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(54) **CONNECTOR**

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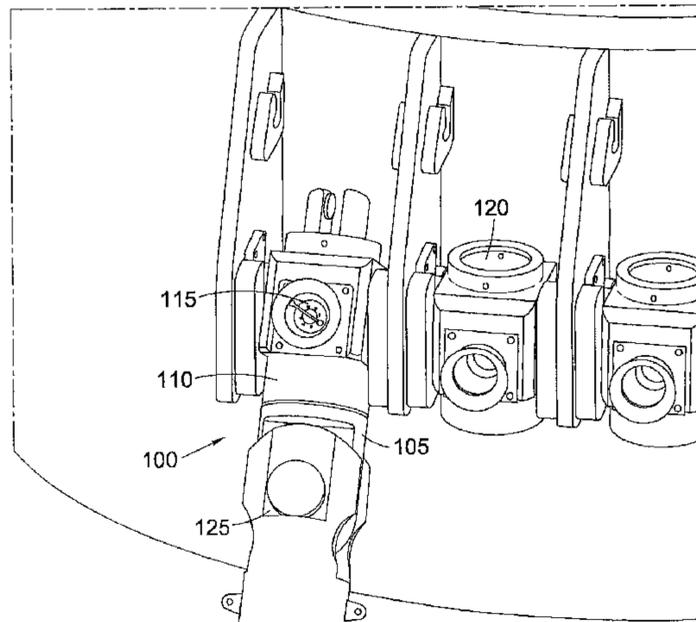
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(57) **ABSTRACT**

The invention relates to a connector, such as a subsea connector (100), for connecting a line or lines such as mooring lines (140), to a subsea structure (145), such as a submerged turret loading or a submerged turret production buoy. The invention also relates to associated apparatus, structures and methods. The subsea connector (100) comprises a first portion (105) and a second portion (110) and means (115) for connecting the first (105) and second portions (110). The means (115) for connecting comprise at least part of a through-passage (120) in the second portion (110). The first portion may comprise means (125) for connection to one or more lines (140), such as mooring lines, allowing rotational movement around or about a transverse axis of the first portion (105) with respect to the line (140). The second portion (110) may comprise means (130) for connection to a subsea structure (145) allowing rotational movement around or about a transverse axis of the second portion (110) with respect to the subsea structure (145). In some examples, the transverse axis of the first portion (105)

(Continued)



may be substantially perpendicular to the transverse axis of the second portion (110).

36 Claims, 21 Drawing Sheets

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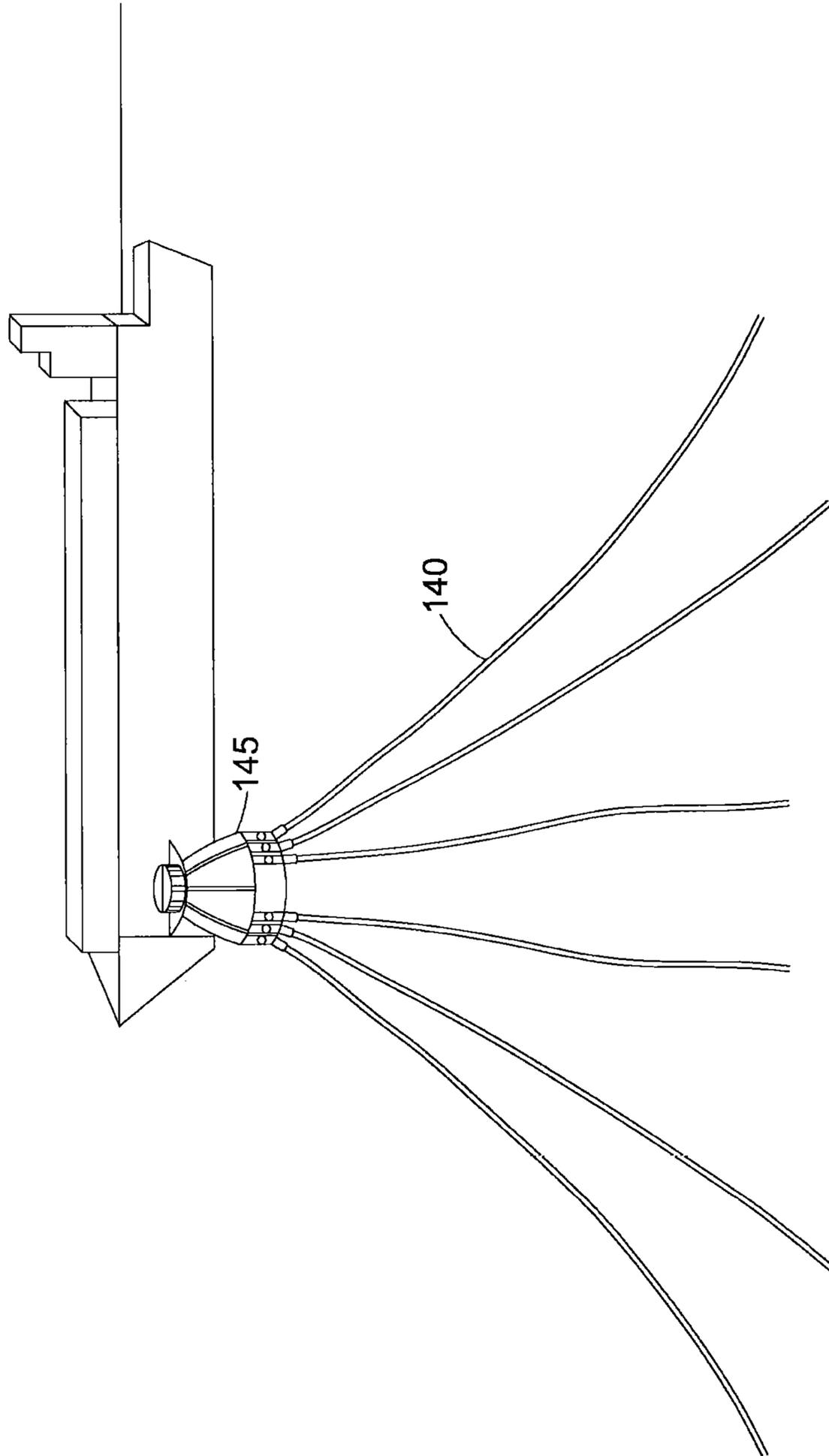


