the connection device 350 via the recesses 353 and comes into engagement with the mentioned tracks 533 of the key lock member 550.

The connection assembly 300 is now ready for the final stage, which is locking of the connection assembly 300 to the connection point 220 of the hollow spherical joint 200.

By further moving the activation and deactivation member 530 axially in the connection assembly, 300, the tapering end 532 of will move into the decagon cone-shaped part 312 of the connector and force/press the mentioned locking balls 510 to the locking position extending protruding outside the decagon cone-shaped part 312 of the connector 310 and received in the locking recess or holes 520 of the connection point 220 of the hollow spherical joint 200. At the same time, the activation and deactivation member 530 is rotated such that the mentioned lock pins or teeth 540 follows the mentioned tracks 553 in the key lock member 550 into the horizontal end of the mentioned tracks 553.

In this manner the connection assembly 300 is locked to the hollow spherical joint 200 by that the parts of the connection assembly 300 is compressed between exterior surface of the hollow spherical joint 200 at one end and by the disc 534 at the other end, thus locking the parts axially to each other.

For detaching the connection assembly 300 from the hollow spherical joint 200, the activation and deactivation member 530 is rotated in the opposite direction and at the same time retracted axially in the connection assembly 300 whereupon the tapering part 332 of the activation and deactivation member 530 is retracted from the decagon-shaped part 312 of the connector 310 resulting in that the locking balls 510 retract from the protruding/locking position, i.e. out of engagement with the locking recesses or holes 520 of the connection point 220 and into the connector 310. The connection assembly 300 can now be removed from the hollow spherical joint 200.

Reference is now made to Fig. 10a-d showing different embodiments of use of the present invention by the use of a hollow spherical joint 200 according to the present invention and a connection assembly 300 according to the present invention. In Fig. 10a-b is both the arrangement of a standalone connection assembly 300, as described above, and the arrangement of two connection assemblies 300, as described above, adjacent each other. As can be seen for the arrangement of two connection assemblies 300 next to each other, the exterior inclined surface of the ring 320 and main body 330 engage each other and provides additional support. As can be seen in the figures, the connection points 220 provide the opportunities to arrange the connection assemblies in different angles in relation to each other.

In Fig. 10c-d are shown structures 100 where structure elements 400 in the form of beams are connected to hollow spherical joints 200 by means of connection assemblies 300 according to the present invention.

By the present invention, it is provided a hollow spherical joint 200 formed by multiple identical interlocking joint members 210 or sets of corresponding identical interlocking joint members 210a-b with unique geometry around and perfect symmetry, and wherein each joint member 210, 210a-b has an interlocking profile enabling the multiple identical joints 210 or sets of the corresponding identical interlocking joint members 210a-b to form the hollow spherical joint 200 at assembly.

Unique strength characteristics is achieved based on optimization of hollow spherical joint wall thickness, connector 310 shape, size and locking ball 510 size and midline shape and tangent line curvature of upper and lower interlocking elements 211, 212, 213, 214, 215. This tangent curvature reinforces the interlocking of the joint members 210, 210a-b when forces are applied without stress points.

The present invention provides a solution that requires no screws, nails or cutting required for assembly of joint members 210, 210a-b into the hollow spherical joint 200, and for connection of structure elements 400 to the hollow spherical joint 200.

By the present invention it is provided a unique ball-based locking mechanism requiring a simple manual twist to move locking balls from unlocked to locked position, optimizing and maximizing surface contact area between connection point 220, connector 310 and locking balls 510 effectively locking a structure element 400 to the hollow spherical joint 200.

By the present invention is provided a hollow spherical joint 200 and connection assembly 300 enabling tool-less assembly of a construction.

By the present invention is further provided a connection assembly 300 that enables easy assembly as well as disassembly of a structure element 400 to the hollow spherical joint 200.

The present invention further provides a solution that is that is easy to adapt according to desired requirements due to the components of the connection assembly 300 are exchangeable to change the features/properties thereof, as well as the possibility to adapt the connection device 300 depending on which structure element 400 is to be connected thereto, which also can be another joint or hollow spherical joint 200.

The more connection points 220 the hollow spherical joint 200 is provided with, the more possible angles a structure element 400 or joint can be arranged thereto with.

Further, by the present invention it is provided a manual assembly construction system enabling rapid assembly of a permanent or temporary construction or disassembly of a construction.

By the present invention is provided a hollow spherical joint 200 and connection assembly 300, wherein the components thereof may be mass-produced and easily altered at construction site by changing the components thereof to adapt the requirements of the construction in question, as well as the components are reusable for other constructions.

The present invention is scalable for any construction and in this manner applicable for small constructions, such as toys for children, to multi-floor large buildings.

The present invention is also suitable for rapid erecting shelters in disaster areas.

Due to the present invention is easy to assemble the environmental footprint compared to prior art solutions is considerably reduced.

The features of the above described embodiments can be combined to form modified embodiments within the scope of the attached claims.

Claims

1. Construction system (100) for assembly of a structural construction, wherein the construction system (100) comprises hollow spherical joints (200) and connection assemblies (300) for structure elements (400) or joints,

wherein the hollow spherical joint (200) is assembled by multiple identical interlocking joint members (210) or sets of corresponding identical interlocking joint members (210a-b), wherein the hollow spherical joint (200) is provided with multiple connection points (220),

wherein the connection assembly (300) is adapted for detachable attachment to the connection points (220) and comprises a locking assembly (500) for locking and unlocking of the connection assembly (300) to the hollow spherical joint (200).

2. Construction system (100) according to claim 1, wherein the interlocking joint members (210) are provided with interlocking profiles replicated at each side.

3. Construction system (100) according to claim 1, wherein the hollow spherical joint (200) is assembled by eight or twenty identical interlocking joint members (210) or sets of ten identical and eight identical corresponding interlocking joint members (210a-b).

4. Construction system (100) according to claim 1, wherein the hollow spherical joint (200) comprises between two and ninety-two connection points (220).

5. Construction system (100) according to claim 1, wherein the connection assembly (300) comprises a connector (310), ring (320), main body (320), adaptor (340) and connection device (350) for structural element (400), assembled in longitudinal direction thereof to form the connection assembly (300).

6. Construction system (100) according to claim 5, wherein the connection points (220) are polygonal and cone-shaped and the connector (310) comprises a polygonal cone-shape part (312) adapted to be accommodated in the connection point (220).

7. Construction system (100) according to claim 6, wherein the connection points (220) are decagon cone-shaped and the connector (310) is decagon cone-shaped.

8. Construction system (100) according to 5, wherein the connector (310) further comprises an elongated polygonal- or decagon-shaped part (311) and the ring (320) is provided with a polygonal- or decagon-shaped through hole (324) and the main body (330) is at lower side provided with a polygonal- or decagon-shaped recess (333), which polygonal- or decagon-shaped through hole (324) and polygonal- or decagon-shaped recess (333) are adapted for receiving and accommodating the connector (310) and retaining the connector (310), ring (320) and main body (330) together.

9. Construction system (100) according to claim 5, wherein the main body (330) at upper end is provided with a polygonal recess (335) and the connection device (350) is provided with a polygonal recess (352) at lower side, and the adapter (340) is provided with polygonal connection flanges (342a-b) at upper and lower side adapted the polygonal recesses (335, 352) of the main body (330) and connection device (350), respectively, retaining the main body (330), adaptor (340) and connection device (350) together.

10. Construction system (100) according claim 5, wherein the ring (320) has an end surface (323) adapted the curvature of the hollow spherical joint (200) and is at least partly elastic or compressibel.

11. Construction system (100) according to any preceding claim, wherein the locking assembly (500) is ball-based and comprises multiple locking balls (510) arranged movable in transversal direction of the polygonal or decagon cone-shaped part (312) of the connector (310) and multiple corresponding locking ball recesses or holes (520) arranged in surfaces of the connection points (220) of the hollow spherical joint (200).

12. Construction system (100) according to claim 9, wherein the locking assembly (500) comprising an activation and deactivation member (530) provided with a number of protruding lock pins or teeth (540) adapted for being received in the connection assembly (300) for activation and deactivation of the mentioned locking balls (510).

13. Construction system (100) according to claim 12, wherein the locking assembly (500) further comprises a key lock member (550) adapted to be accommodated in a recess (344) of the adaptor (340) and wherein the key lock member (550) comprises curved tracks (553) adapted for receiving the lock pins or teeth (540) for locking and unlocking the activation and deactivation member (530) axially in the connection assembly (300).

14. Construction system according to claim 12, wherein the activation and deactivation member (530) comprises a head assembly (533) at upper end thereof enabling rotational movement of the

activation and deactivation member (530) and retaining the ring (320), main body (330), adaptor (540) and connection device (350) axially in the connection assembly (300).

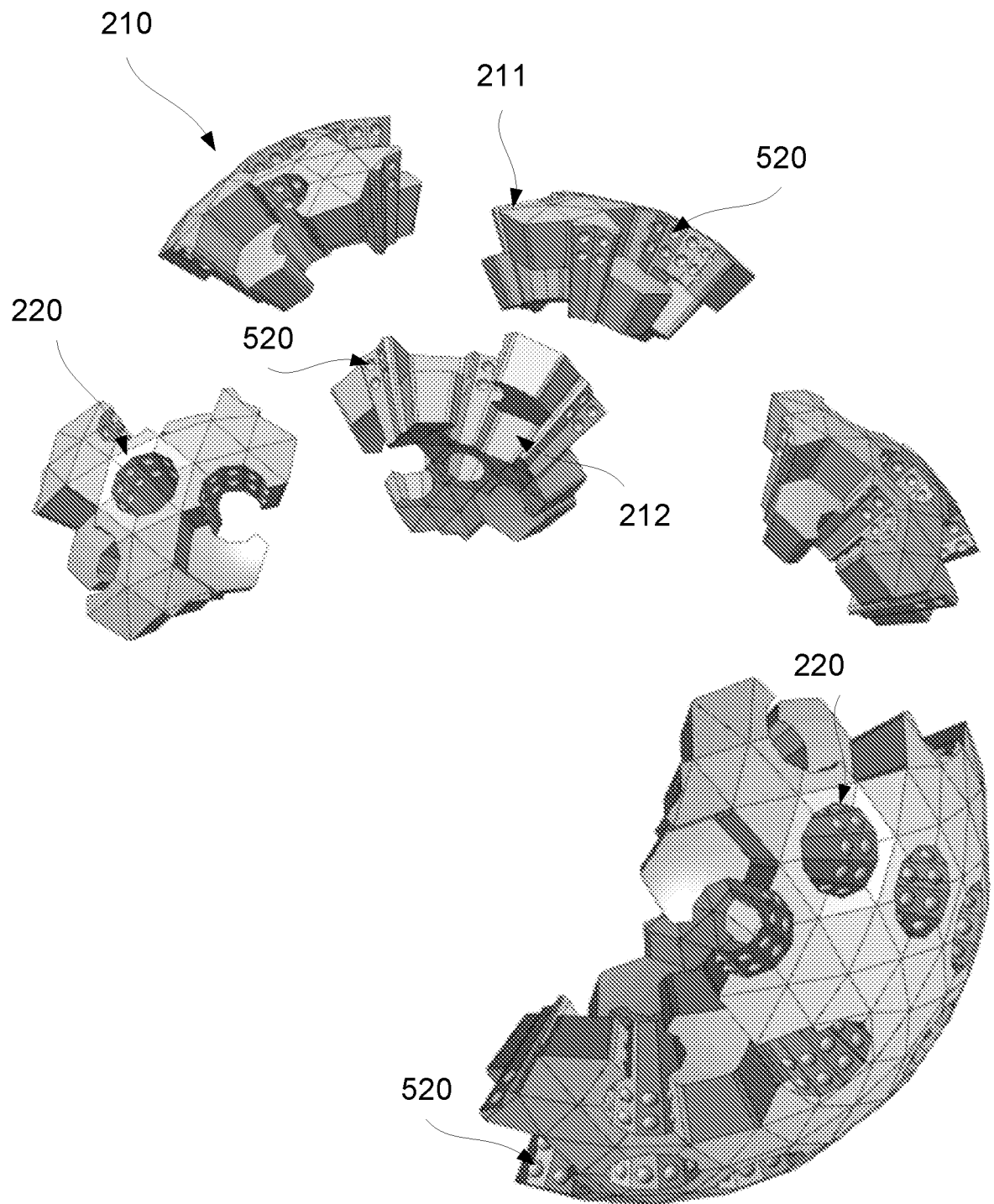
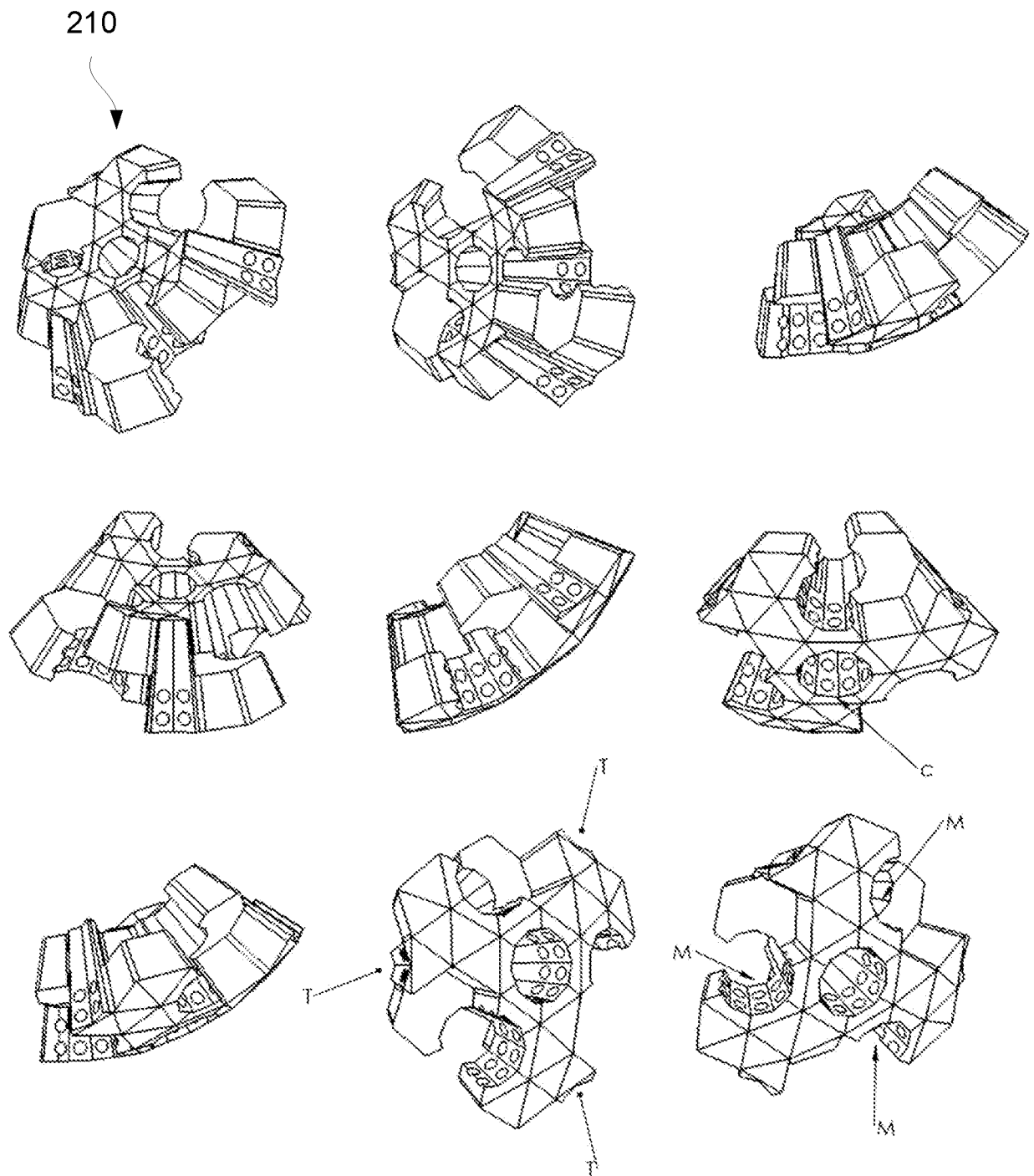
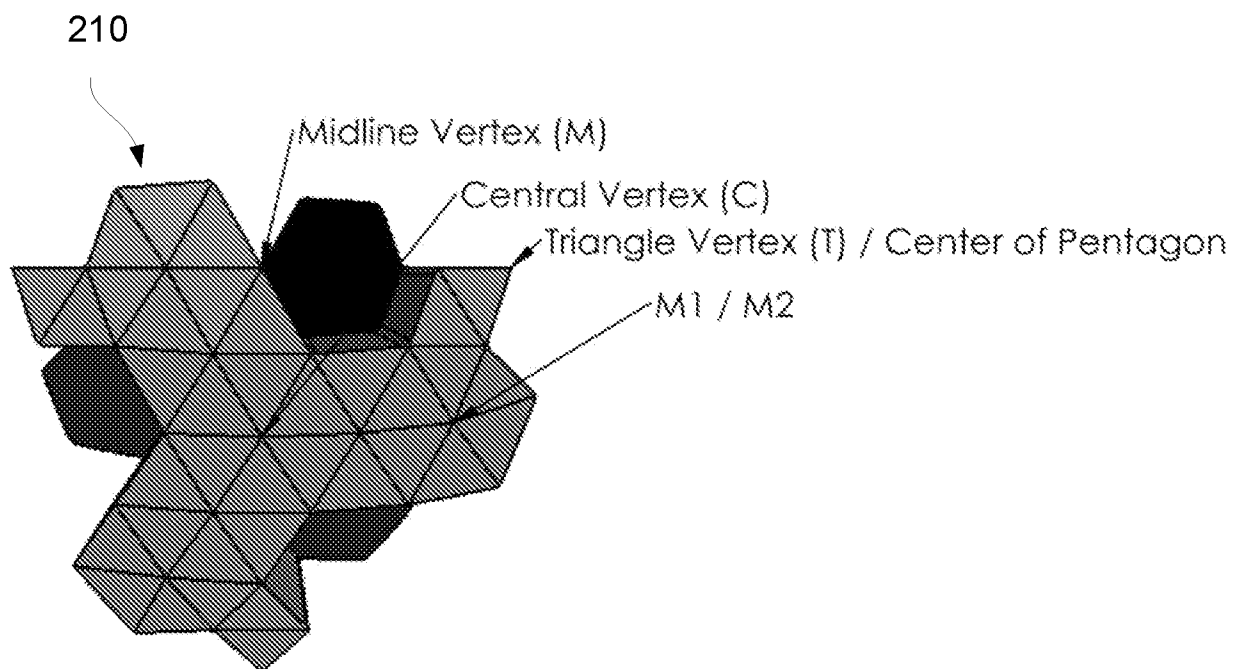
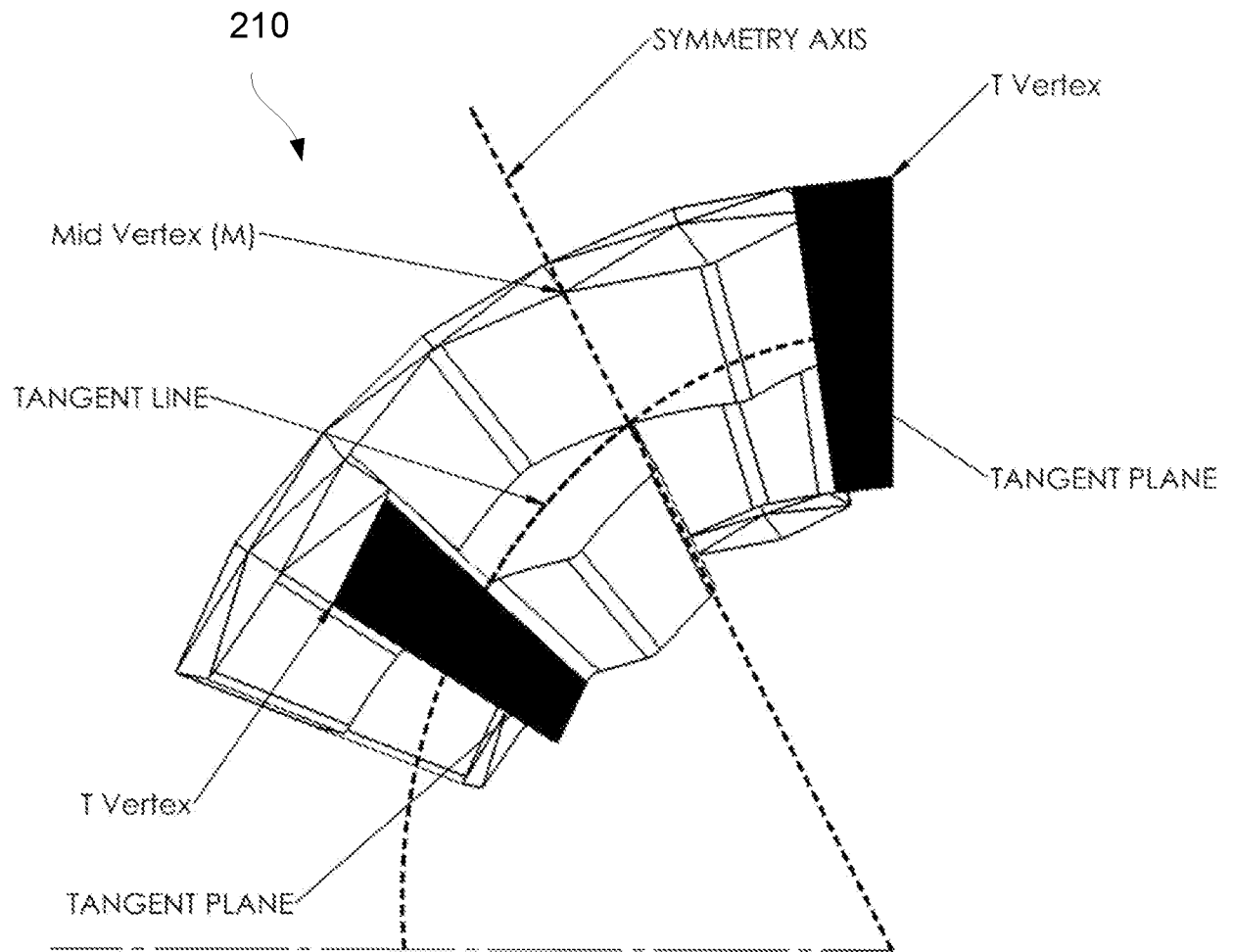


