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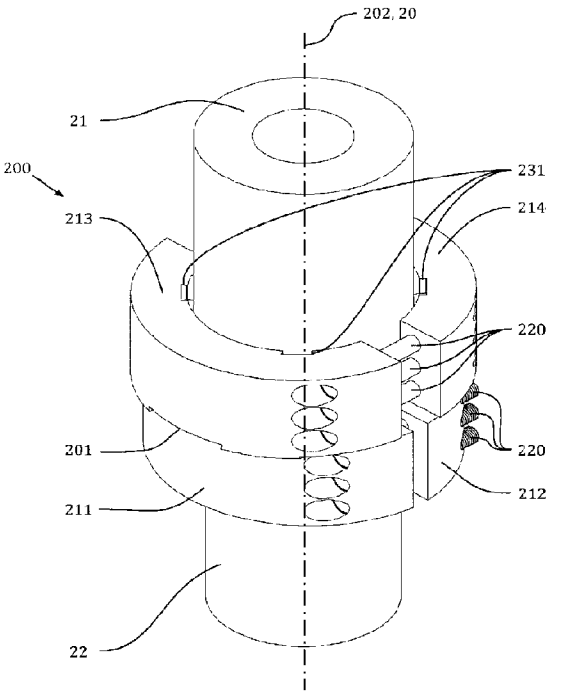

(57) Abrégé/Abstract:
A clamp assembly, for mounting around a tool joint coaxially joining cylindrical upper and lower workpieces, comprises an upper collar assembly and a lower collar assembly, each having semi-cylindrical left and right collar segments. The left and right collar segments of each collar assembly are removably connectable to each other by threaded fasteners to form the collar assembly. The upper and lower collar assemblies are coaxially mountable around the upper and lower workpieces, respectively, such that tightening the fasteners will urge the upper and lower collar assemblies to grip the upper and lower workpieces, respectively, and thus to provide increased resistance to relative rotation between the two workpieces about the tool joint axis. The upper and lower left collar segments, and/or the upper and lower right collar segments, may be interlockingly and radially slidable relative to each other to accommodate differences between the outside diameters of the two workpieces.

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Abstract:

A clamp assembly, for mounting around a tool joint coaxially joining cylindrical upper and lower workpieces, comprises an upper collar assembly and a lower collar assembly, each having semi-cylindrical left and right collar segments. The left and right collar segments of each collar assembly are removably connectable to each other by threaded fasteners to form the collar assembly. The upper and lower collar assemblies are coaxially mountable around the upper and lower workpieces, respectively, such that tightening the fasteners will urge the upper and lower collar assemblies to grip the upper and lower workpieces, respectively, and thus to provide increased resistance to relative rotation between the two workpieces about the tool joint axis. The upper and lower left collar segments, and/or the upper and lower right collar segments, may be interlockingly and radially slidable relative to each other to accommodate differences between the outside diameters of the two workpieces.

TOOL JOINT CLAMP

FIELD

The present disclosure relates in general to tools or devices for creating or augmenting the torque capacity of connections between two adjoining elements or workpieces. In particular, the present disclosure relates to oilfield threaded connections, such as but not limited to tool joints used to connect tubular string segments and drilling tools.

BACKGROUND

Until fairly recently, the use of power tongs in coordination with drilling rig hoisting systems has been the most common method for installing tubular strings (e.g., drill strings and casing strings) in petroleum wells. This method allows such tubular strings, comprising pipe segments with mating threaded ends, to be assembled relatively efficiently using power tongs to screw the threaded ends of pipe segments together, forming threaded connections between sequential pipe segments as a tubular string is assembled and installed in a wellbore (i.e., "make-up" operations). Power tongs can also be used to unscrew threaded connections to disassemble a tubular string being pulled out of a wellbore (i.e., "break-out" operations). This method for installing and removing tubular strings requires two independent systems – namely, power tongs for make-up and break-out operations, and a drilling rig hoisting system for hoisting and lowering the tubular string.

Modern drilling rigs commonly utilize a top drive, which has a primary purpose of enabling the efficient drilling of petroleum wells. These drilling rigs also enable a new method for running casing into a wellbore using tools commonly known as casing running tools (or "CRTs"). CRTs are mounted to and suspended from the top drive quill, grip the upper end of a tubular casing segment, and provide a seal between the bore of the gripped casing segment and the bore of the top drive quill. In coordination with the top drive, CRTs support both make-up and break-out operations as well as both hoisting and lowering of the casing string, thereby eliminating the need to use power tongs for casing make-up and break-out operations.

Commonly, one or more additional components (such as saver subs, torque-turns measurement subs, and/or crossover subs) are installed between the top drive quill and the CRT. The top drive quill, CRT, and additional components are assembled using standardized drill pipe threaded connections (alternatively referred to as "tool joints") in which a male-threaded end (or "pin end") of one component is screwed into a female-threaded end (or "box end") of another component. If insufficient torque is applied to a tool joint during the make-up operation, then the tool joint may become unintentionally loosened during subsequent well construction operations and could result in injury to rig personnel or damage to equipment.

Numerous examples of devices and methods for securing threaded connections such as drill pipe tool joints may be found in the prior art, such as in:

- U.S. Patent No. 1,054,812 (Zierath);
- U.S. Patent No. 4,534,585 (Saliger);
- U.S. Patent No. 7,963,569 (Subbaraman et al.);
- U.S. Patent No. 9,708,865 (Steen et al.);
- U.S. Patent No. 10,815,737 (Buck et al.);
- International Publication No. WO 2000/066929 (Grant Prideco, Inc.);
- Australian Patent Application No. 2009201205 (Haines et al.);
- U.S. Patent No. 4,108,478 (Lynch);
- U.S. Patent No. 9,366,096 (Bowley et al.);
- U.S. Patent No. 10,400,511 (Netecke et al.);
- U.S. Patent No. 3,866,954 (Slater et al.);
- U.S. Patent Pub. No. 2016/0362943 (Malstam et al.);
- CN Patent No. 102839923;
- CN Patent Pub. No. 103742081; and
- CN Patent No. 201526281.

The industry standard API Specification 7-2 "Threading and Gauging of Rotary Shouldered Connections", Second Edition, January 2017, controls certain geometric features of tool joints, such as thread profile and thread dimensions, to ensure adequate load transfer and fluid sealing of the threaded connection between two components ("workpieces"). This standard only loosely controls the outside diameter of the tool joint beyond the threads. Thus, after make-up of a tool joint connection, it is common to find that the outside diameters of the two joined tubular components differ significantly. For optimal effectiveness, therefore, it is preferable for devices and methods for securing and augmenting the torque transfer capacity of tool joints in tubular strings to be capable of accommodating differences between the outside diameters of the tubular components making up the tool joints.

BRIEF SUMMARY

In this patent document, certain components of disclosed embodiments are described using modifying terms including "upper", "lower", "upward", "downward", "left", "right", "horizontal", and "vertical". These terms are used to establish a convenient frame of reference to facilitate explanation and to enhance the reader's understanding of the spatial relationships and relative locations of the various elements and features of the components in question. The use of these terms herein is consistent with how the components are illustrated in the accompanying drawings (in which the longitudinal axis of all illustrated tool joints and tool joint clamp assemblies is vertical), but it is to be understood that they do not necessarily literally represent or correspond to the orientation or spatial relationships of the components as they would appear in operational implementations of the disclosed embodiments.

In general terms, the present disclosure teaches embodiments of a tool joint clamp assembly for mounting around a tool joint, which is to be understood for purposes of this disclosure as meaning a threaded connection coaxially joining two generally cylindrical workpieces, and having a longitudinal tool joint axis. The clamp assembly provides increased resistance to relative rotation between the two workpieces about the tool joint axis, while also accommodating differences between the outside diameters of the two workpieces.

In one exemplary embodiment in accordance with the present disclosure, the tool joint clamp assembly comprises a lower collar assembly and an upper collar assembly, wherein:

(a) the lower collar assembly comprises a semi-cylindrical lower left collar segment and a semi-cylindrical lower right collar segment, wherein:

- the lower left and lower right collar segments are removably connectable to each other by threaded fasteners to form the lower collar assembly; and
- the lower collar assembly is coaxially mountable around the lower workpiece such that tightening the fasteners connecting the lower left and lower right collar segments will urge the lower collar assembly to grip the lower workpiece;

(b) the upper collar assembly comprises a semi-cylindrical upper left collar segment and a semi-cylindrical upper right collar segment, wherein:

- the upper left and upper right collar segments are removably connectable to each other by threaded fasteners to form the upper collar assembly; and
- the upper collar assembly is coaxially mountable around the upper workpiece such that tightening the fasteners connecting the upper left and upper right collar segments will urge the upper collar assembly to grip the upper workpiece;

(c) each of the lower left and lower right collar segments defines an upward-facing semi-annular surface;

(d) each of the upper left and upper right collar segments defines a downward-facing semi-annular surface; and

(e) the upward-facing surface of the lower left collar segment and the downward-facing surface of the upper left collar segment are complementarily profiled to form an interlocking linear slide mechanism allowing relative horizontal sliding of the lower left and upper left collar segments while preventing relative rotation of the lower left and upper left collar segments about the clamp assembly axis, wherein the sliding direction of the linear slide mechanism is parallel to

a vertical reference plane coincident with the clamp assembly axis and bisecting the interlocked lower left and upper left collar segments.

In some embodiments, the interlocking linear slide mechanism is a dovetail slide mechanism comprising slidably interlocking dovetail elements.

In some embodiments, tool joint clamp assemblies in accordance with the present disclosure may be configured such that:

- the lower left and lower right collar segments are identical (meaning functionally interchangeable, in the context of the present disclosure) and are rotationally symmetric about the clamp assembly axis; and
- the upper left and upper right collar segments are identical and are rotationally symmetric about the clamp assembly axis.

In other embodiments, tool joint clamp assemblies in accordance with the present disclosure may be configured such that:

- the lower left and upper left collar segments are identical and are rotationally symmetric about a first transverse axis that lies in a horizontal reference plane generally defined by the upward-facing and downward facing semi-annular surfaces, respectively, of the interlocked lower left and upper left collar segments, is perpendicular to and intersects the clamp assembly axis, and is parallel to the sliding direction of the interlocking linear slide mechanism; and
- the lower right and upper right collar segments are identical and are rotationally symmetric about the first transverse axis.

In other embodiments, tool joint clamp assemblies in accordance with the present disclosure may be configured such that:

- the lower left collar segment and the upper right collar segment are identical and are rotationally symmetric about a second transverse axis that lies in the horizontal reference plane, is perpendicular to and intersects the clamp assembly axis, and is perpendicular to the sliding direction of the interlocking linear slide mechanism; and
- the lower right collar segment and the upper left collar segment are identical and are rotationally symmetric about the second transverse axis.

In further embodiments, tool joint clamp assemblies in accordance with the present disclosure may be configured such that the collar segments are identical and are rotationally symmetric about the first transverse axis.

In some embodiments, tool joint clamp assemblies in accordance with the present disclosure may be configured such that the threaded fasteners may be loosely assembled with barrel nuts (also known as steel cross dowels or dowel nuts) and barrel washers to facilitate mounting of the clamp assembly onto the tool joint and to accommodate angular misalignment between two segments of a collar assembly. A first collar segment of each collar assembly is configured with holes that hold captive the loosely assembled threaded fasteners, barrel washers, and barrel nuts. The second collar segment of each collar assembly is configured with hooks that permit the loosely-assembled threaded fasteners, barrel washers, and barrel nuts to quickly latch the second segment, and securely retain the barrel nut while the threaded fasteners are tightened.

The inner surface of each collar segment that forms part of an interlocking linear slide mechanism may be provided with one or more grip elements each having a gripping surface configured for gripping engagement with a cylindrical outer surface of a workpiece of the threaded connection at one or more circumferential locations. The locations and configurations of the grip elements are preferably selected such that the longitudinal axis of any workpiece within the working size range of the corresponding collar assembly will, when gripped by the collar assembly, be coincident with the previously-mentioned vertical reference plane. This may be readily achieved by providing each collar segment with two grip elements equidistant from the vertical reference plane. However, other embodiments may provide fewer than or more than two grip elements on each collar segment without departing from the scope of the present disclosure.

The grip elements may be formed integrally with or permanently fixed to the inside surfaces of the collar segments, or alternatively may be provided in the form of removable grip elements such as well-known oilfield "tong dies". The size of the tong dies or other types of removable grip elements may be changed to alter the range of workpiece diameters that the collar assembly can grip.

The threaded fasteners are oriented parallel both to each other and to the sliding direction of the interlocking linear slide mechanism(s). Tightening the threaded fasteners increases the gripping force of a collar assembly onto a workpiece of the tool joint, and also causes each segment of the collar assembly to deform. The magnitude of deformation correlates with the magnitude of the gripping force.

Optionally, the segments of the collar assemblies may be provided with gauging surfaces for measurement of the deformation to determine the gripping force, and dimensional gauges may be used to determine whether the deformation, and thus gripping force, is within a desired range.

Clearance holes in the collar segments for the threaded fasteners may be selected to be close fitting with the threaded fasteners, and thus enabling the tool joint clamping assembly to more effectively resist relative rotation between the workpieces of the tool joint by transfer of shear force between the left and right collar segments of the collar assemblies via the threaded fasteners.

Supporting means may be used to facilitate assembly of a clamp assembly onto a tool joint, or disassembly therefrom, by supporting one or more collar segments in place next to the tool joint when the threaded fasteners are not tight during assembly or disassembly. The supporting means may be attached to each collar segment or may be a support device separate from the clamp assembly. One such supporting means is a support device comprising a support platform element and an attachment element. The support platform element provides a surface upon which the collar segments of may rest. The attachment element secures the support device to a workpiece of the tool joint, and may comprise a commonly available lifting magnet as known to persons skilled in the art.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments in accordance with the present disclosure will now be described with reference to the accompanying Figures, in which numerical references denote like parts, and in which:

FIGURE 1 is an isometric view of a first embodiment of a tool joint clamp assembly in accordance with the present disclosure, shown assembled around a tool joint.

FIGURE 2 is a front elevation of the clamp assembly in FIG. 1.

FIGURE 3 is a side elevation of the clamp assembly in FIG. 1.

FIGURE 4 is a top view of the clamp assembly in FIG. 1.

FIGURE 5 is an isometric view of a second embodiment of a tool joint clamp assembly in accordance with the present disclosure, shown assembled around a tool joint, and wherein the respective left and right segments of upper and lower collar assemblies are identical and are rotationally symmetric about the clamp assembly axis.

FIGURE 6 is a front elevation of the clamp assembly in FIG. 5.

FIGURE 7 is a side elevation of the clamp assembly in FIG. 5.

FIGURE 8 is a top view of the clamp assembly in FIG. 5.

FIGURE 9 is an isometric view of a third embodiment of a tool joint clamp assembly in accordance with the present disclosure, shown assembled around a tool joint, and wherein the left and right segments of the upper collar assembly are identical to the corresponding segments of the lower collar assembly, and are rotationally symmetric about a first transverse axis parallel to the sliding direction of the interlocking linear slide mechanism.