Fig. 1

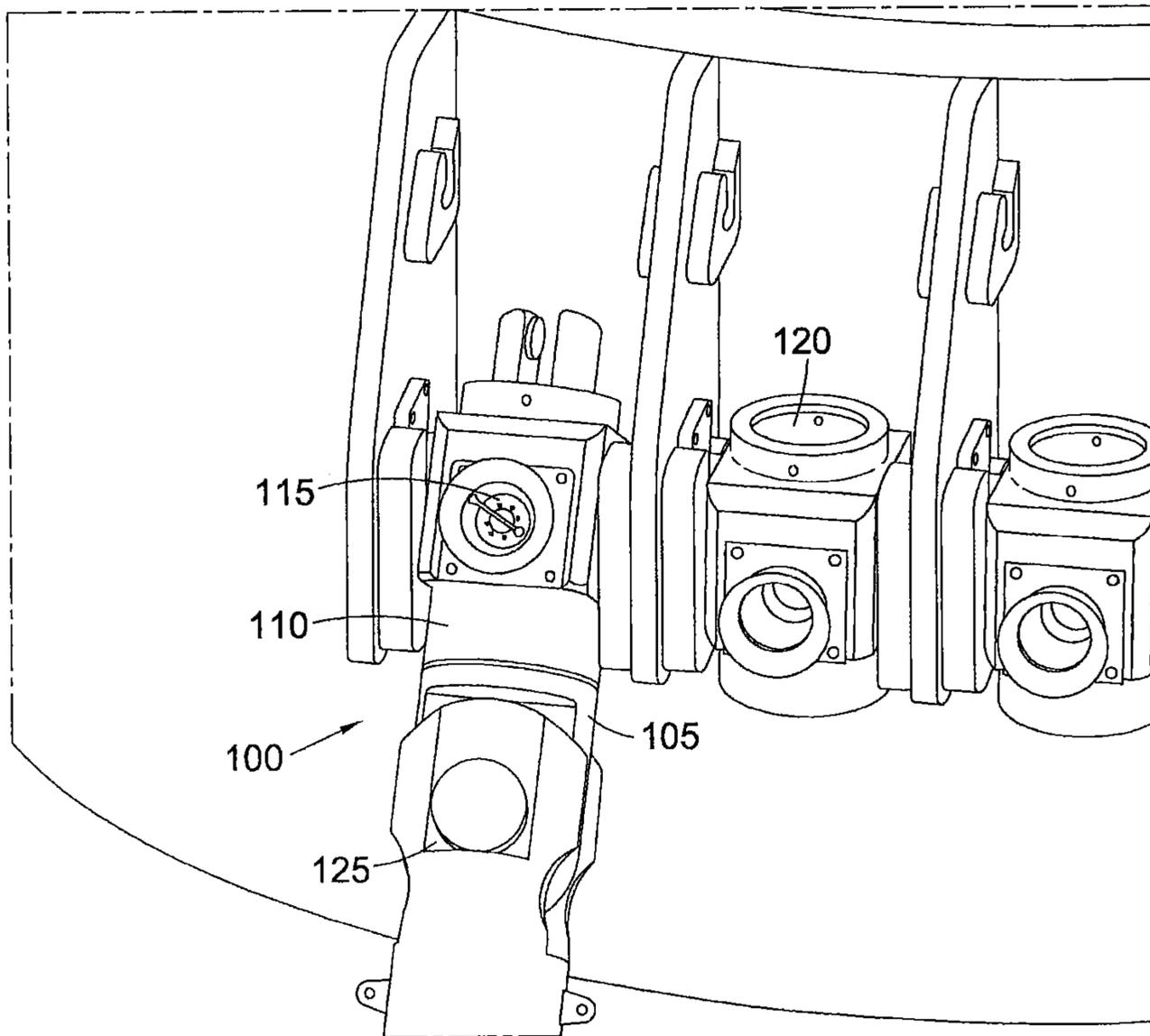


Fig. 2

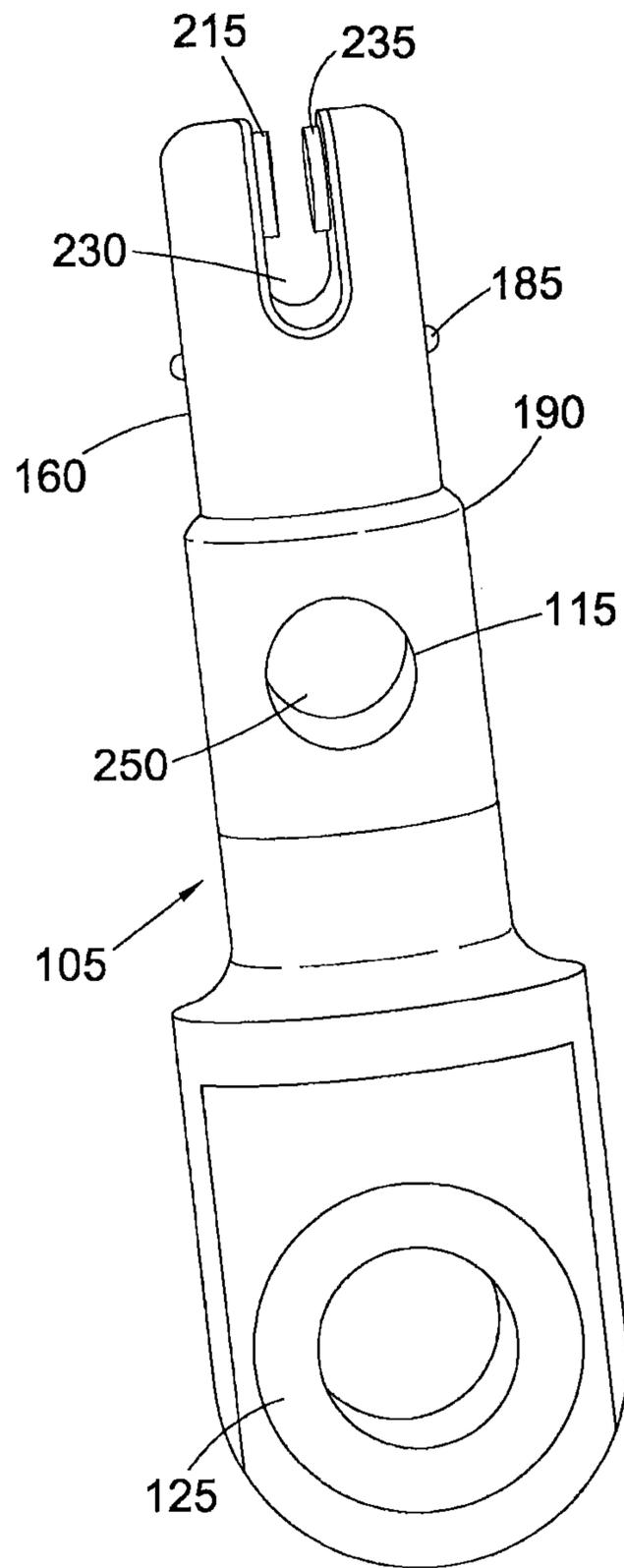


Fig. 3

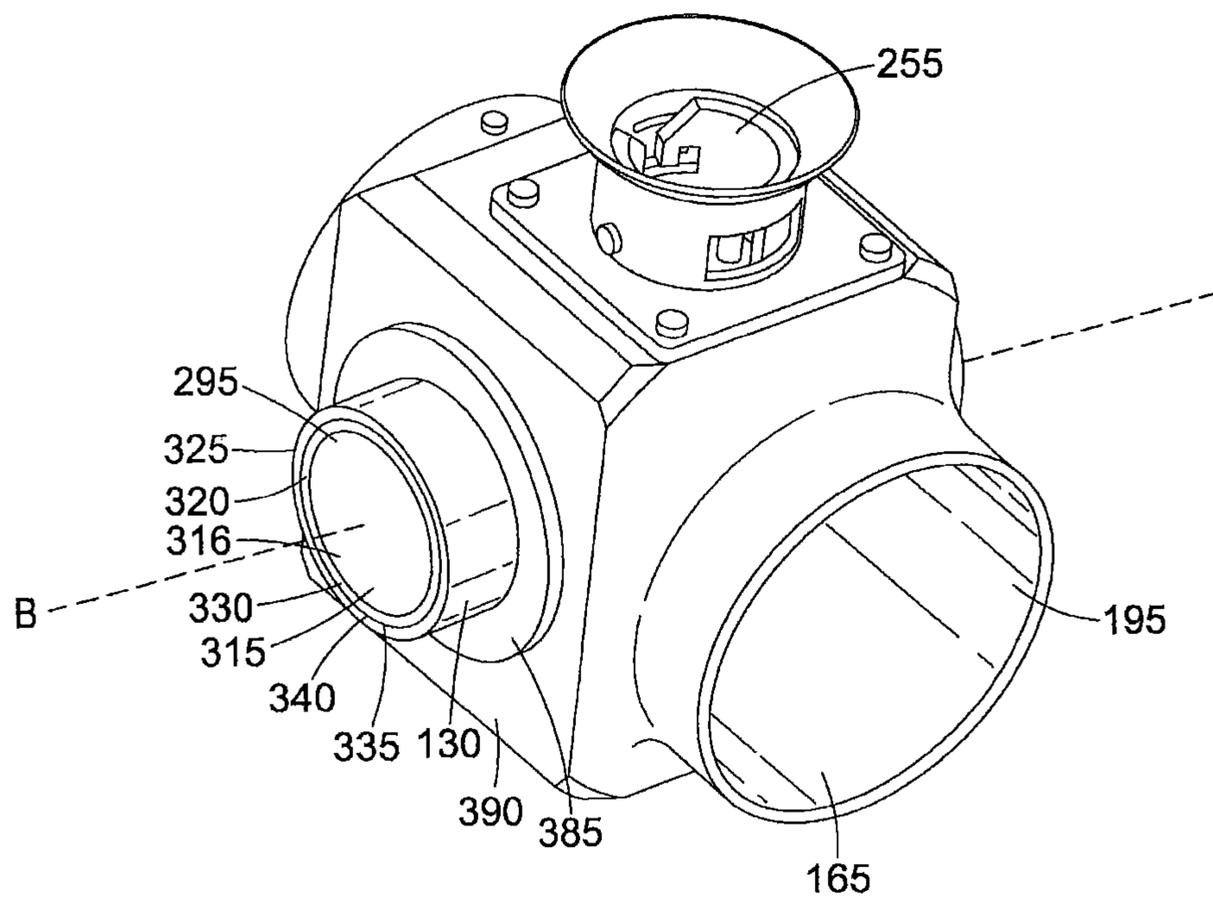


Fig. 4

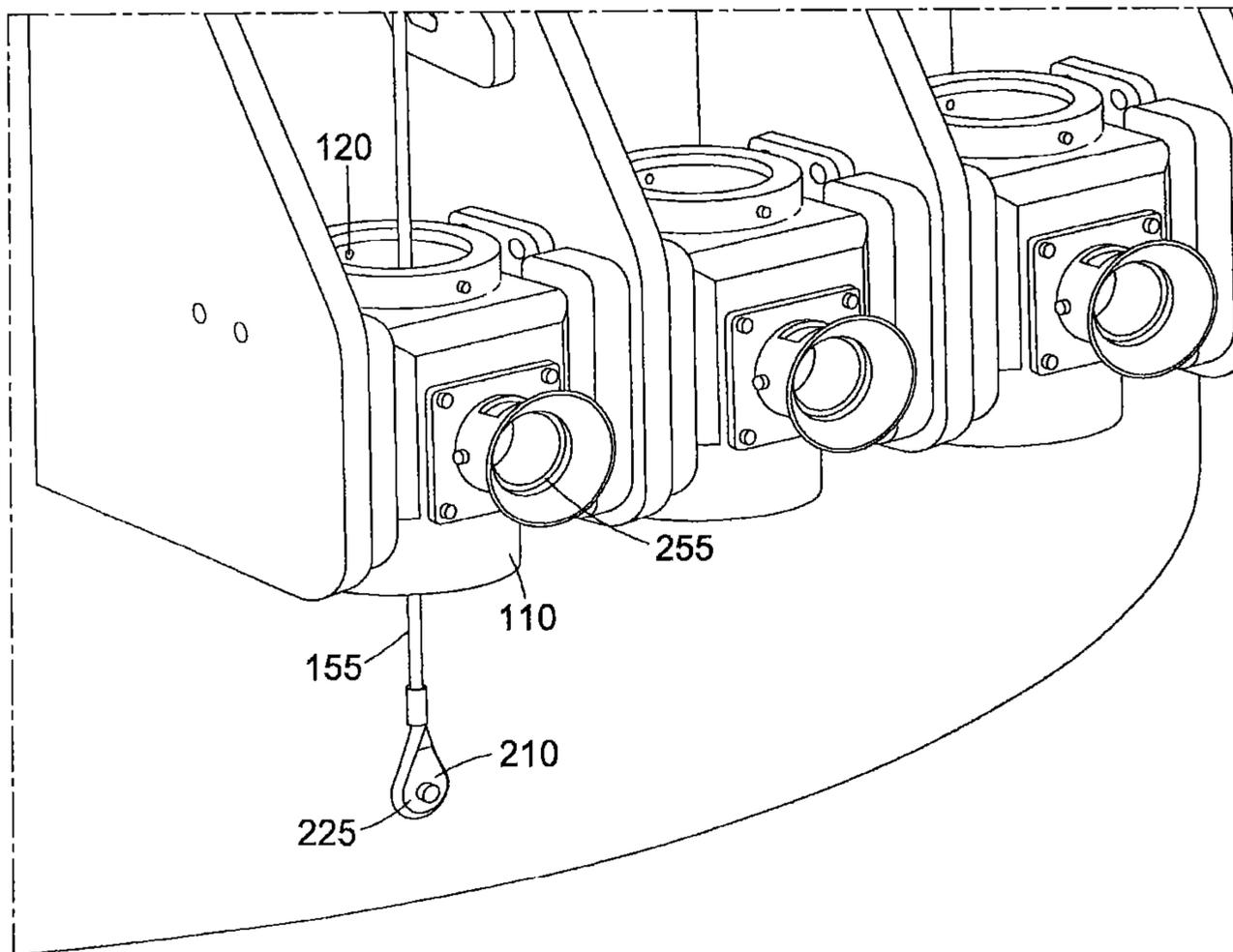


Fig. 5

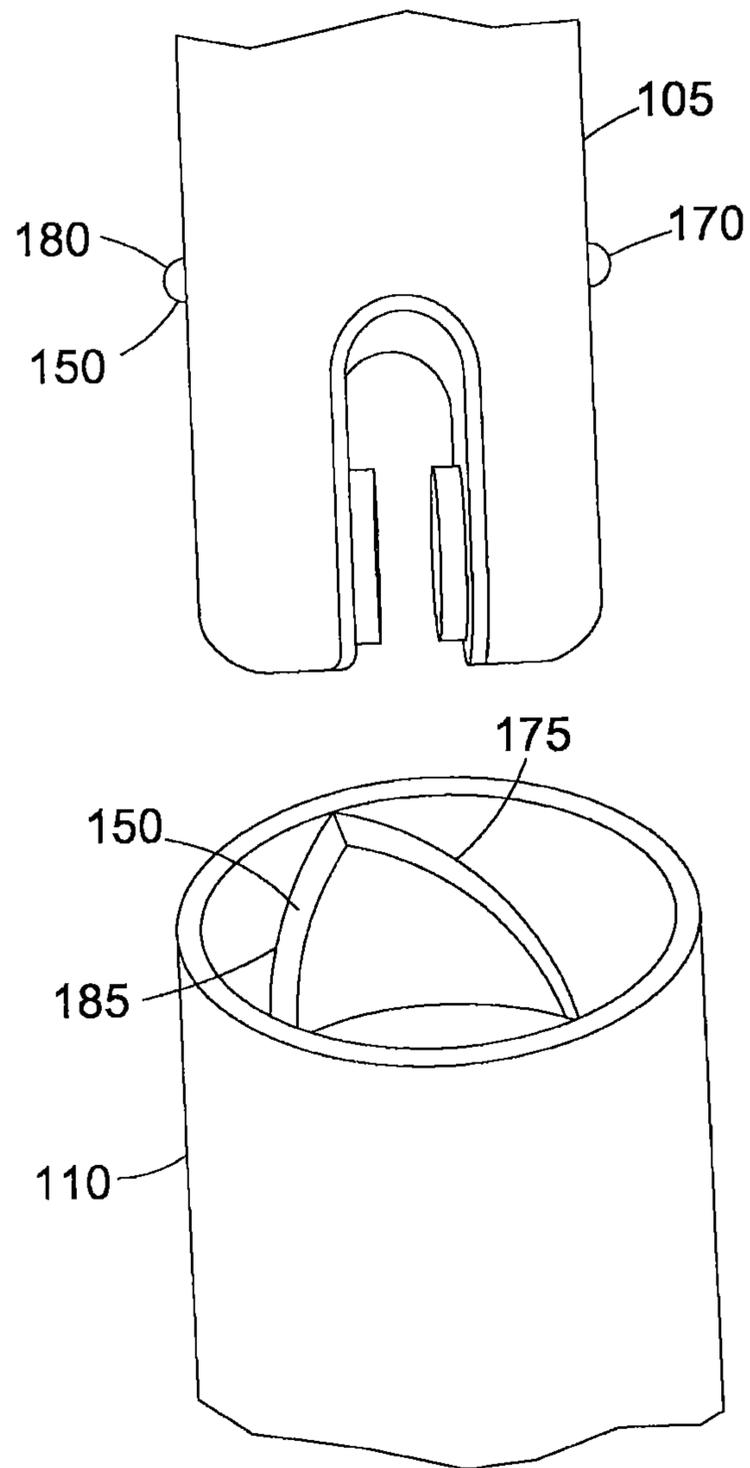


Fig. 6

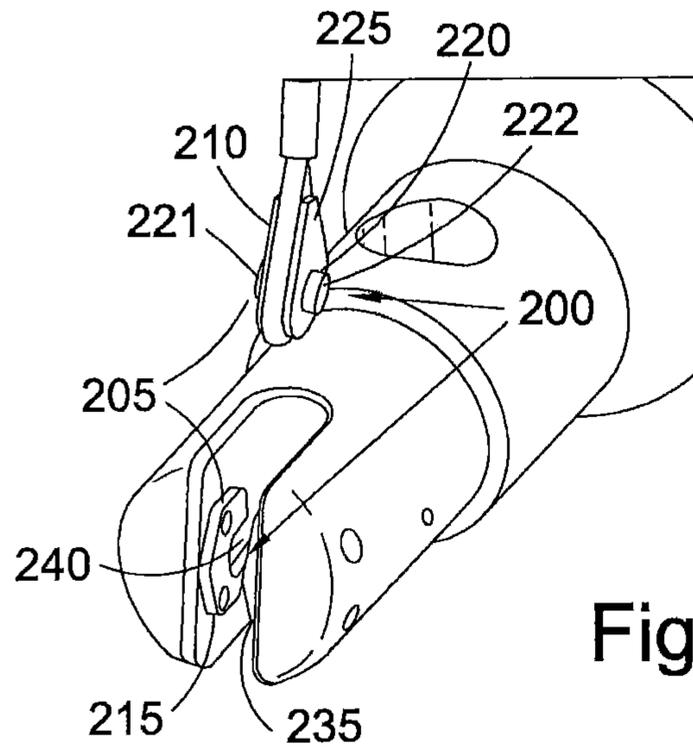


Fig. 7a

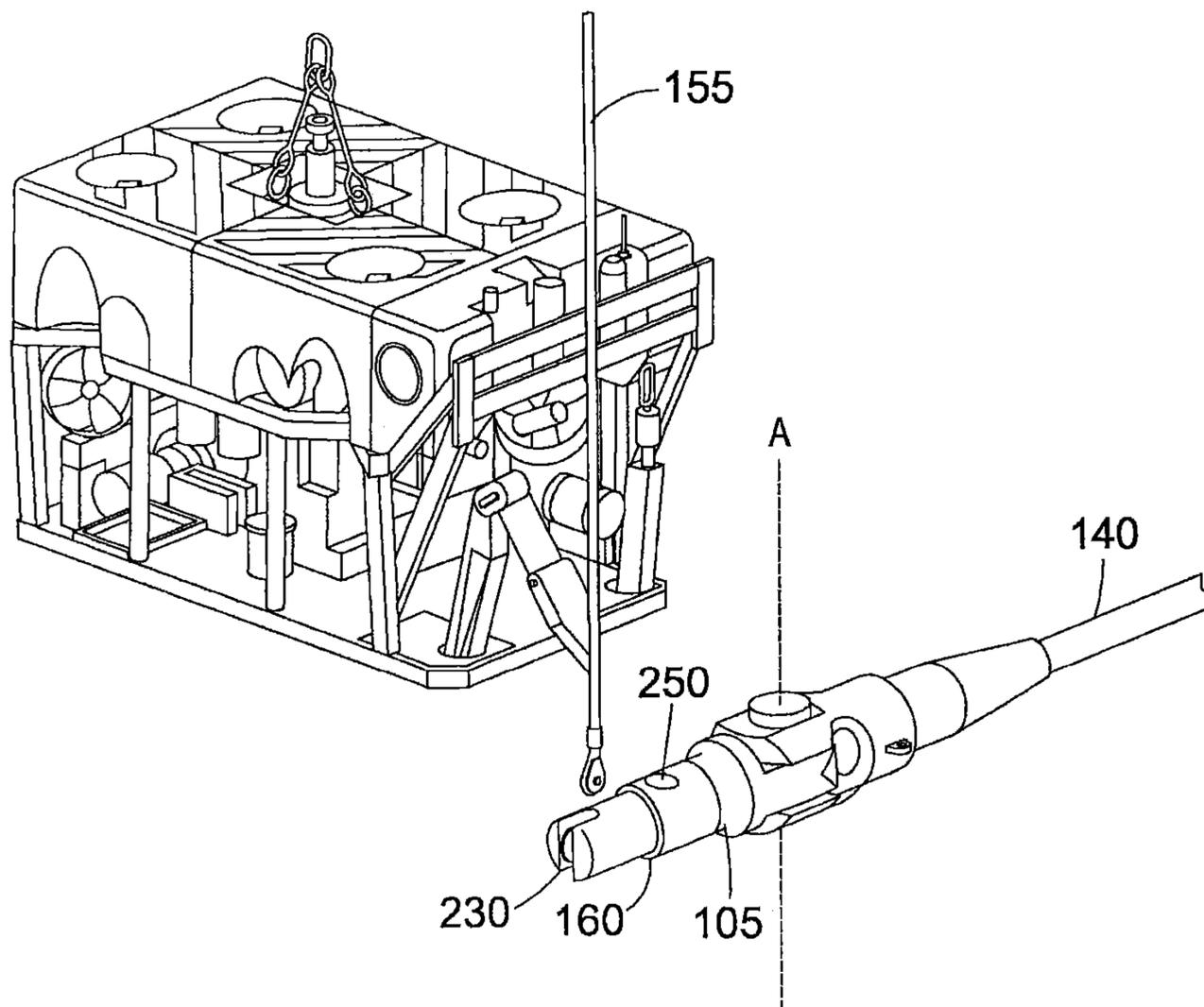


Fig. 7b

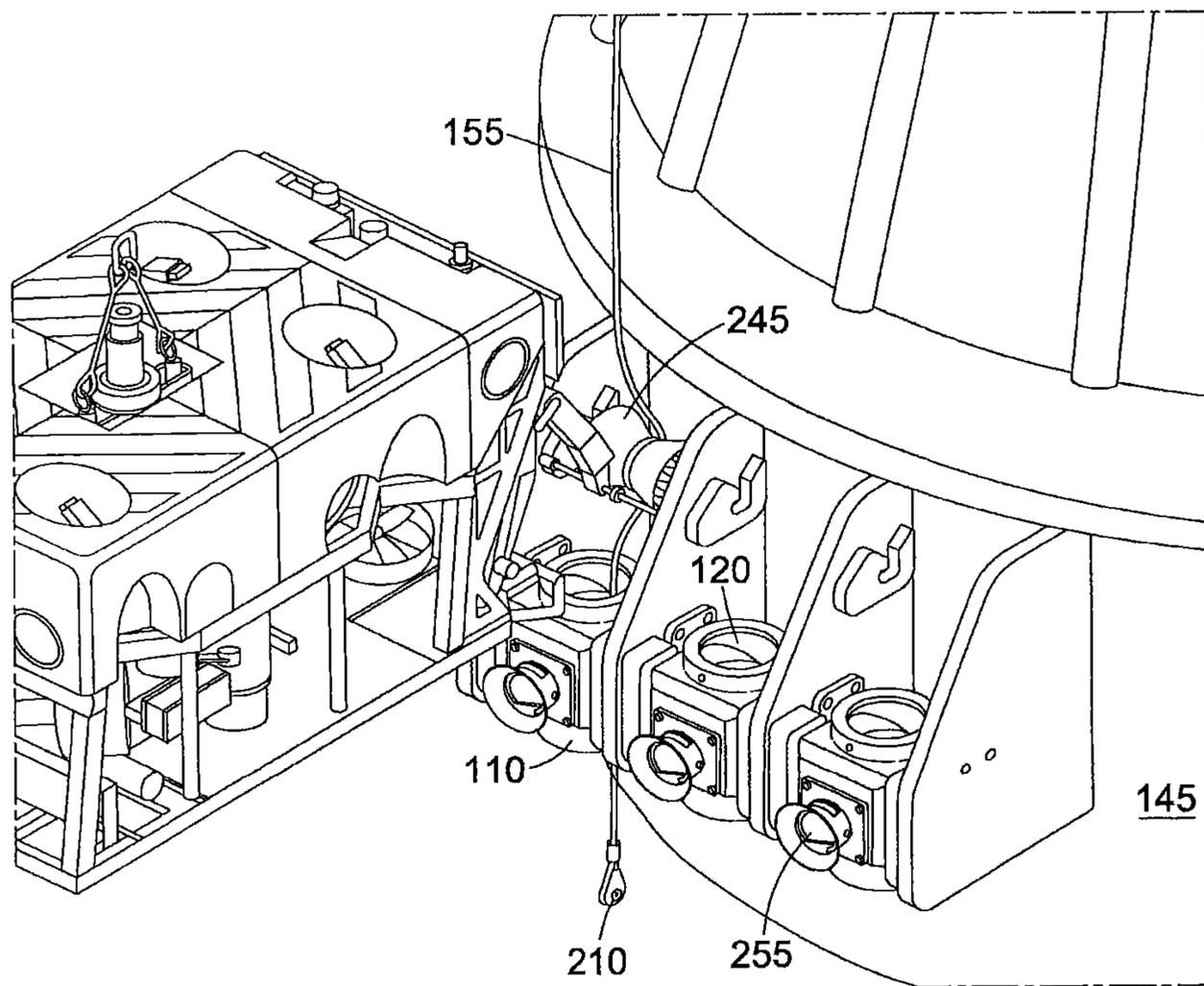


Fig. 8

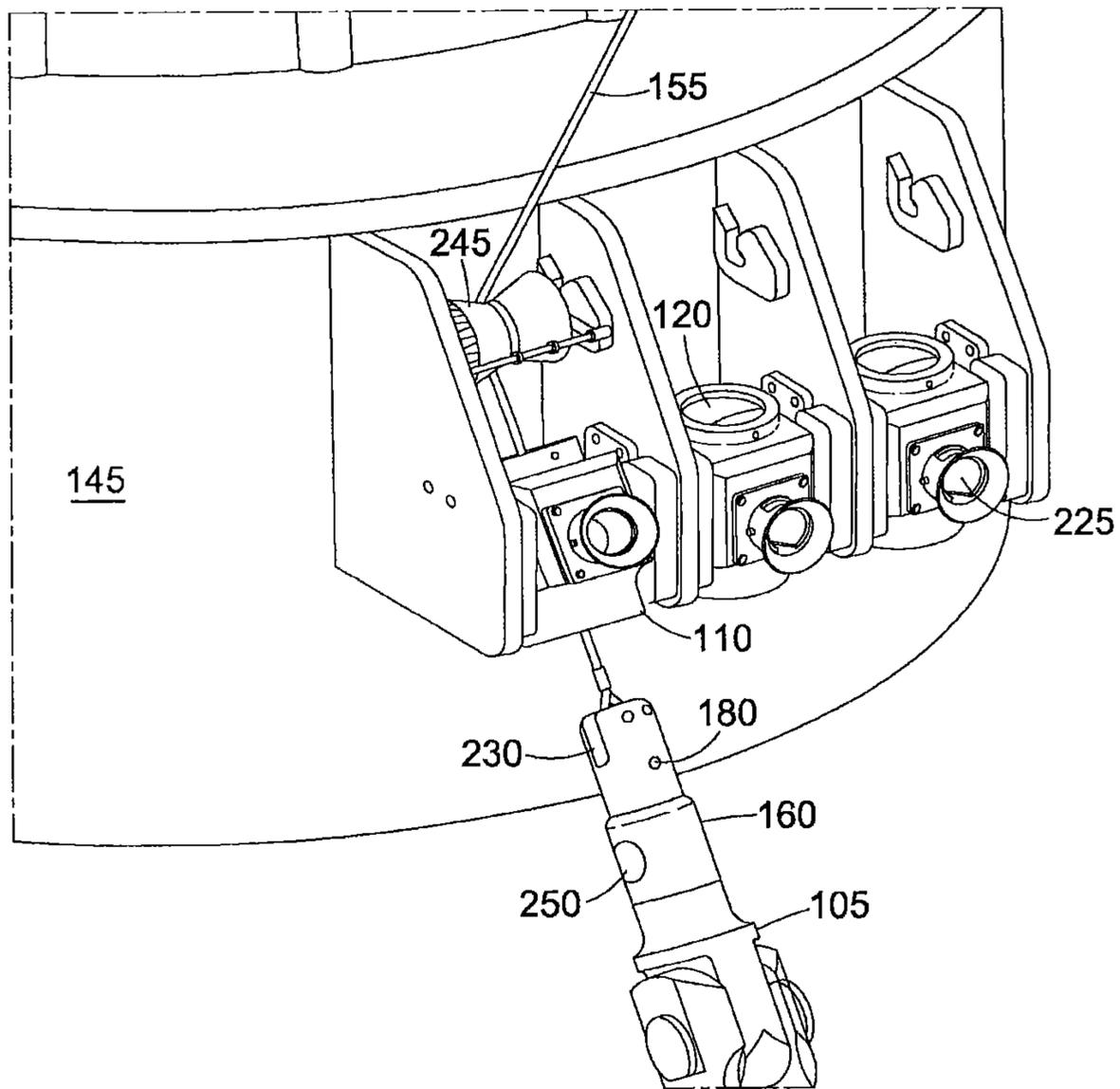


Fig. 9

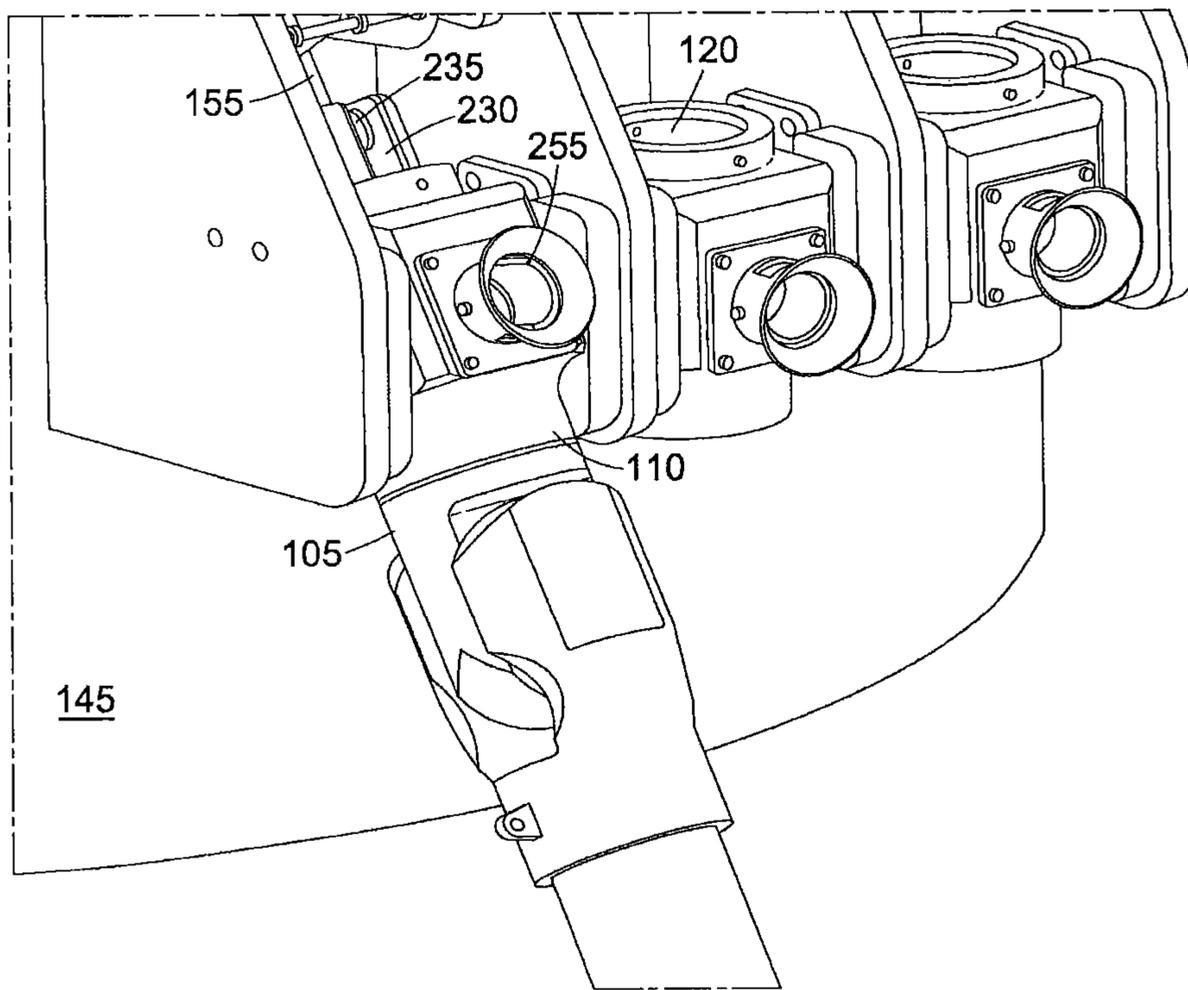


Fig. 10

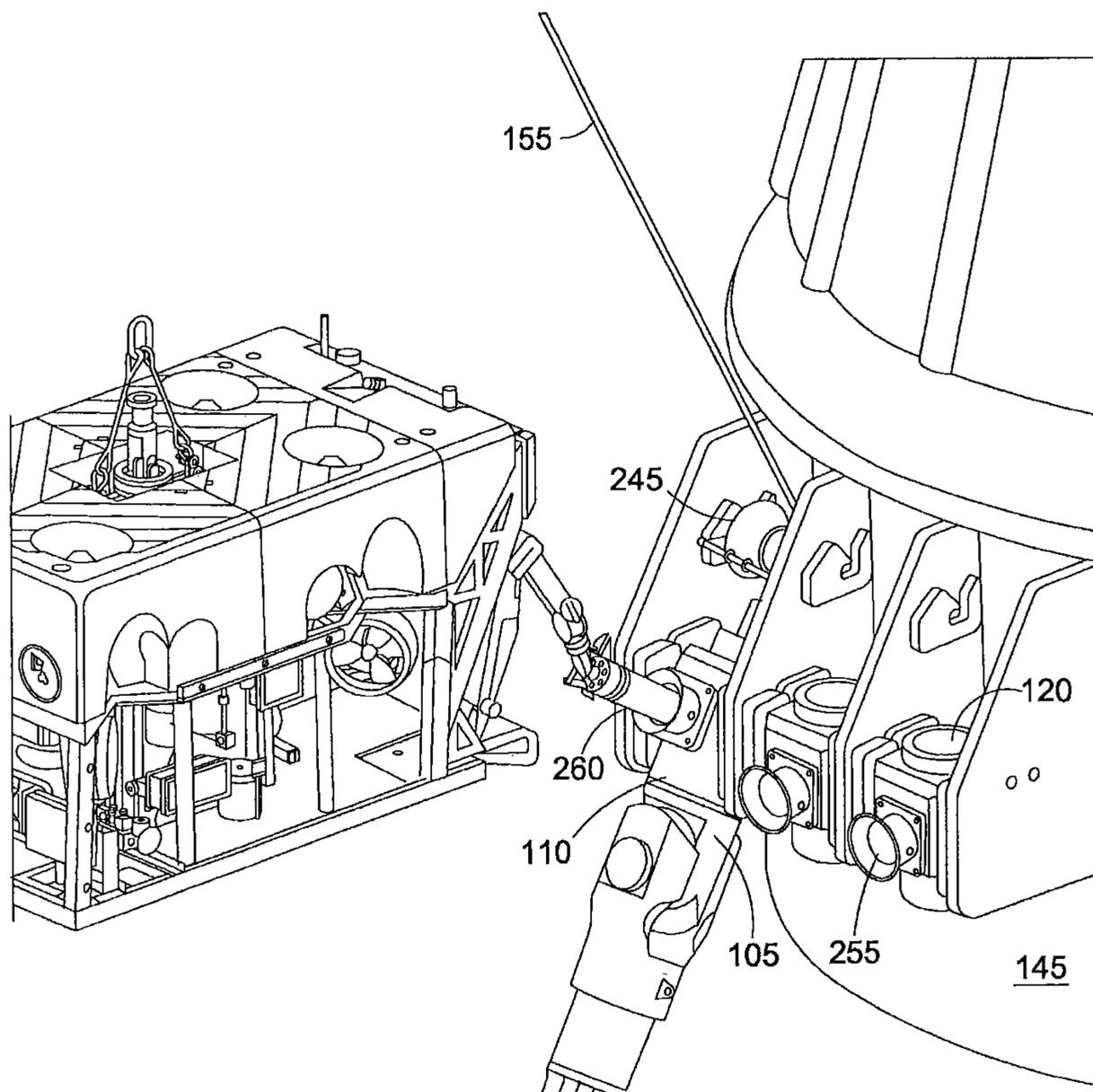


Fig.11

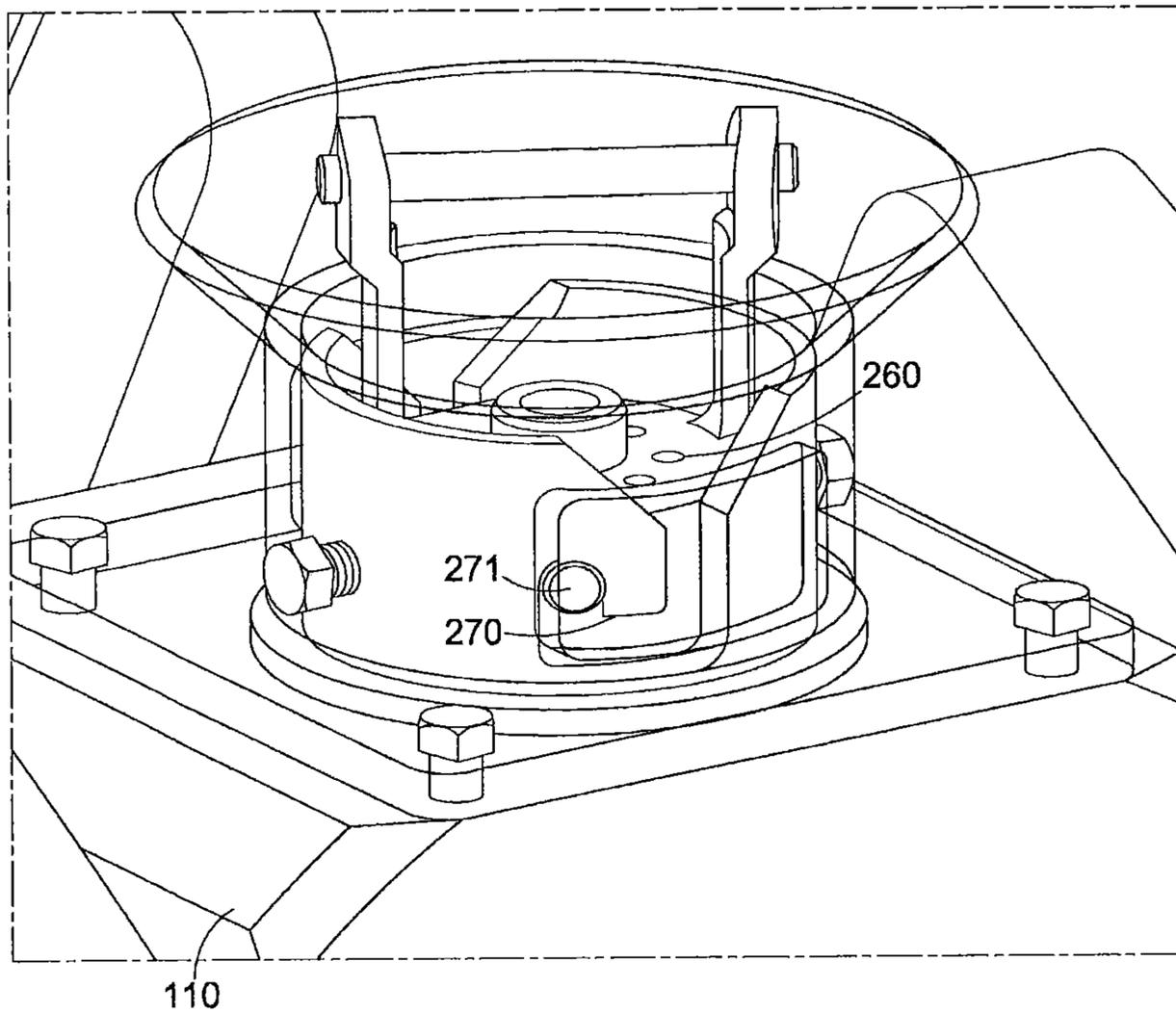


Fig.12

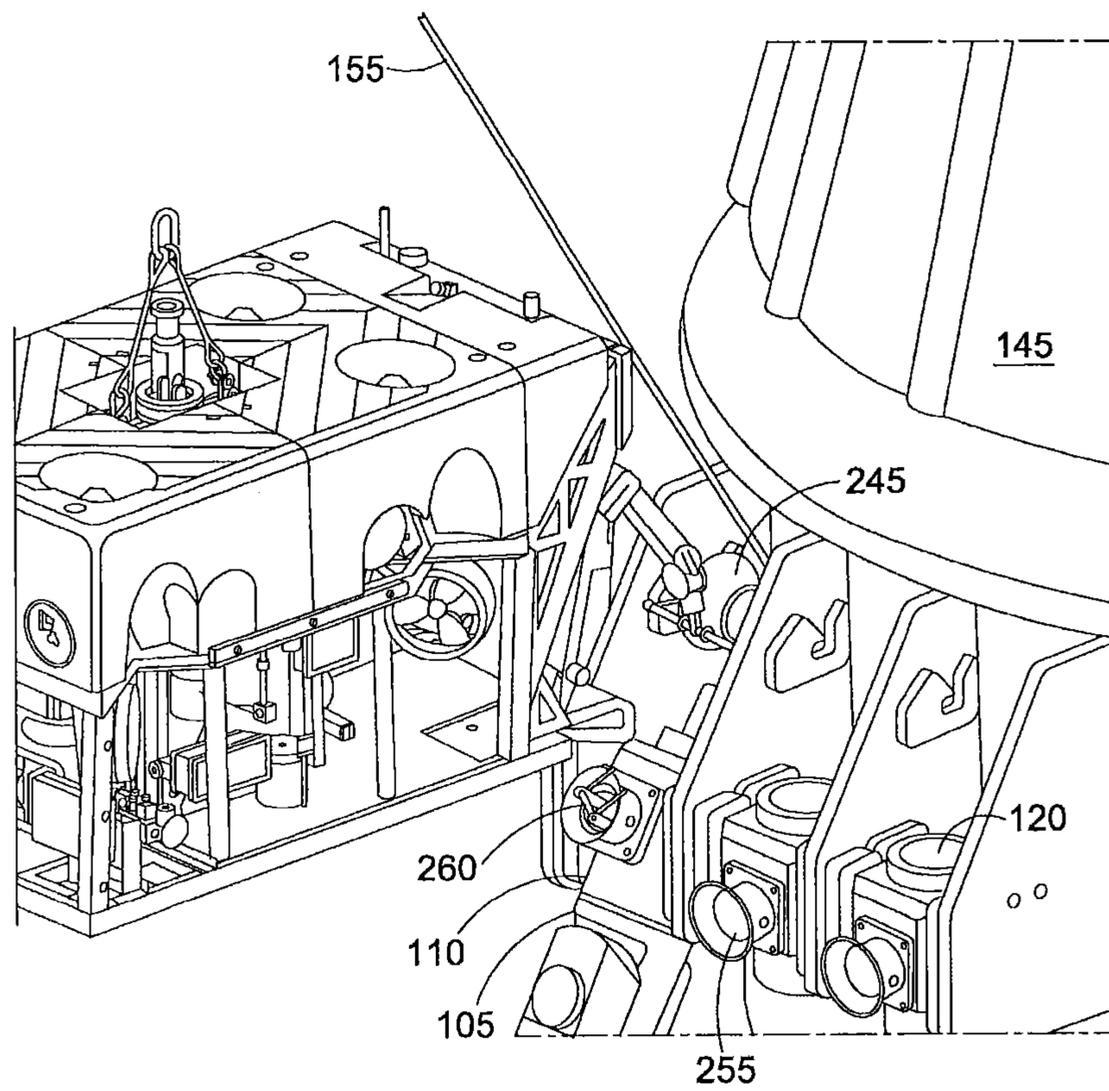


Fig.13

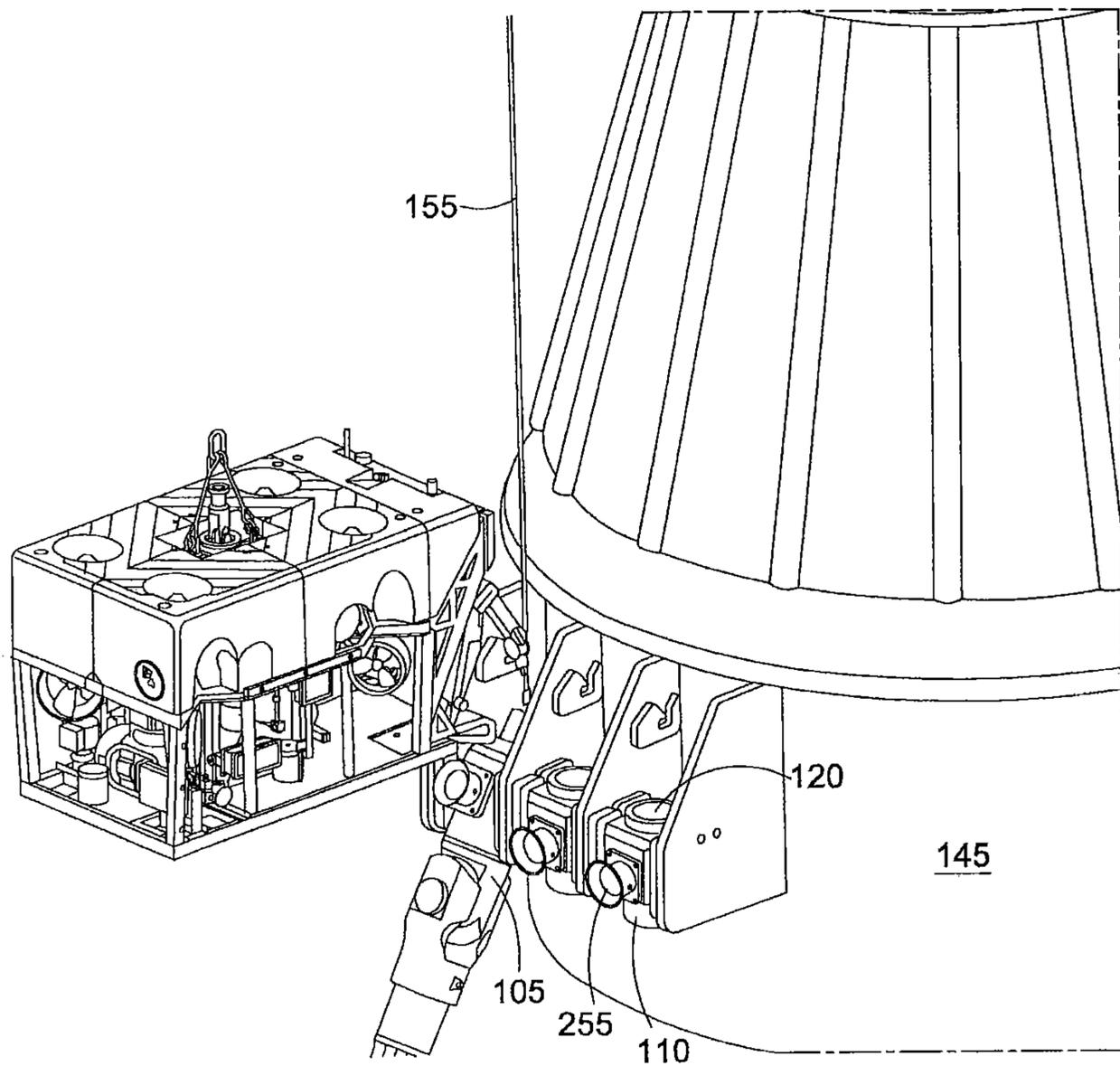


Fig.14

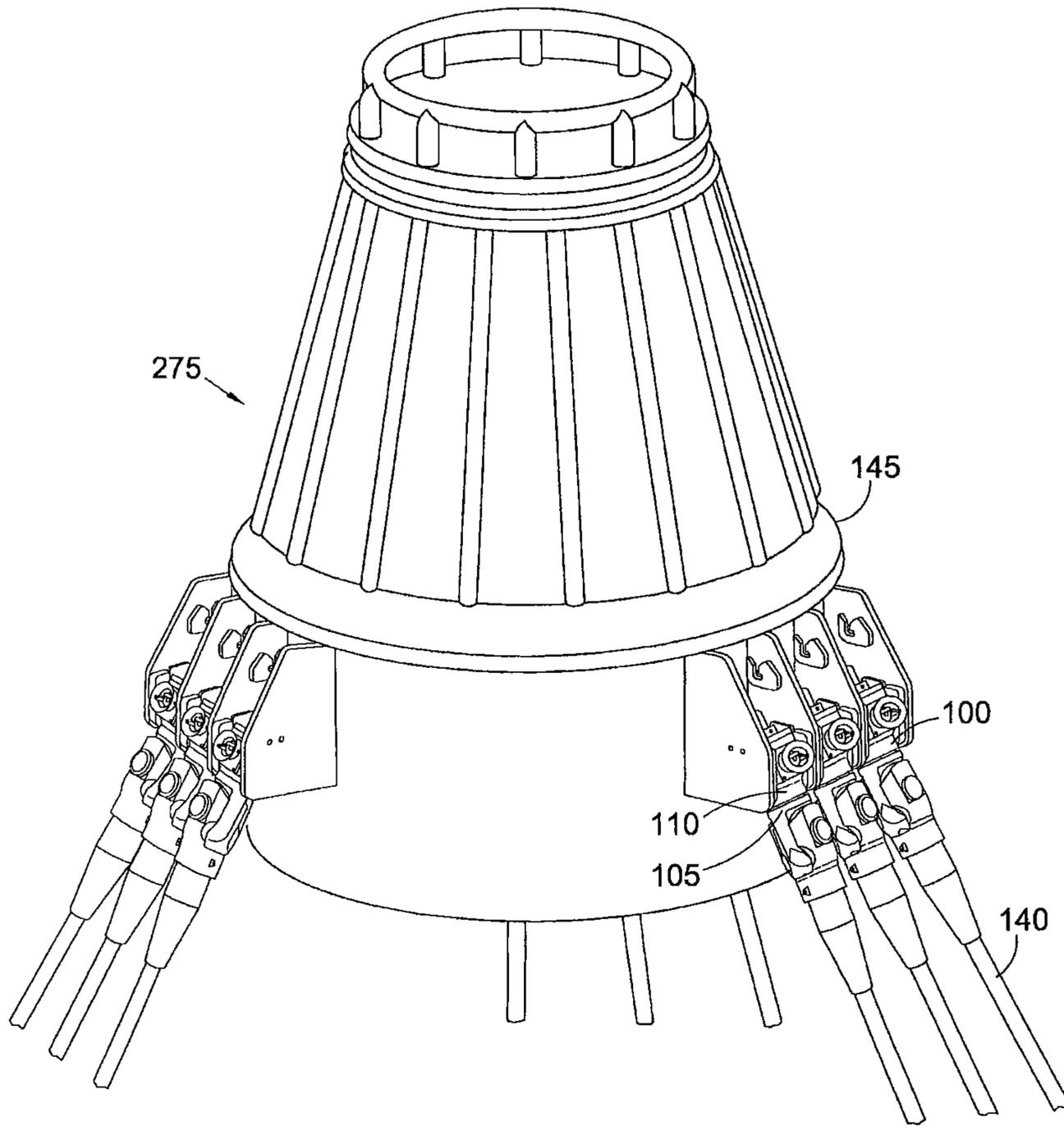


Fig.15

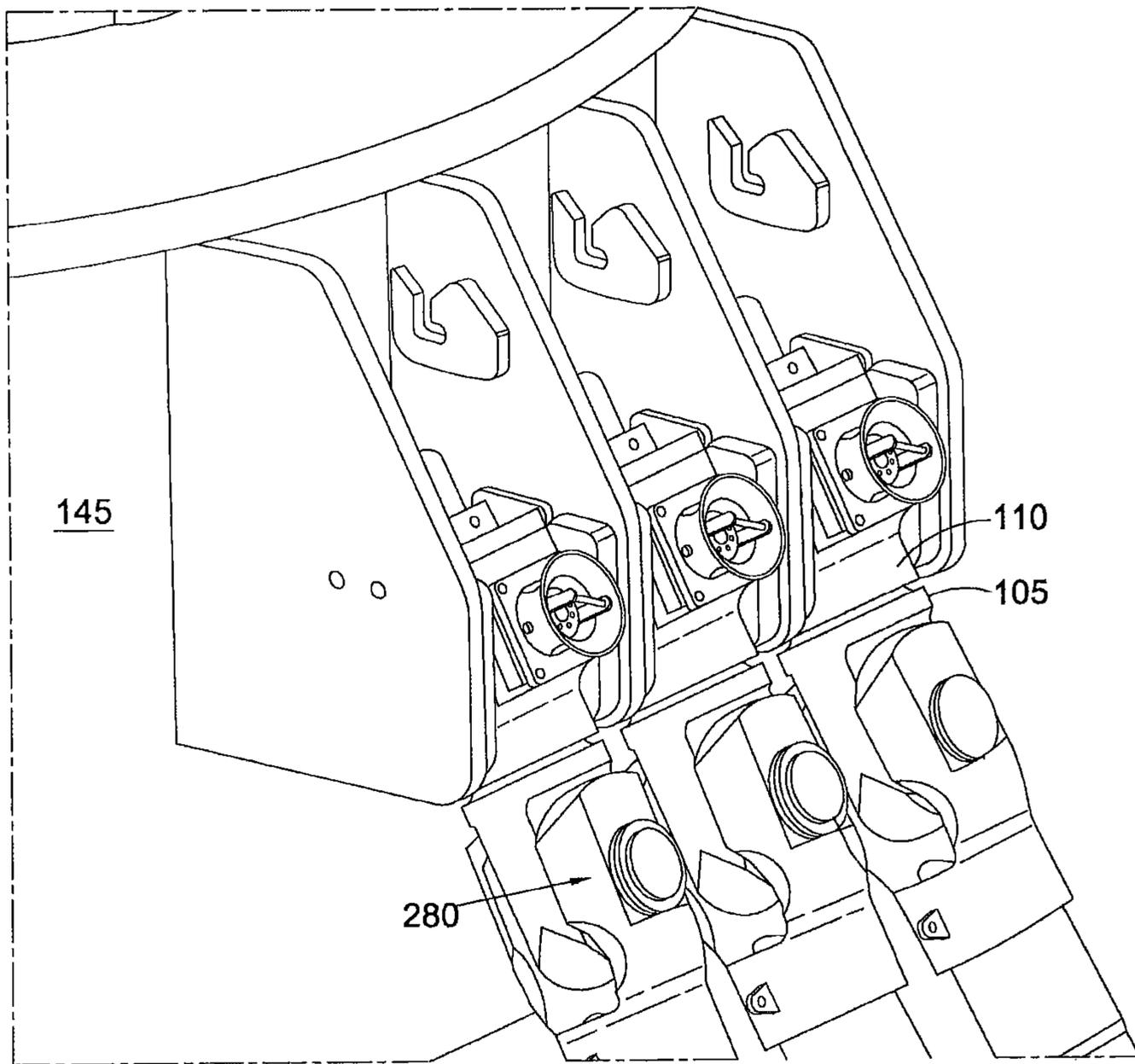


Fig.16

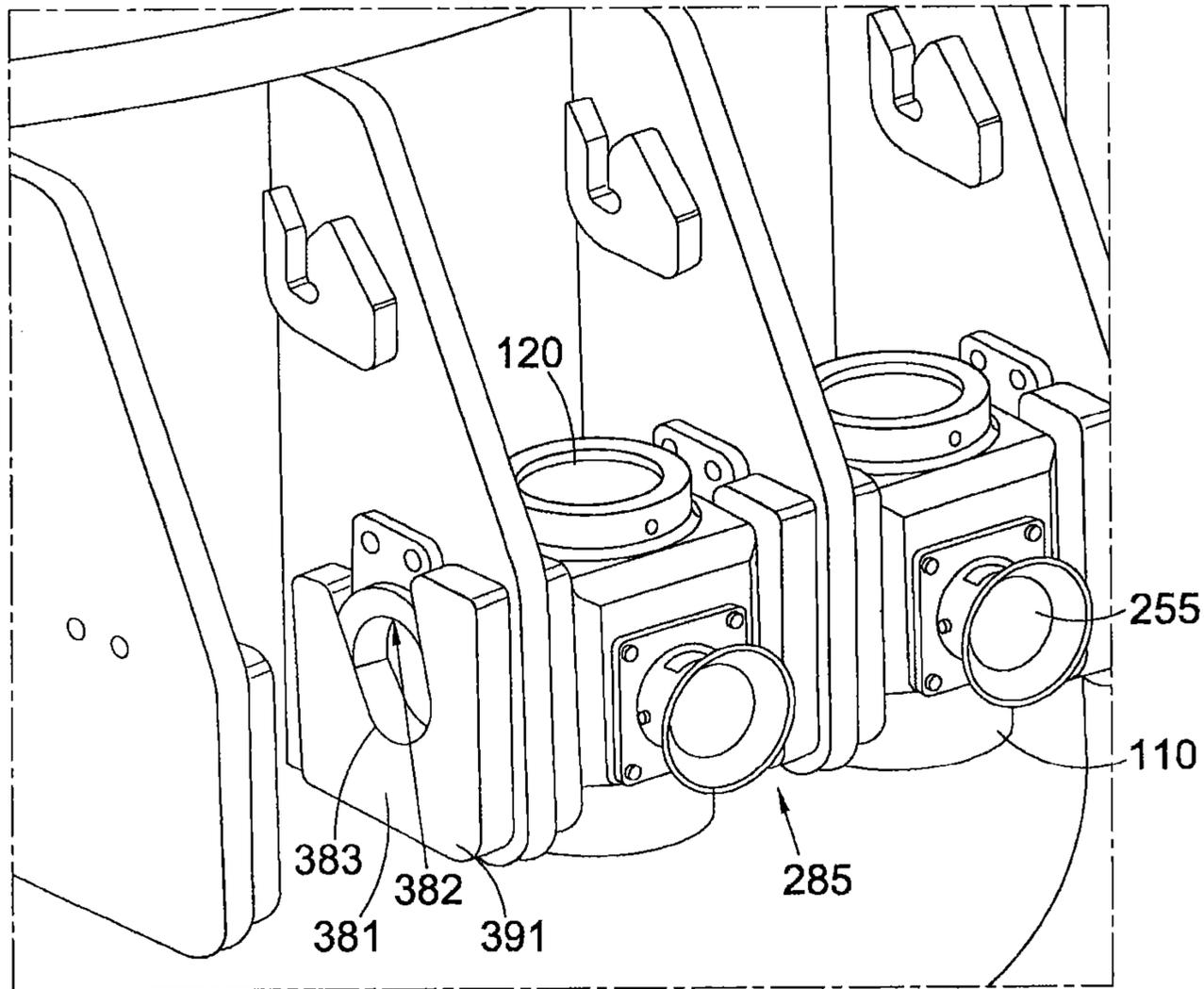


Fig.17

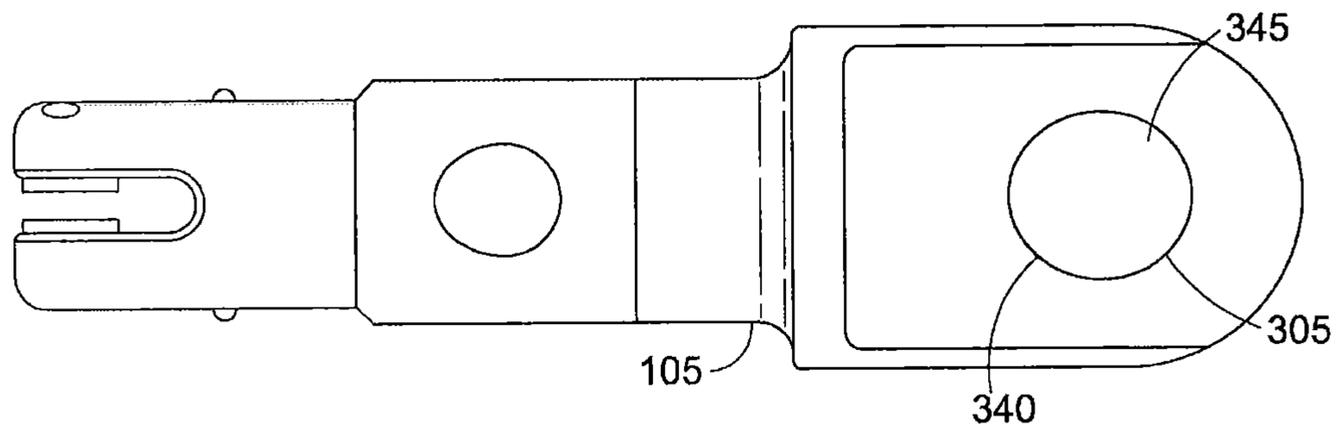


Fig.18a

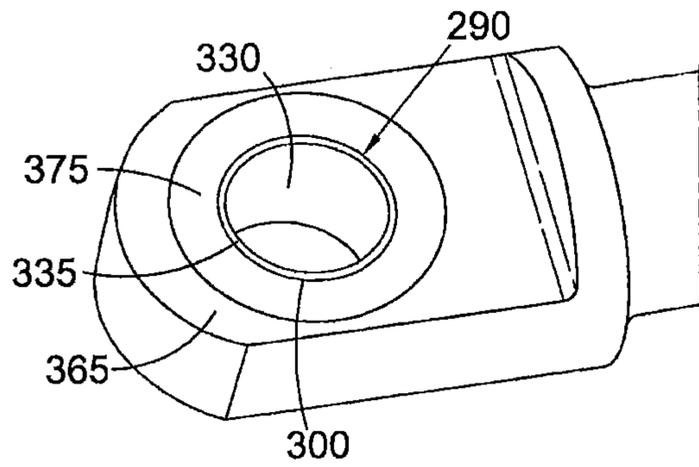


Fig.18b

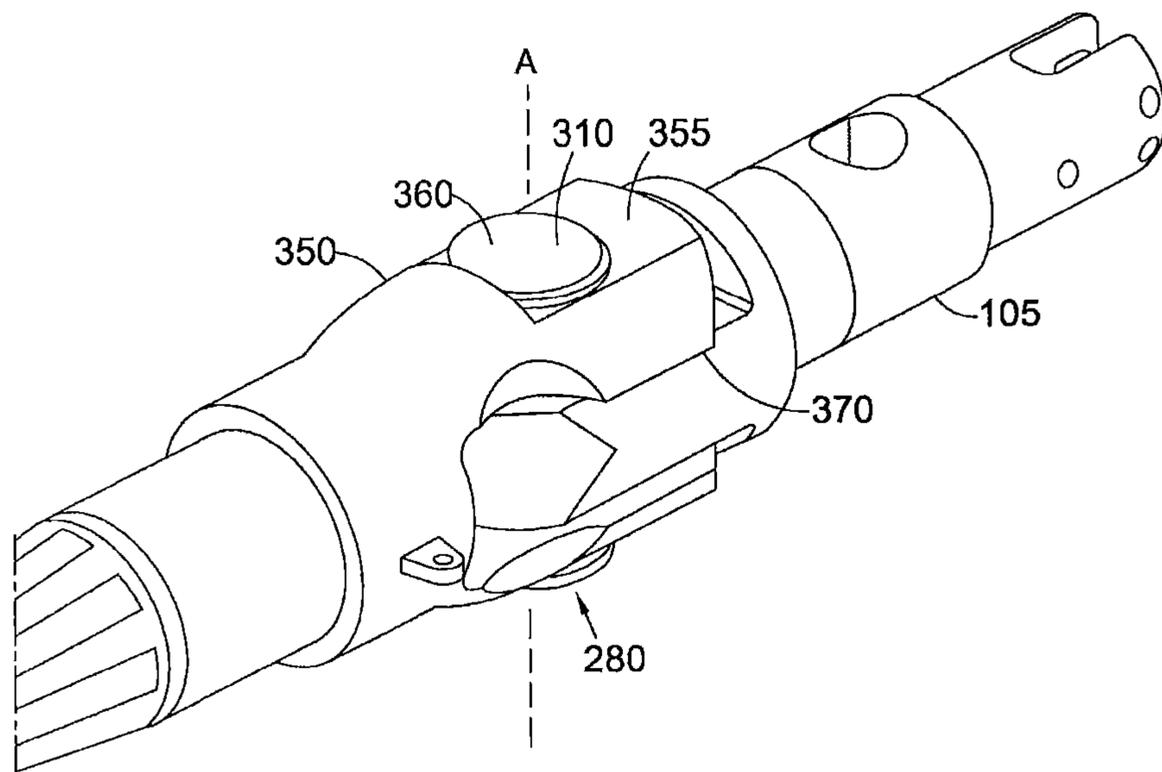


Fig.19

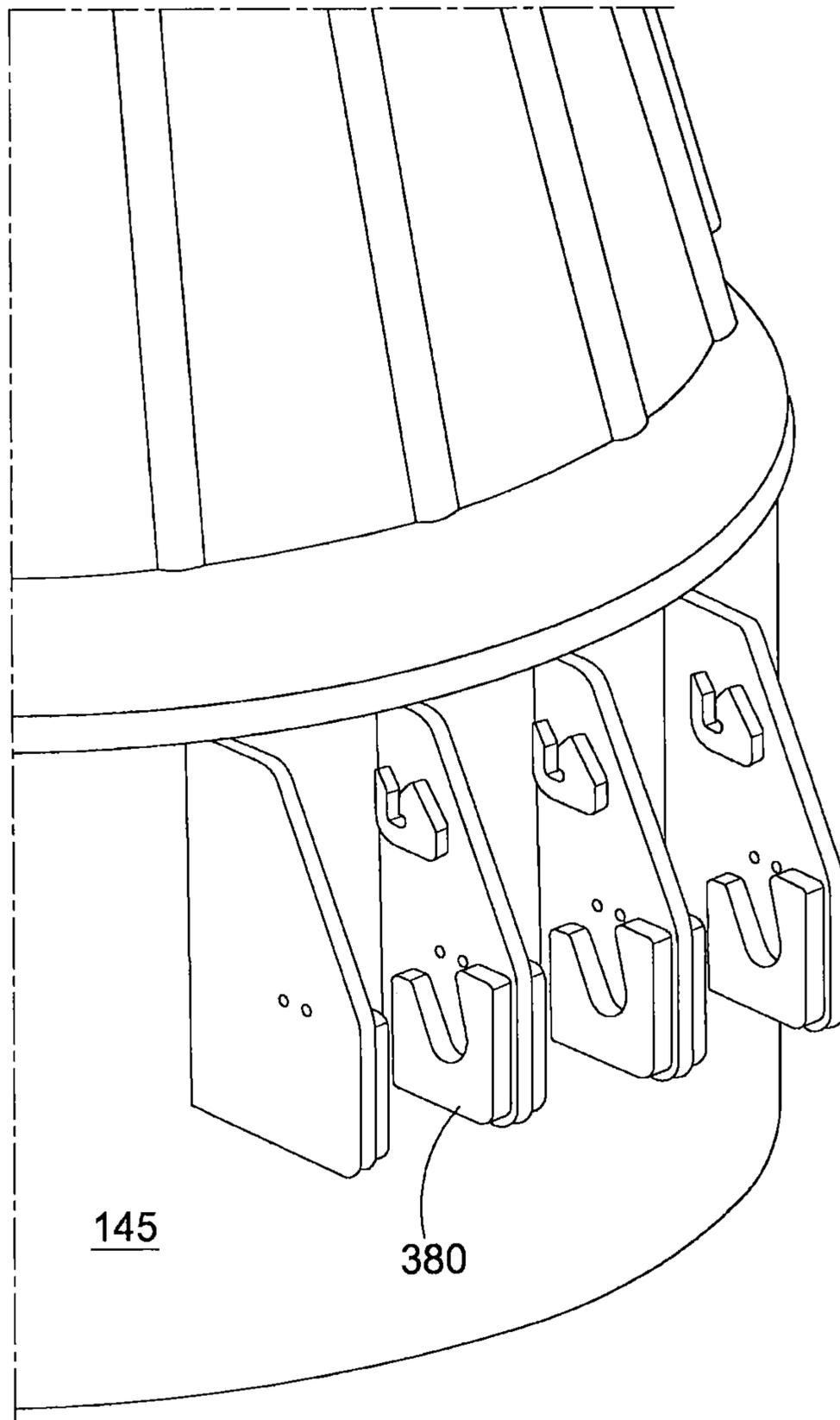


Fig.20

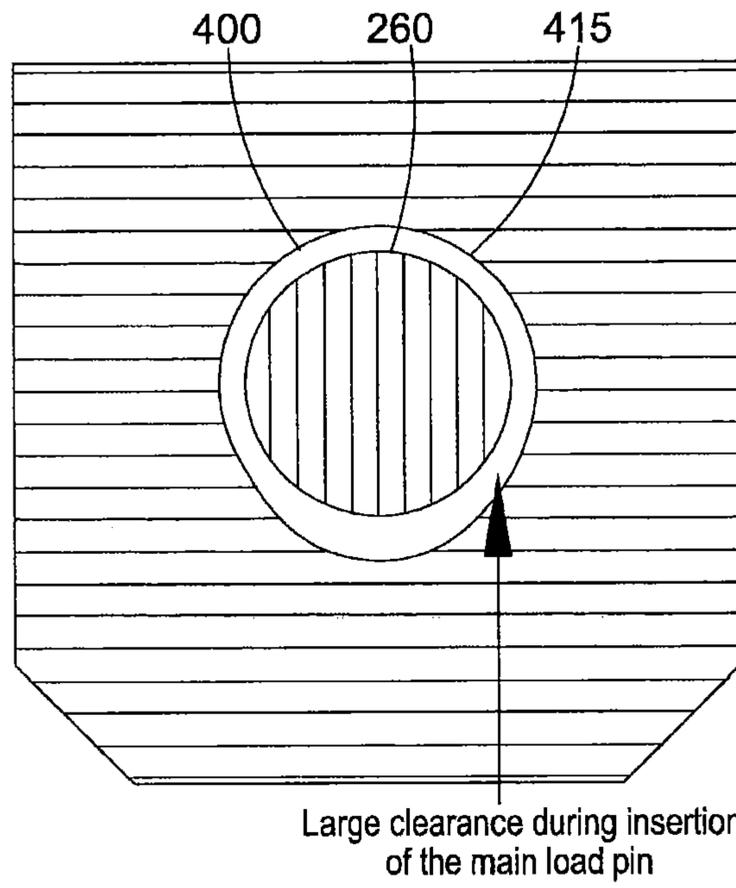


Fig.21(a)

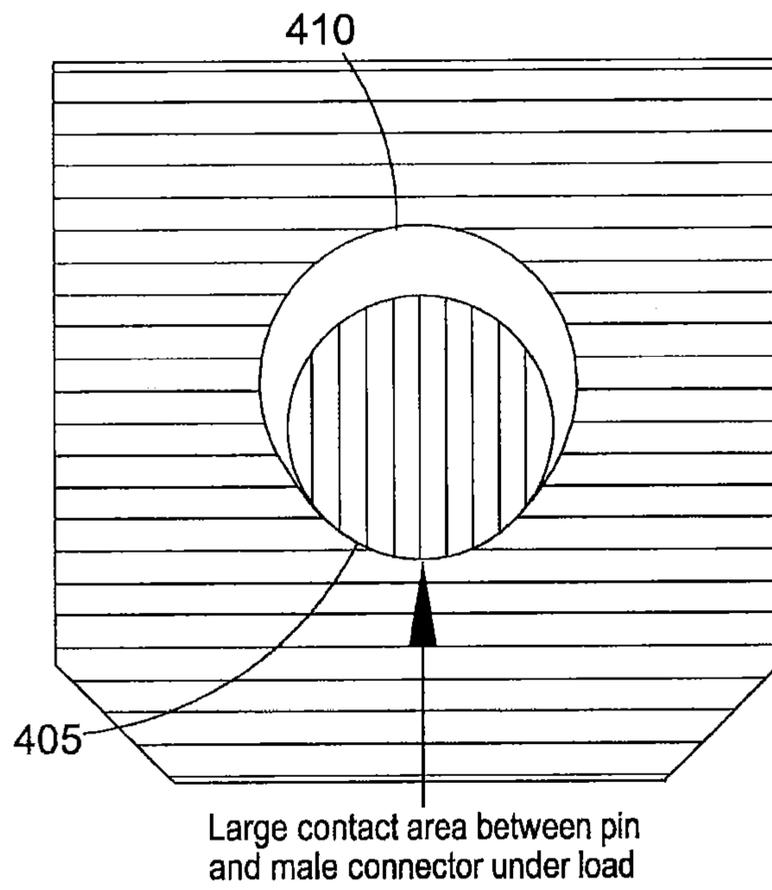


Fig.21(b)

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CONNECTOR

Matter enclosed in heavy brackets [] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue; a claim printed with strikethrough indicates that the claim was canceled, disclaimed, or held invalid by a prior post-patent action or proceeding.

RELATED APPLICATIONS

This application is a 35 U.S.C. § 371 national stage application of PCT Application No. PCT/GB2014/050940, filed on Mar. 25, 2014, which claims priority from British Application No. 1305420.0 filed on Mar. 25, 2013, the contents of which are hereby incorporated herein by reference in their entireties. The above-referenced PCT International Application was published as International Publication No. WO 2014/155094 A1 on Oct. 2, 2014.

FIELD OF INVENTION

The present invention relates to a connector, such as a subsea connector, for connecting a line or lines such as mooring lines, to a subsea structure, such as a submerged turret loading or a submerged turret production buoy. The invention also relates to associated apparatus, structures and methods.

BACKGROUND TO INVENTION

Mooring lines, e.g. wire, chain or synthetic mooring lines (such as polyester lines) used subsea, for example, in the oil, gas, offshore wind, or tidal energy industries, etc., can be attached to those subsea structures by means of a connector. The mooring of such structures may be permanent. However, corrosion of the wires or lines used for mooring may require the replacement of the corroded lines or wires. When such structures are deployed beyond a depth where it is commercially acceptable to use a diver, then such connection may need to be established using a remotely operated vehicle (ROV), which may be used to both connect and disconnect such lines.

Even when not operating beyond a diver depth, better connectors for use with ROVs may be desired, since many operators choose not to use divers, even where practical.

There remains a need for a new, simple, robust and easy to use connector.

SUMMARY OF INVENTION