Fig. 1a.

**Fig. 1b.**



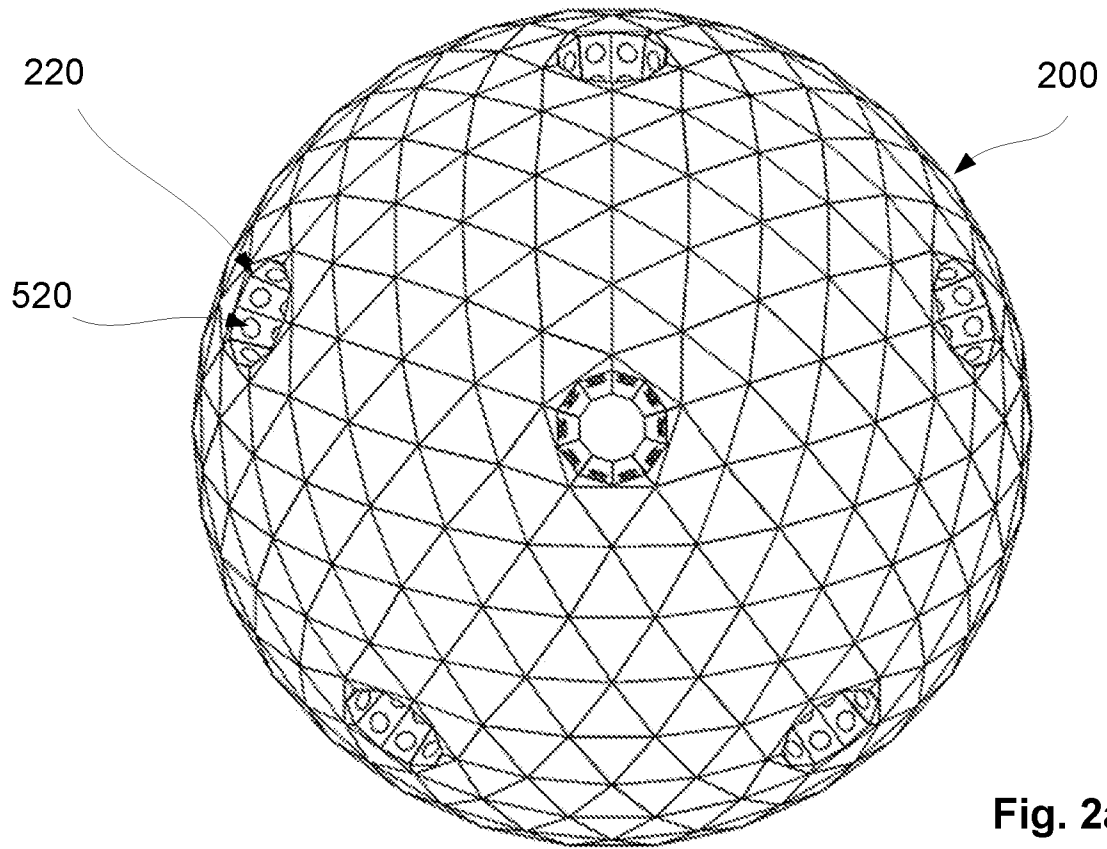


Fig. 2a.

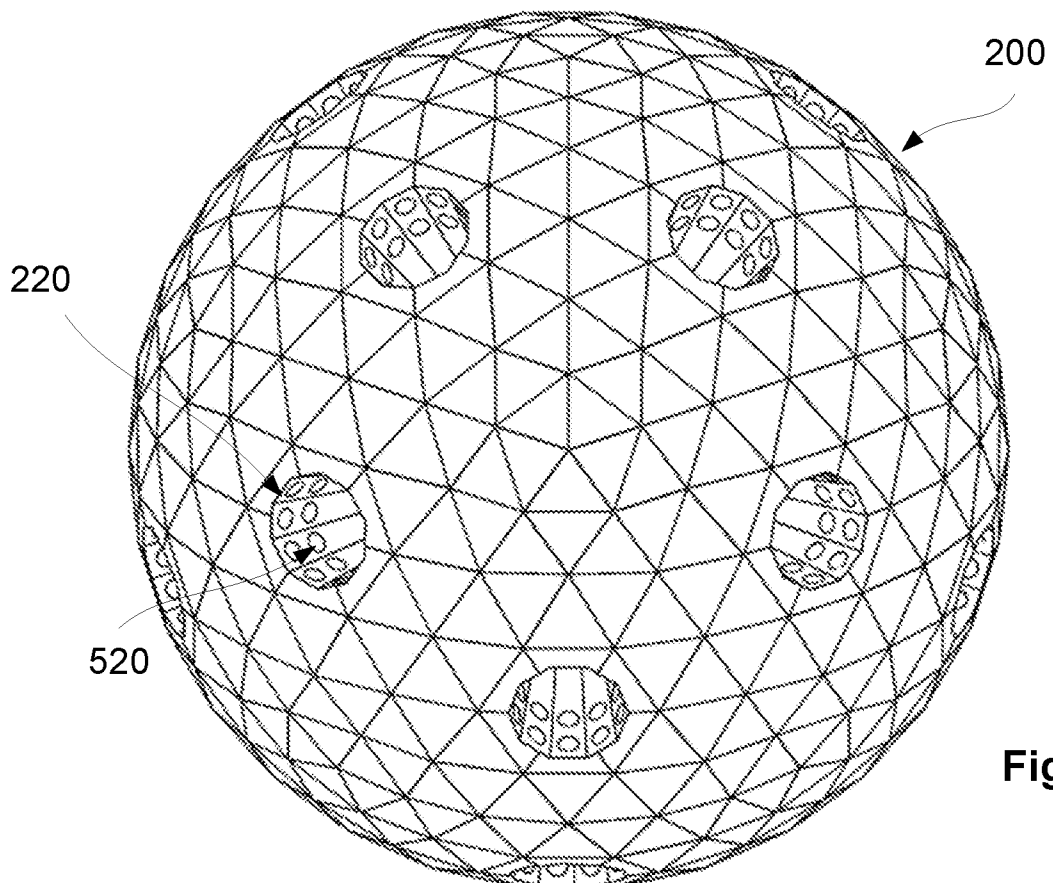


Fig. 2b.

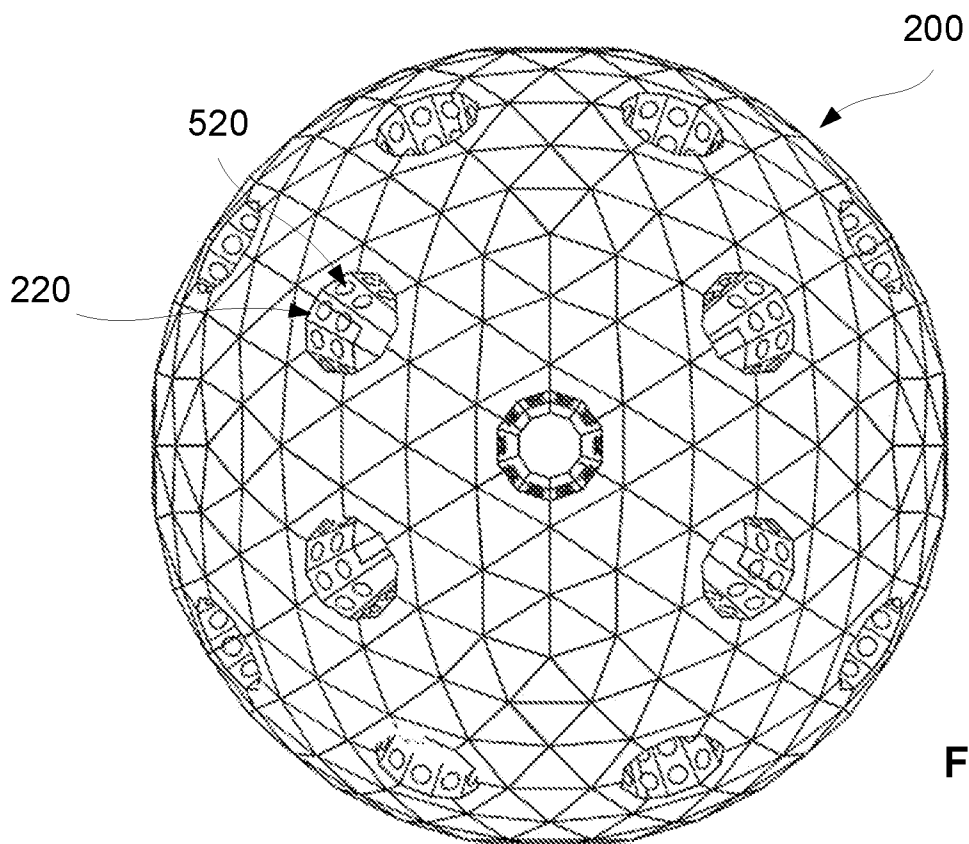


Fig. 2c.

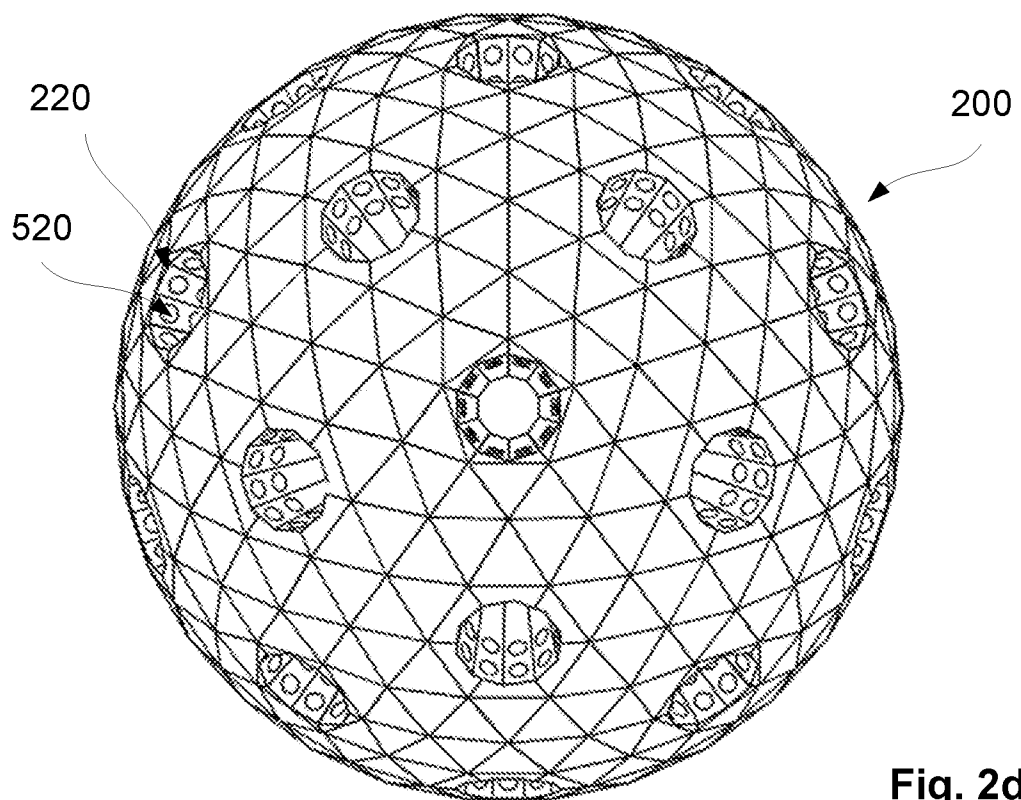


Fig. 2d

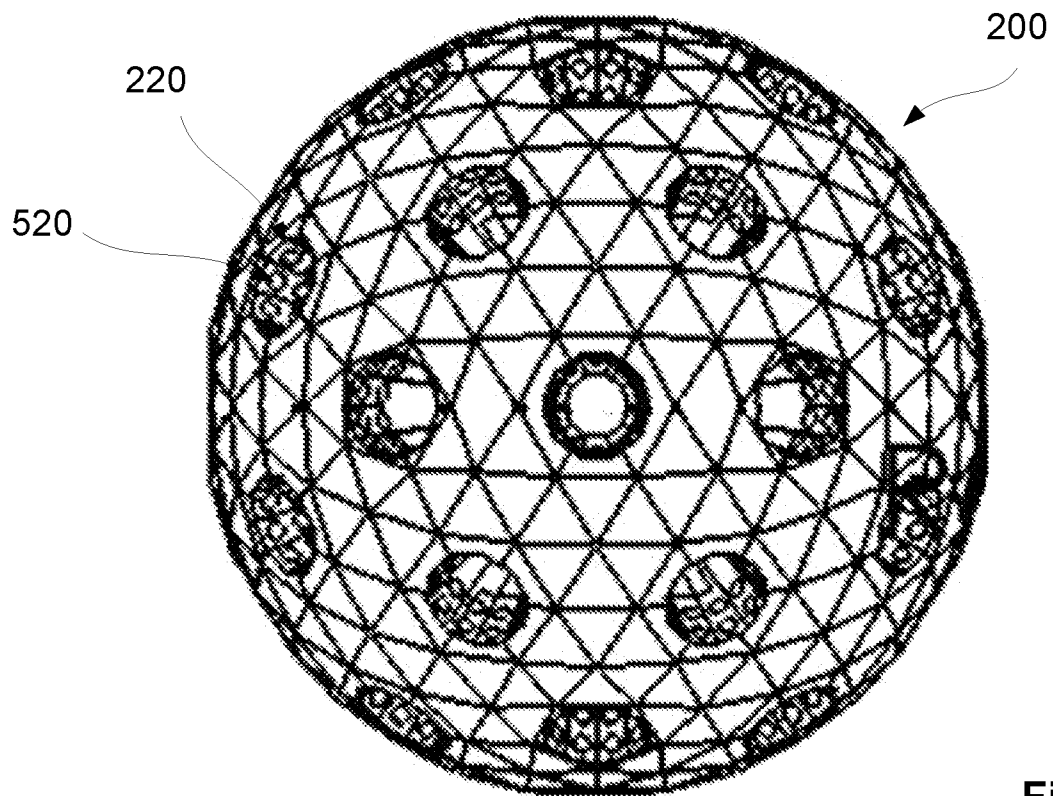


Fig. 2e.

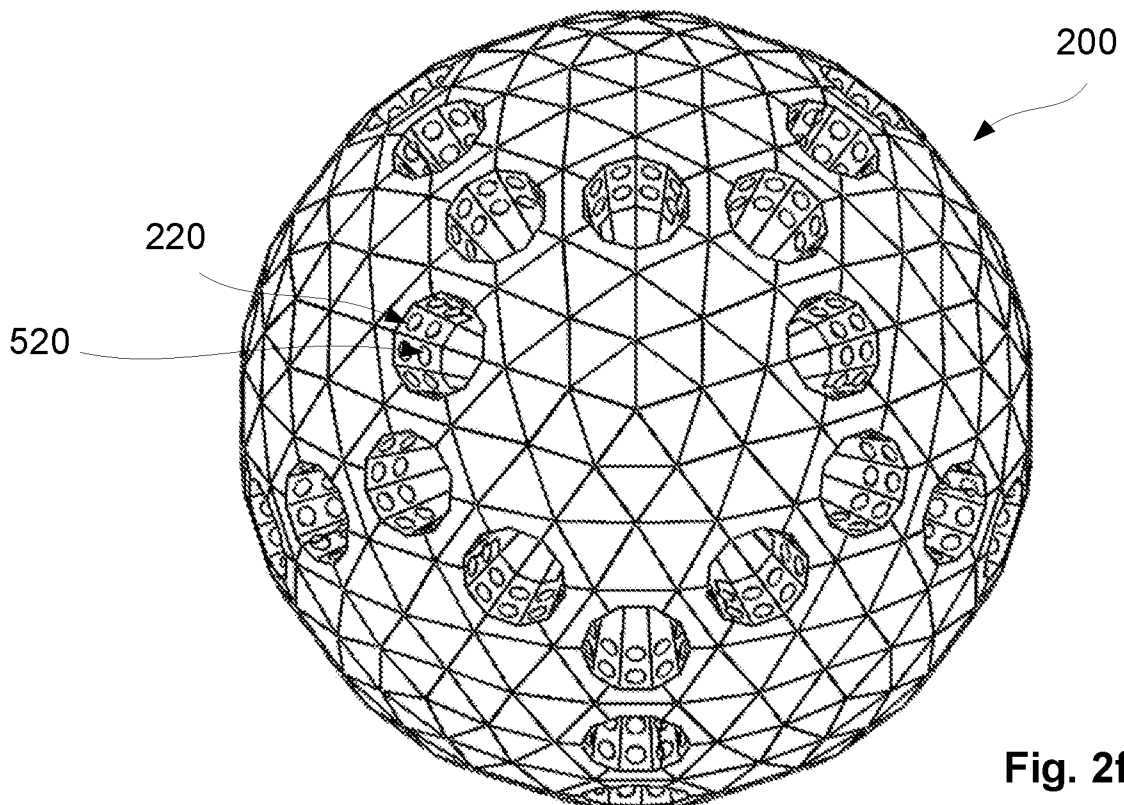


Fig. 2f.