FIGURE 10 is a front elevation of the clamp assembly in FIG. 9.

FIGURE 11 is a side elevation of the clamp assembly in FIG. 9.

FIGURE 12 is a top view of the clamp assembly in FIG. 9.

FIGURE 13 is an isometric view of a fourth embodiment of a tool joint clamp assembly in accordance with the present disclosure, shown assembled around a tool joint, and wherein the segments of the lower and upper collar assemblies are identical and are rotationally symmetric about the clamp assembly axis and about the first transverse axis.

FIGURE 14 is a front elevation of the clamp assembly in FIG. 13.

FIGURE 15 is a side elevation of the clamp assembly in FIG. 13.

FIGURE 16 is a top view of the clamp assembly in FIG. 13.

FIGURE 17 is an isometric view of the tool joint clamp assembly in FIG. 13 with the addition of a support device that facilitates assembly and disassembly of the clamp assembly around or from the tool joint by supporting the collar segments when the threaded fasteners are not tight.

FIGURE 18 is an isometric view of a fifth embodiment of a tool joint clamp assembly in accordance with the present disclosure, shown assembled around a tool joint, and wherein the threaded fasteners are used with barrel nuts and barrel washers to facilitate assembly of the clamp assembly around the tool joint and to accommodate angular misalignment between the collar segments of a collar assembly.

FIGURE 19 is a front elevation of the clamp assembly in FIG. 18.

FIGURE 20 is a side elevation of the clamp assembly in FIG. 18.

FIGURE 21 is a top view of the clamp assembly in FIG. 18.

DETAILED DESCRIPTION

Embodiment #1, with dovetail slide mechanism

FIG. 1 is an isometric view of a first embodiment **200** of a tool joint clamp assembly in accordance with the present disclosure, and comprising:

- a lower collar assembly comprising a lower left collar segment **211** and a lower right collar segment **212**; and
- an upper collar assembly comprising an upper left collar segment **213** and an upper right collar segment **214**.

Tool joint clamp assembly **200** has a longitudinal clamp assembly axis **202**, and incorporates a first interlocking linear slide mechanism **201** provided between lower left collar segment **211** and upper left collar segment **213**, as described in further detail below. Clamp assembly **200** is shown assembled around a tool joint having a longitudinal tool joint axis **20**, and comprising a cylindrical upper workpiece **21** coaxially threaded to a cylindrical lower workpiece **22** such that the clamp assembly axis **202** is coincident with tool joint axis **20**.

FIG. 2 is a front elevation of clamp assembly **200** showing the upper and lower collar assemblies adapted to workpieces **21** and **22** having different outside diameters.

FIG. 3 is a side elevation of clamp assembly **200**. Lower left collar segment **211** and lower right collar segment **212** are shown (by way of non-limiting example) connected to each other by a first set of six threaded fasteners **220**, and upper left collar segment **213** and upper right collar segment **214** are shown connected to each other by a second set of six threaded fasteners **220**.

FIG. 4 is a top view of clamp assembly **200**. In this embodiment, each collar segment carries two grip elements provided in the form of dies **230** which have gripping surfaces configured for gripping engagement with the circumferential outer surface of a corresponding one of workpieces **21** and **22**. In the illustrated embodiment, dies **230** are shown configured in the well-known manner of "tong dies" carried in dovetail grooves **231**. The size of dies **230** may be changed to alter the range of workpiece diameters that the collar assemblies can grip. Tightening fasteners **220** will increase

the force with which the upper and lower collars grip upper and lower workpieces **21** and **22** respectively.

In variant embodiments, the grip elements may alternatively be provided as gripping surfaces integrally formed on the collar segments or otherwise non-removably fixed to the collar segments.

Lower left collar segment **211** defines a generally horizontal upward-facing semi-annular surface **211S**, and lower right collar segment **212** defines a generally horizontal upward-facing semi-annular surface **212S**. Similarly, upper left collar segment **213** defines a generally horizontal downward-facing semi-annular surface **213S**, and lower right collar segment **214** defines a generally horizontal downward-facing semi-annular surface **214S**. Upward-facing surface **211S** on lower left collar segment **211** and downward-facing surface **213S** on upper left collar segment **213** are complementarily configured for interlocking sliding engagement to form first linear slide mechanism **201** whereby lower left collar segment **211** and upper left collar segment **213** are slidingly movable relative to each other in a horizontal direction parallel to a vertical reference plane **RPv** coincident with the clamp assembly axis and bisecting the interlocked lower left and upper left collar segments.

Lower right collar segment **212** and upper right collar segment **214** may form a second linear slide mechanism similar to first linear slide mechanism **201**, but this is optional and not essential.

The linear slide mechanism(s) will transfer force between lower left collar segment **211** and upper left collar segment **213**, and between lower right collar segment **212** and upper right collar segment **213** to resist relative rotation of the upper and lower collar assemblies about clamp assembly axis **202** and, correspondingly, between upper and lower workpieces **21** and **22** about tool joint axis **20**. In preferred embodiments, the linear slide mechanism(s) may be provided by interlocking sliding engagement of mating slide elements of "dovetail" configuration provided on the upward-facing and downward-facing surfaces, respectively, on the lower and upper collar segments in question. However, the linear slide mechanism(s) may be provided in any other functionally effective configuration without departing from the scope of the present disclosure.

Embodiment #2, with rotational symmetry about clamp assembly axis

FIG. 5 is an isometric view of a second embodiment **300** of a tool joint clamp assembly in accordance with the present disclosure. Tool joint clamp assembly **300** has a longitudinal clamp assembly axis **302**, and incorporates:

- a lower collar assembly comprising a lower left collar segment **311LL** and a lower right collar segment **311LR**; and
- an upper collar assembly comprising an upper left collar segment **312UL** and an upper right collar segment **312UR**.

Clamp assembly **300** incorporates at least a first linear slide mechanism **301** functionally similar to first linear slide mechanism **201** of clamp assembly **200**, previously described.

In this embodiment, lower left collar segment **311LL** and lower right collar segment **311LR** are identical (meaning, in the context of the present disclosure, that they are functionally interchangeable) and are rotationally symmetric about clamp assembly axis **302**. Upper left and upper right collar segments **312UL** and **312UR** also are identical, and are rotationally symmetric about clamp assembly axis **302**. Clamp assembly **300** is shown assembled on a tool joint having a longitudinal tool joint axis **30**, and comprising an upper workpiece **31** and a lower workpiece **32** such that clamp assembly axis **302** is coincident with tool joint axis **30**.

FIGS. 5 and 6 are front and side elevations, respectively, of clamp assembly **300**, and show the upper and lower collar assemblies adapted to upper and lower workpieces **31** and **32** having different outside diameters. Lower left and lower right collar segments **311LL** and **311LR** are shown (by way of example) connected to each other by a first set of four threaded fasteners **320**. Similarly, upper left and upper right collar segments **312UL** and **312UR** are shown connected to each other by a second set of four threaded fasteners **320**.

FIG. 8 is a top view of clamp assembly **300**. In a manner similar to that previously described with respect to clamp assembly **200**, and to provide the same functionality, each of the collar segments of clamp assembly **300** carries two grip elements provided in the form of dies **330** which have gripping surfaces for gripping engagement with one of workpieces **31** and **32**.

Embodiment #3, rotational symmetry about a first transverse axis

FIG. 9 is an isometric view of a third embodiment **400** of a tool joint clamp assembly in accordance with the present disclosure. Tool joint clamp assembly **400** has a longitudinal clamp assembly axis **402**, and incorporates:

- a lower collar assembly comprising a lower left collar segment **411LL** and a lower right collar segment **411LR**; and
- an upper collar assembly comprising an upper left collar segment **412UL** and an upper right collar segment **412UR**.

Clamp assembly **400** incorporates at least a first linear slide mechanism **401** functionally similar to first linear linear slide mechanism **201** of clamp assembly **200**, previously described.

In this embodiment, lower left and upper left collar segments **411LL** and **411UL** are identical, and are rotationally symmetric about a first transverse axis **403** that lies in a horizontal reference plane $\mathbf{RP_H}$ generally defined by the upward-facing and downward facing semi-annular surfaces, respectively, of the interlocked lower left and upper left collar segments **411LL** and **411UL**, and is perpendicular to clamp assembly axis **402** and parallel to the sliding direction of linear slide mechanism **401**. Additionally, upper right and lower right collar segments **412UR** and **412LR** are identical and are rotationally symmetric about transverse axis **403**. Clamp assembly **400** is shown assembled around a tool joint having a longitudinal tool joint axis **40**, and comprising an upper workpiece **41** and a lower workpiece **42** such that clamp assembly axis **402** is coincident with tool joint axis **40**.

In a variant of this embodiment, lower right and upper right collar segments **412LR** and **414UR** do not form an interlocking linear slide mechanism.

FIGS. 10 and 11 are front and side elevation, respectively, of clamp assembly **400**, and illustrate the upper and lower collar assemblies adapted to upper and lower workpieces **41** and **42** having different outside diameters. Lower left and lower right collar segments **411LL** and **412LR** are shown connected to each other by a first set of four threaded fasteners **420**. Similarly, upper left and upper right collar segments **411UL** and **412UR** are shown connected to each other by a second set of four threaded fasteners **420**.

FIG. 12 is a top view of clamp assembly **400**. In a manner similar to that previously described with respect to clamp assembly **200**, and to provide the same functionality, each of the collar segments of clamp assembly **400** carries two grip elements provided in the form of dies **430** which have gripping surfaces for gripping engagement with one of workpieces **41** and **42**.

Dovetail grooves **431** are provided with slots **432** into which retaining clips (not shown) may be installed to prevent dies **430** from sliding axially out of dovetail grooves **431**, with the retaining clips preferably being configured for an interference fit with slots **432** to retain them in place.

Embodiment #4, with collar rotational symmetry about clamp assembly axis and about transverse axes

FIG. 13 is an isometric view of a fourth embodiment **600** of a tool joint clamp assembly in accordance with the present disclosure. Tool joint clamp assembly **600** has a longitudinal clamp assembly axis **602**, and incorporates:

- a lower collar assembly comprising a lower left collar segment **611LL** and a lower right collar segment **611LR**; and
- an upper collar assembly comprising an upper left collar segment **611UL** and an upper right collar segment **611UR**.

Clamp assembly **600** incorporates at least a first linear slide mechanism **601** functionally similar to first linear slide mechanism **201** of clamp assembly **200**, previously described.

In this embodiment, lower left collar segment **611LL**, lower right collar segment **611LR**, upper left collar segment **611UL**, and upper right collar segment **611UR** are identical, and are rotationally symmetric about clamp assembly axis **602**, and about a first transverse axis **603** that lies in a horizontal reference plane $\mathbf{RP_H}$ generally defined by the upward-facing and downward facing semi-annular surfaces, respectively, of the interlocked lower left and upper left collar segments, and is perpendicular to clamp assembly axis **602** and parallel to the sliding direction of linear slide mechanism **601**. Clamp assembly **600** is shown assembled on a tool joint having a longitudinal tool joint axis **60**, and comprising an upper workpiece **61** and a lower workpiece **62** such that clamp assembly axis **602** is coincident with tool joint axis **60**.

FIGS. 14 and 15 are front and side elevations, respectively, of clamp assembly **600**, and show the upper and lower collar assemblies adapted to upper and lower workpieces **61** and **62** having different outside diameters. Lower left and lower right collar segments **611LL** and **611LR** are shown connected to each other by a first set of four threaded fasteners **620**. Similarly, upper left and upper right collar segments **611UL** and **611UR** are connected to each other by a second set of four threaded fasteners **620**.

FIG. 16 is a top view of clamp assembly **600**. In a manner similar to that previously described with respect to clamp assembly **200**, and to provide the same functionality, each of the collar segments of clamp assembly **600** carries two grip elements provided in the form of dies **630** which have gripping surfaces for gripping engagement with one of workpieces **61** and **62**.

Dovetail grooves **631** are provided with slots **632** into which retaining clips (not shown) may be installed to prevent dies **630** from sliding axially out of dovetail grooves **631**, where the retaining clips preferably being configured for an interference fit with slots **632** to retain them in place.

Gauging surfaces **615LL**, **615LR**, **615UL**, and **615UR** are provided on each end of collar segments **611LL**, **611LR**, **611UL**, and **611UR**, respectively, for measurement of the deformation of each collar segment when fasteners **620** are tightened. A measurement device, such as a suitably-sized outside micrometer or vernier caliper, may be adapted to measure the magnitudes of deformation of the collar segments, and the measured magnitudes of deformation can be used to determine the gripping force. Dimensional gauges may be used to determine:

- whether the deformation of a collar segment is greater than a first threshold, and thereby to confirm whether the gripping force is greater than a minimum desired value; and
- whether the deformation of a collar segment is less than a second threshold, and thereby to confirm whether the gripping force is less than a maximum desired value.

FIG. 17 is an isometric view of clamp assembly **600** used in conjunction with a support device **690** that facilitates assembly or disassembly of clamp assembly **600**

around or from the tool joint by supporting the collar segments when threaded fasteners **620** are not tight during the assembly or disassembly stage. Support device **690** comprises an attachment element **691** and a support platform element **692**. Attachment element **691** may comprise a commonly available lifting magnet to support device **690** to lower workpiece **62**. Support platform element **692** provides a support surface **693** upon which the collar segments may rest when threaded fasteners **260** are not tight.

When clamp assembly **600** is assembled on a tool joint comprising upper and lower workpieces of the same diameter, collar segments **611UL** and **611LR** and collar segments **611LL** and **611UR** are also rotationally symmetric about a second transverse axis **605** that lies in horizontal reference plane $\mathbf{RP_H}$, is perpendicular to and intersects clamp assembly axis **602**, and is perpendicular to the sliding direction of interlocking linear slide mechanism **601**.

Embodiment #5, with barrel nuts and barrel washers to facilitate mounting

FIG. 18 is an isometric view of a fifth embodiment **700** of a tool joint clamp assembly in accordance with the present disclosure. Clamp assembly **700** has a longitudinal clamp assembly axis **703**, and incorporates:

- a lower collar assembly comprising a lower left collar segment **711** and a lower right collar segment **712**; and
- an upper collar assembly comprising an upper left collar segment **713** and an upper right collar segment **714**.

Clamp assembly **700** incorporates at least a first linear slide mechanism **701** functionally similar to first linear slide mechanism **201** of clamp assembly **200**, previously described. Clamp assembly **700** is shown assembled around a tool joint having a longitudinal tool joint axis **70**, and comprising an upper workpiece **71** and a lower workpiece **72** such that clamp assembly axis **702** is coincident with tool joint axis **70**.

In this embodiment, threaded fasteners **720** may be loosely assembled with barrel nuts **721** and barrel washers **722** to facilitate mounting of the clamp assembly around the tool joint and accommodate angular misalignment between the two segments of a given collar assembly.

FIGS. 19 and 20 are front and side elevations, respectively, of clamp assembly **700**, and show the upper and lower collar assemblies adapted to upper and lower workpiece **71** and **72** having different outside diameters. Lower left collar segment **711** and lower right collar segment **712** are shown connected to each other by a first set of four threaded fasteners **720**. Similarly, upper left collar segment **713** and upper right collar segment **714** are shown connected to each other by a second set of four threaded fasteners **720**.