According to a first aspect there is provided a subsea connector. The connector may comprise a first portion and a second portion. The connector may comprise means for connecting the first and second portions, comprising at least part of a through-passage in the second portion.

The first portion may comprise means for connecting or connection to one or more lines, such as mooring lines, allowing rotational movement around or about a transverse axis of the first portion with respect to the line.

The second portion may comprise means for connecting or connection to a subsea structure allowing rotational movement around or about a transverse axis of the second portion with respect to the subsea structure.

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The transverse axis of the first portion may be substantially perpendicular to the transverse axis of the second portion.

The second portion may comprise the through passage.

At least part of the first portion may be receivable within the at least part of the through-passage.

The first portion of the subsea connector may comprise means for connecting to one or more lines, such as one or more mooring lines.

The second portion of the subsea connector may comprise means for connecting to a subsea structure, e.g. a submerged or partially submerged turret loading or a submerged turret production buoy.

The subsea connector may further comprise means for aligning, e.g. self-aligning the first portion and the second portion with respect to one another.

The through-passage may be capable of (threadably) receiving a work line or wire.

The first portion may comprise a male part.

The second portion may comprise a female part.

The means for connecting may comprise means for releasably connecting.

The means for aligning the first and second portions may comprise first and second means carried by or provided on the first and second portions, respectively.

The first and second alignment means may co-act, in use, when the first and second portions are brought together.

The first alignment means may comprise at least one first protrusion.

The second alignment means may comprise at least one second protrusion. In some examples, the first and second protrusions may define a cam follower arrangement, such as a helical cam follower arrangement.

The at least one first and second protrusions may co-act, in use, and rotate the first and second portions with respect to one another around a longitudinal axis, when the first and second portions are brought together.

The male part may comprise a cylindrical portion.

The at least part of the through-passage may be a cylindrical bore e.g. an open bore.

The female part may comprise the at least part of the through passage, within which the male part or cylindrical portion may be received in a substantially tight or snug fit.

The first portion may comprise means for releasably connecting to the work line or wire. The line connecting means may be an inter-engaging coupling arrangement. The inter-engaging coupling arrangement may be configured for pulling or moving the first portion of the subsea connector towards the second portion. The line connecting means may comprise first and second line connection means.

The first line connection means may be configured for releasably engaging with the second line connection means.