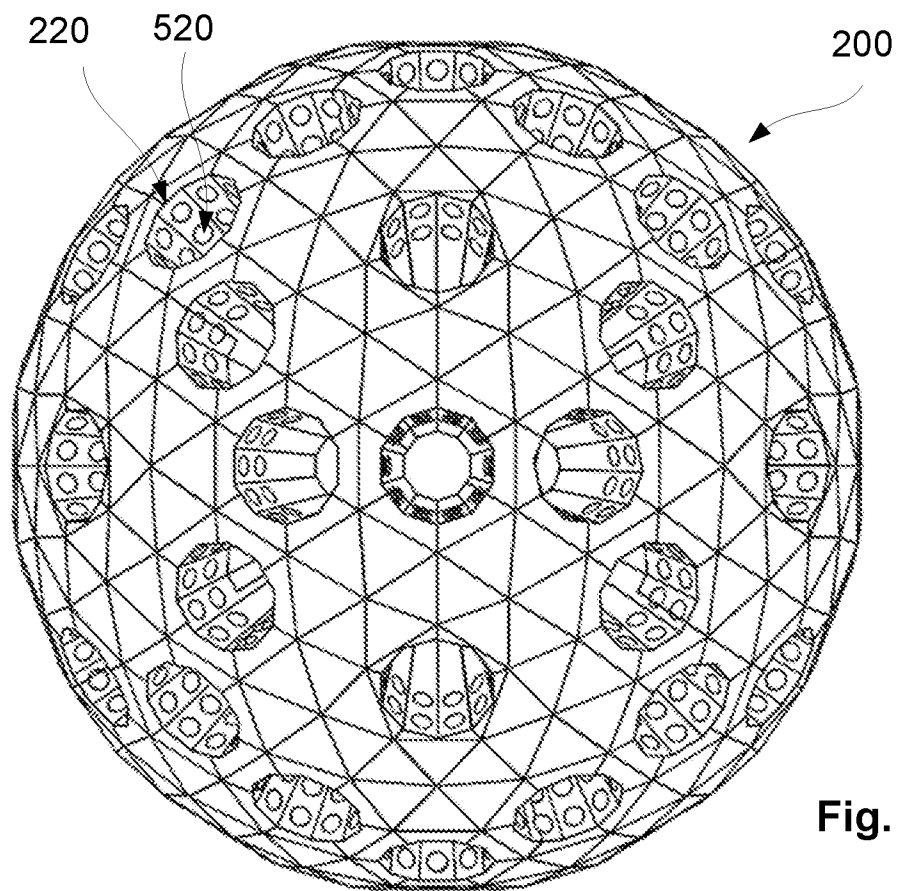


Fig. 2g.

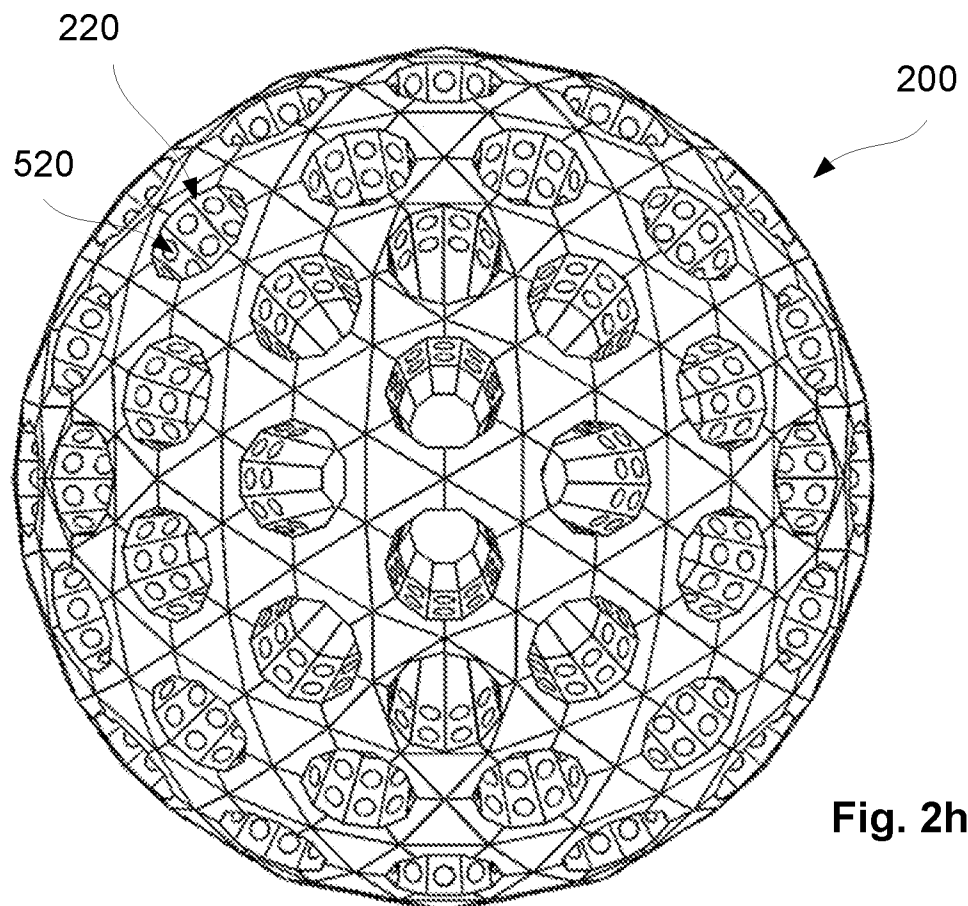
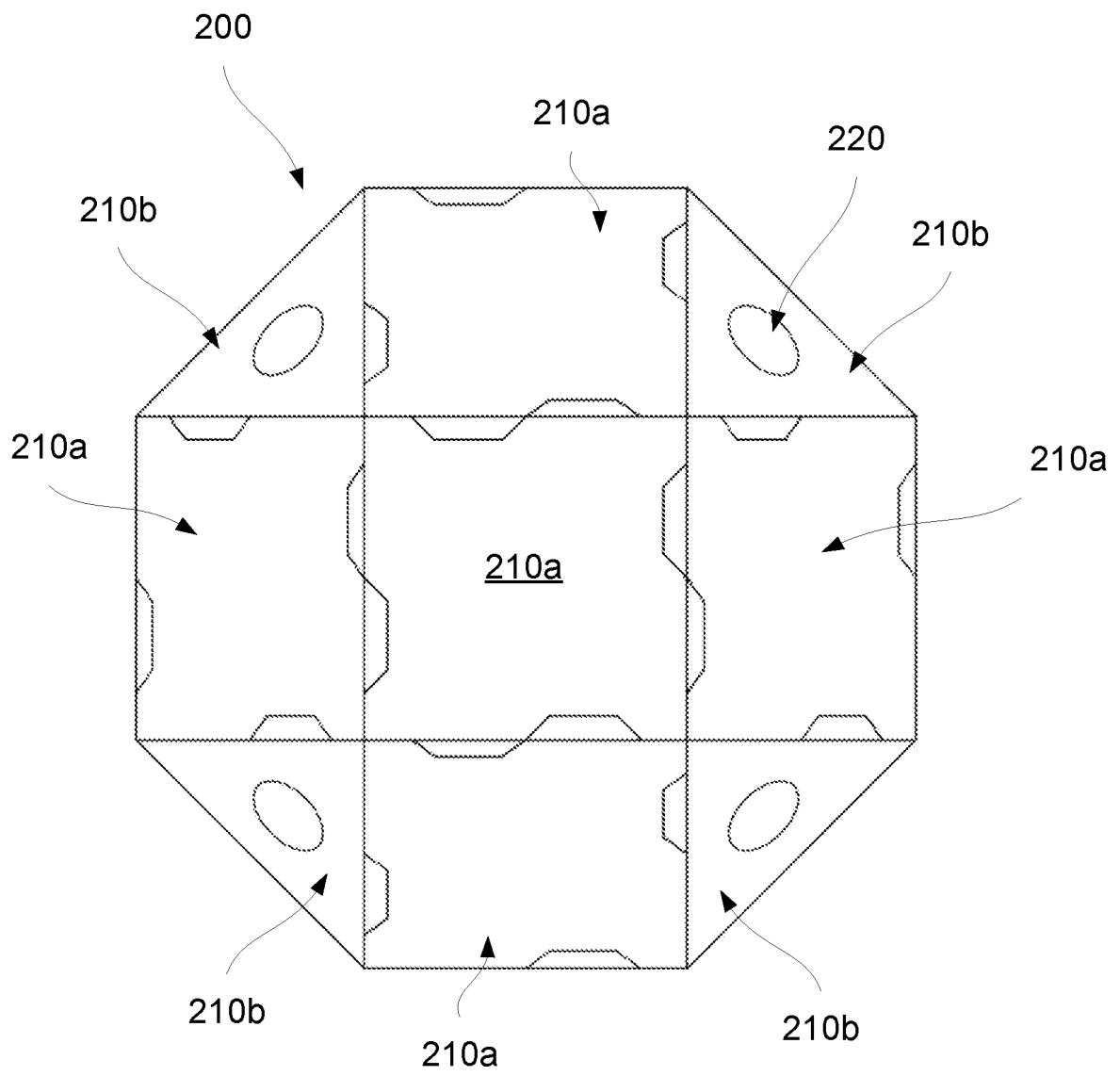


Fig. 2h.

**Fig. 2i.**

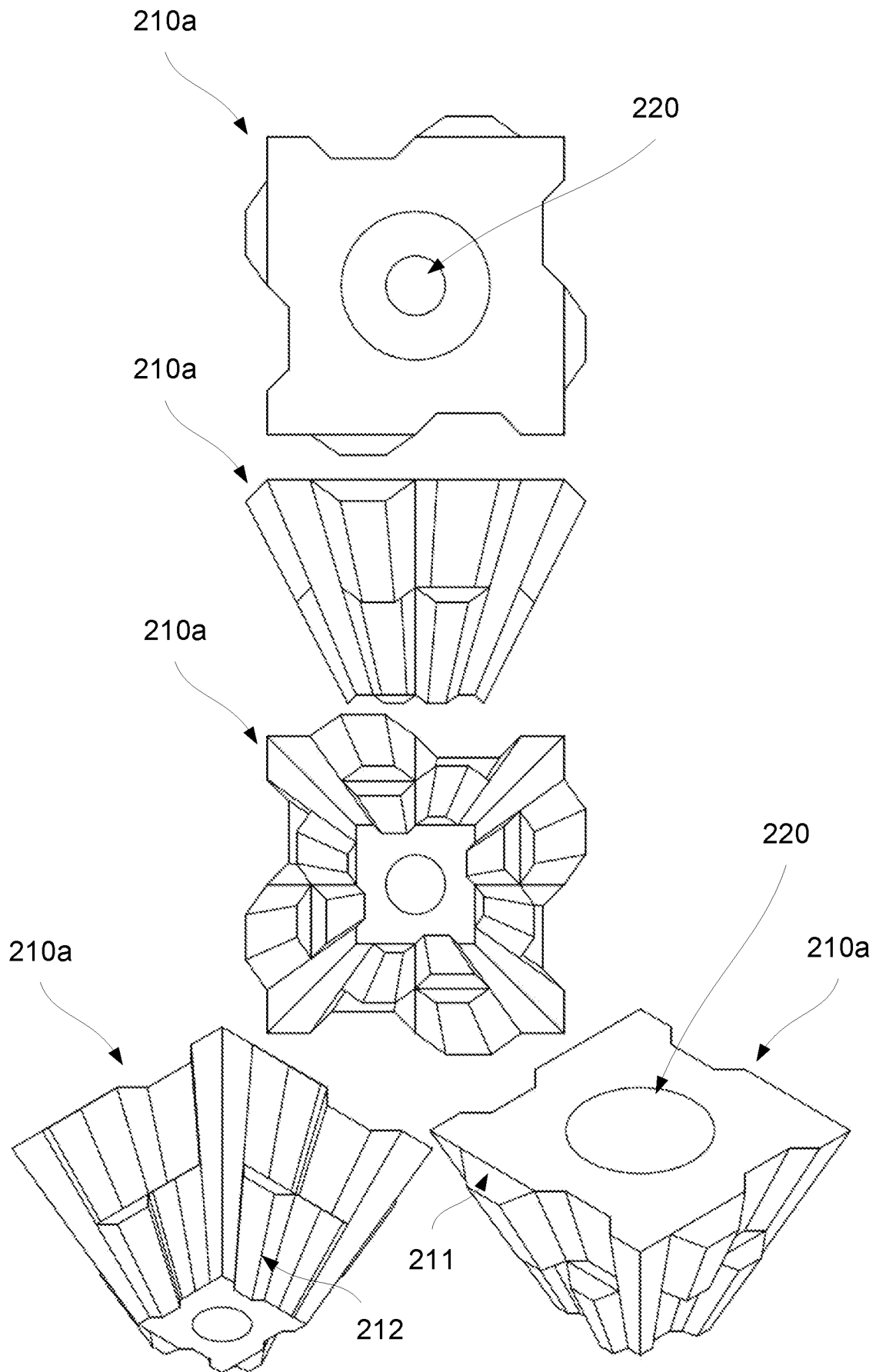


Fig. 2j.

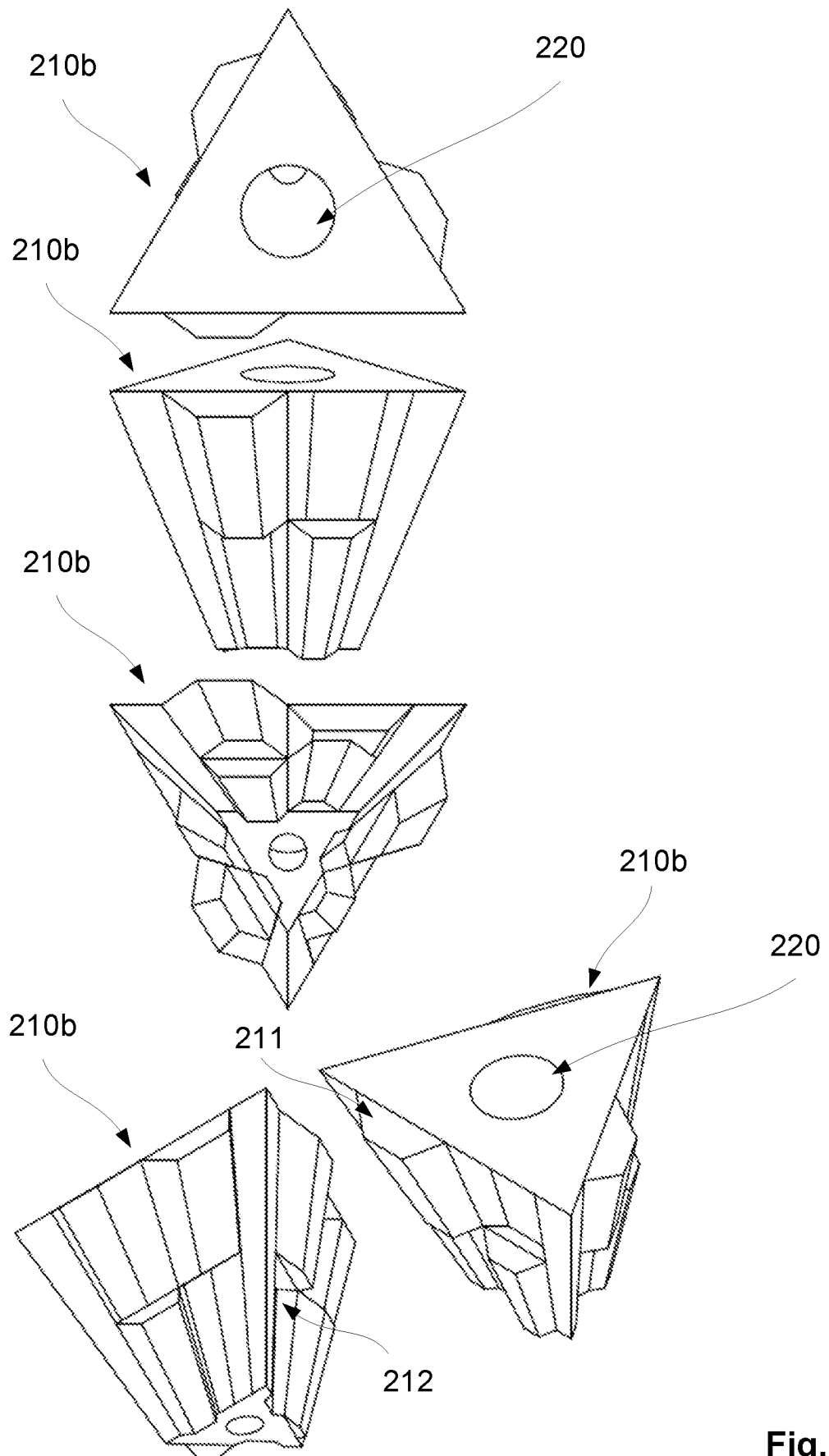


Fig. 2k.

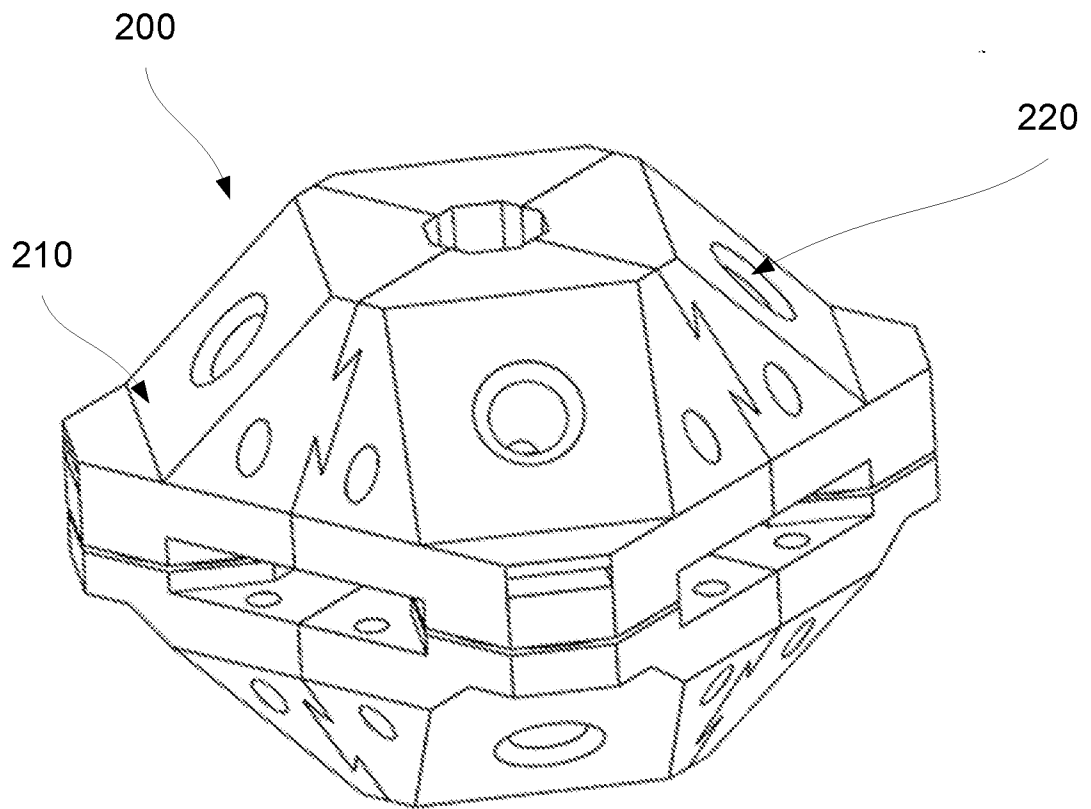


Fig. 2l.