Lower left collar segment **711** and upper left collar segment **713** are configured with holes that captively retain the loosely-assembled fasteners **720**, barrel washers **722**, and barrel nuts **721**. Lower right collar segment **712** and upper right collar segment **714** are configured with hooks **715** that permit the loosely-assembled fasteners **720**, barrel washers **722**, and barrel nuts **721** to quickly latch lower right collar segment **712** and upper right collar segment **714,** and securely hold retain barrel nuts **721** while fasteners **720** are tightened.

FIG. 21 is a top view of clamp assembly **700**. Each collar segment of clamp assembly **700** carries two grip elements provided in the form of dies **730** which have gripping surfaces for gripping engagement with one of workpieces **71** and **72**.

Dovetail grooves **731** are shown provided with slots into which retaining clips **733** are placed to prevent dies **730** from sliding axial out of dovetail grooves **731**, retaining clips **733** preferably being configured for an interference fit with slots **732** to retain them in place.

It will be readily appreciated by persons skilled in the art that various modifications to embodiments in accordance with the present disclosure may be devised without departing from the scope of the present teachings, including modifications that use equivalent structures or materials hereafter conceived or developed.

It is especially to be understood that the scope of the present disclosure is not intended to be limited to described or illustrated embodiments, and that the substitution of a variant of any claimed or illustrated element or feature, without any substantial resultant change in functionality, will not constitute a departure from the scope of the disclosure. For example, while the Figures show upper workpieces having a larger

outside diameter than the lower workpieces, all embodiments in accordance with this disclosure are readily adaptable to threaded connections where the upper workpiece has a smaller outside diameter than the lower workpiece.

In this patent document, any form of the word "comprise" is to be understood in its non-limiting sense to mean that any element or feature following such word is included, but elements or features not specifically mentioned are not excluded. A reference to an element or feature by the indefinite article "a" does not exclude the possibility that more than one such element or feature is present, unless the context clearly requires that there be one and only one such element or feature.

Any use herein of any form of the terms "connect", "engage", "mount", "attach", or any other term describing an interaction between elements is not meant to limit the interaction to direct interaction between the subject elements, and may also include indirect interaction between the elements such as through secondary or intermediary structure.

Relational and conformational terms such as (but not limited to) "parallel", "perpendicular", "vertical", "horizontal", "axial", "cylindrical", "semi-cylindrical", "symmetric", and "coincident" are not intended to denote or require absolute mathematical or geometrical precision. Accordingly, such terms are to be understood as denoting or requiring substantial precision only (e.g., "substantially perpendicular" or "generally symmetric") unless the context clearly requires otherwise. Unless specifically noted otherwise, any reference to an element being "generally cylindrical" is intended to denote that the element in question would appear substantially cylindrical in transverse cross-section, although the cross-sectional configuration of the element may vary along its length.

Wherever used in this document, the terms "typical" and "typically" are to be understood and interpreted in the sense of being representative of common usage or practice, and are not to be understood or interpreted as implying essentiality or invariability.

LIST OF ILLUSTRATED ELEMENTS

Element Number	Description
RP_H	horizontal reference plane
RP_V	vertical reference plane
20	tool joint axis
21	upper workpiece
22	lower workpiece
200	tool joint clamp assembly
201	interlocking linear slide mechanism
202	clamp assembly axis
211	lower left collar segment
211S	upward-facing semi-annular surface
212	lower right collar segment
212S	upward-facing semi-annular surface
213	upper left collar segment
213S	downward-facing semi-annular surface
214	upper right collar segment
214S	downward-facing semi-annular surface
220	threaded fastener
230	workpiece gripping element (die insert)
231	dovetail groove for gripping element
30	tool joint axis
31	upper workpiece
32	lower workpiece
300	tool joint clamp assembly
301	interlocking linear slide mechanism
302	clamp assembly axis
311LL	lower left collar segment
311LR	lower right collar segment
312UL	upper left collar segment
312UR	upper right collar segment
320	threaded fastener
330	workpiece gripping element (die insert)
331	dovetail groove for gripping element

LIST OF ILLUSTRATED ELEMENTS (continued)

Element Number	Description
40	tool joint axis
41	upper workpiece
42	lower workpiece
400	tool joint clamp assembly
401	interlocking linear slide mechanism
402	clamp assembly axis
403	transverse axis perpendicular to clamp assembly axis
411LL	lower left collar segment
411UL	upper left collar segment
412LR	lower right collar segment
412UR	upper right collar segment
420	threaded fastener
430	workpiece gripping element (die insert)
431	dovetail groove for gripping element
432	slot for gripping element retaining clip
60	tool joint axis
61	upper workpiece
62	lower workpiece
600	tool joint clamp assembly
601	interlocking linear slide mechanism
602	clamp assembly axis
603	first transverse axis
605	second transverse axis
611LL	lower left collar segment
611UL	upper left collar segment
611LR	lower right collar segment
611UR	upper right collar segment
615LL	lower left clamping force gauging surface
615UL	upper left clamping force gauging surface
615LR	lower right clamping force gauging surface
615UR	upper right clamping force gauging surface

LIST OF ILLUSTRATED ELEMENTS (continued)

Element Number	Description
620	threaded fastener
630	workpiece gripping element (die insert)
631	dovetail groove for gripping element
632	slot for gripping element retaining clip
690	clamp assembly support device
691	attachment element
692	support platform element
693	support surface
70	tool joint axis
71	upper workpiece
72	lower workpiece
700	tool joint clamp assembly
701	interlocking linear slide mechanism
702	clamp assembly axis
711	lower left collar segment
712	lower right collar segment
713	upper left collar segment
714	upper right collar segment
715	clamping force gauging surface
716	hook for barrel nut
720	threaded fastener
721	barrel nut
722	barrel washer
730	workpiece gripping element (die insert)
731	dovetail groove for gripping element
733	gripping element retaining clip

THE EMBODIMENTS IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. A clamp assembly for mounting on a tool joint comprising coaxially-aligned cylindrical upper and lower workpieces and having a tool joint axis, said clamp assembly having a clamp assembly axis and comprising a cylindrical lower collar assembly and a cylindrical upper collar assembly, wherein:

(a) the lower collar assembly comprises a semi-cylindrical lower left collar segment and a semi-cylindrical lower right collar segment, wherein:

(a.1) the lower left and lower right collar segments are removably connectable to each other by threaded fasteners to form the lower collar assembly; and

(a.2) the lower collar assembly is coaxially mountable around the lower workpiece such that tightening the fasteners connecting the lower left and lower right collar segments will urge the lower collar assembly to grip the lower workpiece;

(b) the upper collar assembly comprises a semi-cylindrical upper left collar segment and a semi-cylindrical upper right collar segment, wherein:

(b.1) the upper left and upper right collar segments are removably connectable to each other by threaded fasteners to form the cylindrical upper collar assembly; and

(b.2) the upper collar assembly is coaxially mountable around the upper workpiece such that tightening the fasteners connecting the upper left and upper right collar segments will urge the upper collar assembly to grip the upper workpiece;

(c) each of the lower left and lower right collar segments defines an upward-facing semi-annular surface;

(d) each of the upper left and upper right collar segments defines a downward-facing semi-annular surface;

(e) the upward-facing surface of the lower left collar segment and the downward-facing surface of the upper left collar segment are complementarily profiled to form a first interlocking linear slide mechanism allowing relative horizontal sliding of the lower left and upper

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left collar segments while preventing relative rotation of the lower left and upper left collar segments about the clamp assembly axis, wherein the sliding direction of the first interlocking linear slide mechanism is parallel to a vertical reference plane coincident with the clamp assembly axis and bisecting the interlocked lower left and upper left collar segments; and

(f) the clamp assembly defines:

(f.1) a first transverse axis that lies in a horizontal reference plane generally defined by the upward-facing and downward facing semi-annular surfaces, respectively, of the interlocked lower left and upper left collar segments, is perpendicular to and intersects the clamp assembly axis, and is parallel to the sliding direction of the first interlocking linear slide mechanism; and

(f.2) a second transverse axis that lies in a horizontal reference plane generally defined by the upward-facing and downward facing semi-annular surfaces, respectively, of the interlocked lower left and upper left collar segments, is perpendicular to and intersects the clamp assembly axis, and is perpendicular to the sliding direction of the first interlocking linear slide mechanism.

2. The clamp assembly as in Claim 1 wherein the first interlocking linear slide mechanism is a dovetail slide mechanism.

3. The clamp assembly as in any one of Claim 1 or Claim 2 wherein:

(a) the lower left and lower right collar segments are identical and are rotationally symmetric about the clamp assembly axis; and

(b) the upper left and upper right collar segments are identical and are rotationally symmetric about the clamp assembly axis.

4. The clamp assembly as in Claim 1 or Claim 2 wherein:

(a) the lower left and upper right collar segments are identical and are rotationally symmetric about the first transverse axis; and

(b) the lower right and upper left collar segments are identical and are rotationally symmetric about the first transverse axis.

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5. The clamp assembly as in Claim 1 or Claim 2 wherein:

(a) the lower left and upper right collar segments are identical and are rotationally symmetric about the second transverse axis; and

(b) the lower right and the upper left collar segments are identical and are rotationally symmetric about the second transverse axis.

6. The clamp assembly as in Claim 1 or Claim 2 wherein all of the collar segments are identical and are rotationally symmetric about the clamp assembly axis, the first transverse axis, and the second transverse axis.

7. The clamp assembly as in any one of Claims 1, 2, and 4 wherein the upward-facing surface of the lower right collar segment and the downward-facing surface of the upper right collar segment are complementarily profiled to form a second interlocking linear slide mechanism allowing relative horizontal sliding of the lower right and upper right collar segments while preventing relative rotation of the lower right and upper right collar segments about the clamp assembly axis.

8. The clamp assembly as in any one of Claims 1, 2, 4, 5, and 7 wherein:

(a) the threaded fasteners are loosely assembled with barrel nuts and barrel washers to facilitate mounting of the clamp assembly onto the upper and lower workpieces and to accommodate angular misalignment between the two collar segments of each collar assembly;

(b) a first one of the collar segments of each collar assembly is configured with holes that hold captive the loosely-assembled threaded fasteners, barrel washers, and barrel nuts; and

(c) a second one of the collar segments of each collar assembly is configured with hooks that permit the loosely-assembled threaded fasteners, barrel washers, and barrel nuts to quickly latch the second one of the collar segments, and to securely hold the barrel nut when the threaded fasteners are tightened.

9. The clamp assembly as in any one of Claims 1-8 wherein an inner surface of each collar segment is provided with one or more grip elements each having a gripping surface.

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10. The clamp assembly as in Claim 9 wherein at least one of the one or more grip elements is a removable grip element.

11. The clamp assembly as in Claim 10 wherein the removable grip element comprises a tong die.

12. The clamp assembly as in Claim 9 wherein at least one of the one or more grip elements is formed integrally with the associated collar segment.

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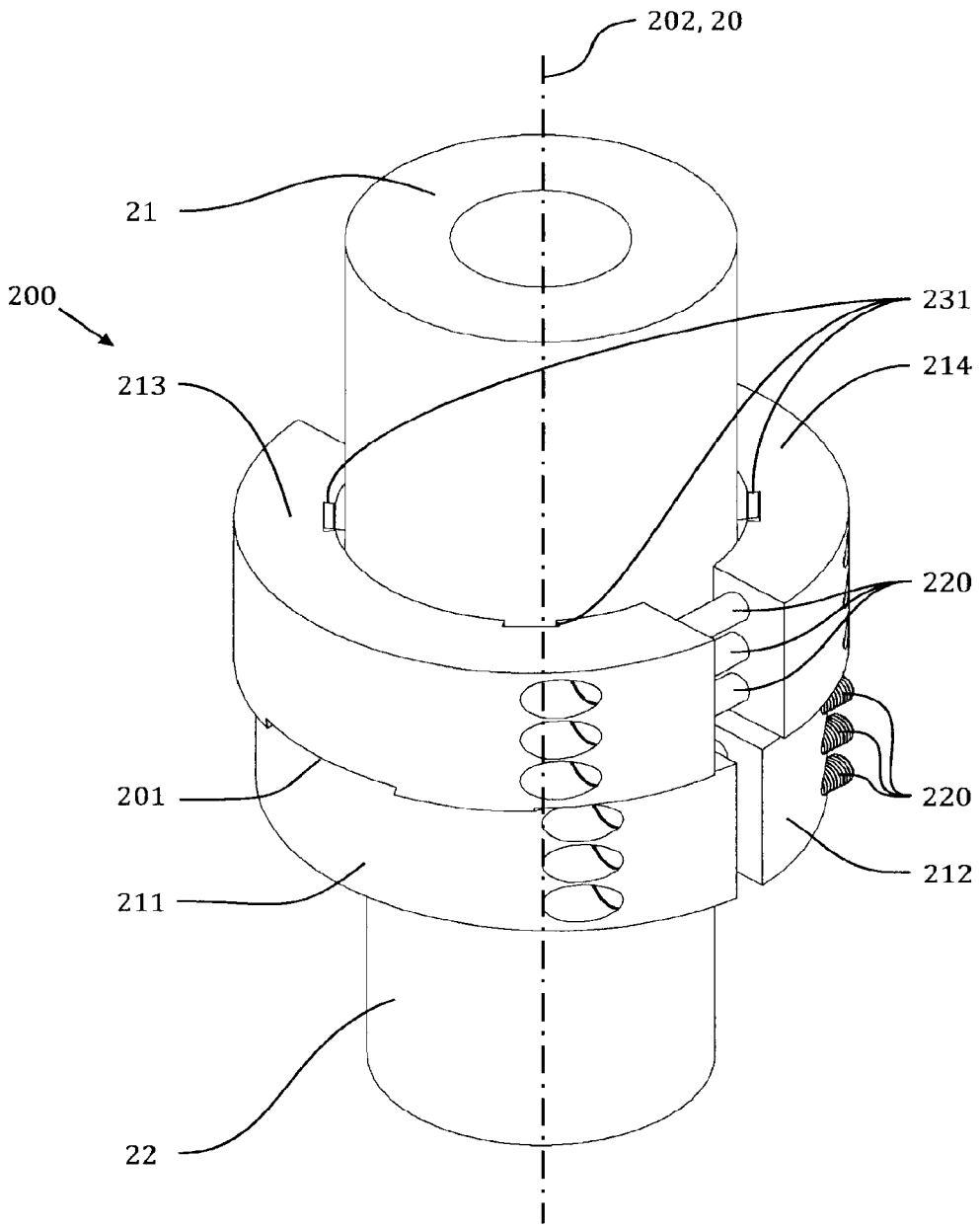