Alternatively, the second line connection means may be configured for releasably engaging with the first line connection means. The engagement between the first and second line connection means may be caused by tension created between the work line or wire and the first portion of the subsea connector.

The first line connection means may be provided by or carried on a free end of the line or wire. The first line connection means may comprise a first and second protrusion disposed on opposite sides of a plate member or attachment member of the wire or line. The first and second protrusions may be a first and second pin.

The male part may comprise an open recess or slot on a free end thereof. The second line connection means may be located or disposed within the open recess or slot of the male part.

The second line connection means may comprise a first and second retaining member. The first and second retaining members may be disposed on opposite sides, opposing each other, of the width of the open recess or slot. The first and second retaining members may comprise a further opening or recess adapted for receiving the first and second pins of the first line connection means. The opening or recess of the first and second retaining members may be adapted to face opposite to that of the male part, e.g. in a downward direction with respect to the first portion.

Alternatively, the second line connection means may comprise an elongate member or bar spanning the width of the open recess or slot.

Alternatively, the first line connection means may comprise a member for connecting to the elongate member or bar of the male part, such as a hook or the like.

In use, an ROV may run the work line or wire through the bore of the female part.

The ROV may connect the work line or wire, comprising the first line connection means, to the second line connection means of the male part.

In use, engagement between the first and second line connection means may be caused by tension in an upward direction created between the work line or wire and the first portion of the subsea connector, i.e. the first and second pins may co-act or engage with the first and second retaining members. Alternatively, the hook may engage with elongate member.

Subsequently, the ROV may pull the male part towards the female part such that the male part is inserted into the female part. A temporary sheave member may facilitate the pulling of the first portion towards the second portion.

In use, insertion of the male part into the female part may cause the first alignment means and second alignment means to rotationally co-act, thereby relatively (longitudinally) rotating the male part into a pre-selected or pre-determined rotational disposition in the female part.

The means for connecting the first portion and the second portion may comprise a first aperture in the male part, e.g. a pair of diametrically or width-wise spanning the cylindrical portion of the male part.

The means for connecting the first portion and the second portion may comprise at least one second aperture, e.g. a pair of diametrically opposed apertures, in the female part. The means for connecting the first portion and the second portion may comprise a pin, e.g. a load (bearing) pin, removably receivable within the first and second apertures when such are aligned.