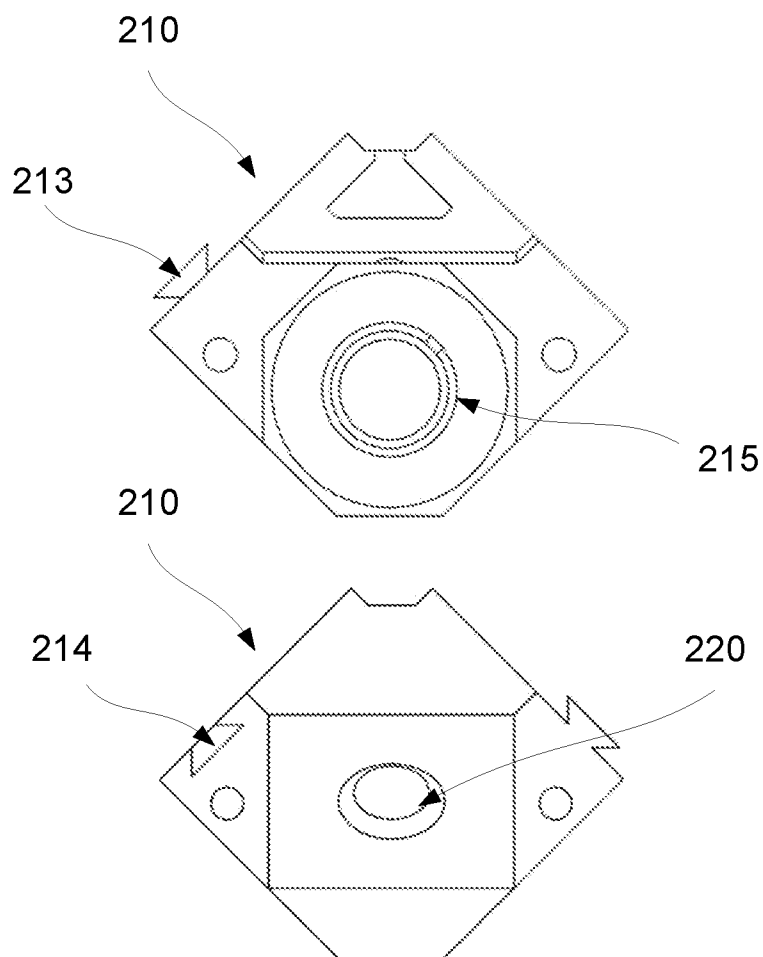


Fig. 2m.

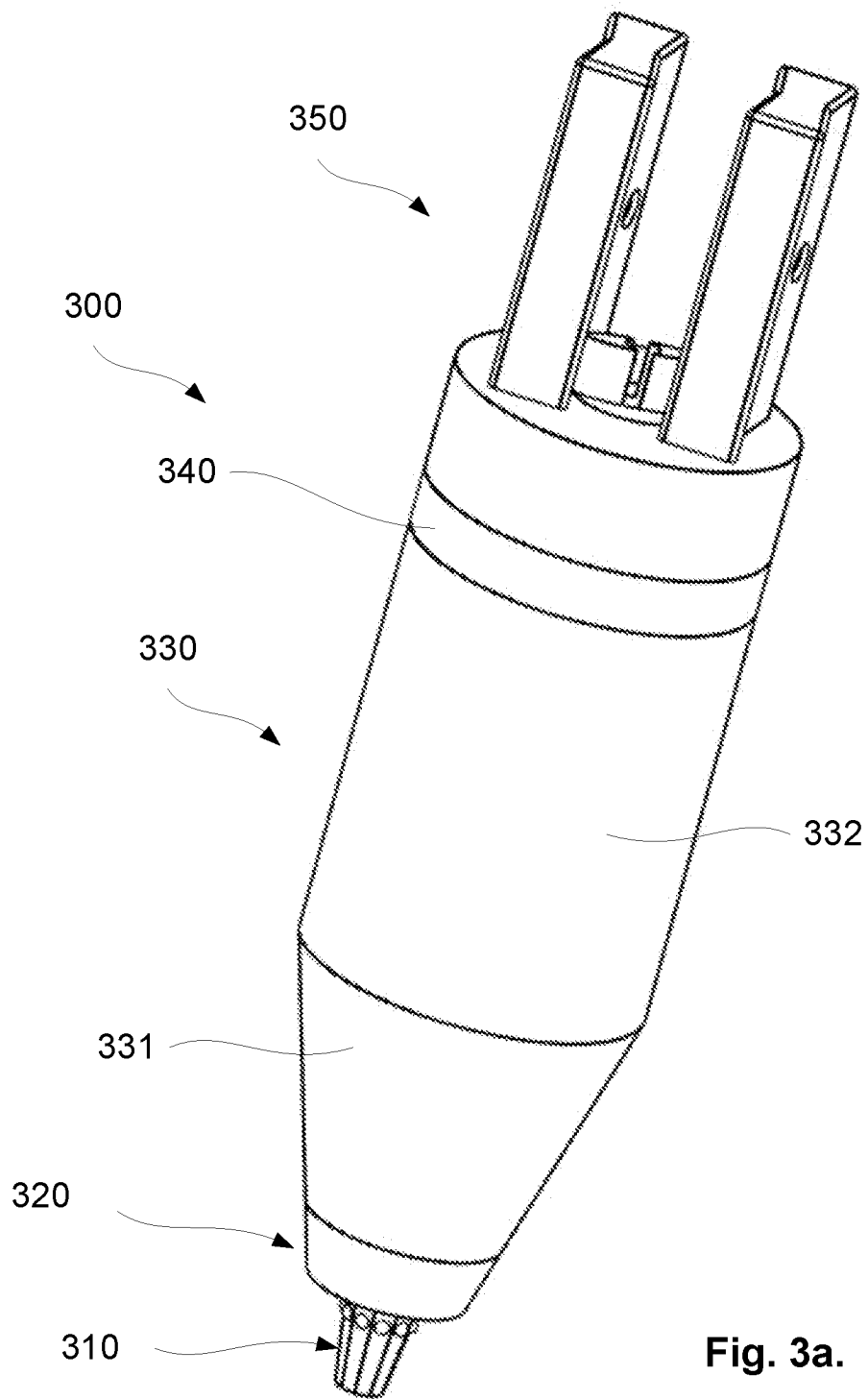


Fig. 3a.

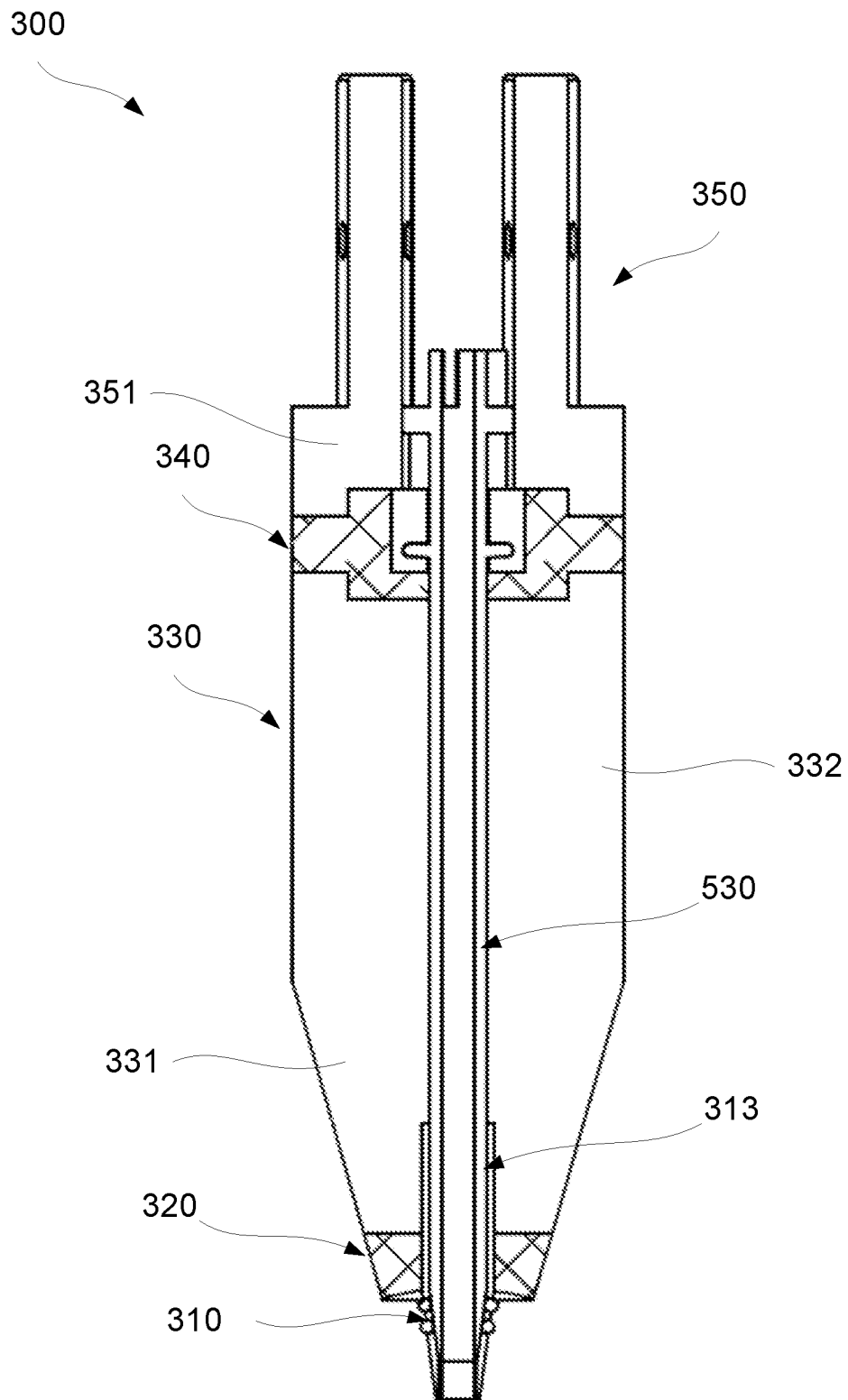


Fig. 3b.

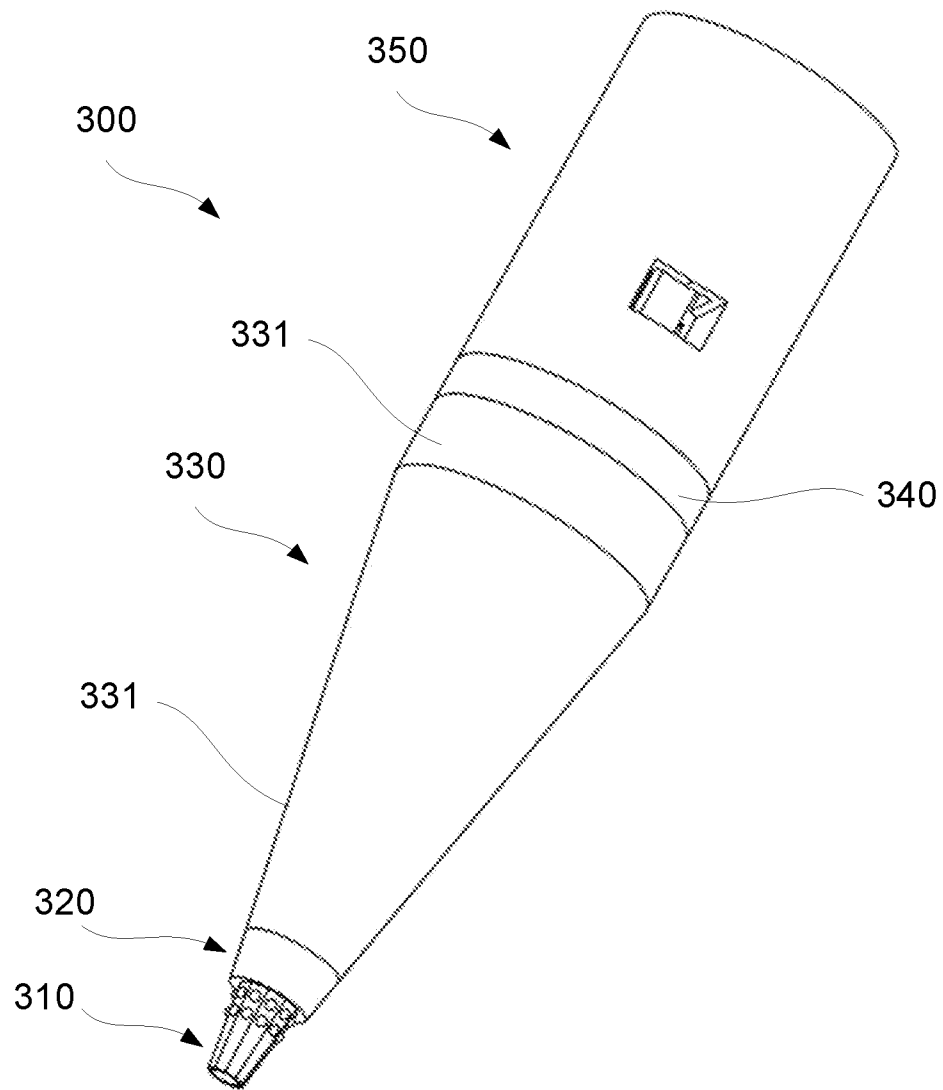


Fig. 3c.

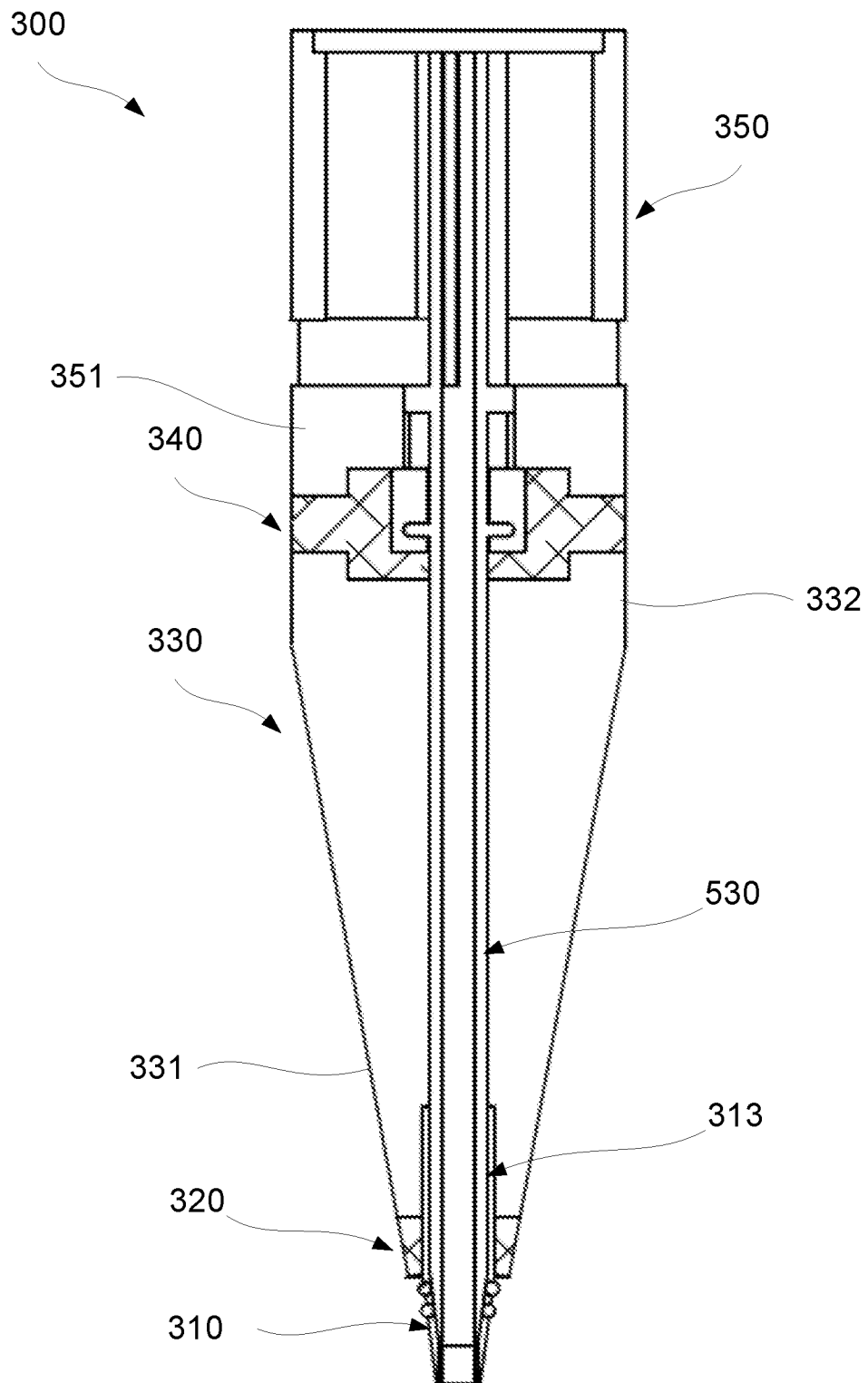


Fig. 3d.