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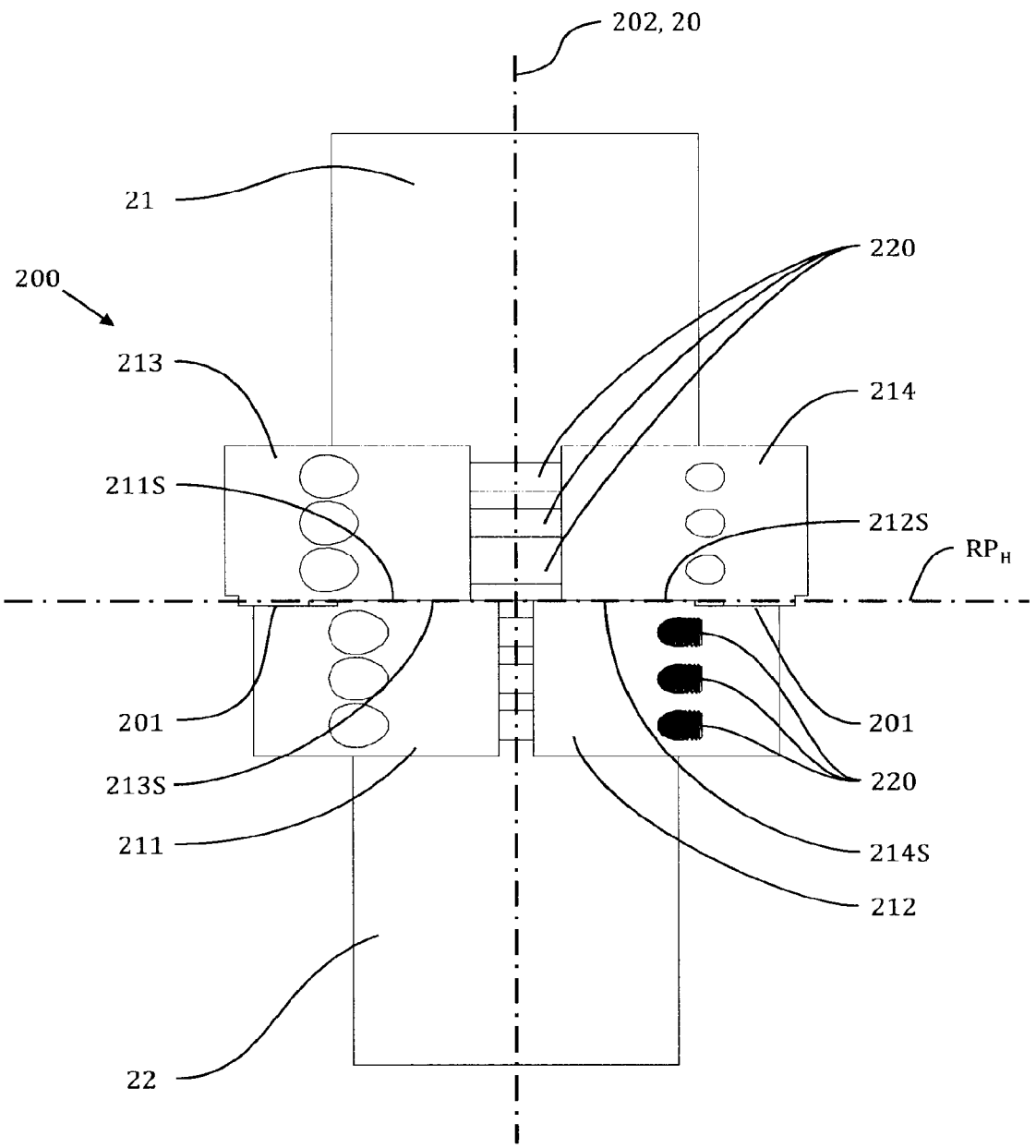
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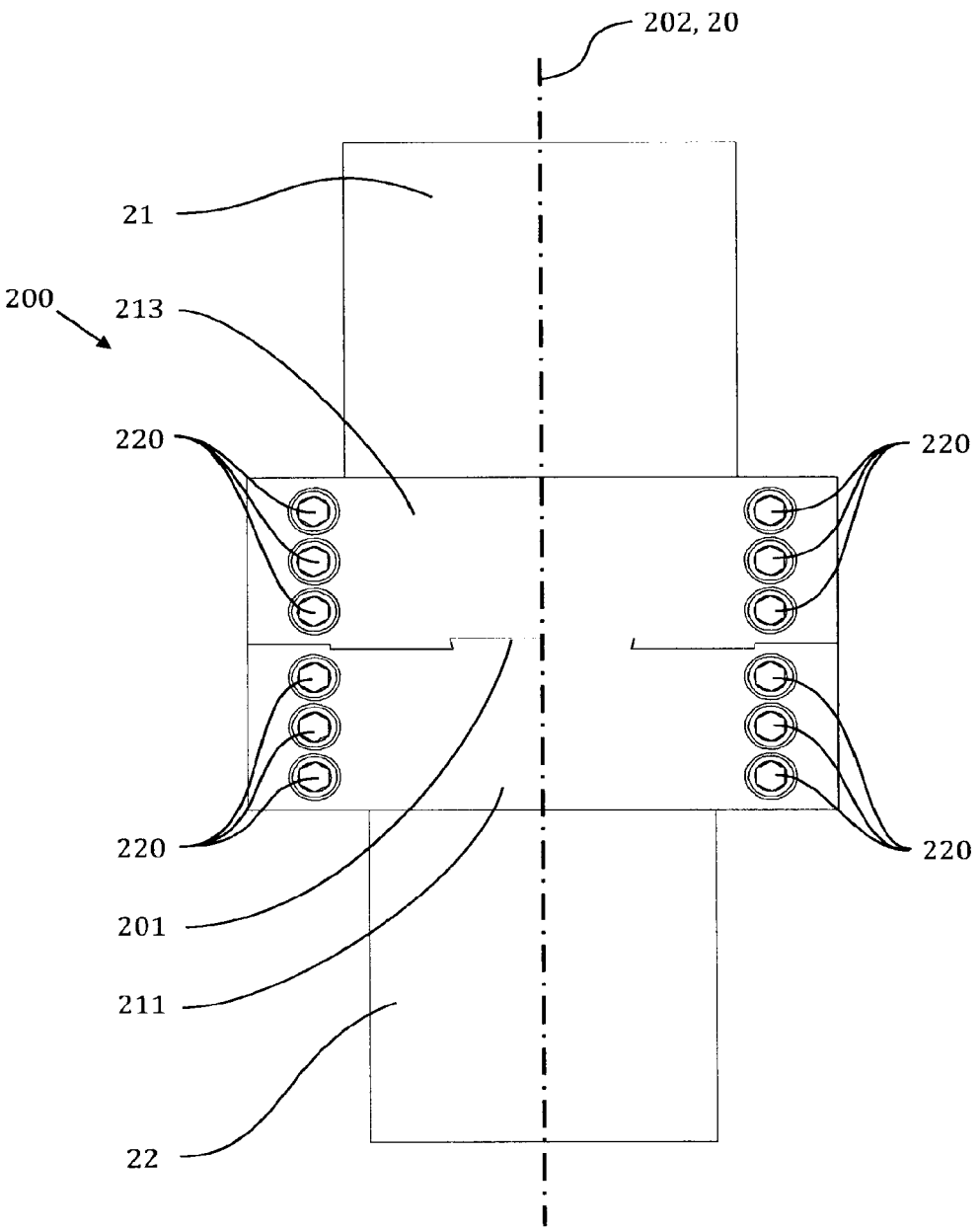
Figure 2



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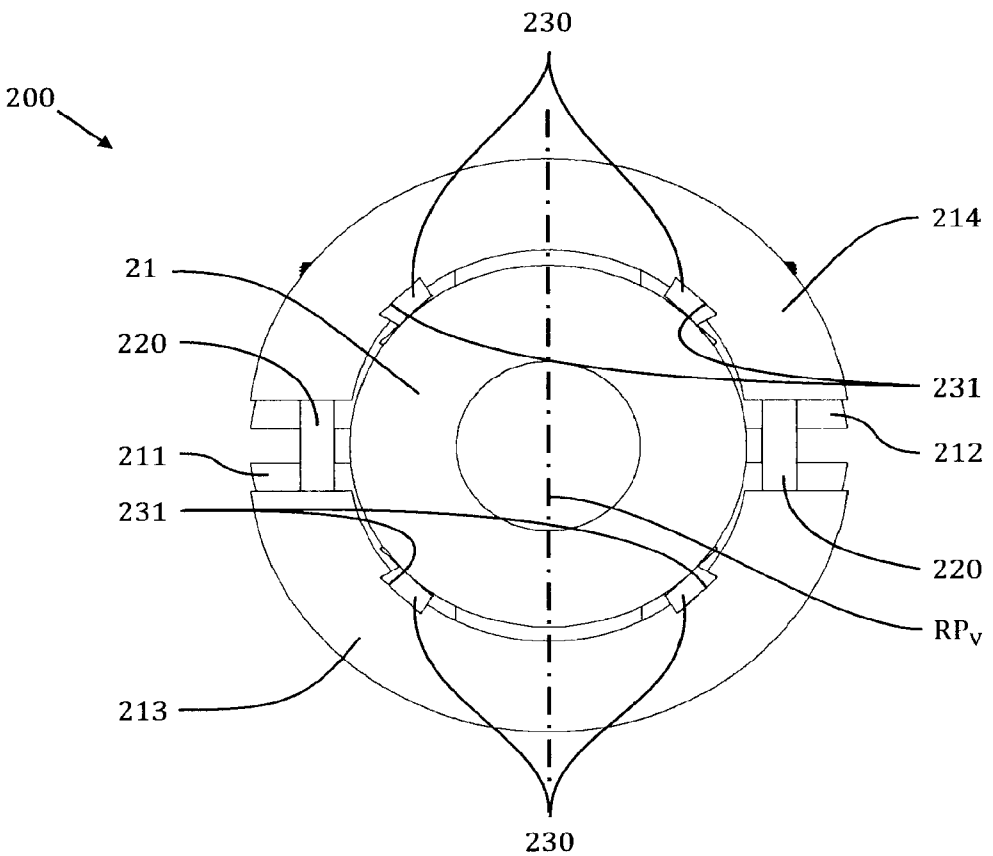

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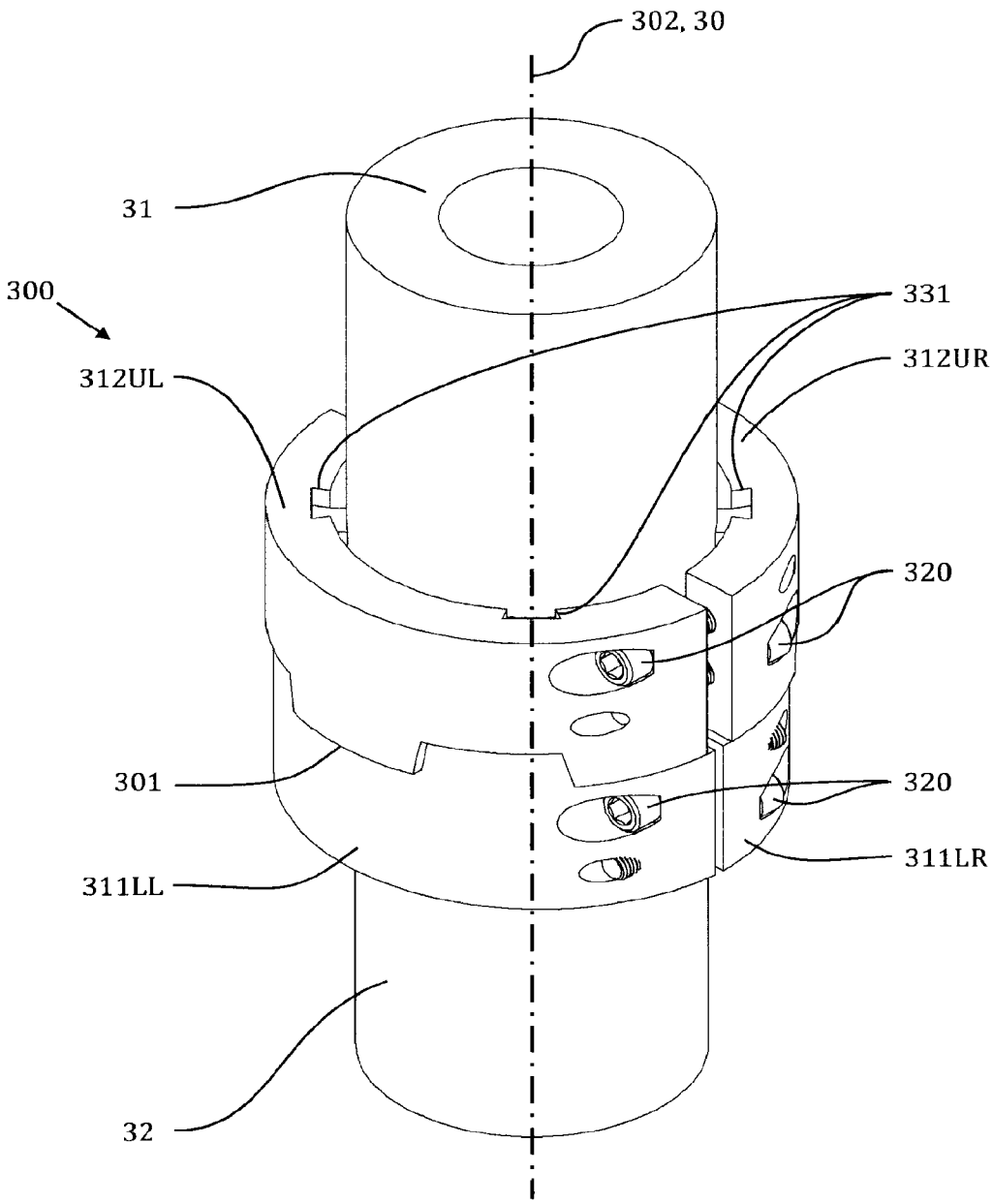