The first and/or second apertures may be configured so as to provide a clearance or space, e.g. an increased clearance or space, between the pin and the first and/or second aperture during insertion of the pin. Alternatively or additionally, the first and/or second aperture may be configured so as to provide a contact area, e.g. an increased contact area, between the pin and the first and/or second apertures when the first portion is connected to the second portion, e.g., in use.

The first and/or second apertures may define or comprise a profile or cross section. The first and/or second aperture and/or the profile of the first and/or second aperture may comprise a load bearing surface or portion, which may substantially match or complement a profile or shape of the pin and/or a load bearing surface or portion of the pin. The

load bearing surface of the first and/or second apertures may be in contact with the load bearing surface of the pin when the first portion is connected to the second portion by the pin, in use. The load bearing surface may define or comprise the contact area between the pin and the first and/or second aperture. The load bearing surface of the pin may transfer or distribute a load to the first and/or second portion via the load bearing surface of the first and/or second aperture.

The first and/or second aperture and/or the profile of the first and/or second apertures may comprise a non-load bearing surface or portion, which may provide clearance around the pin during insertion. By providing clearance or space between the pin and the first and/or second apertures, insertion or installation of the pin may be facilitated. The first and/or second apertures may define or comprise a substantially oval or egg-shaped profile or cross section, or that of two overlapping circles of differing radii.

Beneficially, the first and second apertures are aligned in said pre-selected rotational disposition. In the pre-selected rotational disposition, the profile of the first and second aperture may be aligned. During installation and/or removal of the pin, the non-load bearing surfaces of each of the first and second aperture may be substantially aligned, such as concentrically aligned. When the first and second apertures are aligned, the load bearing surface or contact area of the first aperture may be located or positioned substantially opposite or opposed to the load bearing surface or contact area of the second aperture. By arranging the load bearing surface of the first aperture substantially opposite the load bearing surface of the second aperture, a load may be transferred through the load bearing surfaces to the first and/or second portion, in use.

In use, the ROV may mate and/or release the first and second portions, e.g. subsea/underwater, and/or to insert and/or remove the pin.

The pin may have a tapered end, which may facilitate insertion thereof into the apertures. The pin may comprise a further inter-engaging coupling arrangement configured for locking the pin with respect to the subsea connector. The further inter-engaging coupling arrangement may comprise a bayonet configuration carried or provided by the pin and the second portion.