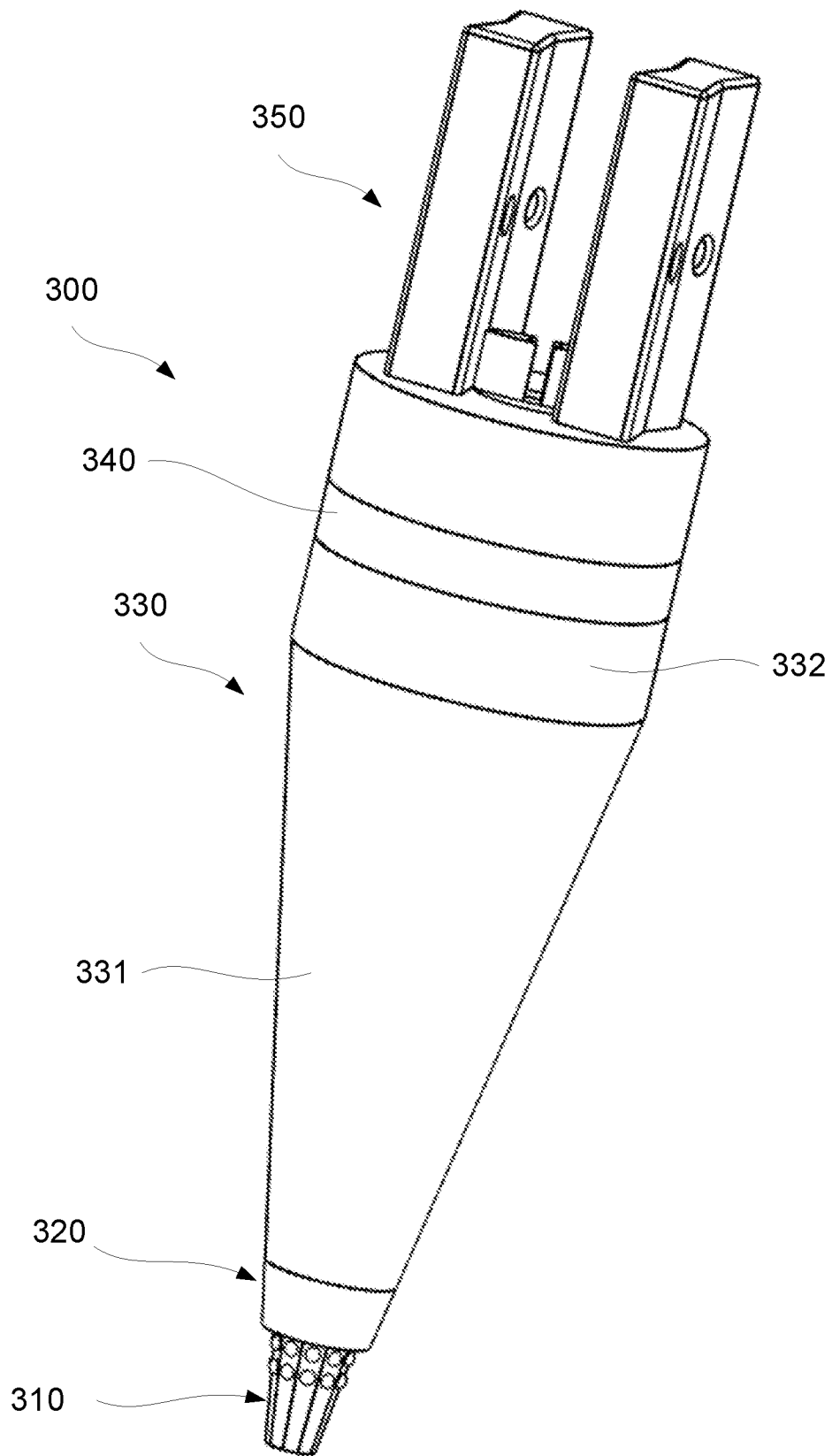


Fig. 3e.

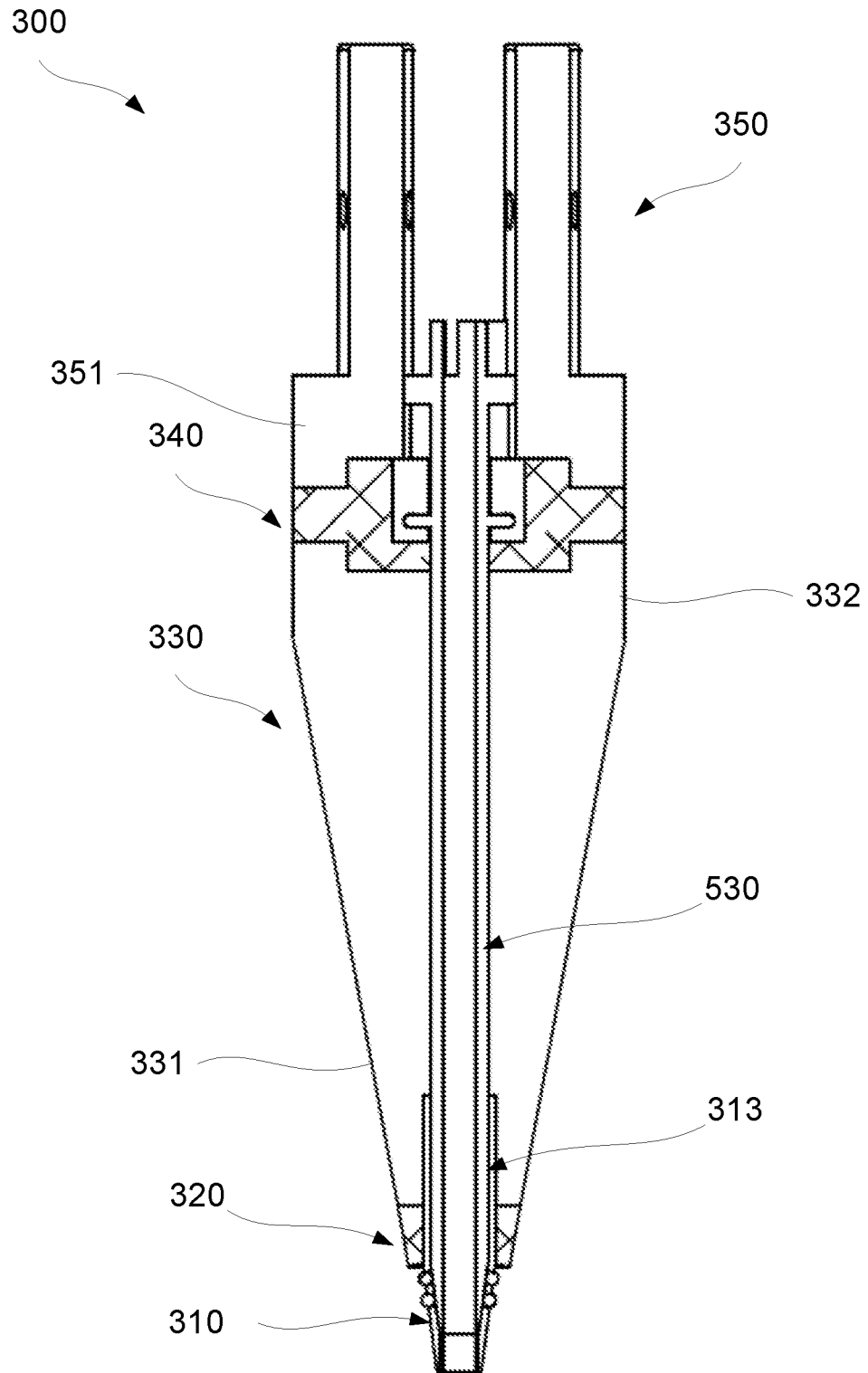
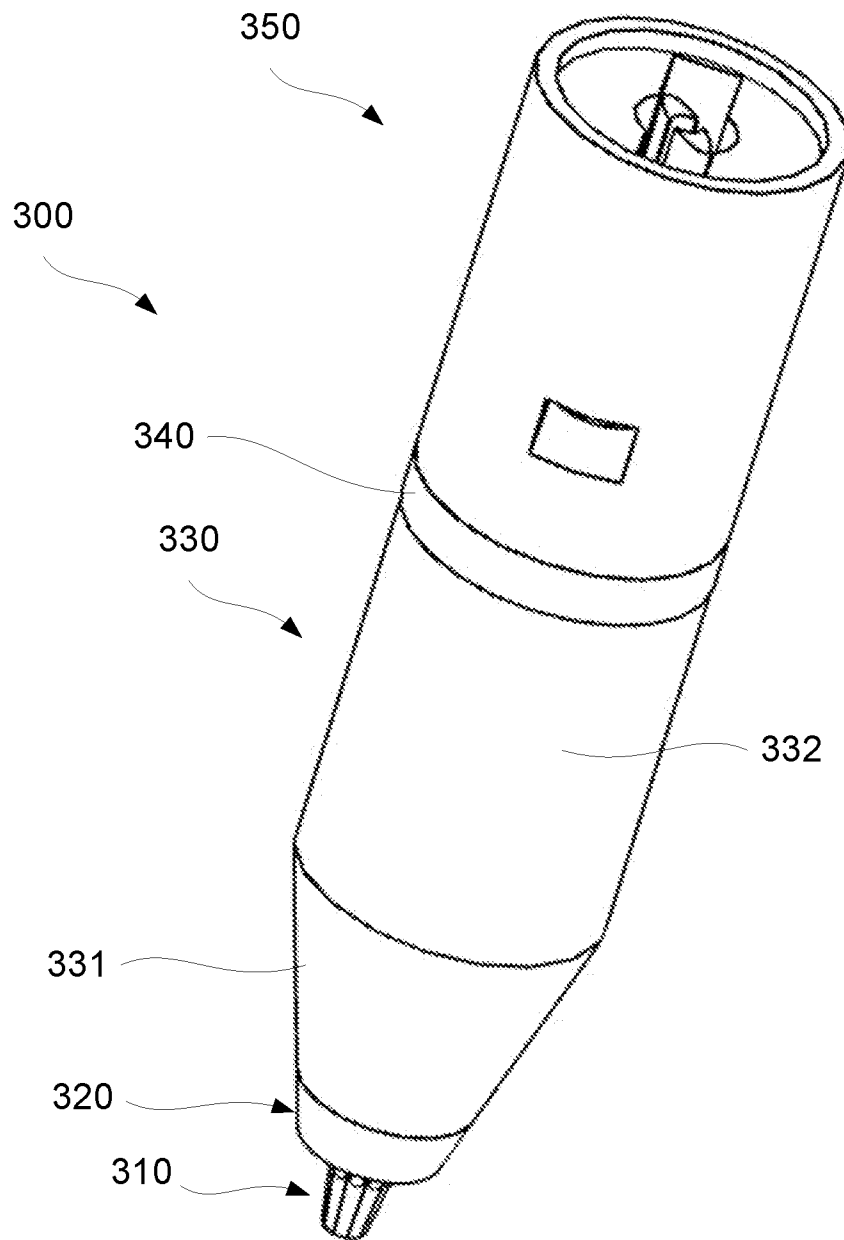


Fig. 3f.

**Fig. 3g.**

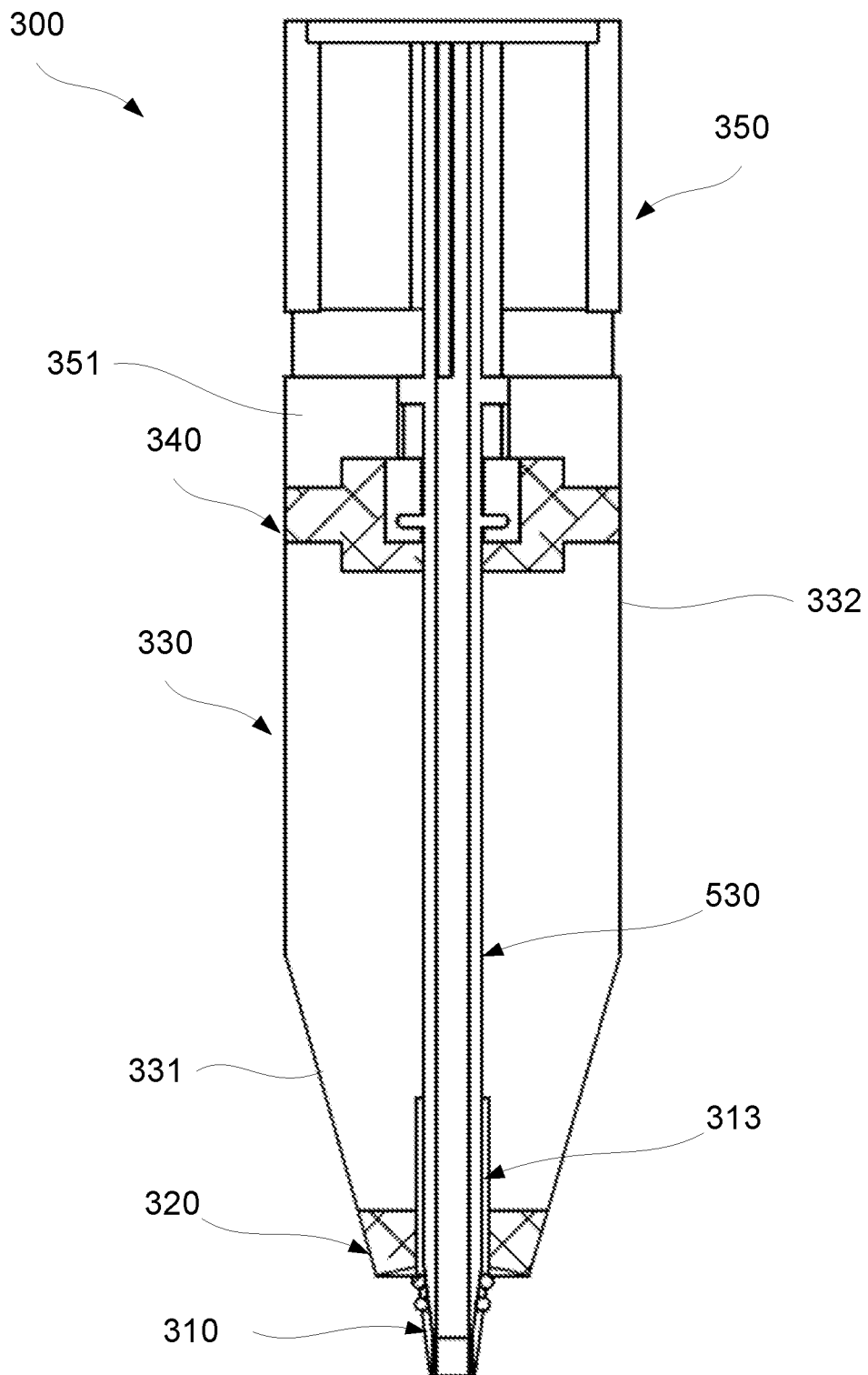


Fig. 3h.

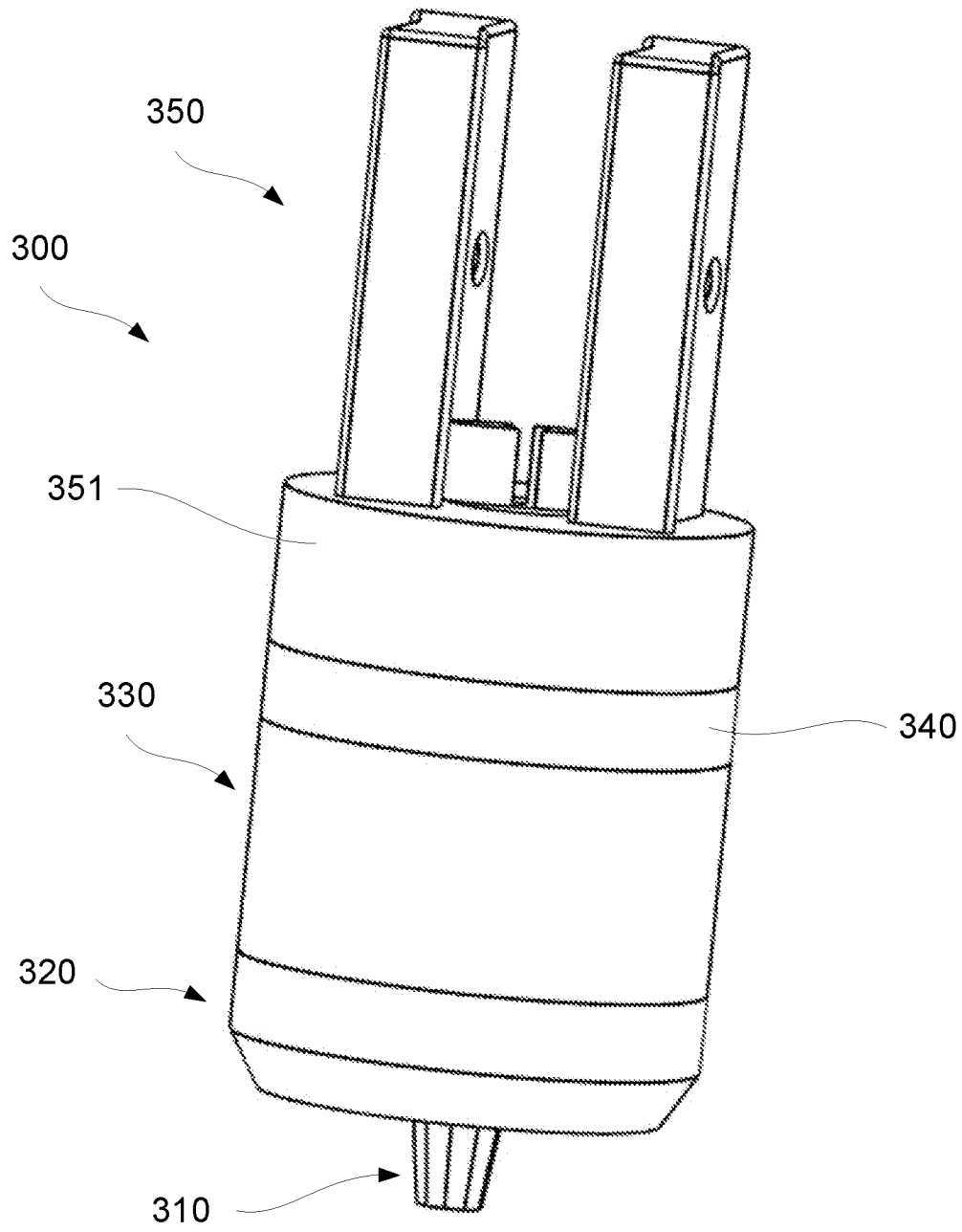


Fig. 3i.

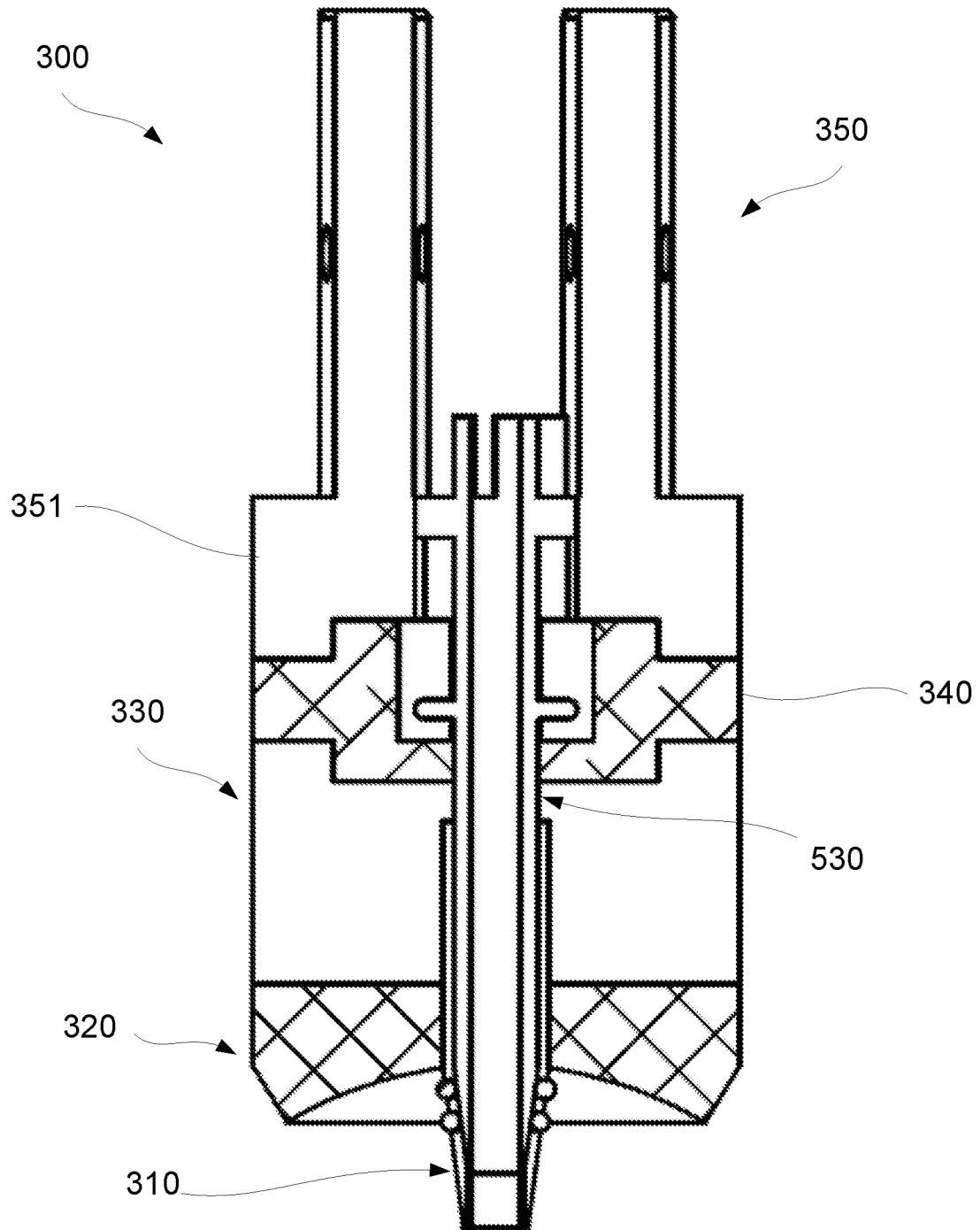


Fig. 3j.