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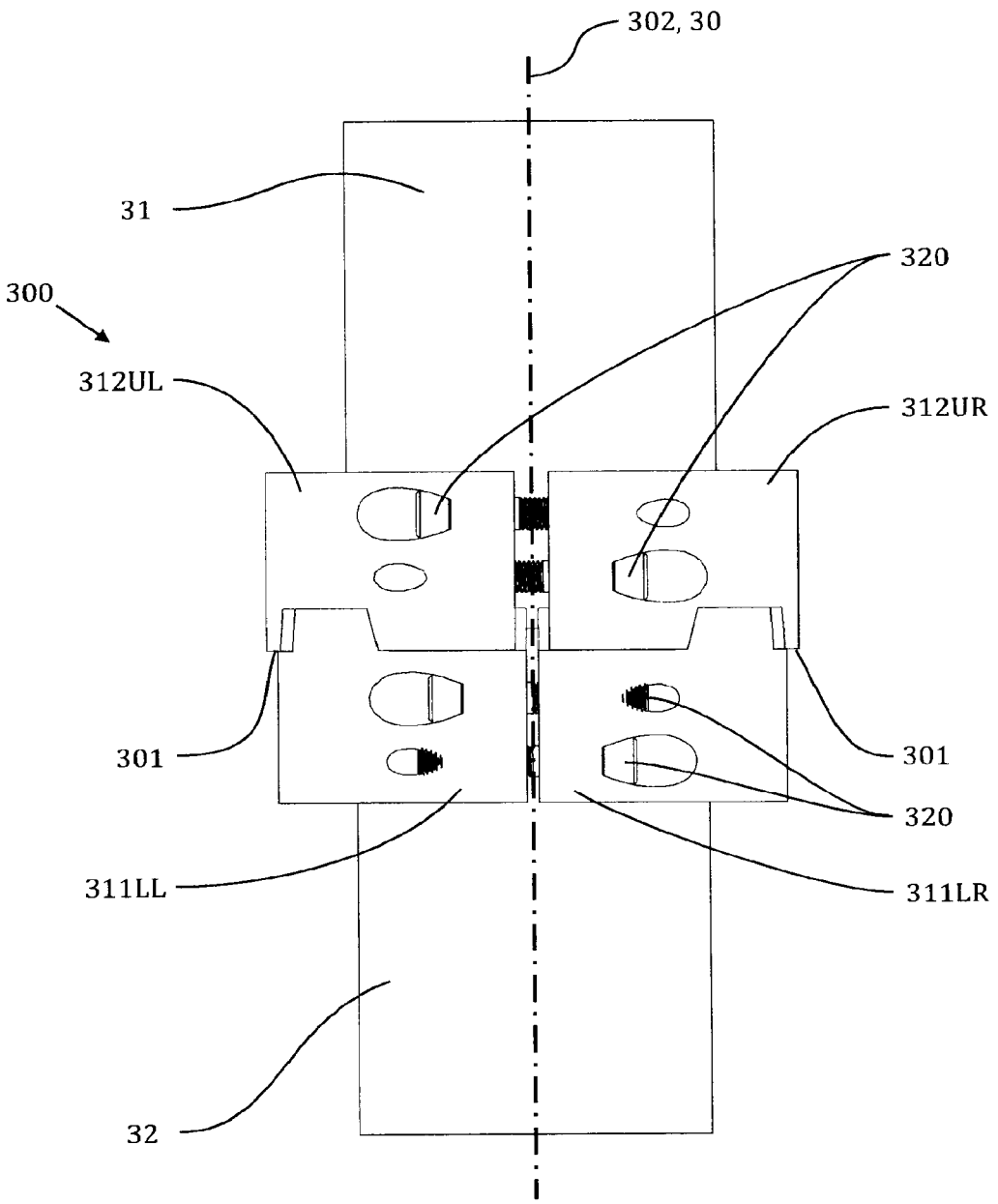

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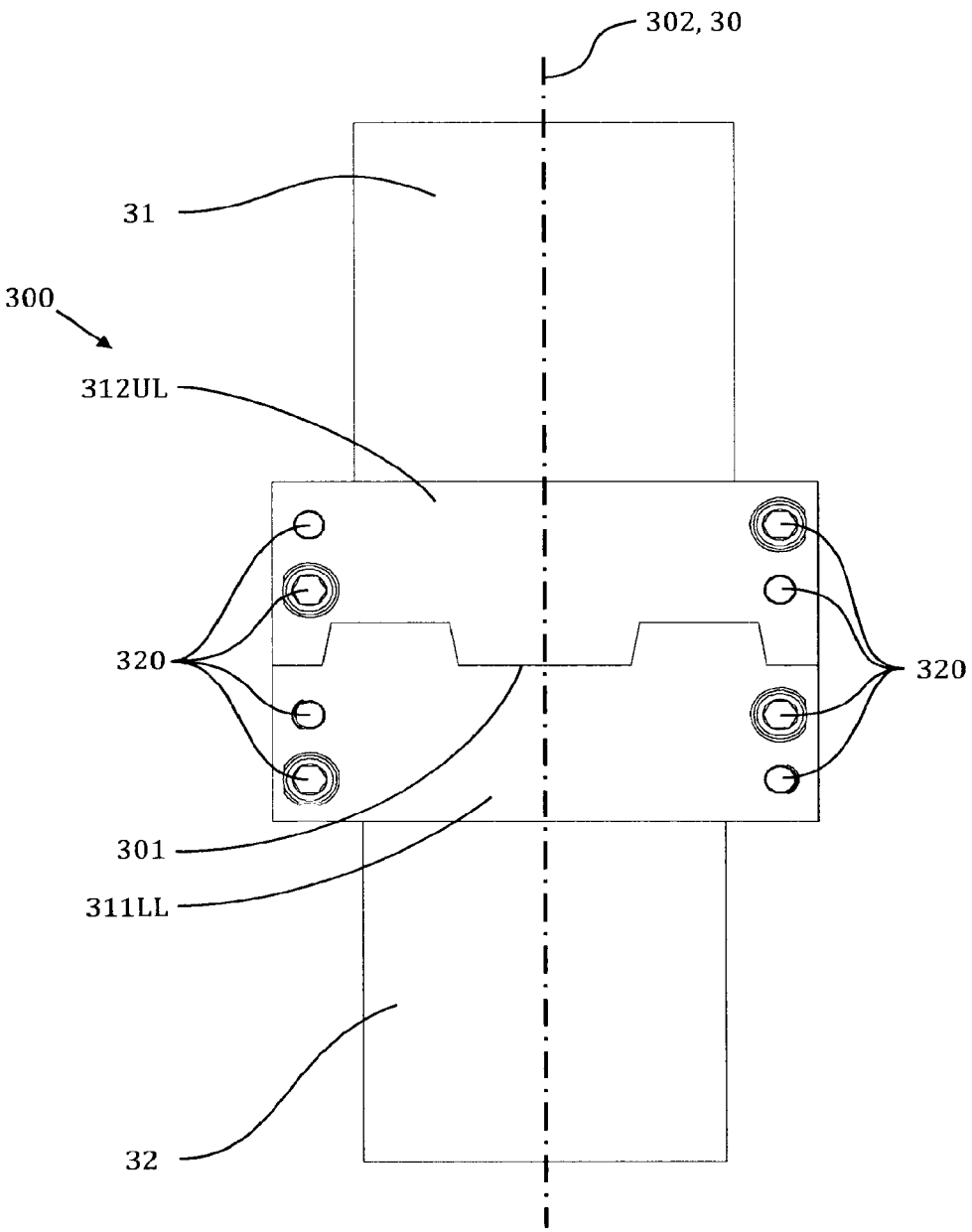

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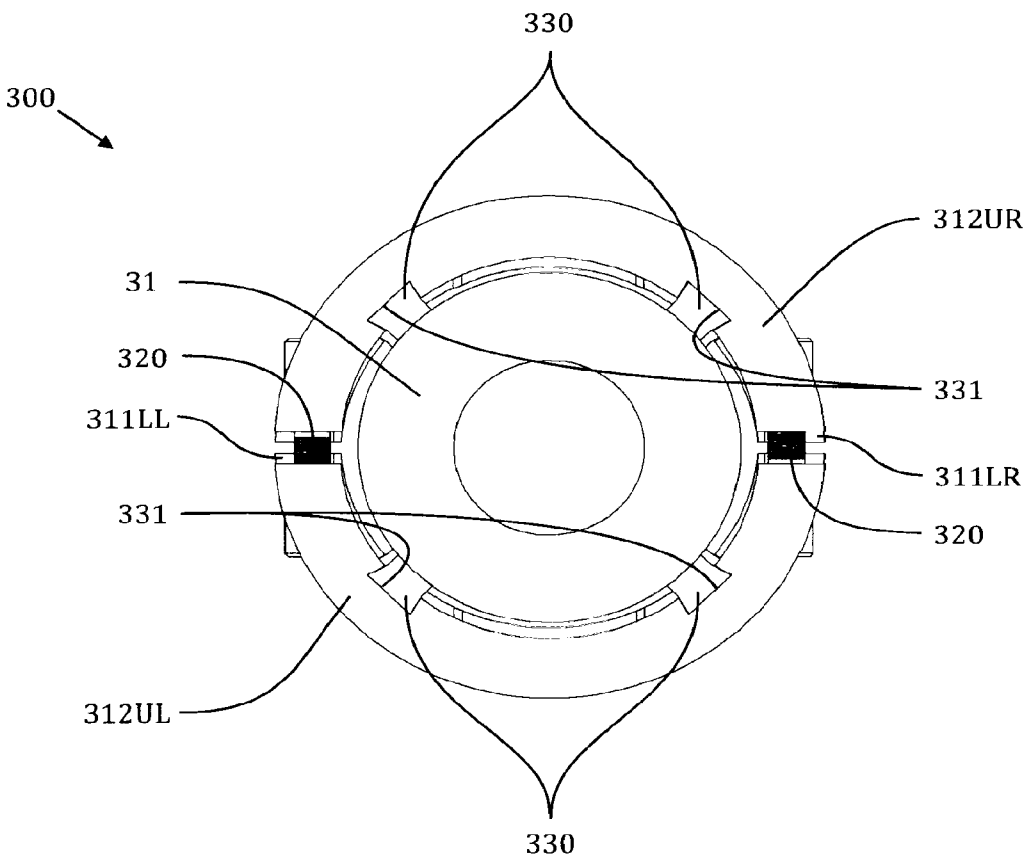

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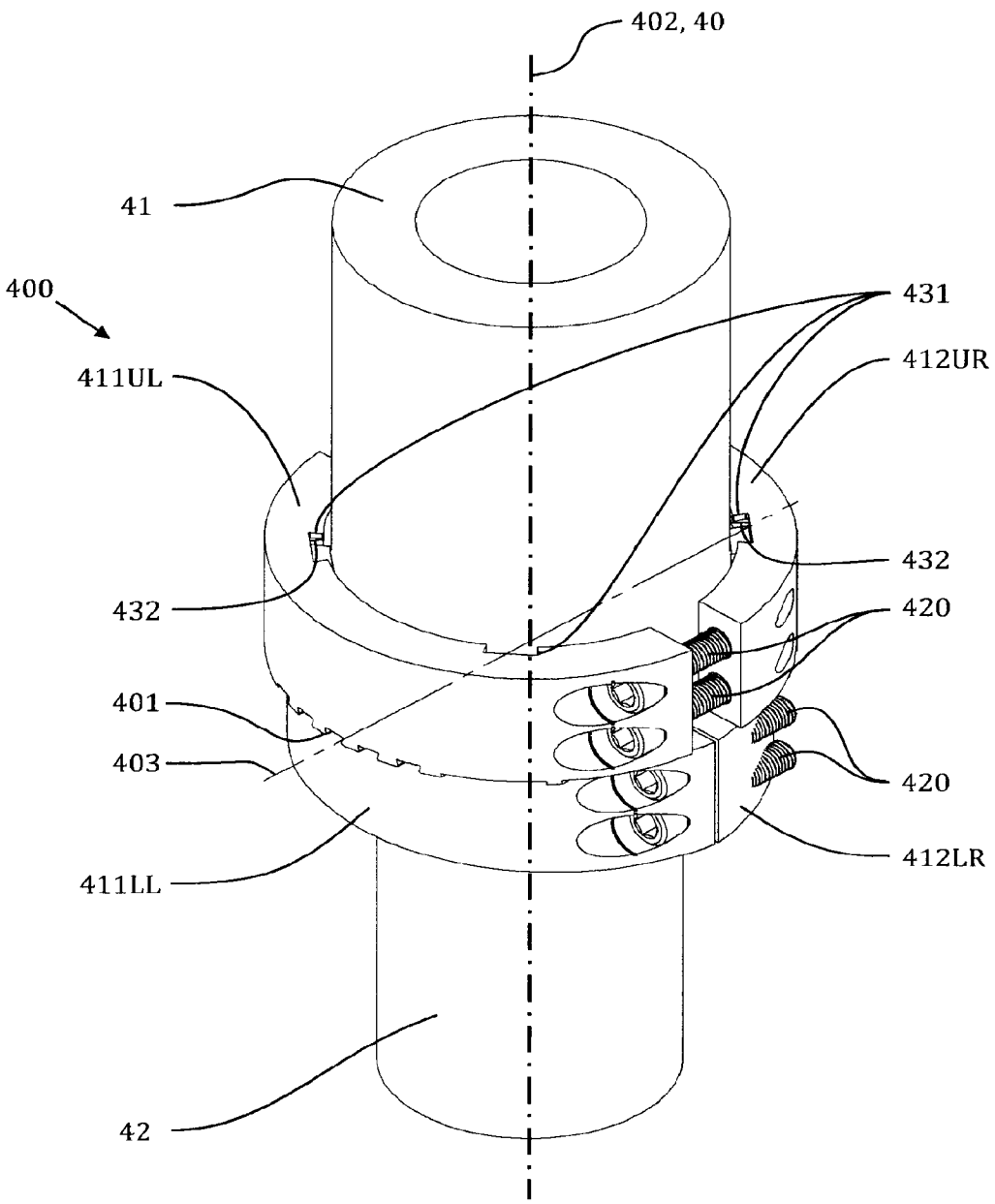
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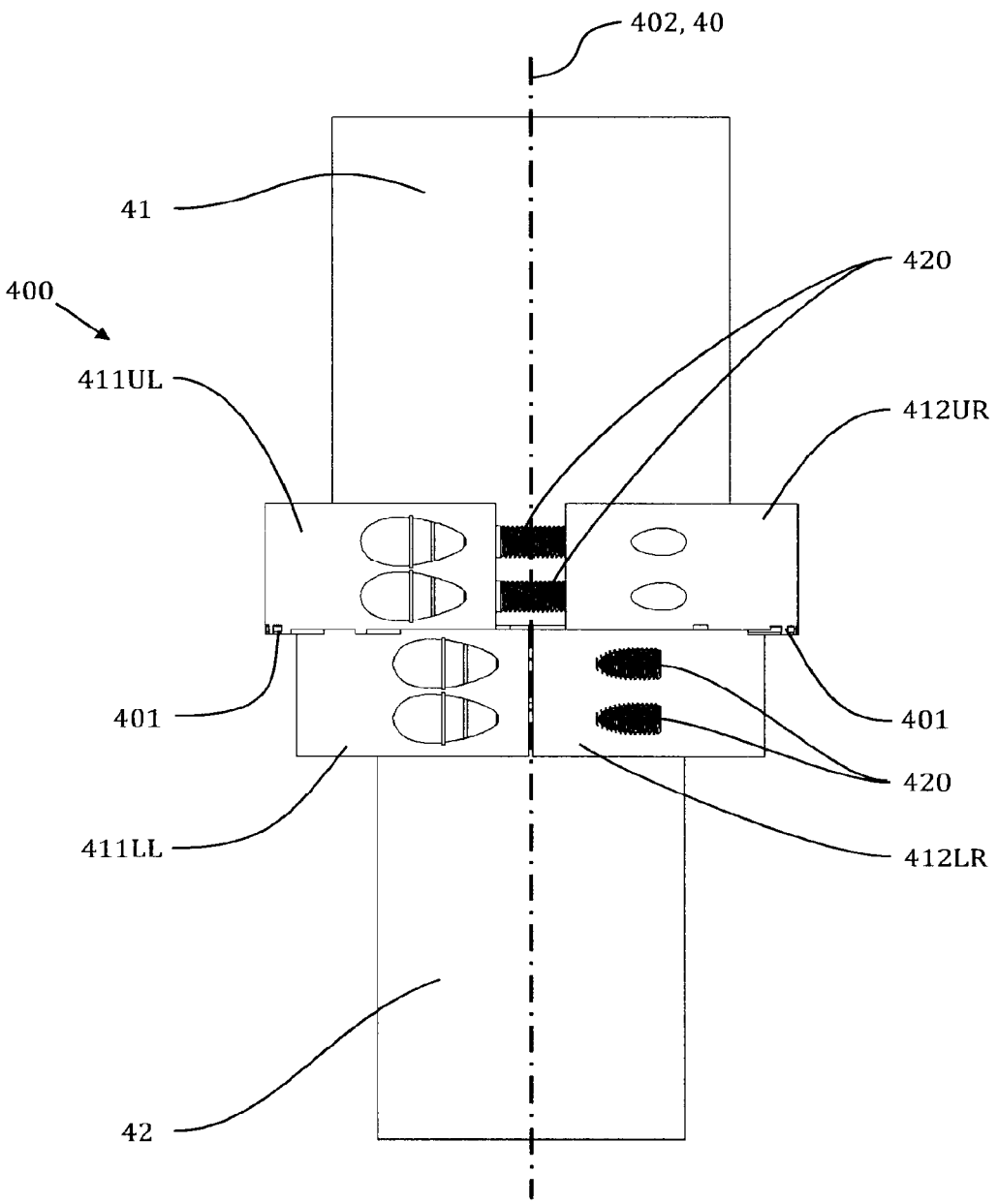
Figure 9