Subsequently, the ROV may remove the temporary sheave member which may lead to a reduction in tension of the work line or wire.

In use, the ROV may disconnect the work line or wire from the male portion by disengaging the first line connection means from the second line connection means.

Beneficially, the first portion, second portion and/or pin may be made from a metal or metallic material. Beneficially the first portion, second portion and/or pin are made by forging.

The first portion may be connected to one or more lines, such as one or more mooring, tethering or anchoring lines or the like. The one or more lines may be a chain, wire, rope or the like. The first portion may be connected to one or more lines so as to allow rotational movement of the first portion with respect to one or more lines. The rotational movement of the first portion may be about a transverse axis, e.g. discrete transverse axis, of the first portion, e.g. perpendicular to a longitudinal axis of the first portion. A means for connecting the first portion to one or more lines may allow rotational movement of the first portion, e.g. rotational movement about the transverse axis of the first portion. For example, the first portion may be connected to one or more lines by one or more first bearing means, which may be

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provided or carried by the first portion. In some examples, the first bearing means may define or comprise a clevis arrangement or the like.

The second portion may be connected to a subsea structure. The second portion may be connected to a subsea structure so as to allow rotational movement of the second portion with respect to a subsea structure. The rotational movement of the second portion may be about a transverse axis, e.g. discrete transverse axis, of the second portion, e.g. perpendicular to a longitudinal axis of the second portion. A means for connecting the second portion to a subsea structure may allow rotational movement of the second portion, e.g. rotational movement about the transverse axis of the second portion. The transverse axis of the second portion may be a substantially horizontal axis. The transverse axis of the first portion may be or be oriented substantially perpendicular to the transverse axis of the second portion. By connecting the second portion to a subsea structure so as to allow rotational movement about the transverse axis of the second portion, fabrication of the means for connecting the second portion to a subsea structure may be facilitated. By allowing rotational movement of the second portion about the transverse axis thereof, weight of the means for connecting the second portion to a subsea structure may be reduced.

For example, the second portion may be connected to a subsea structure by one or more second bearing means, which may be provided or carried by the second portion. The second bearing means may comprise one or, more trunnions or protrusions, which may provide the transverse axis of the second portion. The bearing means may provide rotational movement about a transverse axis of the second portion with respect to the subsea structure. By allowing rotational movement of second portion about a transverse axis thereof, loads and/or stresses, for example in a longitudinal direction or axis of the second portion, which may act on the second portion and/or a subsea structure, may be reduced, e.g. when the second portion is connected to the first portion and/or to a subsea structure, in use.

The transverse axis of the first portion may be substantially orthogonal or perpendicular to the transverse axis of the second portion, in use, e.g. when the first and second portions are connected. In some examples, the transverse axis of the first portion may be offset, e.g. offset in a longitudinal direction of the first portion and/or second portion, from the transverse axis of the second portion, e.g. there may be a space or distance between the transverse axis of the first portion and the transverse axis of the second portion. The transverse axis of the first portion and/or the transverse axis of the second portion may define a universal-joint arrangement, such as an extended universal-joint arrangement. In other examples, the transverse axis of the first portion may coincide with the transverse axis of the second portion.

In use, insertion of the male part into the female part may cause (longitudinal) rotational movement of the male part into the pre-selected rotational disposition in the female part. The (longitudinal) rotational movement of the male part may align the transverse axis of the first portion relative to the transverse axis of the second portion. The male part may be aligned so that the transverse axis of the first portion is substantially perpendicular to the transverse axis of the second portion.

The means for connecting the first portion to one or more lines may define or allow movement, such as rotational movement, of the first portion with respect to one or more lines, comprising at least one first degree of freedom. The

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means for connecting the first portion to one or more line may provide a connection or joint comprising the at least one first degree of freedom. The means for connecting the second portion to a subsea structure may define or allow movement, such as rotational movement, of the second portion relative to a subsea structure, comprising at least one second degree of freedom. The means for connecting the second portion to a subsea structure may provide a further connection or joint comprising the at least one second degree of freedom. In use, connection of the first portion to the second portion may allow movement, e.g. rotational movement, with two or more degrees of freedom, of one or more lines relative to a subsea structure. The transverse axes of the first and second portion, which may provide the two or more degrees of freedom, may be orthogonal or perpendicular. The means for connecting the first portion to one or more lines and/or the means for connecting the second portion to a subsea structure may provide movement of the line relative to a subsea structure in two or more directions and/or planes.

By providing movement of one or more lines relative to a subsea structure in two or more degrees of freedom, loading and/or stress on a subsea structure and/or the connector may be reduced e.g. when a vessel connects to a subsea structure, in use.

According to a second aspect of the present invention there is provided a first portion of a subsea connector configured for connection to a second portion of the subsea connector by means for pulling the first portion into the second portion.

The means for pulling may be capable of pulling or moving the first portion into alignment within the second portion.

According to a third aspect of the present invention there is provided a second portion of a subsea connector configured for connection to a first portion of the subsea connector by means for pulling the second portion into the first portion.

The means for pulling may be capable of pulling or moving the second portion into alignment within the first portion.

According to a fourth aspect of the present invention there is provided a system for providing a subsea connection between a subsea, underwater or offshore equipment, apparatus or structure and one or more lines, such as mooring lines, the system comprising a subsea connector according to the first aspect of the present invention.

A first portion of the subsea connector may comprise means for connecting to one or more lines, such as mooring lines.

A second portion of the subsea connector may comprise means for connecting to a subsea structure, e.g. a submerged turret loading or a submerged turret production buoy.

The first portion may be connected to one or more lines. Preferably, the connection between the first connector portion and the line may be adapted as to allow rotational movement around or about a (discrete) transverse axis of the first connector portion with respect to line.

The second portion may be connected to the subsea structure. The connection between the second connector portion and the subsea structure may be adapted as to allow rotational movement around or about a (discrete) transverse axis of the second connector portion with respect to subsea structure.

The (discrete) transverse rotational axis of the first portion may be substantially perpendicular to the (discrete) transverse rotational axis of the second portion.

According to a fifth aspect of the present invention there is provided a method of mooring, anchoring or fixing a subsea, underwater or offshore equipment, apparatus or structure by one or more lines comprising the step of connecting at least one line of said lines to a subsea, underwater or offshore equipment, apparatus or structure by using a subsea connector according to a first aspect of the present invention.

According to a sixth aspect of the present invention there is provided a first and a second bearing of a subsea connector comprising first bearing means provided by or carried on a first portion of the subsea connector and second bearing means provided by or carried on a second portion of the subsea connector.

The first and second bearings may be configured for allowing pivotal or rotational movement of the first and second portions when connected to a subsea structure or a line, such as a mooring line. When connected, the first and second portions may pivot or rotate around or about a transverse axis of the first and/or a transverse axis of the second portion.

The first bearing means may comprise a first inner bearing ring/sleeve and a first outer bearing ring or sleeve.

The first portion of the subsea connector may be configured for receiving a first bearing shaft.

The second bearing means may comprise a second bearing shaft, a first inner bearing ring/sleeve and a first outer bearing ring/sleeve.

The first and second inner bearing ring/sleeve may be positioned radially outside the first and second bearing shaft, respectively. The first and second inner ring/sleeve may be configured for allowing rotational movement of the first and second shaft with respect first and second outer ring/sleeve. The first and second inner ring/sleeve may provide a low friction bearing surface, which may be provided by low friction bush, such as an Orkot bush.

The first and second outer bearing ring/sleeve may be positioned radially outside the first and second inner bearing ring/sleeve.

A first surface of the first and second inner bearing ring may be in slidable contact with a first surface of the first and second shaft, respectively.

A second surface of the first and second inner bearing ring may be in slidable contact with a first surface of the first and second outer bearing ring/sleeve, respectively.

The first and second inner bearing rings/sleeves may be configured for providing low friction rotational movement of the first and second shaft with respect to the first and second outer rings/sleeves.

The first portion of the subsea connector may comprise an aperture located on a distal end thereof. The aperture may provide the first outer ring/sleeve, which may be located inside the aperture.

A clevis arrangement may be used for connecting the first portion to the line. The clevis arrangement may comprise a clevis member and a pin or bolt. The clevis arrangement may connect or attach the first portion to one or more lines.

The pin or bolt of the clevis arrangement may act as the first bearing shaft once the first portion is connected to the line. The clevis member may be connected to a free end of the line.

The clevis member, may comprise at least one second aperture, e.g. a pair of diametrically opposed apertures, configured for receiving the first bearing shaft.

The first bearing shaft may be receivable within the aperture of the first portion and second apertures of the clevis member when such are aligned.

Preferably, the first bearing shaft may be rotatably fixed with respect to the clevis member, i.e. rotational movement of the first bearing shaft with respect to the clevis member may be prohibited.

The first portion may comprise at least one first surface, e.g. a pair of surfaces opposing each other.

The clevis member may comprise at least one second surface, e.g. a pair of surfaces opposing each other.

At least one first surface(s) and at least one second surface(s) may abut one another once the first portion and clevis member are brought together. At least one spacing member may be located between the at least one first and the at least one second surfaces. The at least one spacing member may provide low friction between the first and second surfaces. The at least one spacing member may be a thrust bearing or washer, such as an Orkot washer.

The second bearing shaft may be provided by at least one protrusion, e.g. a pair of protrusions located on opposite sides on a transverse axis of the second connector portion. The at least one protrusion may be a trunnion or pin, configured for allowing pivotal movement around or about a transverse axis of the second portion with respect to the subsea structure when connected to the subsea structure. Preferably, the trunnion may be adapted to act as the second bearing shaft.

The connection means for connecting the second portion to a subsea structure may comprise at least one further retaining member, e.g. a pair of further retaining members, positioned opposite each other on an outer surface of the subsea structure, may be configured to secure or attach the second portion of the subsea connector to the subsea structure.

The at least one further retaining member may comprise a further first retaining member and a further second retaining member.

The further first retaining member may comprise a recess or slot adapted for receiving the second bearing means. The recess or slot may be substantially upward facing. The further first retaining member may be adapted to prohibit any downward movement and/or movement in a horizontal direction of the second portion with respect to the subsea structure.

The further second retaining member may prevent movement of the second portion along the recess or slot of the further first retaining member. For example, the further second retaining member may be adapted to secure the second portion to the subsea structure and prohibit any upward movement thereof. The further first and second retaining portions may clamp or fix the second outer bearing ring/sleeve with respect to the subsea structure such that any translational and/or rotational movement of the second outer bearing sleeve is prohibited.

At least one second spacing member may be placed between adjacent surfaces of the second portion and the further retaining member(s). The at least one second spacing member may be capable of providing low friction between the second portion and the further retaining member(s) during rotational movement of the second portion with respect to the subsea structure. The at least one second spacing member may be a thrust bearing or washer, such as an Orkot washer.

According to a seventh aspect of the present invention there is provided a first bearing configured for allowing rotational movement of a first portion of a subsea connector with respect to a subsea, underwater or offshore equipment, apparatus or structure, or a mooring line or wire.

According to a eighth aspect of the present invention there is provided a second bearing configured for allowing rotational movement of a second portion of a subsea connector with respect to a subsea, underwater or offshore equipment, apparatus or structure, or a mooring line or wire.

According to a ninth aspect there is provided a bearing system for providing rotational movement of a subsea, underwater or offshore equipment, apparatus or structure with respect to a mooring line or wire in one or more directions, the subsea, underwater or offshore equipment, apparatus or structure being connected to the mooring line or wire by a subsea connector according to a first aspect of the present invention.

The system may comprise first and second bearings.

The first bearing may be provided by connecting a first portion of the connector to one or more lines. The first bearing may be adapted as to allow rotational movement around or about a (discrete) transverse axis of the first connector portion with respect to the line.

The second bearing may be provided by connecting a second portion of the connector to a subsea structure. The second bearing may be adapted as to allow rotational movement around or about a (discrete) transverse axis of the second connector portion with respect to the subsea structure.

The transverse rotational movement of the first portion may be substantially perpendicular to the transverse rotational movement of the second portion.

According to a tenth aspect of the present invention there is provided a method of assembling a first and second bearing of a subsea connector, comprising the steps of producing a first bearing by connecting or mounting a first or second portion of the subsea connector to at least one mooring line or wire, and producing a second bearing by connecting or mounting a first or second portion of the subsea connector to a subsea, underwater or offshore equipment, apparatus or structure according to the sixth aspect of the present invention and connecting the first and second portions of the subsea connector according to a first aspect of the present invention.

It should be understood that the features defined above in accordance with any aspect of the present invention or below in relation to any specific embodiment of the invention may be utilised, either alone or in combination with any other defined feature, in any other aspect or embodiment of the invention.

BRIEF DESCRIPTION OF DRAWINGS

An embodiment of the present invention will now be described by way of example only, and with reference to the accompanying drawings, which are:

FIG. 1 a schematic view of a subsea structure connected to a vessel with the subsea structure moored to the seabed;

FIG. 2 a schematic view of a subsea connector in accordance with an embodiment of the present invention;

FIG. 3 a schematic view of a first portion of the subsea connector of FIG. 2;

FIG. 4, a schematic view of a second portion and second bearing means of the subsea connector of FIG. 2;

FIG. 5 a schematic view of a second portion of the subsea connector of FIG. 2 with a work wire run through a bore thereof;

FIG. 6 a schematic view of alignment means of the subsea connector of FIG. 2;

FIG. 7(a) a further schematic view of the first portion of the subsea connector of FIG. 2;

FIG. 7(b) a further schematic view of the first portion of the subsea connector of FIG. 2 connected to a line;

FIG. 8 a schematic view of the second portion of the subsea connector of FIG. 2 connected to subsea structure and temporary sheave member installed;

FIG. 9 a schematic view of the subsea connector of FIG. 2, with the first portion being pulled towards the second portion;

FIG. 10 a schematic view of the subsea connector of FIG. 2; with the first portion received by and within the second portion;

FIG. 11 a schematic view of the subsea connector of FIG. 2 with the pin received within the subsea connector;

FIG. 12 a schematic view of the inter-engaging coupling arrangement for locking the pin to the subsea connector of FIG. 2;

FIG. 13 a schematic view of the subsea connector of FIG. 2 connected to subsea structure and removal of temporary sheave member;

FIG. 14 a schematic view of the subsea connector of FIG. 2 and disengagement of the work wire;

FIG. 15 a schematic view of the subsea structure connected to lines by connector of FIG. 2;

FIG. 16 a schematic view of a first bearing of the subsea connector of FIG. 2;

FIG. 17 a schematic view of a second bearing of the subsea connector of FIG. 2;

FIG. 18(a) a schematic view of first bearing means of the first portion of subsea connector of FIG. 2;

FIG. 18(b) an exploded schematic view of the first bearing means of the first portion of the subsea connector of FIG. 2;

FIG. 19 a schematic view of a clevis arrangement for connection of first portion of the subsea connector of FIG. 2 to a line;

FIG. 20 a schematic view of retaining members configured for securing the second portion of the subsea connector of FIG. 2 to the subsea structure;

FIG. 21(a) a cross sectional view of a first or second aperture of the first or second portion and a pin for connecting the first portion to the second portions of the connector of FIG. 2;

FIG. 21(b) a cross sectional view of a first or second aperture of the first or second portion and a pin for connecting the first portion to the second portions of the connector, wherein the pin is contact with a load bearing surface of the first or second aperture of the connector of FIG. 2.

DETAILED DESCRIPTION OF DRAWINGS

Referring to FIG. 1, there is shown a subsea structure 145 such as a submerged turret loading or a submerged turret production buoy, which in this Figure is shown connected to a vessel. It will be appreciated that the term "submerged" can include both fully submerged (e.g. entirely beneath a waterline) as well as partially submerged (e.g. partially beneath a waterline). As is shown in FIG. 1, the subsea structure 145 is moored to the seabed by one or more mooring lines 140.

Referring to FIGS. 2 to 7, there is shown a subsea connector 100 generally designated 100 according to one embodiment of the present invention. Such a connector may be used for connecting the structure 145 to one or more mooring lines 140. Here, the subsea connector 100 comprises a first portion 105 and a second portion 110. In this example, the first portion 105 may be considered to be a male portion, while the second portion 110 may be considered to be a female portion. The connector 100 further

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comprises means **115** for connecting the first and second portions **105,110**, which comprises at least part of a through-passage **120** in the second portion **110**, as will be explained. The means **115** for connecting may comprise means **115** for releasably connecting.

Referring to FIG. 3, there is shown the first portion **105** of a subsea connector **100** configured for connection to the second portion **110** of the subsea connector **100** by means for pulling **200** (see FIG. 7a) the first portion **105** into the second portion **110**. The means for pulling **200** are capable of pulling or moving the first portion **105** into alignment within the second portion **110**. Of course, in other embodiments, the second portion **110** of a subsea connector **100** may be configured for connection to the first portion **105** of the subsea connector **100** by means for pulling **200** the second portion **110** into the first portion **105**, where the means for pulling may be capable of pulling or moving the second portion into alignment within the first portion.

Here, at least part of the first portion **105** is receivable within the at least part of the through-passage **120**. Further, the through-passage **120** is capable of receiving (for example threadably receiving) a work line **155** or wire, as will be described, and as is shown in FIG. 5.

The first portion **105** of the subsea connector **100** further comprises means **125** for connecting to one or more lines **140**, such as mooring lines, whereas the second portion **110** comprises means **130** for connecting to the subsea structure **145** (e.g. see FIG. 4).

The means **125** for connecting the first portion **105** to one or more lines **140** allow rotational movement about a transverse axis A of the first portion **105**.

The means for connecting the first portion **105** to one or more lines **140** defines or allows movement, e.g. rotational movement, of the first portion **105** with respect to one or more lines **140**, comprising at least one first degree of freedom. In some examples, the means **125** for connecting the first portion **105** to one or more lines **140** can provide a joint or connection, which comprises at least one first degree of freedom of rotational movement. In some embodiments, the first portion **105** can be connected to one or more lines **140** by one or more first bearing means **290**, which are provided by the first portion **105**. In this embodiment, the first bearing **290** means include a clevis arrangement **350** or the like. The transverse axis A of the first portion **105** can be provided by a clevis pin or bolt **360**. The clevis arrangement **350** allows rotational movement between the line **140** and the first portion **105** about the clevis pin **360**.