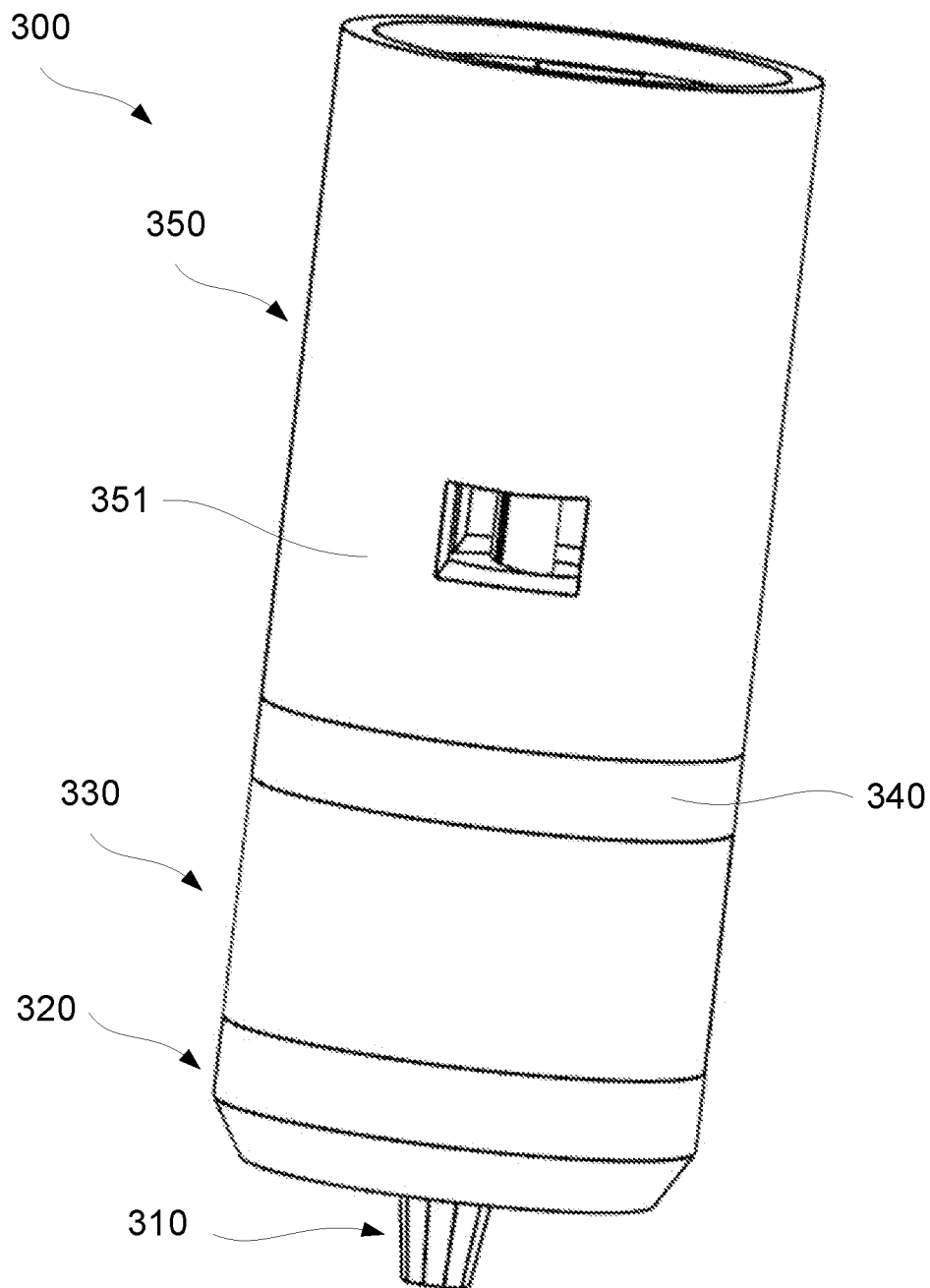


Fig. 3k.

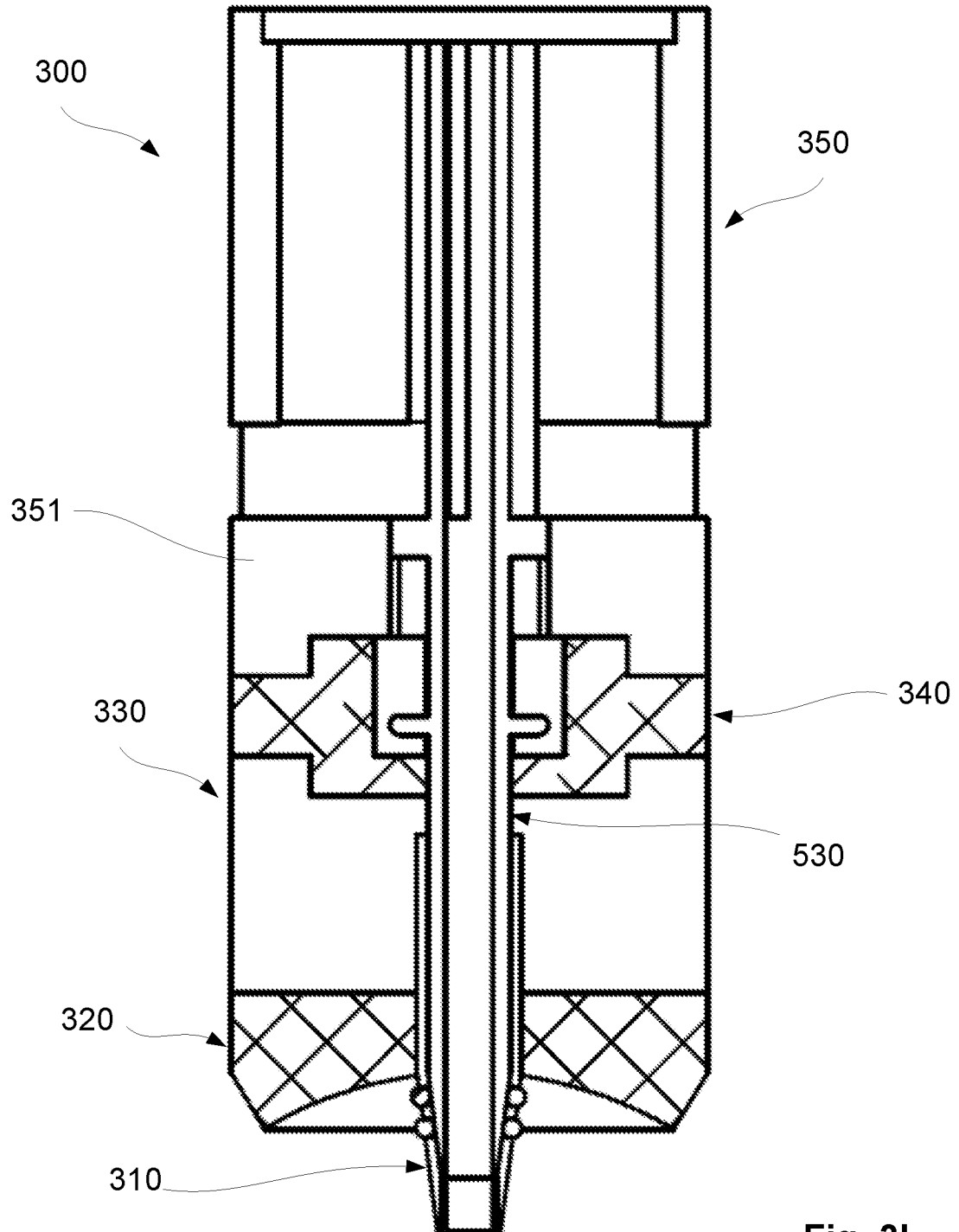
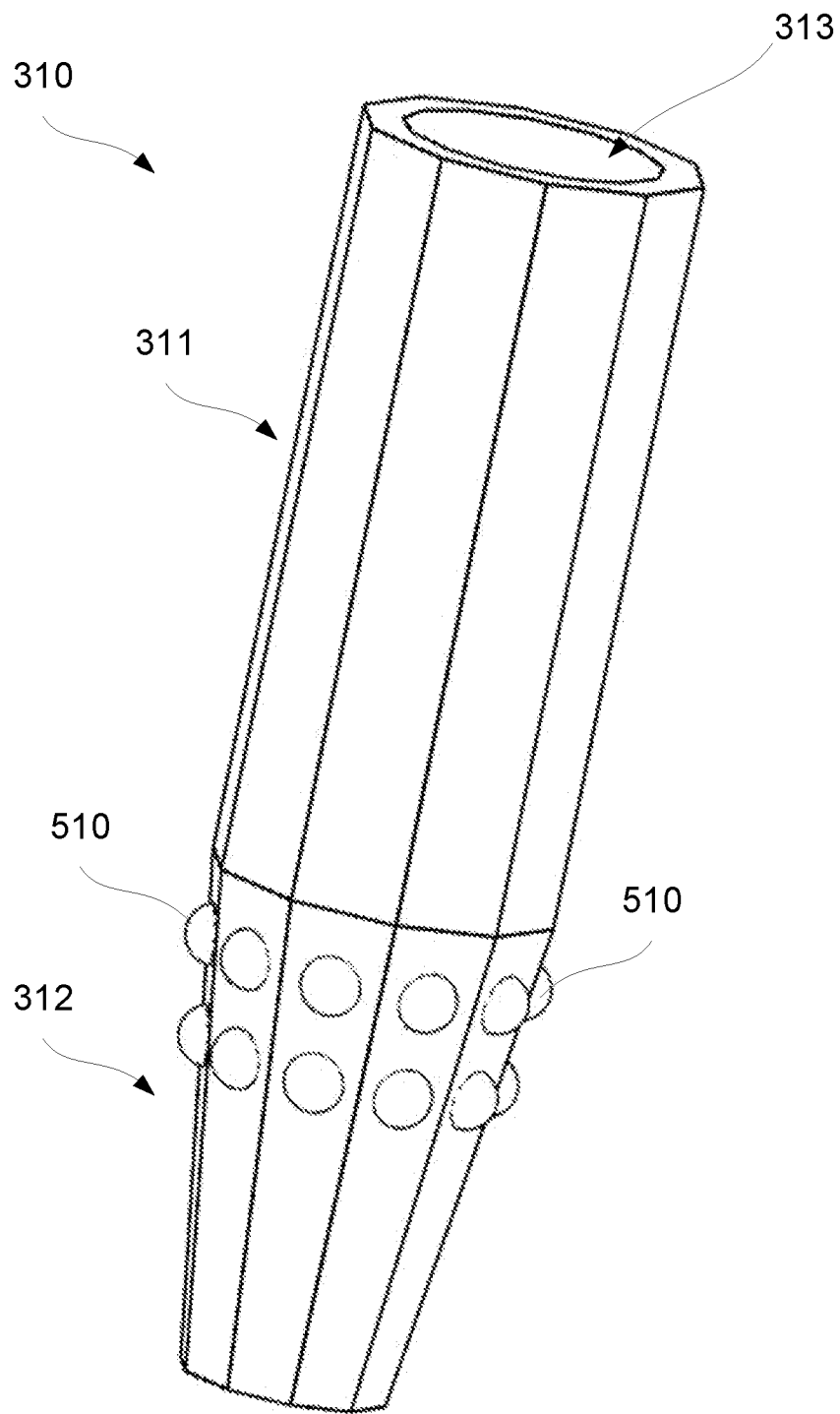


Fig. 3I.

**Fig. 4.**

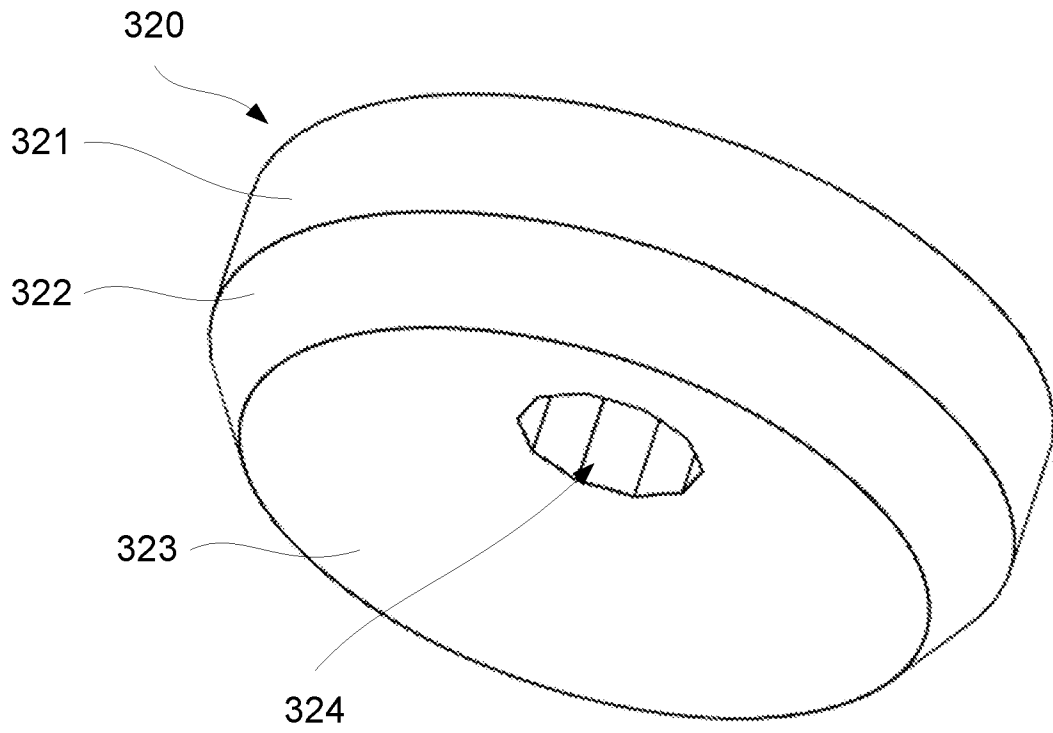


Fig. 5a.

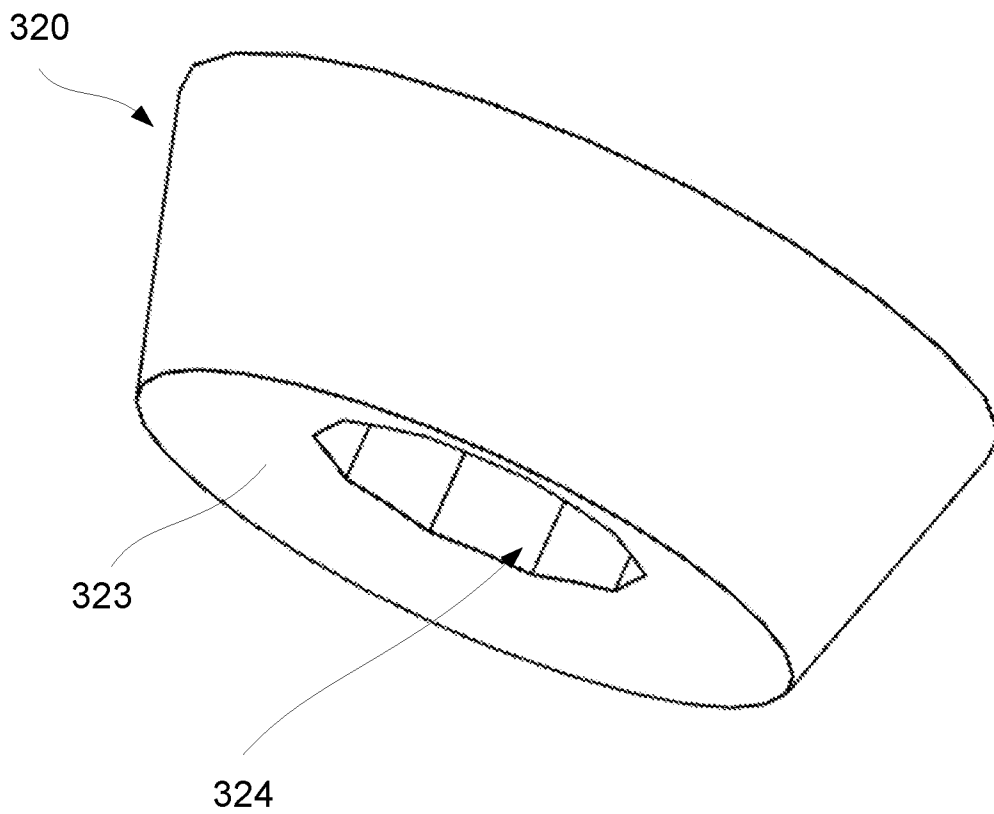


Fig. 5b.

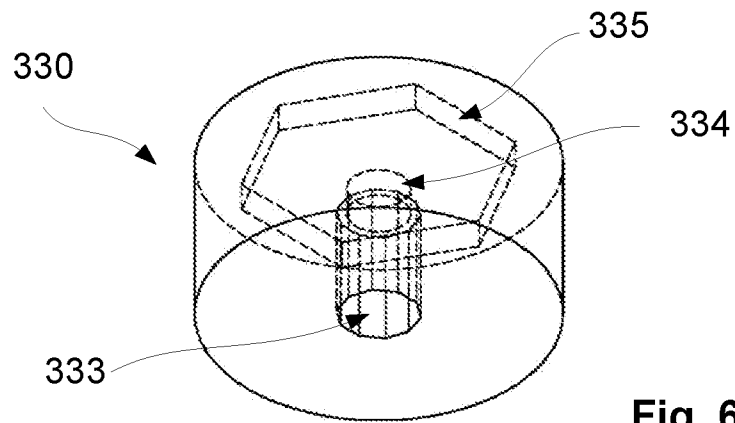


Fig. 6a.