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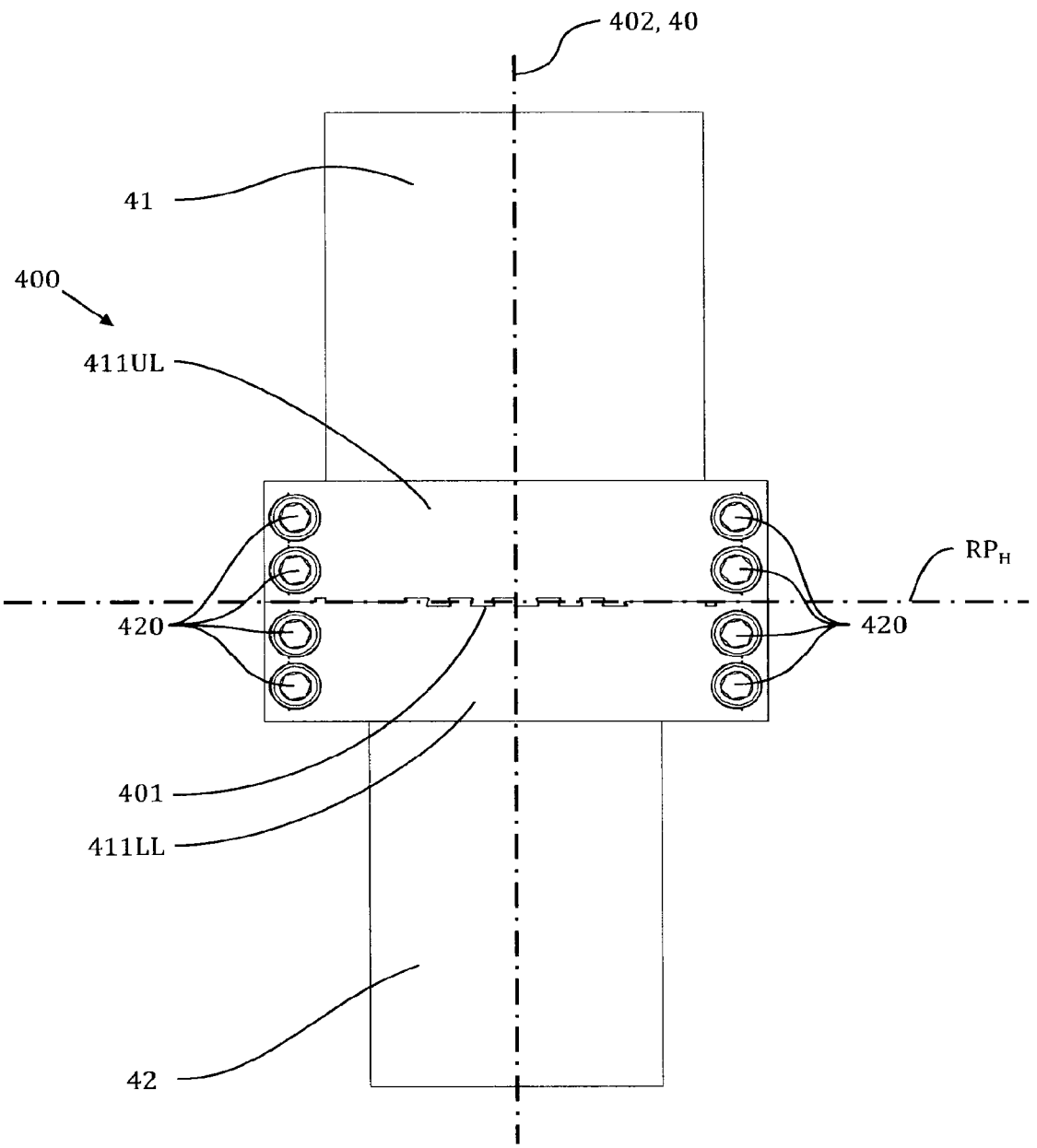

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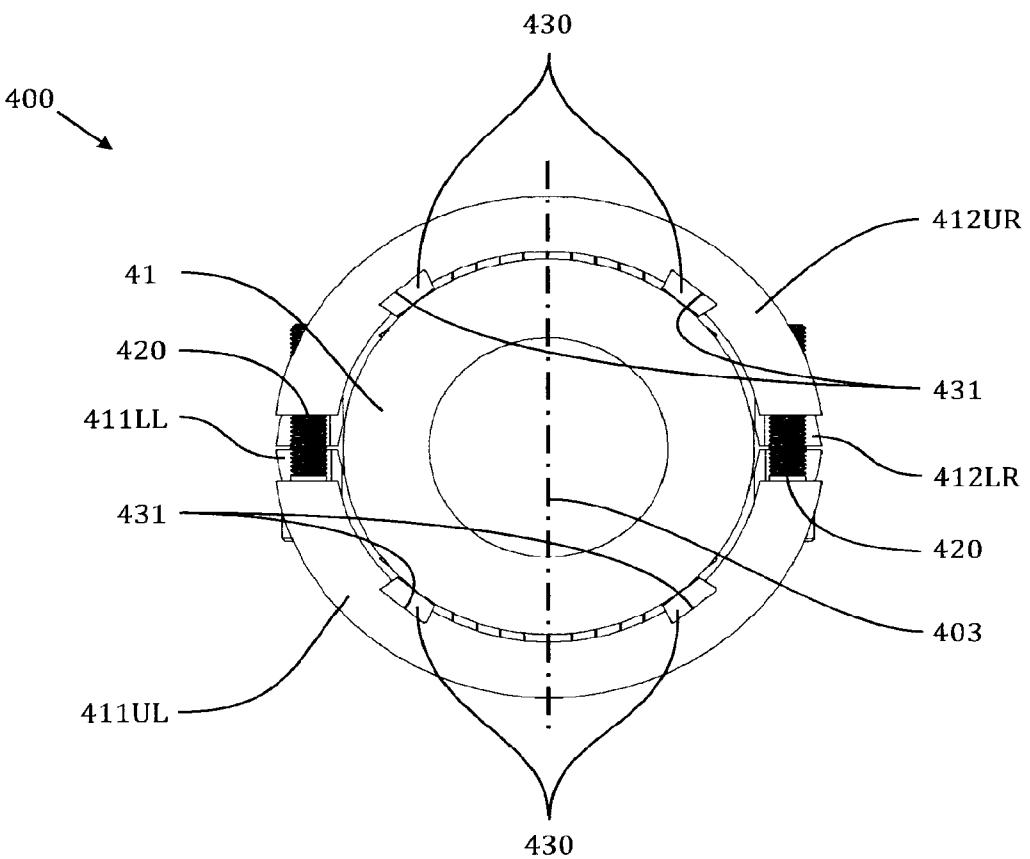

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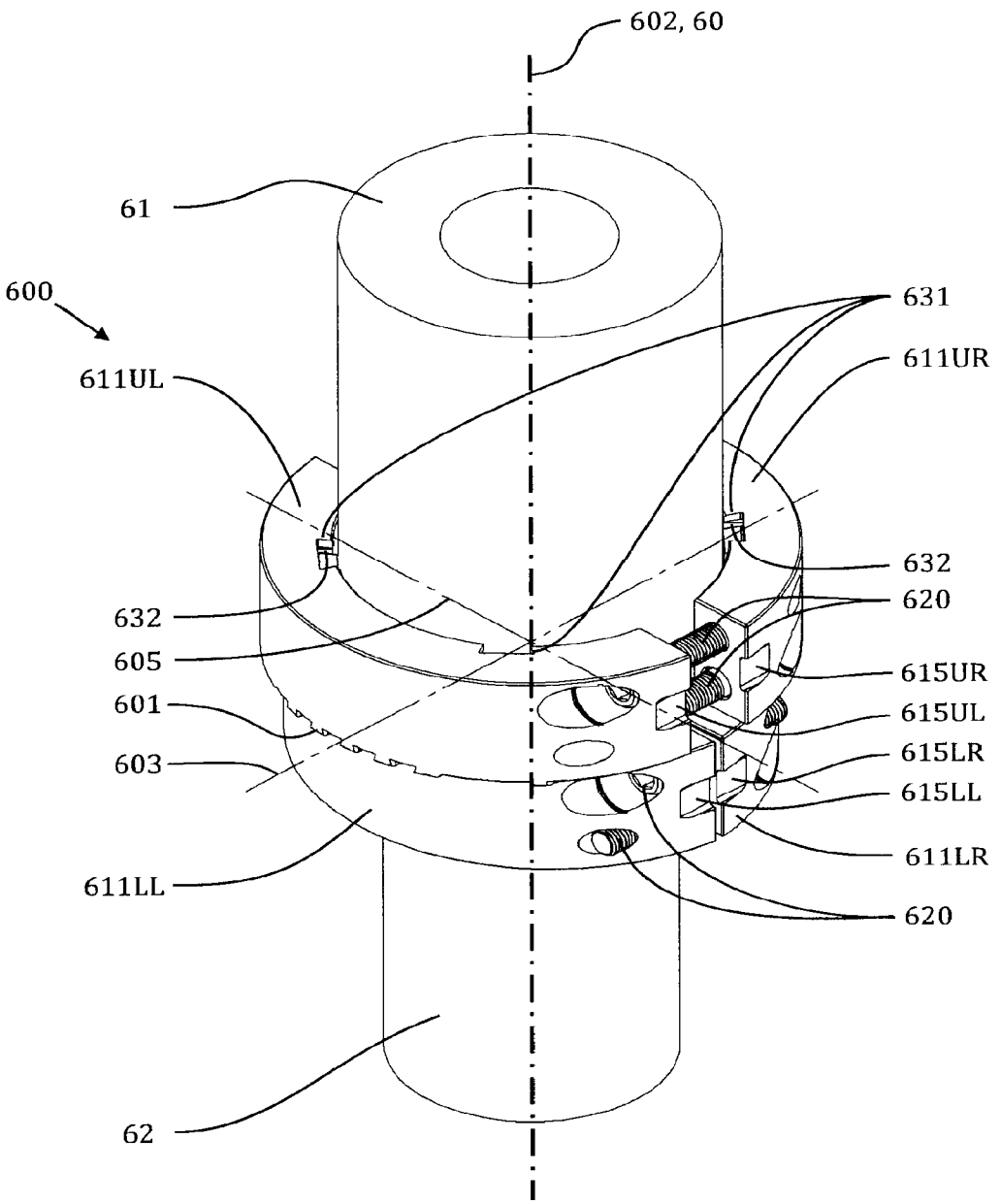
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Figure 13

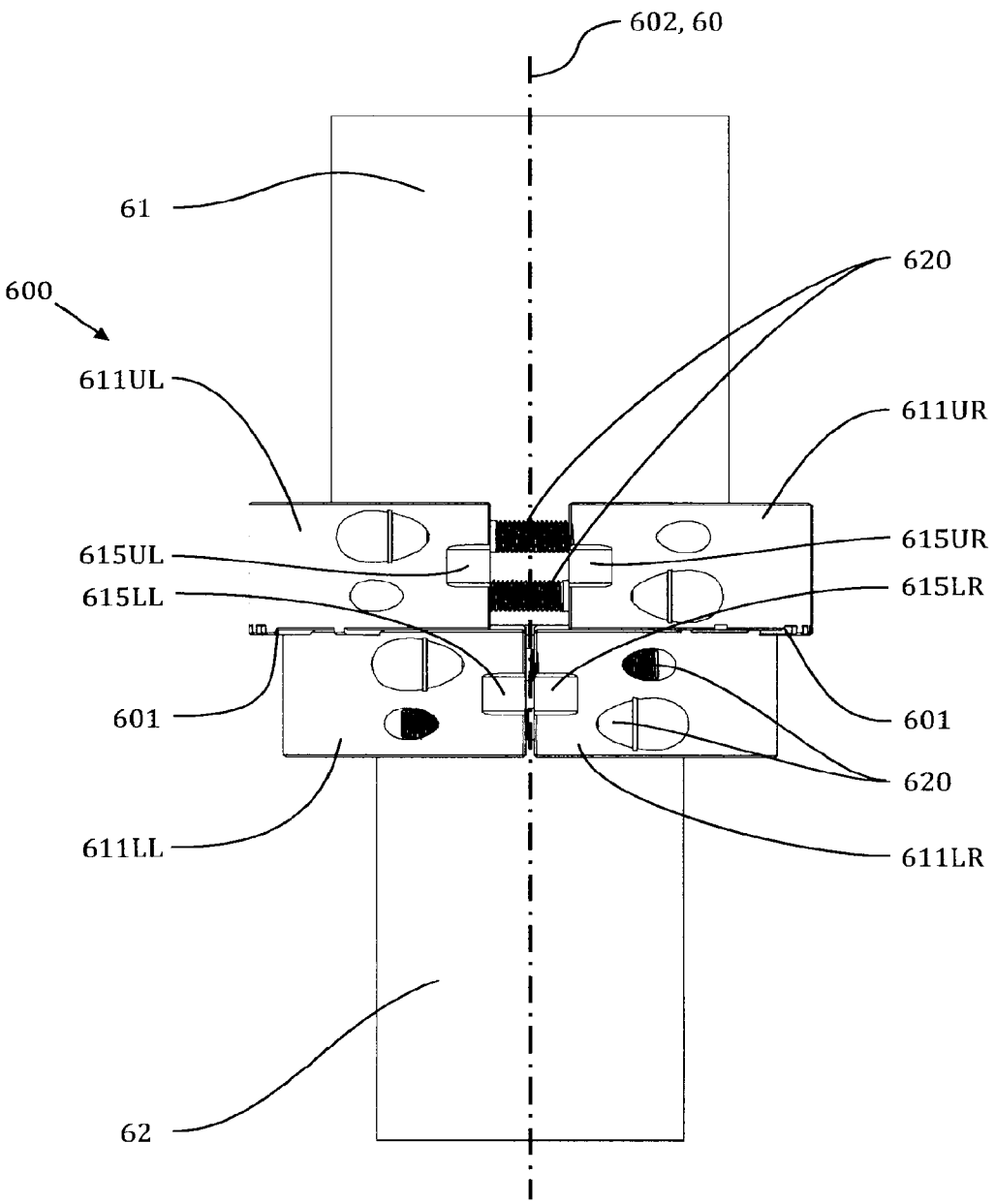
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Figure 14