The second portion **110** is connected to a subsea structure **145** so as to allow rotational movement of the second portion **110** with respect to a subsea structure **145**. The rotational movement of the second portion **110** is about a transverse axis B of the second portion **110**, which is perpendicular to a longitudinal axis (not shown) of the second portion **110**. The means **130** for connecting the second portion **110** to a subsea structure **145** allow for rotational movement of the second portion about the transverse axis of the second portion, which is in this embodiment a substantially horizontal axis B. By connecting the second portion **110** to a subsea structure so as to allow rotational movement about the transverse axis B of the second portion, fabrication of the means **130** for connecting the second portion **110** to a subsea structure may be facilitated. By allowing rotational movement of the second portion **110** about the transverse axis B, weight of the means **130** connecting the second portion to a subsea structure and/or connector **100** may be reduced.

In this example, the second portion **110** is connected to a subsea structure **145** by one or more second bearing means

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295, which can be carried by the second portion **110**. The second bearing **145** means comprise one or more trunnions **316**. The second bearing means **295** provide rotational movement about the transverse axis B of the second portion **110** with respect to the subsea structure. By allowing rotational movement of second portion **110** about the transverse axis B thereof, loads and/or stresses, for example in a longitudinal direction or axis of the second portion **110**, which may act on the connector **100**, second portion **110** and/or a subsea structure **145**, may be reduced when the second portion **110** is connected to the first portion **105**, in use.

As can be seen in FIGS. 2, 10 and 11, the transverse axis A of the first portion **105** is substantially perpendicular to the transverse axis B of the second portion **110**, in use, when the first **105** and second **110** portions are connected. In this embodiment, the transverse axis A of the first portion **105** is provided offset in a longitudinal direction of connector **100** from the transverse axis B of the second portion **110** so that there is a space or distance between the transverse axis A of the first portion **105** and the transverse axis B of the second portion **110**. The connector in this embodiment has an extended universal joint arrangement.

The means **130** for connecting the second portion **110** to a subsea structure **145** defines or allows movement, e.g. rotational movement, of the second portion **110** relative to a subsea structure **145**, comprising at least one second degree of freedom.

In some examples, the means **130** for connecting the second portion **110** to a subsea structure **145** provide a further joint or connection, which has at least one second degree of freedom of rotational movement. In use, connection of the first portion **105** to the second portion **110** allows rotational movement with two or more degrees of freedom of one or more lines relative to a subsea structure **145**. When connected, the first and second connection means allow for movement of the one or more lines **140** relative to the subsea structure **145** in two or more planes and/or directions.

As is shown in FIG. 6, for example, the subsea connector **100** additionally comprises means **150** for aligning, e.g. self-aligning the first portion **105** and the second portion **110** with respect to one another. When brought together so as to be connected, the means **150** for aligning on both the first and second portion interoperate with one another so as to orientate the first portion **110** in a particular configuration with respect to the second portion **120**. As is shown in FIG. 6, the means **150** for aligning the first and second portions **105, 110** comprise first and second means **170, 175** carried by, or provided on, the first and second portions **105,110**, respectively. Those first and second alignment means **170, 175** co-act, in use, when the first and second portions **105, 110** are brought together. Here, the first alignment means **170** comprises at least one first protrusion **180**, and the second alignment means **175** comprises at least one second protrusion **185** also such that the at least one first and second protrusions **180, 185** co-act, in use, and rotate the first and second portions **105, 110** with respect to one another around a longitudinal axis, when the first and second portions **105, 110** are brought together. Of course, in further examples, one or more protrusions and complementary recesses may be provided, as will be appreciated.

As is shown (e.g. in FIG. 3), a male part **160** of the first portion **105** comprises a cylindrical portion **190**, whereas the at least part of the through-passage **120** is a cylindrical bore **195** e.g. an open bore (see FIG. 4), such that the female part comprises the through-passage **120**, within which the male

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part **160** or cylindrical portion **190** is received. The male part **160** may be received in a substantially tight or snug fit.

In this example, the first portion **105** also comprises means **205** for releasably connecting to a work line **155** or wire. Here, the line connecting means **205** are an inter-engaging coupling arrangement, although alternative configurations will be evident. The inter-engaging coupling arrangement is configured for pulling, or at least moving, the first portion **105** of the subsea connector **100** towards the second portion **110**. The line connecting means **205** comprises first and second line connection means **210**, **215**, respectively.

In the example shown, the first line connection means **210** is configured for releasably engaging with the second line connection means **215**. Alternatively, however, the second line connection means **215** may be configured for releasably engaging with the first line connection means **210**. Engagement of the first and second line connection means **210,215** can be caused by tension created between the work line or wire **155** and the first portion **105** of the subsea connector **100**.

In this example, the first line connection means **210** is provided by, or carried on, a free end of the line or wire **155**, and comprises a first and second protrusion **220** (shown as pins **221**, **222**) disposed on opposite sides of a plate member or attachment member **225** of the wire or line.

The male part **160** of the first portion **105** comprises an open recess or slot **230** on a free end thereof, and the second line connection **215** means can be located or disposed within the open recess or slot **230** of that male part **160**.

The second line connection means **215** also comprises a first and second retaining member **235**, which are disposed on opposite sides, opposing each other, of the width of the open recess or slot **230**. The first and second retaining members **235** comprise a further opening or recess **240** adapted for receiving the first and second pins **221,222** of the first line connection means **210**. Here, the opening or recess **240** of the first and second retaining members **235** is adapted to face opposite to that of the male part **160**, e.g. in a downward direction with respect to the first portion **105**. In other words, the opening or recess **240** faces inwardly towards the body of the first portion). In alternative embodiments, the second line connection means **215** may comprise an elongate member or bar spanning the width of the open recess or slot **230**.

In further alternative embodiments, the first line connection means **210** may comprise a member for connecting to the elongate member or bar of the male part, such as a hook or the like.

In use (e.g. see FIG. 8), an ROV is able to run the work line or wire **155** through the bore **195** of the female part **165**, as shown in FIG. 5. The ROV can then connect the work line or wire **155**, comprising the first line connection means **210**, to the second line connection means **215** of the male part **160**.

With specific reference to FIGS. 7 to 9, engagement between the first and second line connection means **210, 215** can be caused by tension in an upward direction created between the work line or wire **155** and the first portion **105** of the subsea connector **100**, e.g. the first and second pins **221, 222** co-act or engage with the first and second retaining members **235**. Of course, in alternative examples, a hook or the like may engage with an elongate member (not shown).

Subsequently, the ROV can pull the male part **160** towards the female part **165** such that the male part **160** is inserted into the female part **165**. A temporary sheave

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member **245** facilitates the pulling of the first portion **105** towards the second portion **110**, as shown in FIG. 9.

Insertion of the male part **160** into the female part **165** can cause the first alignment means and second alignment means **170, 175** (see FIG. 6) to rotationally co-act, thereby relatively (longitudinally) rotating the male part and the female part into a pre-selected or pre-determined rotational disposition, as shown in FIG. 10.

The means **115** for connecting the first portion and the second portion **105, 110** comprises a first aperture **250** in the male part, e.g. a pair of diametrically or width-wise apertures spanning the cylindrical portion **190** of the male part **160**. The means **115** for connecting the first portion and the second portion **105, 110** comprises at least one second aperture **255**, e.g. a pair of diametrically opposed apertures, in the female part **165**.

Referring to FIG. 11, the means **115** for connecting the first portion **105** and the second portion **110** comprises a pin **260**, e.g. a pin, such as a load bearing pin, removably receivable within the first and second apertures **250,255** when are aligned, for example, when aligned in a pre-selected rotational disposition.

As such, the ROV can mate and/or release the first and second portions **105,110**, e.g. subsea/underwater, and/or to insert and/or remove the pin **260**.

In the example shown, the pin **260** has a tapered end, which can facilitate ease of insertion thereof into the apertures **250,255**.

Referring to FIG. 12, the pin **260** comprises a further inter-engaging coupling arrangement **270** configured for locking, or at least retaining, the pin **260** with respect to the subsea connector **100**. In this example, the further inter-engaging coupling arrangement **270** comprises a bayonet configuration **271** carried or provided by the pin **260** and the second portion **110**.

After the pin **260** has been located, and retained, the ROV can remove any temporary sheave member **245**, which leads to a reduction in tension of the work line or wire **155**, as shown in FIG. 13. The ROV can then disconnect the work line or wire **155** from the male portion **160** by disengaging the first line connection means from the second line connection means **210, 215** (e.g. see FIG. 14).

In some examples, the aforementioned first portion **105**, second portion **110** and/or pin **260** are made from a metal or metallic material (e.g. made by forging).

As will be appreciated, the above described connector **100** may be used with a system **275** comprising one or more such connectors **100**. An example of such a system is shown in FIG. 15. Such a system **275** can be used to provide a subsea connection between subsea, underwater and/or offshore equipment, apparatus or structures **145** and one or more lines **140**, such as mooring lines. In the example shown, the system **275** comprises a plurality of subsea connectors **100**. As is shown, each first portion **105** of each subsea connector **100** has means **125** for connecting to one or more lines **140**, such as mooring lines, and each second portion **110** of each subsea connector comprises means **130** for connecting to a subsea structure **145**, e.g. a submerged turret loading or a submerged turret production buoy.

It will be appreciated that with such a connector **100** (or system **245**) it may be helpful to permit some relative movement, such as rotation, of any mooring line and connected subsea structure. As such, in the embodiment shown, the connection between the first portion **105** and the line **140** is adapted so as to allow for such rotational movement around or about a (discrete) transverse axis A (FIG. 7b) of the first portion **105** with respect to line **140**. Further, the

connection between the second portion **110** and the subsea structure **145** is adapted so as to allow rotational movement around or about a (discrete) transverse axis B (FIG. 4) of the second portion **110** with respect to subsea structure **145**. In the example described, the (discrete) transverse rotational axis A of the first portion **105** may be considered to be substantially perpendicular to the (discrete) transverse rotational axis B of the second portion **105**. As such, the use of such a connector may obviate the need for any additional rotation coupling in the mooring line, or the like (e.g. no need for an additional uni-joint, or the like).

With specific reference to FIGS. **16** to **19**, and also FIG. **4**, there is shown first and second bearings of a subsea connector **100**. The first and second bearings comprise first bearing means **290** provided by or carried on the first portion **105** and second bearing means **295** provided by or carried on the second portion **110**. The first and second bearings **280,285** are configured for allowing movement (e.g. pivotal movement) of the first and second portions **105,110** when connected to a subsea structure **145** or a line **140**. When connected, the first and second portions **105,110** are able to pivot or rotate around or about a transverse axis of the first portion and/or a transverse axis of the second portion.

Here, the first bearing means **290** comprises a first inner bearing ring/sleeve **300** and a first outer bearing ring or sleeve **305**. The first portion **105** of the subsea connector **100** may be considered to be configured to receive a first bearing shaft **310**.

The second bearing means **295** comprises a second bearing shaft **315**, a first inner bearing ring/sleeve **320** and a first outer bearing ring/sleeve **325**.

The first and second inner bearing ring/sleeved **300, 320** are positioned radially outside the first and second bearing shaft **310,315**, respectively. The first and second inner ring/sleeve **300,320** are configured for allowing rotational movement of the first and second shaft **310,315** with respect to first and second outer ring/sleeve **305,325**. In this example, the first and second inner ring/sleeve **300,320** provides a low friction bearing surface, which is provided by low friction bush; such as an Orkot bush. The first and second outer bearing ring/sleeves **305,325** are positioned radially outside the first and second inner bearing ring/sleeve **300,320**. A first surface **330** of the first and second inner bearing ring/sleeve **300,320** is in slidable contact with a first surface of the first and second shaft **310,315**, respectively, and a second surface **335** of the first and second inner bearing ring/sleeve **300,320** is in slidable contact with a first surface **340** of the first and second outer bearing ring/sleeve **305 325**, respectively.

As such, the first and second inner bearing rings/sleeves **300,320** are configured for providing low friction rotational movement of the first and second shaft **310, 315** with respect to the first and second outer rings/sleeves **305,325**.

As is shown in the Figures, the first portion **105** of the subsea connector **100** comprises an aperture **345**, which can be considered to be located on a distal end thereof. The aperture **345** provides the first outer ring/sleeve **305**, which is located inside the aperture **345**, such that a clevis arrangement **350** can be used for connecting the first portion **105** to the line **140**. In the example given, the clevis arrangement **350** comprises a clevis member **355** and a pin or bolt **360** such that the pin or bolt **360** acts as the first bearing shaft **310** once the first portion **105** is connected to the line **140**. The clevis member **350** can be considered to be connected to a free end of the line **140**.

The first bearing shaft **310** is receivable within the aperture **345** of the first portion **105** and second apertures of the clevis member **350** when such are aligned. Here, the first

bearing shaft **310** is rotatably fixed with respect to the clevis member **350**, i.e. rotational movement of the first bearing shaft **310** with respect to the clevis member **350** is inhibited, or prohibited.

It may be considered that the first portion **105** comprises at least one first surface **365**, e.g. a pair of surfaces opposing each other, while the clevis member **350** comprises at least one second surface **370**, e.g. a pair of surfaces opposing each other, such that the respective at least one first surface(s) **365** and at least one second surface(s) **370** abut one another once the first portion **105** and clevis member **350** are brought together. In some examples, a sealing member **375** may be located between the at least one first and the at least one second surfaces **365,370**. Such a sealing member **375** may provide low friction between the first and second surfaces **365,370**. An example of such a sealing member **375** may be an Orkot washer.

The second bearing shaft **315** of the second portion **110** is provided by at least one protrusion **316**, e.g. a pair of protrusions located on opposite side on a transverse axis of the second connector portion **110**. The at least one protrusion **316** may be considered to be a trunnion, protrusion or pin, configured for allowing pivotal movement around or about a transverse axis B of the second portion **100** with respect to the subsea structure **145** when connected to the subsea structure **145**. In some examples, the trunnion **316** is adapted to act as the second bearing shaft **315**.

With specific reference to FIGS. **17** and **20**, for example, at least one further retaining member **380**, e.g. a pair of further retaining members, are positioned opposite each other on an outer surface of the subsea structure **145**, and are configured to secure or attached the second portion **105** of the subsea connector **100** to the subsea structure **145**. Here, the at least one further retaining member **380** comprises a first retaining member **381** and a second retaining member **382**. The further first retaining member **381** comprises an upward facing recess **383** adapted for receiving the second bearing means **295** such that the first retaining member **381** is adapted to prohibit any downward movement and/or movement in a horizontal direction of the second portion **110** with respect to the subsea structure **145**. In a similar manner, the second retaining member **382** is adapted to secure the second portion **110** to the subsea structure **145** and prohibit any upward movement thereof. The further first and second retaining portions **381,382** clamp or fix the second outer bearing ring/sleeve **325** with respect to the subsea structure **145**.

A second spacing member **385** is placed between contacting surfaces **390,391** of the second portion **110** and the first and second retaining members **381,382**. The second spacing member **385** is capable of providing low friction between the second portion **110** and the first and second further retaining members **381,382** during rotational movement of the second portion **110** with respect to the subsea structure **145**. As above, the second spacing member **385** may be an Orkot washer, or the like.

Referring to FIG. **19**, and as explained above, there is provided a first bearing **280** that is configured to allow for rotational movement of the first portion **105** of the subsea connector **100** with respect to a subsea, underwater or offshore equipment, apparatus or structure **145**, or a mooring line or wire **140**. Further, and referring to FIG. **17**, there is shown, and as has been described, a second bearing **285** configured for allowing rotational movement of the second portion **110** of a subsea connector with respect to a subsea, underwater or offshore equipment, apparatus or structure **145**, or a mooring line or wire **140**. Such a bearing system

395 can provide rotational movement of a subsea, under-water or offshore equipment, apparatus or structure 145 with respect to a mooring line or wire 140 in one or more directions, while that apparatus or structure is connected to the mooring line or wire by a subsea connector 100.

While in the above example first and second bearings have been described, it will be appreciated that in other systems, only one may be provided.

The example of FIG. 21(a) shows the profile or cross section of an aperture 415, for example the profile of a first aperture 250 or second aperture 255, and pin 260. The aperture 415 is configured to provide a clearance or space 400, e.g. large or increase clearance or space 400, around the pin 260 during insertion of the pin 260, as shown in FIG. 21(a).

As shown in FIG. 21(b), the aperture 415 can also be configured to provide a contact area between the pin 260 and the aperture 415. For example, when the first 105 and second 110 portions are assembled and the connector is under loading conditions, the pin 260 will be pulled into contact with the contact area. In this example, the profile of the aperture 415 is substantially oval or egg shaped. In other examples, the aperture 410 can have a profile, which is substantially that of two overlapping circles.

The profile of the aperture 415 comprises a load bearing surface 405, which substantially matches or complements a profile of the pin 260 and/or a load bearing surface of the pin 260. For example, a pin 260 with circular cross section can be used, and the load bearing surface 405 can be designed to be an arc or the like with substantially the same radius as that of the pin 260. The load bearing surface 405 of the aperture 410 is in contact with the pin when, for example, the first portion is connected to the second portion is in use, as shown in FIG. 21(b).

In some examples, the profile of the aperture 415 comprises a non-load bearing surface 410, which can provide clearance 400 around the pin 260 during insertion, as shown in FIG. 21(a). By providing clearance 400 between the pin and the aperture 410, insertion or installation of the pin may be facilitated.

The first aperture 250 and/or the second aperture 255 can have a profile substantially as shown by the aperture 415 in FIG. 21(a). When aligned, the load bearing surfaces 405 of the first aperture 250 and second aperture 255 can be substantially opposite each other.