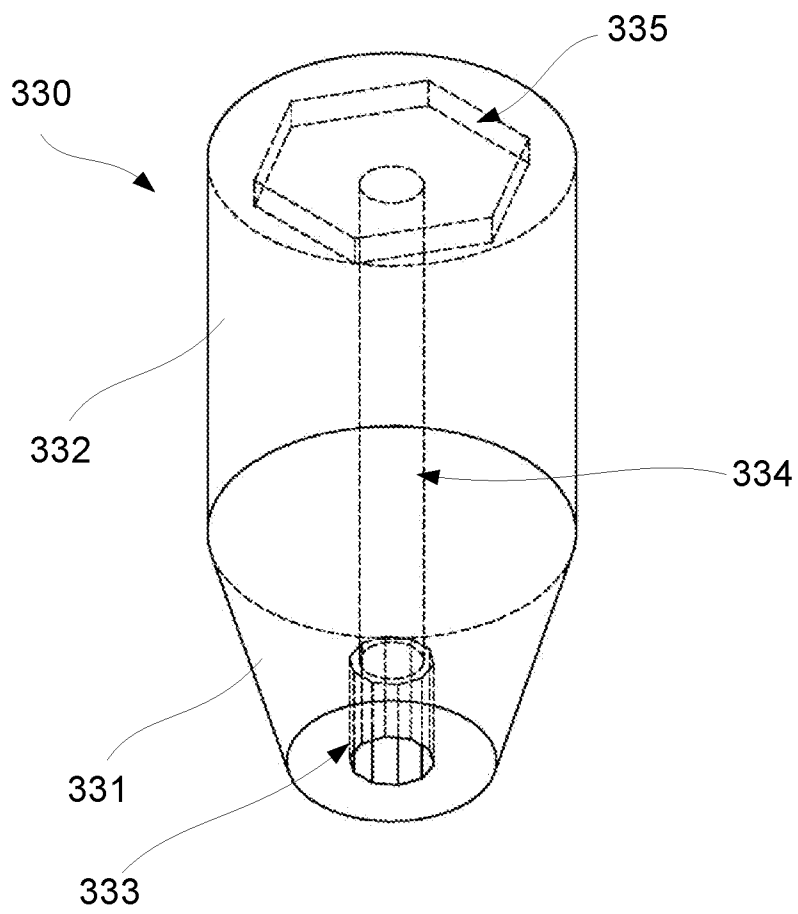


Fig. 6b.

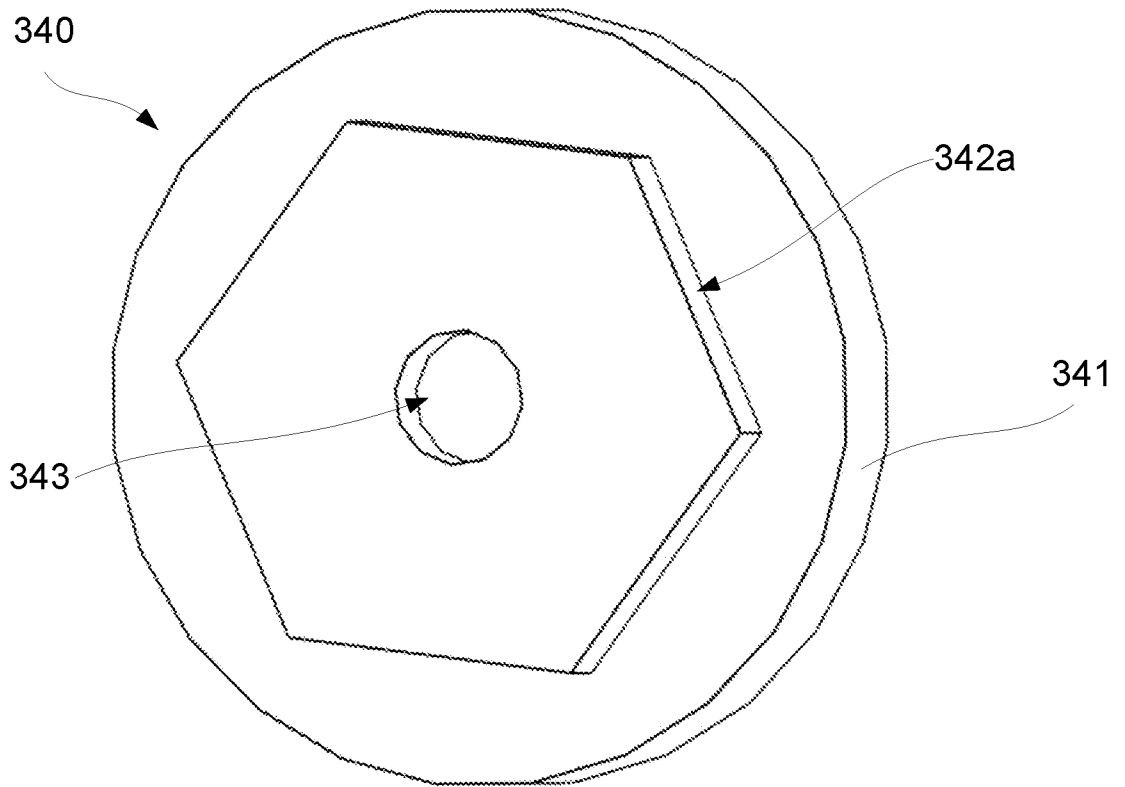


Fig. 7a.

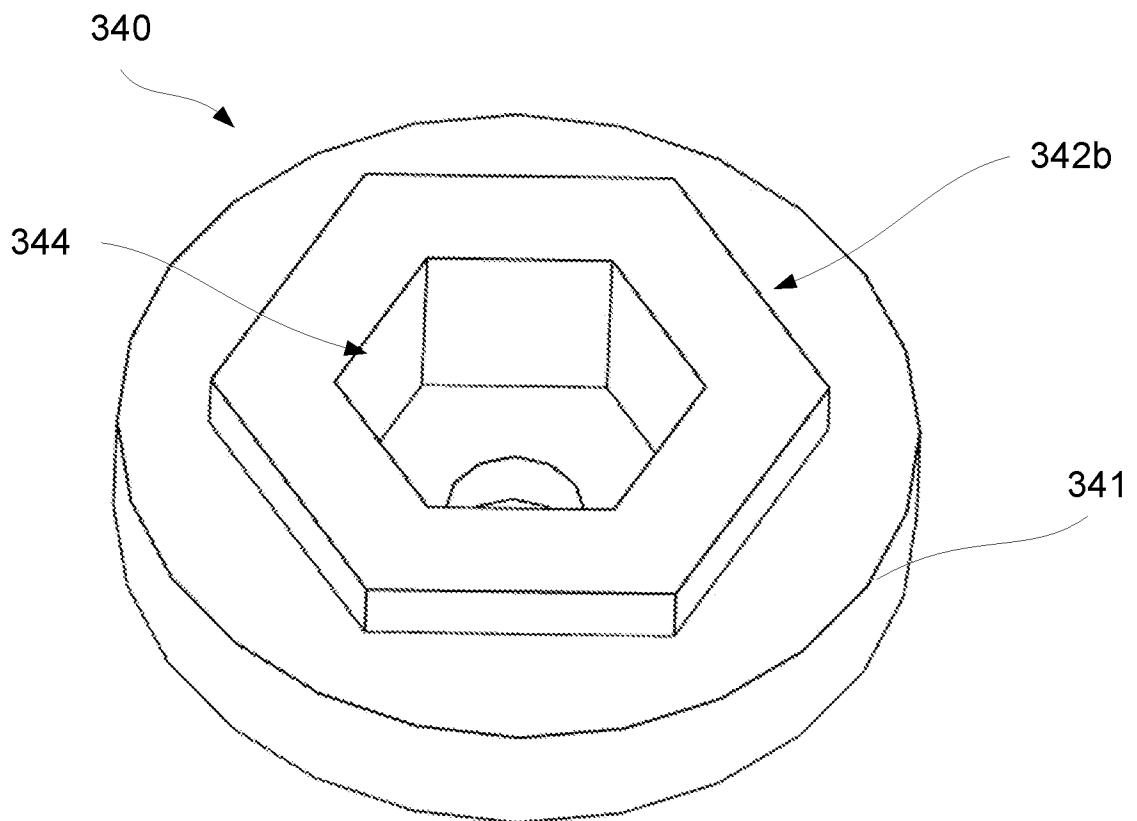


Fig. 7b.

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Fig. 8a

350



356a

356b

357

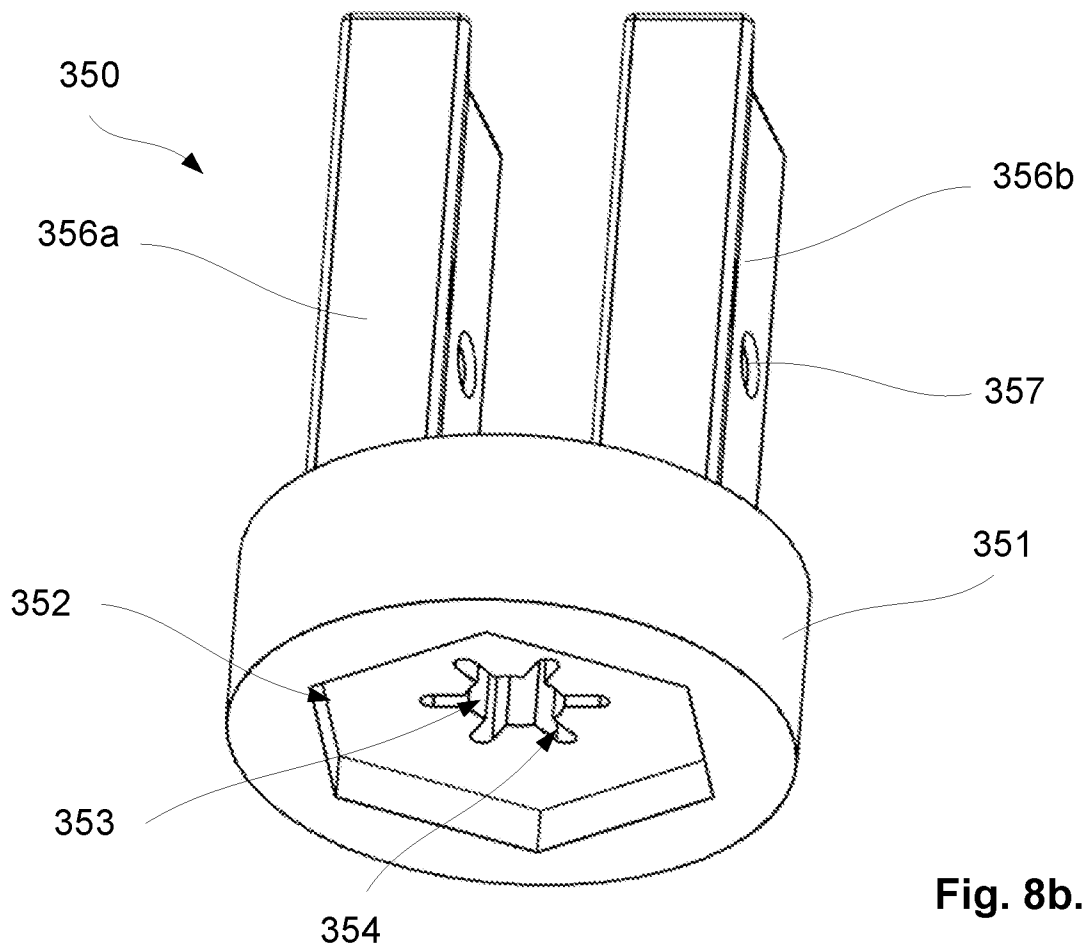
351

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Fig. 8b.



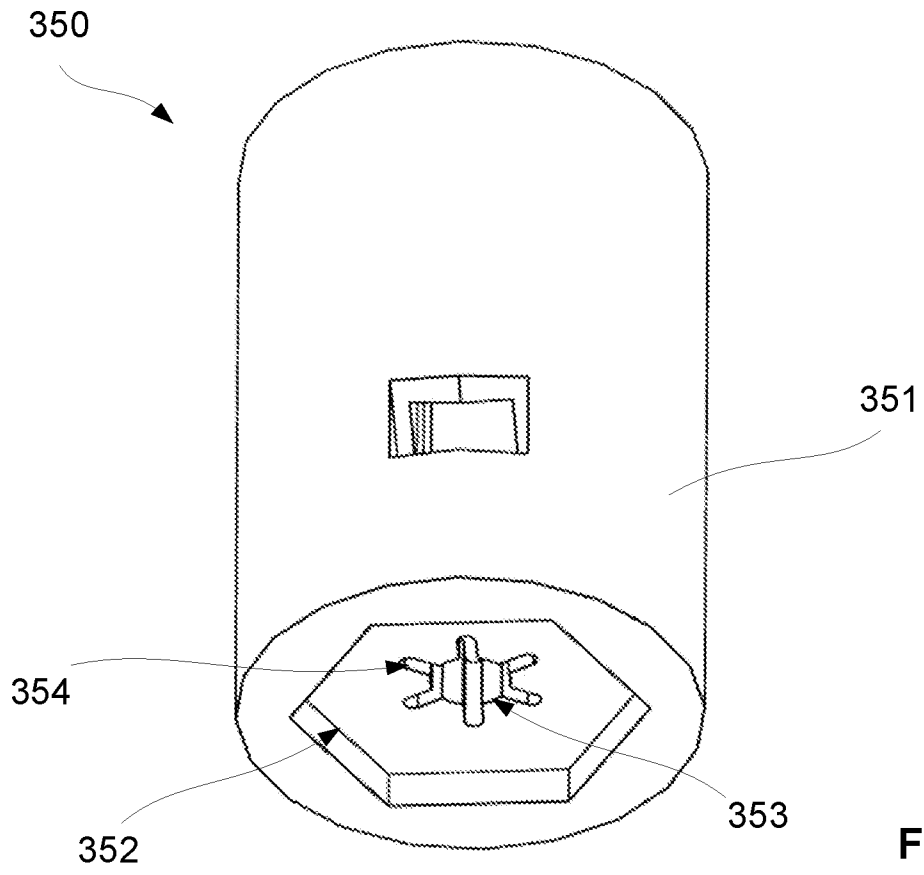


Fig. 8c.

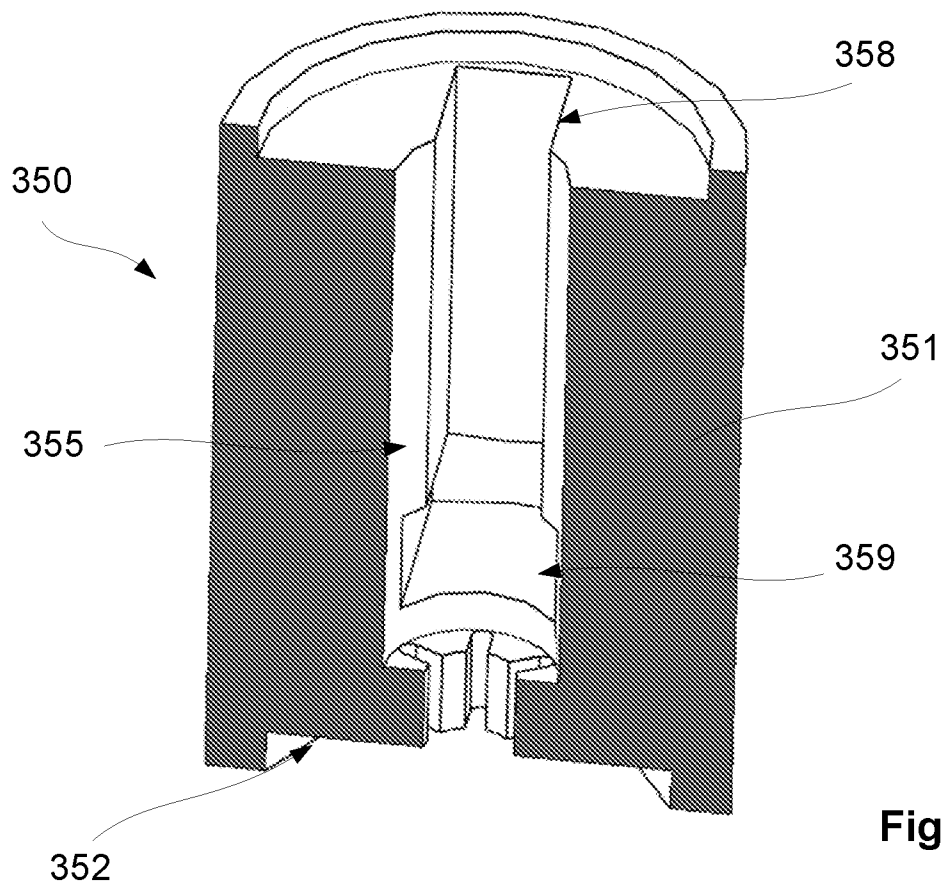


Fig. 8d.

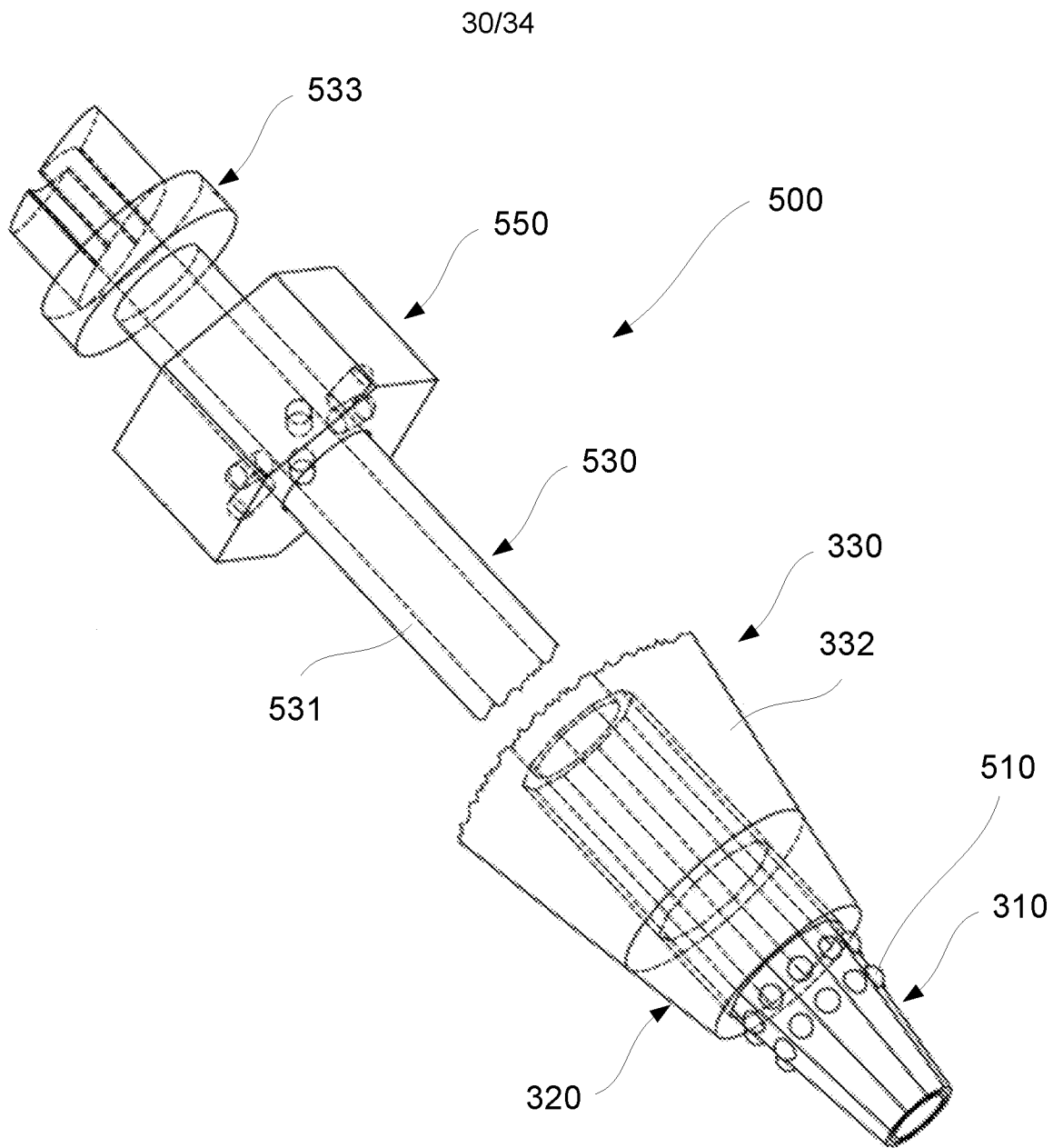


Fig. 9a.