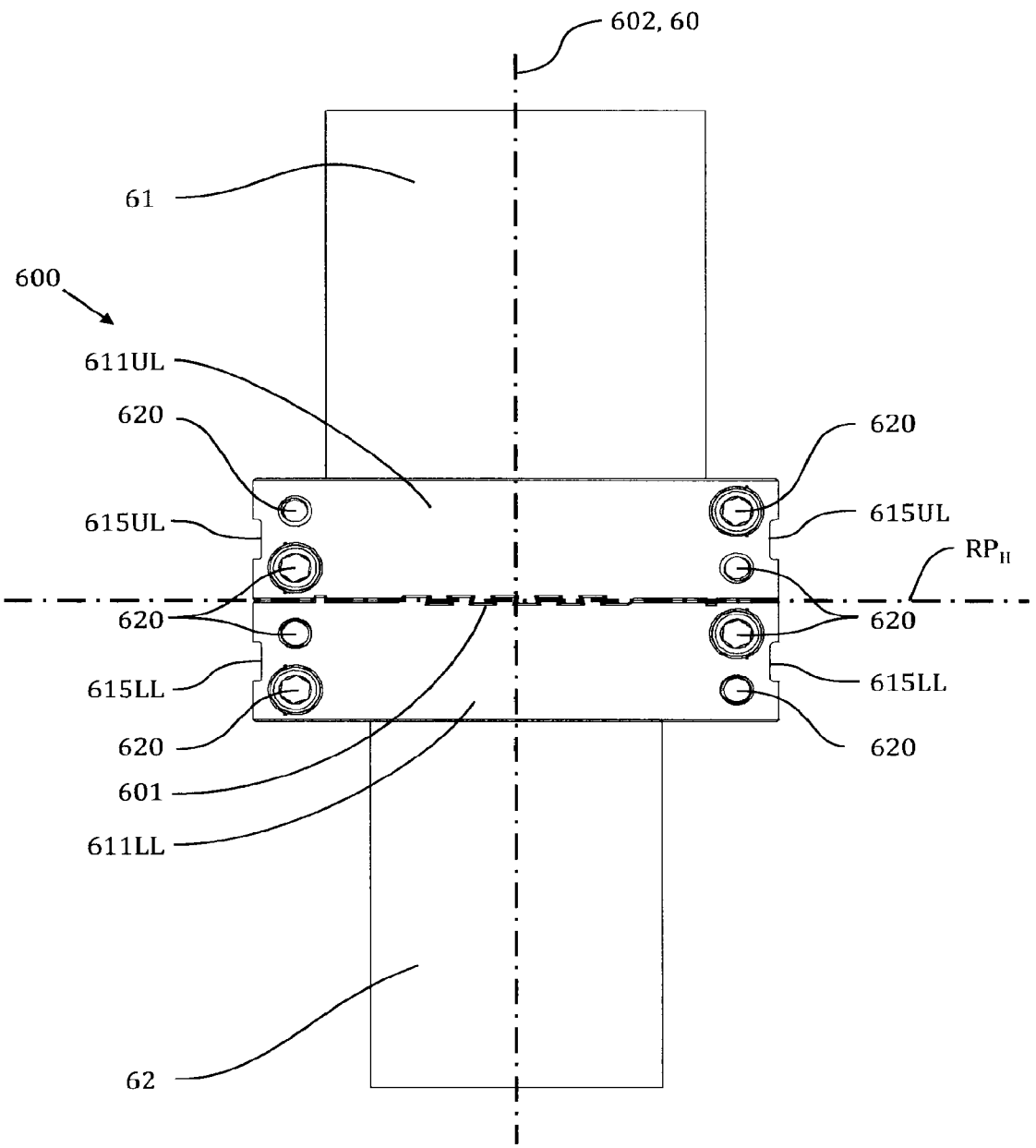
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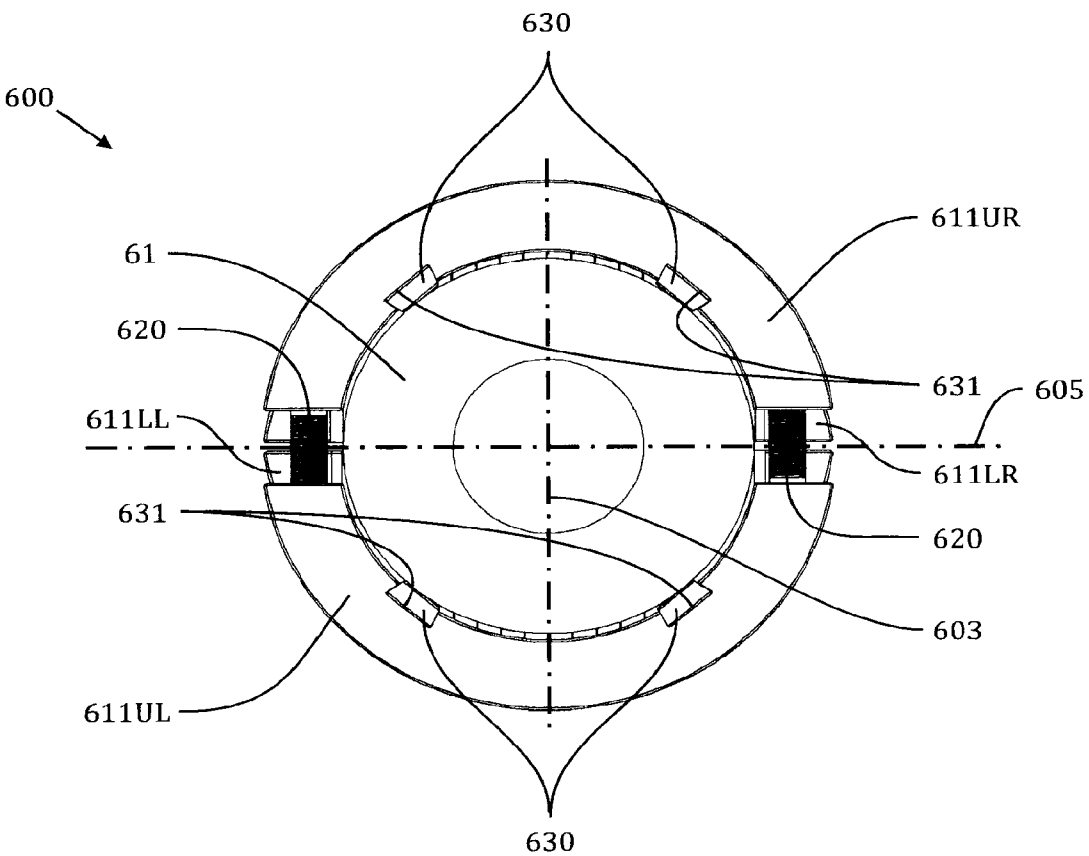
Figure 15



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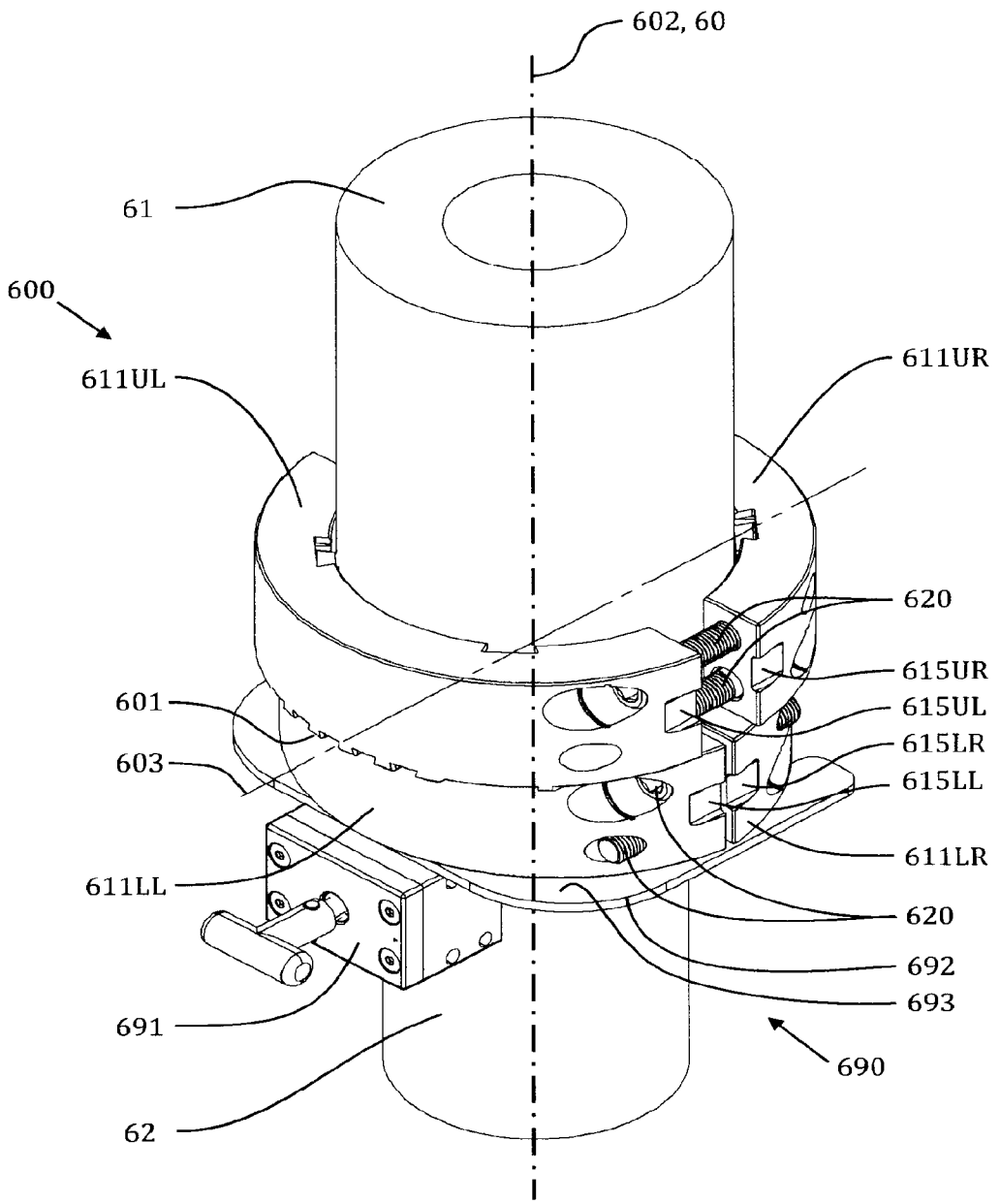
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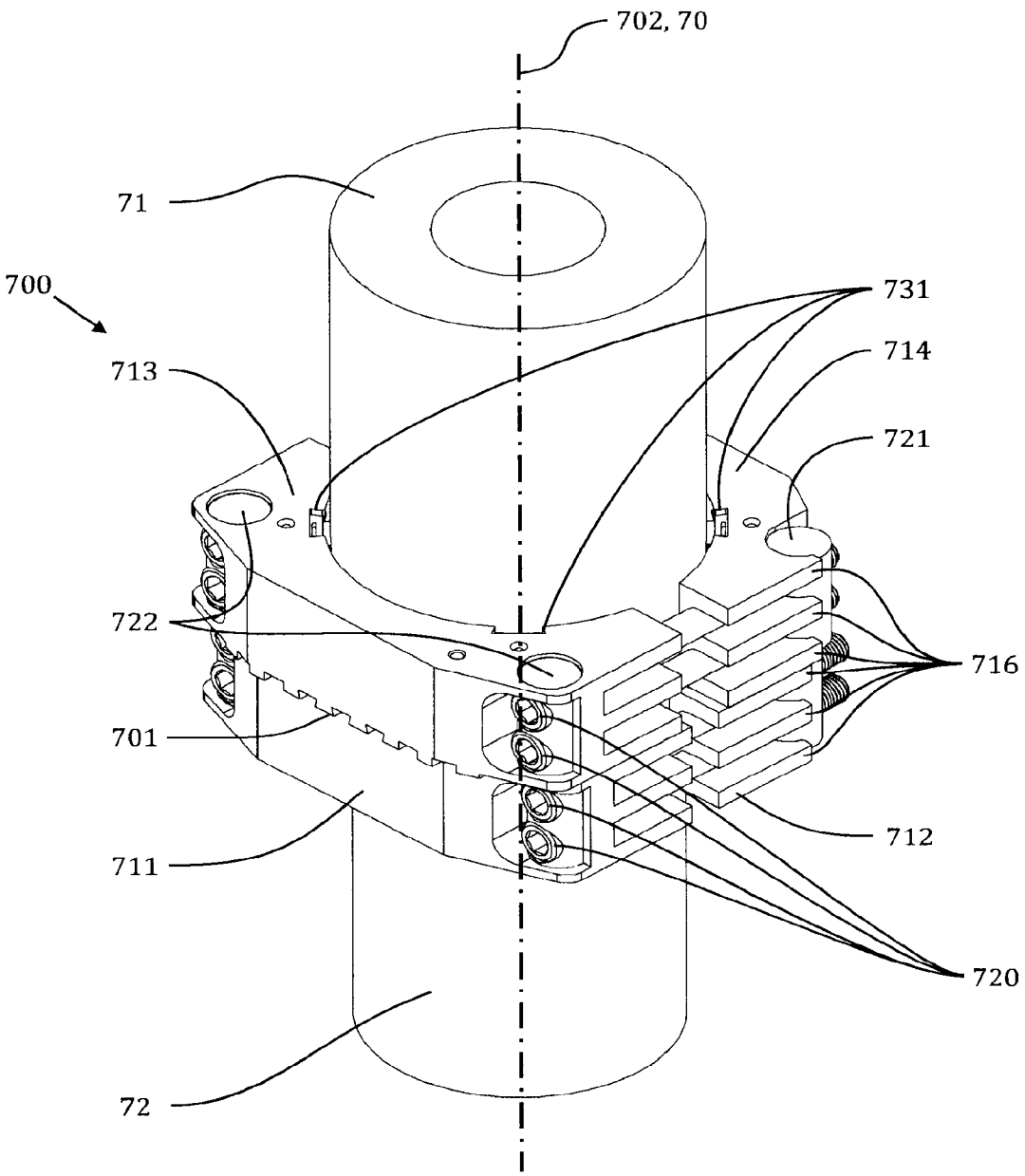
Figure 17



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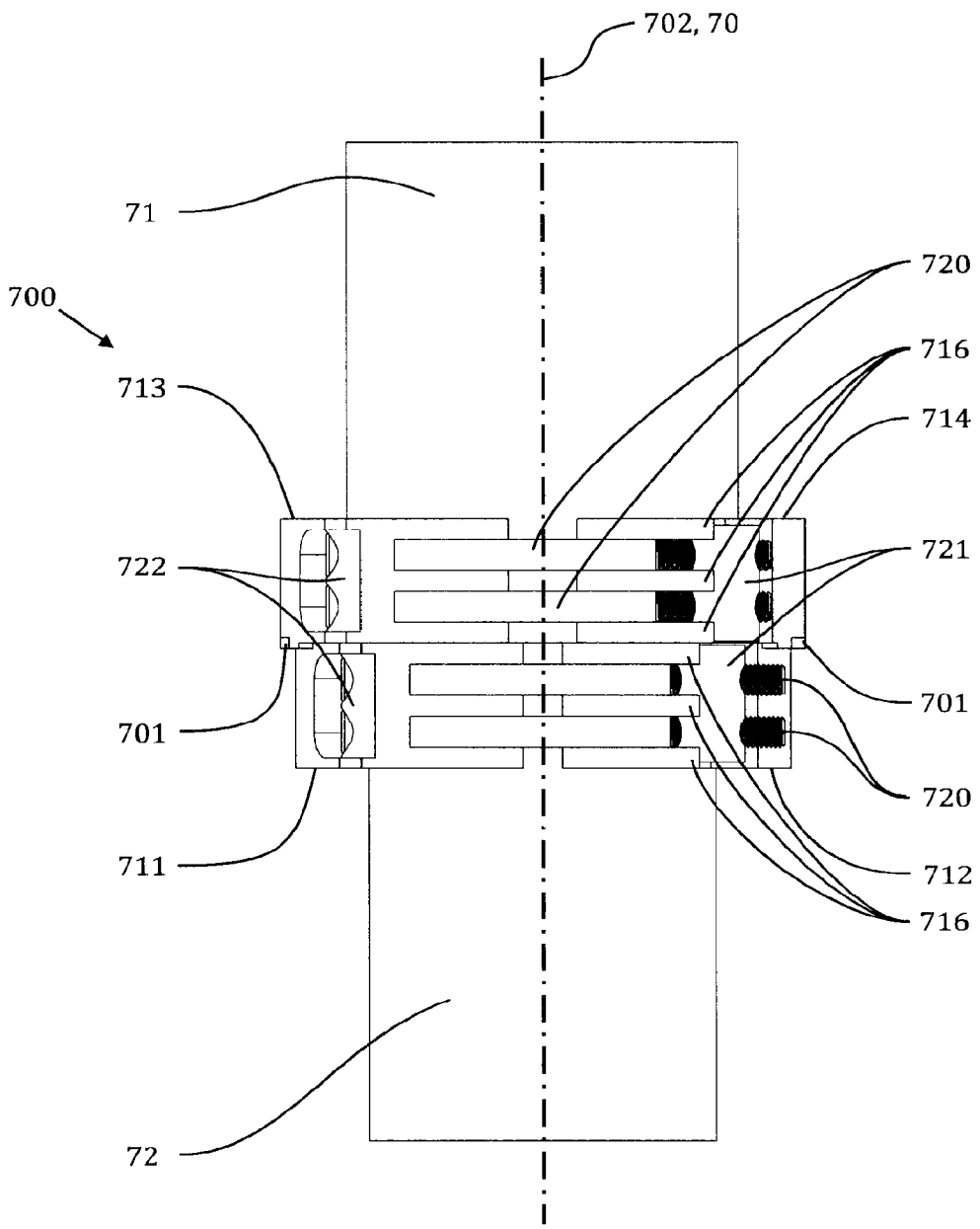

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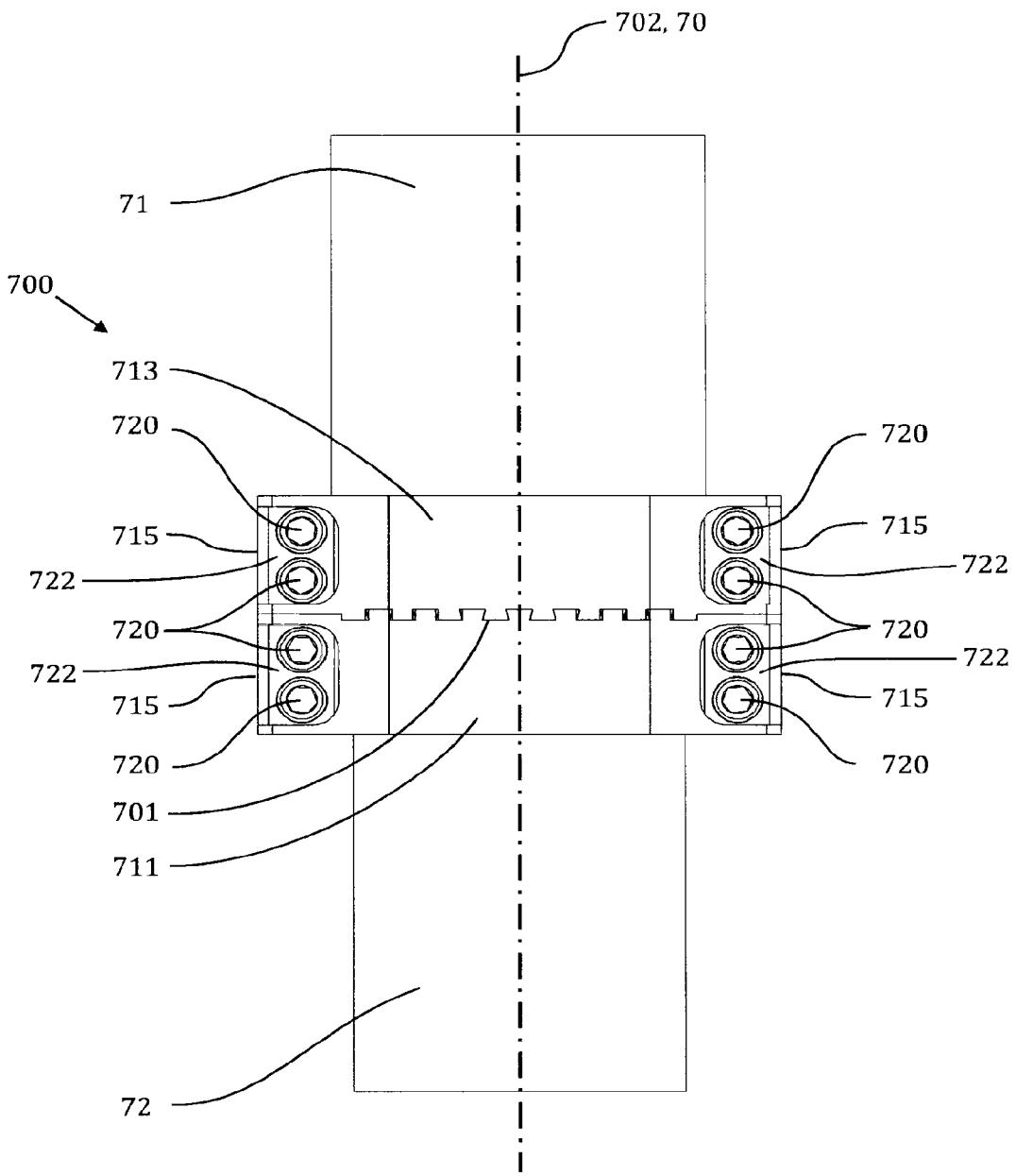
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Figure 20

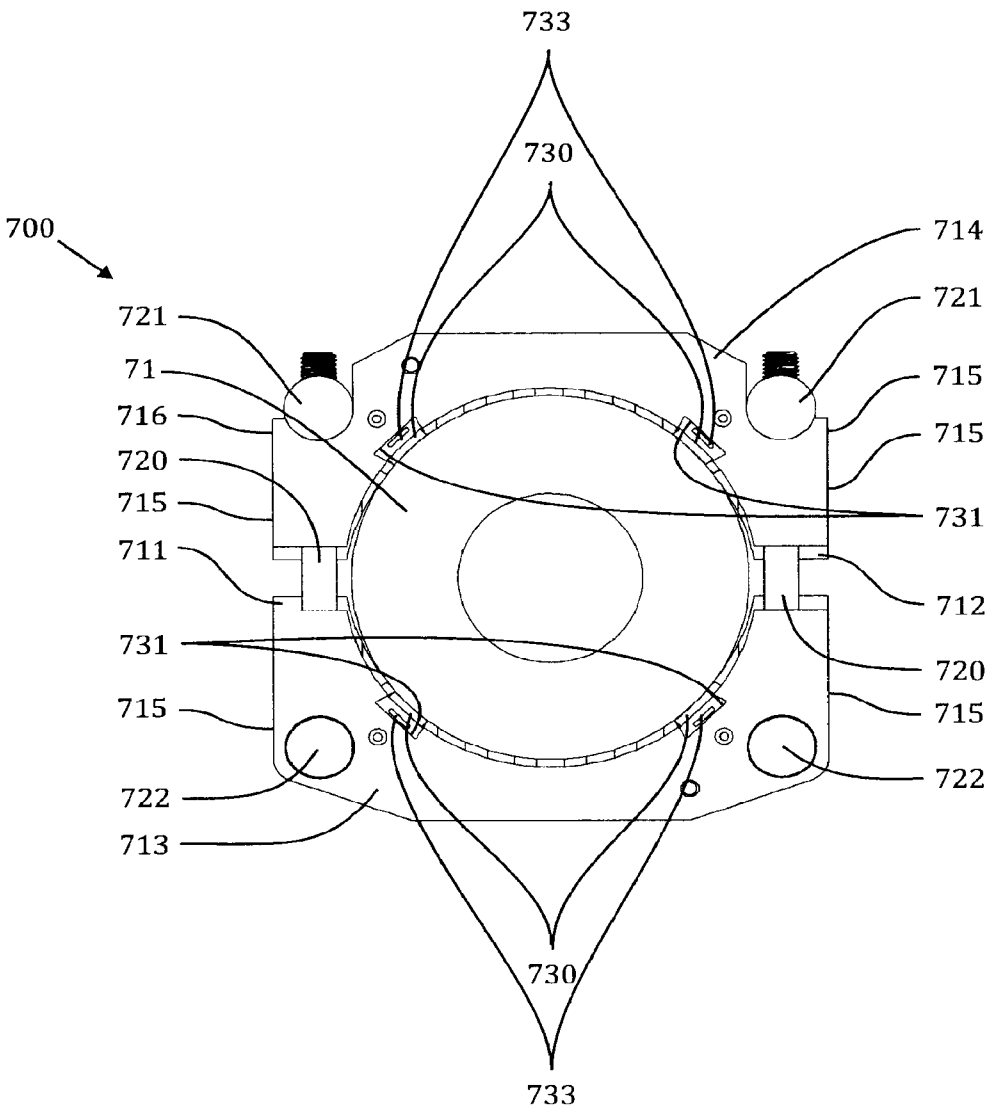
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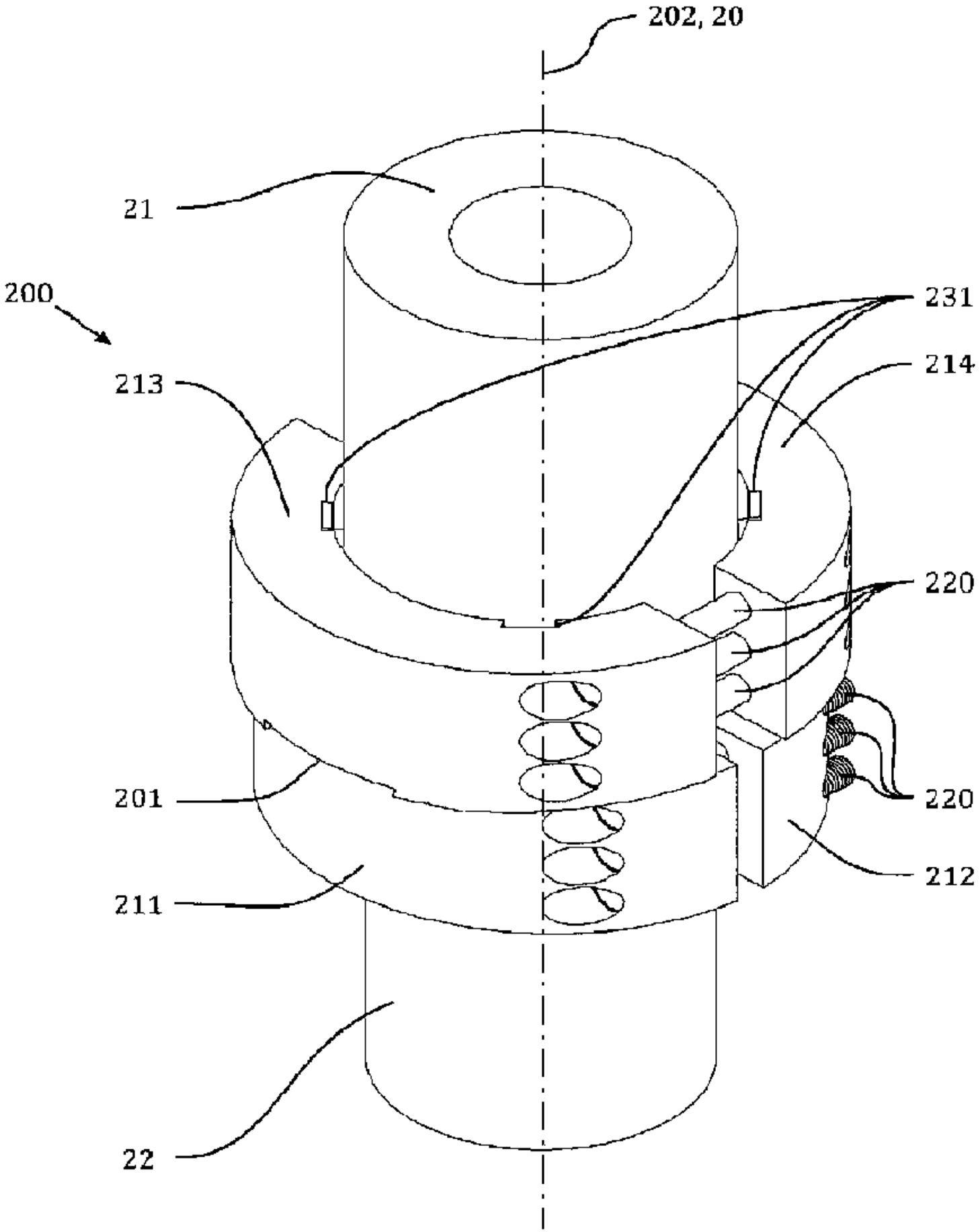
Figure 21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