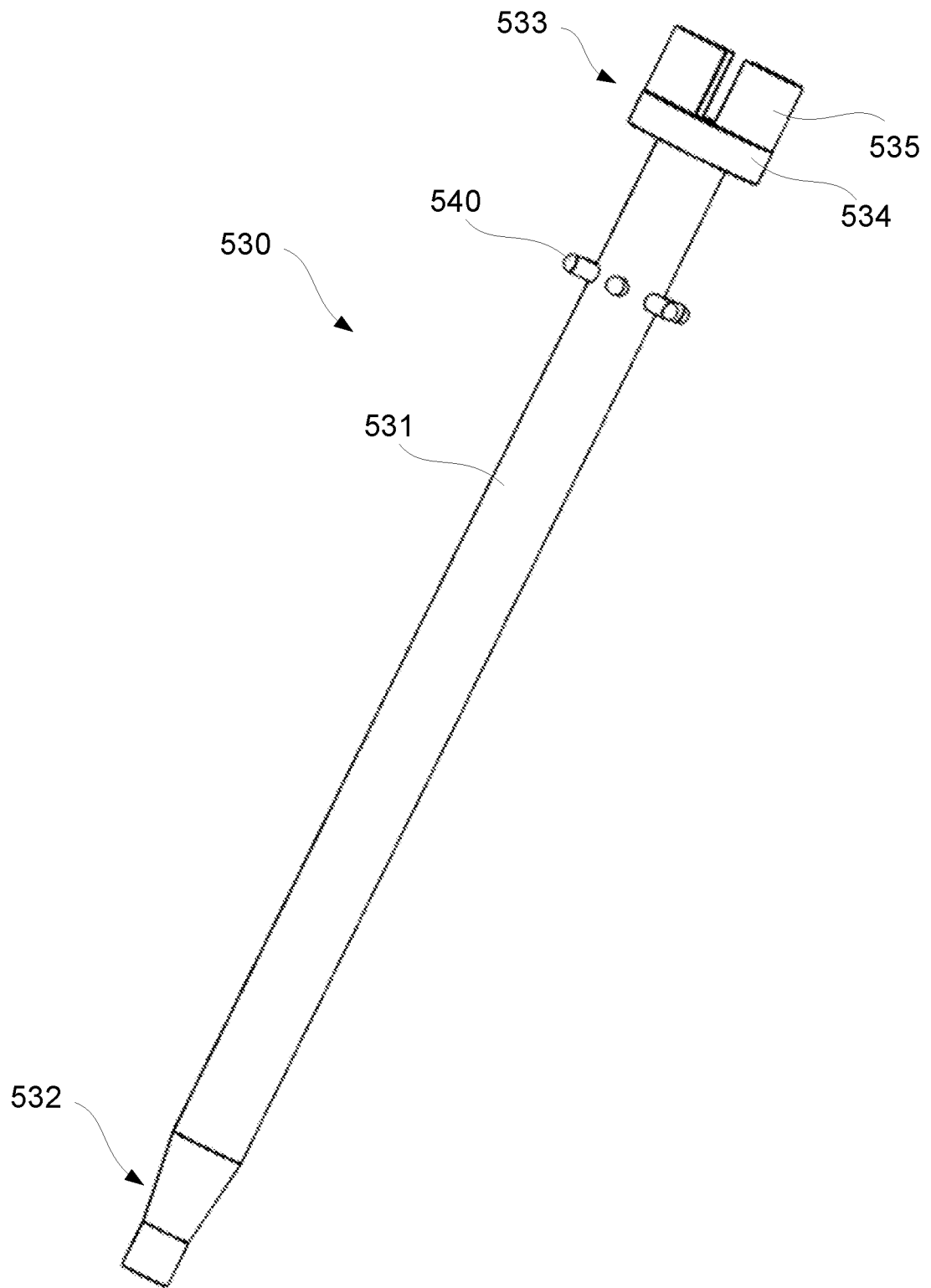
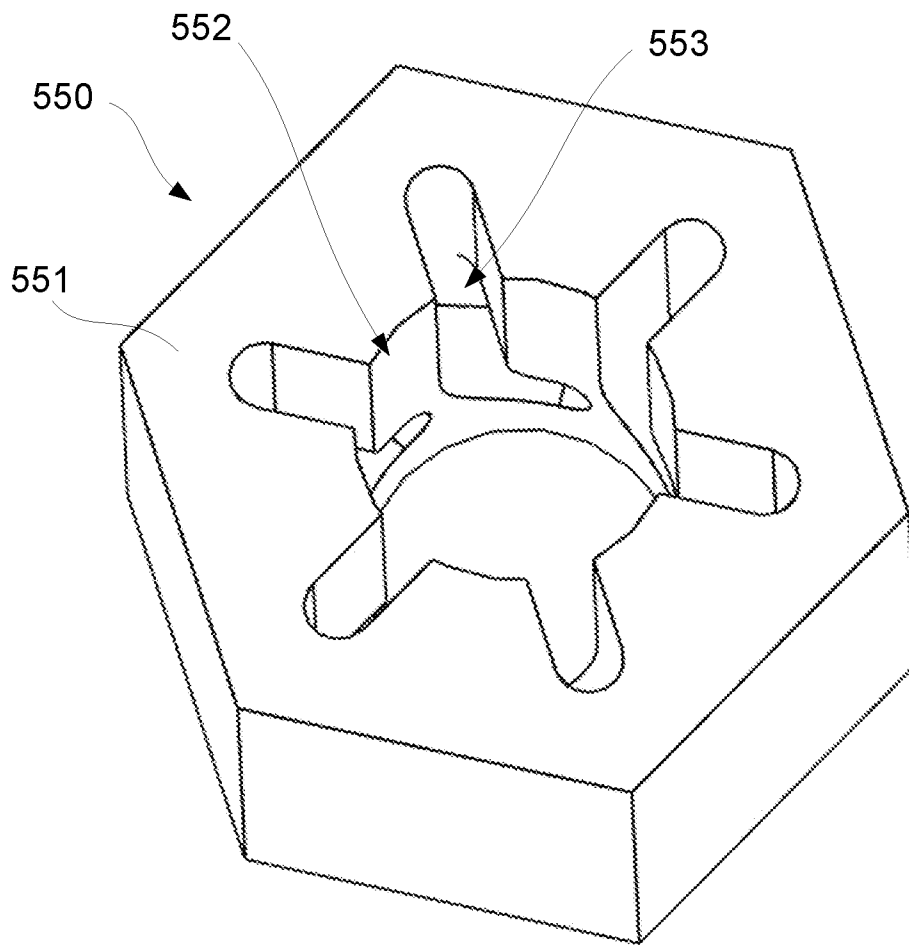


Fig. 9b.

**Fig. 9c.**

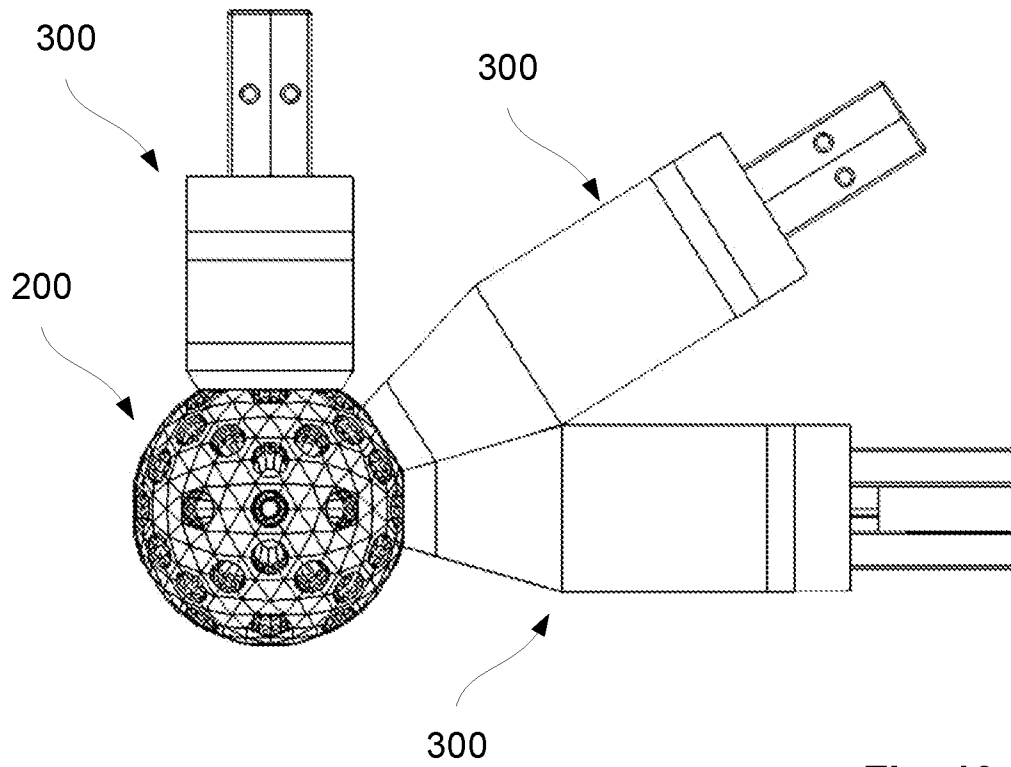


Fig. 10a.

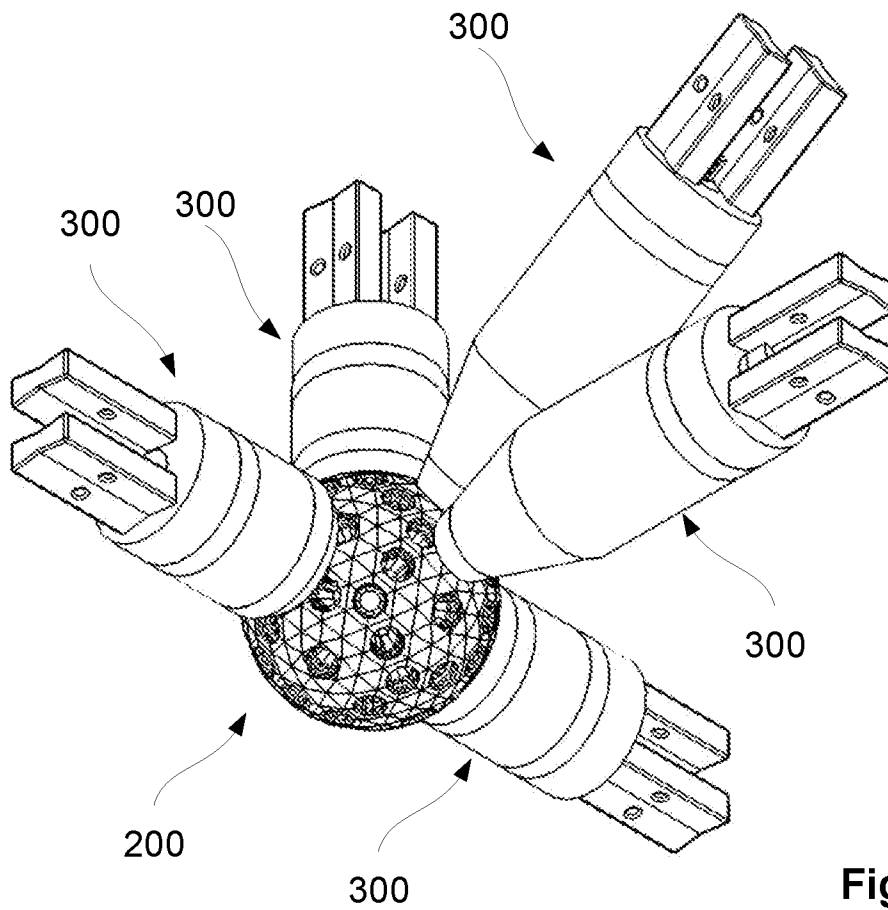


Fig. 10b.

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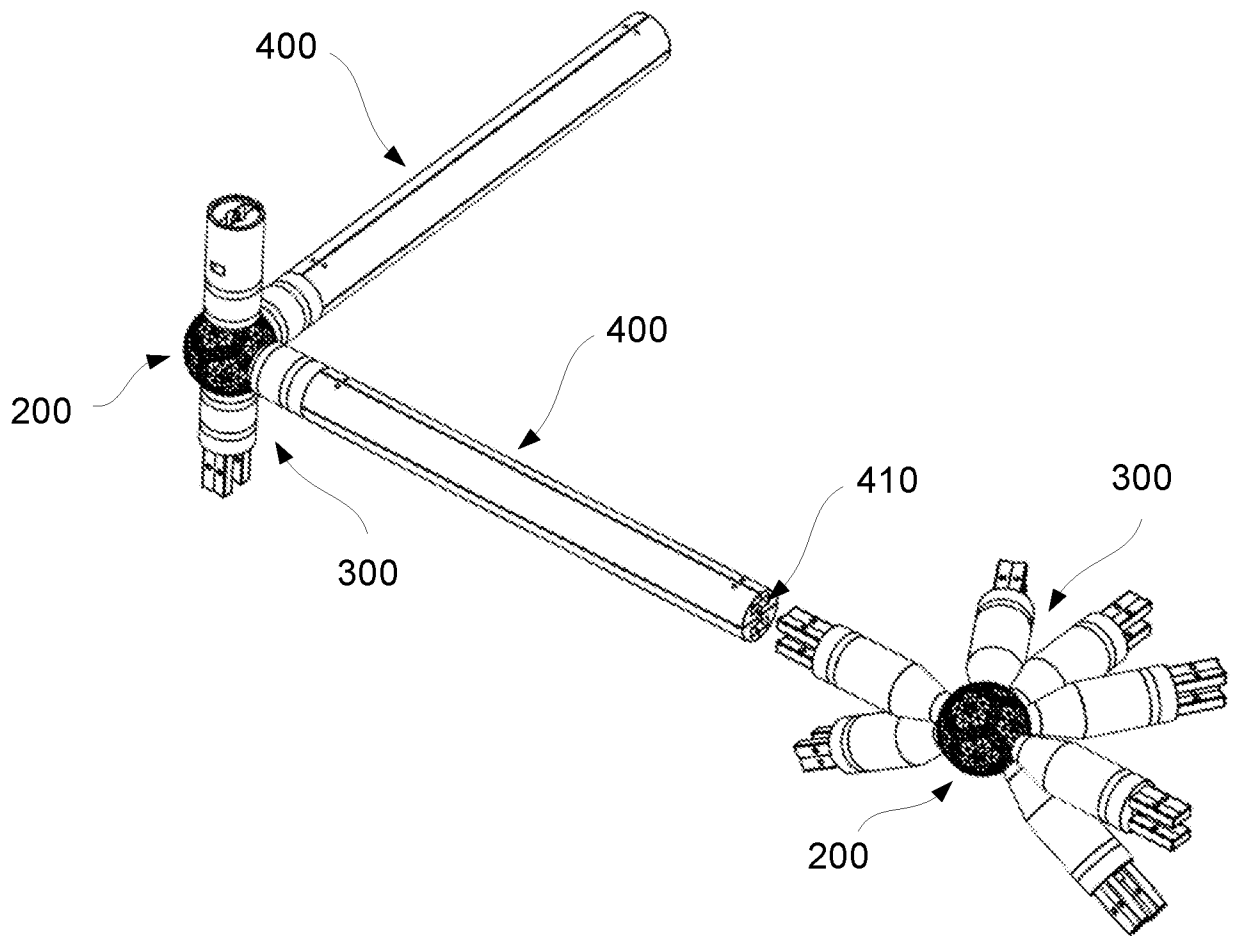


Fig. 10c.

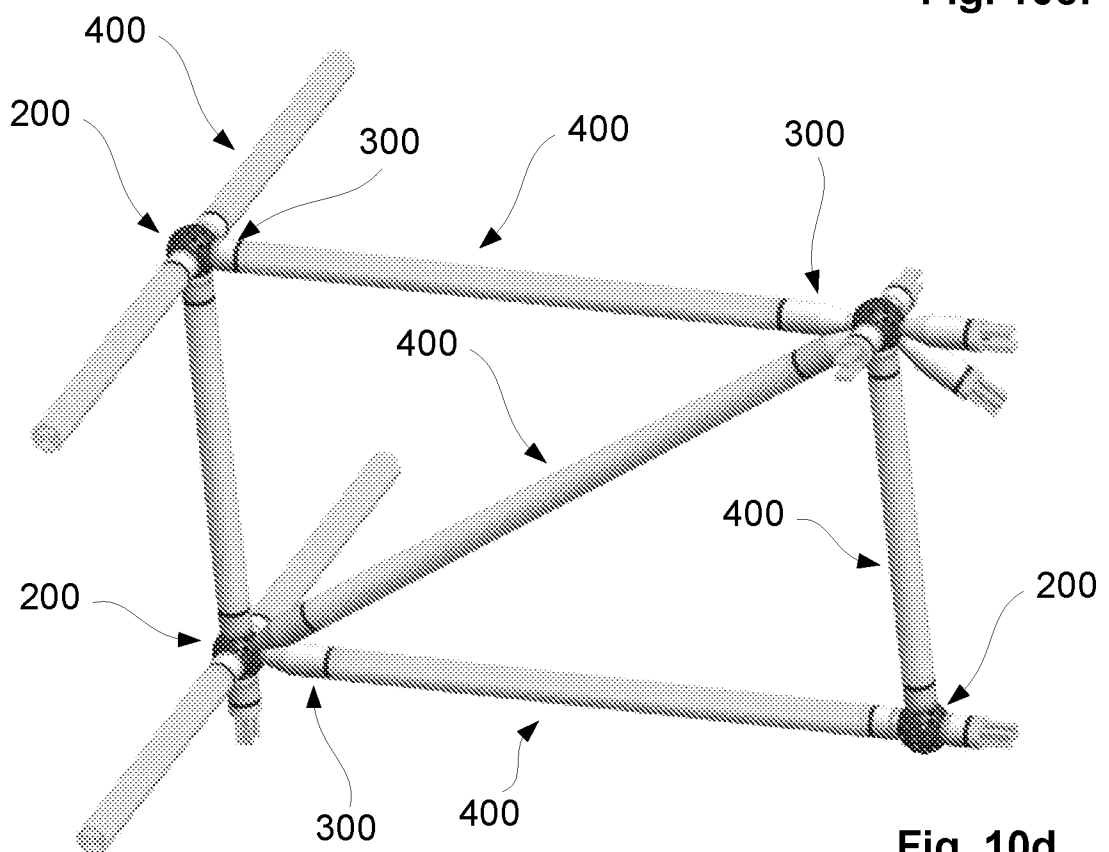


Fig. 10d.