During installation and/or removal of the pin 260, the non-load bearing surface 410 of each the first 250 and second 255 apertures are substantially aligned, such as concentrically aligned. When the first 250 and second 255 apertures are aligned the load bearing surface 405 or contact area of the first aperture is substantially opposite or opposed to the load bearing surface 405 or contact area of the second aperture 255. By arranging the load bearing surface 405 of the first aperture 250 substantially opposite the load bearing surface 405 of the second aperture 255, a load may be transferred through the load bearing surfaces 405 to the first 105 and/or second 110 portion, in use.

During installation, tension is maintained on the work line or wire 155, pulling the first aperture 250 and second aperture 255 into alignment, which may allow an ROV to insert the pin 260. By maintaining tension on the work wire 155 clearance 400 may be provided, which can facilitate installation of the main load bearing pin 260.

The applicant hereby discloses in isolation each individual feature described herein and any combination of two or more such features, to the extent that such features or combinations are capable of being carried out based on the

present specification as a whole in the light of the common general knowledge of a person skilled in the art, irrespective of whether such features or combinations of features solve any problems disclosed herein, and without limitation to the scope of any claims. The applicant indicates that aspects of the invention may consist of any such individual feature or combination of features. In view of the foregoing description it will be evident to a person skilled in the art that various modifications may be made within the scope of the invention, and that the description provides only one example embodiment of how the invention may be implemented.

The invention claimed is:

[1. A subsea connector comprising:

a first portion;

a second portion; and

a connection arrangement that connects the first and second portions,

wherein the connection arrangement comprises at least part of a through-passage in the second portion,

wherein the first portion comprises a first connection arrangement that connects the first portion to one or more lines, the first connection arrangement allowing rotational movement around or about a transverse axis of the first portion with respect to the one or more lines,

wherein the second portion comprises a second connection arrangement that connects the second portion to a subsea structure, the second connection arrangement allowing rotational movement around or about a transverse axis of the second portion with respect to the subsea structure; and

wherein the transverse axis of the first portion is substantially orthogonal or perpendicular to a transverse axis of the second portion, in use, when the first and second portions are connected.]

[2. A subsea connector according to claim 1, wherein at least part of the first portion is receivable within the at least part of the through-passage.]

[3. A subsea connector according to claim 1, wherein the subsea connector further comprises an alignment arrangement for aligning the first portion and the second portion with respect to one another.]

4. A subsea connector[,] comprising:

a first portion;

a second portion; and

a connection arrangement that connects the first and second portions,

wherein the connection arrangement comprises at least part of a through-passage in the second portion,

wherein the through-passage is capable of receiving a work line or wire, and

wherein the first portion comprises at least part of [a means] an arrangement for releasably connecting to the work line or wire, and engagement between the at least part of the releasable line connection [means] arrangement and the work line or wire is caused by tension between the first portion and the work line or wire.

[5. A subsea connector according to claim 1, wherein the first connection arrangement comprises one or more bearings.]

[6. A subsea connector according to claim 1, wherein the second connection arrangement comprises one or more bearings.]

[7. A subsea connector according to claim 6, wherein the one or more bearings comprises one or more protrusions or

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trunnions, the one or more protrusions or trunnions providing the transverse axis of the second portion.]

[8. A subsea connector according to claim 1, wherein a transverse axis of the first portion coincides with or is offset from a transverse axis of the second portion.]

[9. A subsea connector according to claim 1, wherein a transverse axis of the first portion and a transverse axis of the second portion define a universal joint arrangement.]

[10. A subsea connector according to claim 1, wherein the first portion comprises a male part and the second portion comprises a female part, insertion of the male part into the female part causing rotational movement of the male part into a pre-selected rotational disposition in the female part.]

[11. A subsea connector according to claim 10, wherein the rotational movement of the male part aligns a transverse axis of the first portion relative to a transverse axis of the second portion so that the transverse axis of the first portion is substantially perpendicular to the transverse axis of the second portion.]

[12. A subsea connector according to claim 1, wherein the first connection arrangement defines or allows rotational movement of the first portion with respect to the one or more lines comprising at least one degree of freedom.]

[13. A subsea connector according to claim 12, wherein the first connection arrangement provides a connection or joint comprising the at least one degree of freedom.]

[14. A subsea connector according to claim 1, wherein the second connection arrangement defines or allows rotational movement of the second portion relative to a subsea structure comprising at least one degree of freedom.]

[15. A subsea connector according to claim 14, wherein the second connection arrangement provides a further connection or joint comprising the at least one degree of freedom.]

[16. A subsea connector according to claim 1, wherein, in use, connection of the first portion to the second portion allows movement of the one or more lines relative to a subsea structure with two or more degrees of freedom.]

[17. A subsea connector according to claim 1, wherein the first portion comprises a first connection arrangement and the second portion comprises a second connection arrangement, the first and second connection arrangements providing movement of one or more lines relative to a subsea structure in two or more directions or planes.]

[18. A subsea connector according to claim 3, wherein the alignment arrangement comprises first and second alignment elements carried by or provided on the first and second portions, respectively, the first and second alignment elements co-acting, in use, when the first and second portions are brought together.]

[19. A subsea connector according to claim 18, wherein the first alignment element comprises at least one first protrusion and the second alignment element comprises at least one second protrusion.]

[20. A subsea connector according to claim 19, wherein the at least one first and second protrusions co-act, in use, and rotate the first and second portions with respect to one another around a longitudinal axis, when the first and second portions are brought together.]

[21. A subsea connector according to claim 18, wherein the first portion comprises a male part and the second portion comprises a female part, in use, insertion of the male part into the female part causes the first alignment element and second alignment element to rotationally co-act, thereby relatively rotating the male part and the female part into a pre-selected or pre-determined rotational disposition.]

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[22. A subsea connector according to claim 1, wherein the first portion comprises a male part and the second portion comprises a female part, the connection arrangement comprising at least one of:

- a first aperture in the male part;
- a second aperture in the female part; and
- a pin, removably receivable within the first aperture in the male part and the second aperture in the female part, when the male and female parts are aligned.]

[23. A subsea connector according to claim 22, wherein the first or second aperture is configured to provide at least one of:

- a clearance or space between the pin and the first aperture or the second aperture during insertion of the pin; and
- a contact area between the pin and the first or second aperture when the first portion is connected to the second portion.]

[24. A subsea connector according to claim 22, wherein the first or second apertures define or provide a profile or cross-section, the profile of the first or second aperture comprising at least one of:

- a load bearing surface or portion, which substantially matches or complements a profile or shape of the pin or a load bearing surface or portion of the pin;
- a load bearing surface or portion, which substantially matches or complements a profile or shape of the pin and a load bearing surface or portion of the pin; and
- a non-load bearing surface or portion, which provides clearance around the pin during insertion.]

[25. A subsea connector according to claim 24, wherein the load bearing surface of the first or second aperture is in contact with the load bearing surface of the pin when the first portion is connected to the second portion by the pin, in use.]

[26. A subsea connector according to claim 24, wherein during installation or removal of the pin, the non-load bearing surface of each aperture is substantially aligned.]

[27. A system for providing a subsea connection between a subsea, underwater or offshore equipment, apparatus or structure and one or more lines, the system comprising:

- a subsea connector according to claims 1; and
- at least one of:
 - a subsea, underwater or offshore equipment, apparatus or structure; and
 - one or more lines.]

[28. A system according to claim 27, wherein the system comprises a pair of retaining members, the pair of retaining member being positioned opposite each other on an outer surface of the subsea structure, and being configured to secure or attached to a second portion of the subsea connector to the subsea structure.]

[29. A method of mooring, anchoring or fixing a subsea, underwater or offshore equipment, apparatus or structure by one or more lines comprising the step of connecting at least one line of said lines to a subsea, underwater or offshore equipment, apparatus or structure by using a subsea connector according to claim 1.]

[30. The method according to claim 29, wherein the method comprises at least one of the steps of:

- running a work line or wire through the through-passage of a female part of the subsea connector;
- connecting a work line or wire to a male part of the subsea connector;
- pulling a male part of the subsea connector towards a female part of the subsea connector such that the male part is inserted into the female part;
- mating the first and second portions;

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inserting a pin within first and second apertures of the subsea connector; and
disconnecting a work line or wire from a male portion of the subsea connector.]

[31. A subsea connection arrangement comprising:
a subsea connector according to claim 1, the connector comprising at least part of a line connection arrangement for releasably connecting to a work line or wire; and
a wire or work line, the line being adapted to be releasably connectable to the at least part of the releasable line connection arrangement of the first portion.]

[32. A subsea connection arrangement according to claim 31, wherein engagement between the at least part of the releasable line connection arrangement is caused by tension between a first portion and a work line or wire.]

[33. A subsea connection arrangement according to claim 31, wherein the releasable line connection arrangement comprises a first line connection element provided on the work line or wire and a second line connection element provided on the first portion.]

[34. A subsea connection arrangement according to claim 33, wherein the first line connection element comprises a first and a second protrusion disposed on opposite sides of a plate member or attachment member of the wire or work line.]

[35. A subsea connection arrangement according to claim 33, wherein the first portion comprises a male part, the male part comprising an open recess or slot on a free end thereof, the second line connection element being located or disposed within the open recess or slot of the male part.]

36. A subsea connector according to claim 4, wherein the first portion comprises at least one of:

a first connection arrangement that connects the first portion to one or more lines, the first connection arrangement allowing rotational movement around or about a transverse axis of the first portion with respect to the one or more lines; and
a male part.

37. A subsea connector according to claim 4, wherein the second portion comprises at least one of:

a second connection arrangement that connects the second portion to a subsea structure, the second connection arrangement allowing rotational movement around or about a transverse axis of the second portion with respect to the subsea structure; and
a female part.

38. A subsea connector according to claim 4, wherein [the] a transverse axis of the first portion is substantially orthogonal or perpendicular to a transverse axis of the second portion, in use, when the first and second portions are connected.

39. A subsea connector comprising:
a first portion comprising a male part;
a second portion comprising a female part for receiving the male part; and
a connection arrangement that connects the first and second portions,

wherein the connection arrangement comprises at least part of a through-passage in the female part of the second portion, and insertion of the male part into the female part causes rotational movement of the male part into a pre-selected rotational disposition in the female part, said rotational movement of the male part aligning a transverse axis of the first portion relative to the transverse axis of the second portion so that the

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transverse axis of the first portion is substantially perpendicular to the transverse axis of the second portion,
wherein the first portion further comprises a first connection arrangement that connects the first portion to one or more lines, the first connection arrangement allowing rotational movement around or about the transverse axis of the first portion with respect to the one or more lines, and the second portion comprises a second connection arrangement that connects the second portion to a subsea structure, the second connection arrangement comprising one or more bearings allowing rotational movement around or about the transverse axis of the second portion with respect to the subsea structure, the transverse axis of the second portion comprising a transverse axis of the through-passage of the female part of the second portion, and wherein the transverse axis of the first portion is substantially orthogonal or perpendicular to the transverse axis of the second portion, in use, when the first and second portions are connected.

40. A subsea connector according to claim 39, wherein at least part of the first portion is receivable within the at least part of the through-passage.

41. A subsea connector according to claim 39, wherein the first connection arrangement comprises one or more bearings.

42. A subsea connector according to claim 41, wherein the one or more bearings of the second connection arrangement comprise one or more protrusions or trunnions, the one or more protrusions or trunnions providing the transverse axis of the second portion.

43. A subsea connector according to claim 39, wherein the transverse axis of the first portion coincides with or is offset from the transverse axis of the second portion.

44. A subsea connector according to claim 39, wherein the transverse axis of the first portion and the transverse axis of the second portion define a universal joint arrangement.

45. A subsea connector according to claim 39, wherein the first connection arrangement defines or allows rotational movement of the first portion with respect to the one or more lines comprising at least one degree of freedom.

46. A subsea connector according to claim 45, wherein the first connection arrangement provides a connection or joint comprising the at least one degree of freedom.

47. A subsea connector according to claim 39, wherein the second connection arrangement defines or allows rotational movement of the second portion relative to a subsea structure comprising at least one degree of freedom.

48. A subsea connector according to claim 47, wherein the second connection arrangement provides a further connection or joint comprising the at least one degree of freedom.

49. A subsea connector according to claim 39, wherein, in use, connection of the first portion to the second portion allows movement of the one or more lines relative to a subsea structure with two or more degrees of freedom.

50. A subsea connector according to claim 39, wherein the first and second connection arrangements provide movement of one or more lines relative to a subsea structure in two or more directions or planes.

51. A subsea connector according to claim 39, wherein the subsea connector further comprises an alignment arrangement for aligning the first portion and the second portion with respect to one another.

52. A subsea connector according to claim 51, wherein the alignment arrangement comprises first and second

alignment elements carried by or provided on the first and second portions, respectively, the first and second alignment elements co-acting, in use, when the first and second portions are brought together.

53. A subsea connector according to claim 52, wherein the first alignment element comprises at least one first protrusion and the second alignment element comprises at least one second protrusion.

54. A subsea connector according to claim 53, wherein the at least one first and second protrusions co-act, in use, and rotate the first and second portions with respect to one another around a longitudinal axis, when the first and second portions are brought together.

55. A subsea connector according to claim 52, wherein in use, insertion of the male part into the female part causes the first alignment element and second alignment element to rotationally co-act, thereby relatively rotating the male part and the female part into a pre-selected or pre-determined rotational disposition.

56. A subsea connector according to claim 39, wherein the connection arrangement that connects the first and second portions comprises at least one of:

- a first aperture in the male part;
- a second aperture in the female part; and
- a pin, removably receivable within the first aperture in the male part and the second aperture in the female part, when the male and female parts are aligned.

57. A subsea connector according to claim 56, wherein the first or second aperture is configured to provide at least one of:

- a clearance or space between the pin and the first aperture or the second aperture during insertion of the pin; and
- a contact area between the pin and the first or second aperture when the first portion is connected to the second portion.

58. A subsea connector according to claim 56, wherein the first or second aperture defines or provides a profile or cross-section, the profile of the first or second aperture comprising at least one of:

- a load bearing surface or portion, which substantially matches or complements a profile or shape of the pin or a load bearing surface or portion of the pin;
- a load bearing surface or portion, which substantially matches or complements a profile or shape of the pin and a load bearing surface or portion of the pin; and
- a non-load bearing surface or portion, which provides clearance around the pin during insertion.

59. A subsea connector comprising:

- a first portion comprising a male part;
- a second portion comprising a female part for receiving the male part; and
- a connection arrangement that connects the first and second portions,

wherein the connection arrangement comprises at least part of a through-passage in the female part of the second portion and insertion of the male part into the female part causes rotational movement of the male part into a pre-selected rotational disposition in the female part,

wherein the first portion further comprises a first connection arrangement that connects the first portion to one or more lines, the first connection arrangement allowing rotational movement around or about a transverse axis of the first portion with respect to the one or more lines, and the second portion further comprises a second connection arrangement that connects the sec-

ond portion to a subsea structure, the second connection arrangement comprising one or more bearings allowing rotational movement around or about a transverse axis of the second portion with respect to the subsea structure, the transverse axis of the second portion comprising a transverse axis of the through-passage of the female part of the second portion; and wherein the transverse axis of the first portion is substantially orthogonal or perpendicular to the transverse axis of the second portion, in use, when the first and second portions are connected,

wherein the connection arrangement that connects the first and second portions further comprises at least one of:

- a first aperture in the male part;
- a second aperture in the female part; and
- a pin, removably receivable within the first aperture in the male part and the second aperture in the female part, when the male and female parts are aligned, wherein the first or second aperture defines or provides a profile or cross-section, the profile of the first or second aperture comprising at least one of:

- a load bearing surface or portion, which substantially matches or complements a profile or shape of the pin or a load bearing surface or portion of the pin;
- a load bearing surface or portion, which substantially matches or complements a profile or shape of the pin and a load bearing surface or portion of the pin; and
- a non-load bearing surface or portion, which provides clearance around the pin during insertion, and wherein the load bearing surface of the first or second aperture is in contact with the load bearing surface of the pin when the first portion is connected to the second portion by the pin, in use.

60. A subsea connector according to claim 58, wherein during installation or removal of the pin, the non-load bearing surface of each of the first and second apertures are substantially aligned.

61. A system for providing a subsea connection between a subsea, underwater or offshore equipment, apparatus or structure and one or more lines, the system comprising: a subsea connector according to claim 39; and at least one of:

- a subsea, underwater or offshore equipment, apparatus or structure; and
- one or more lines.

62. A system according to claim 61, wherein the system comprises a pair of retaining members, the pair of retaining members being positioned opposite each other on an outer surface of the subsea, underwater or offshore equipment, apparatus or structure, and being configured to secure or attach the second portion of the subsea connector to the subsea, underwater or offshore equipment, apparatus or structure.

63. A system according to claim 61, wherein the system further comprises a sheave member mountable on the subsea, underwater or offshore equipment, apparatus or structure.

64. A method of mooring, anchoring or fixing a subsea, underwater or offshore equipment, apparatus or structure by one or more lines comprising the step of connecting at least one line of said one or more lines to the subsea, underwater or offshore equipment, apparatus or structure by using a subsea connector according to claim 39.

65. The method according to claim 64, wherein the method comprises the steps of:

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*running a work line or wire through the through-passage of the female part of the subsea connector;
connecting the work line or wire to the male part of the subsea connector;*

pulling the male part of the subsea connector towards the female part of the subsea connector such that the male part is inserted into the female part;

mating the first and second portions;

inserting a pin within first and second apertures of the subsea connector; and

disconnecting the work line or wire from the male part of the subsea connector.

66. A subsea connection arrangement comprising:

a subsea connector according to claim 39, the subsea connector comprising at least part of a line connection arrangement for releasably connecting to a work line or wire; and

a wire or work line, the wire or work line being adapted to be releasably connectable to the at least part of the line connection arrangement of the subsea connector.

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67. A subsea connection arrangement according to claim 66, wherein engagement between the at least part of the line connection arrangement is caused by tension between the first portion and the wire or work line.

68. A subsea connection arrangement according to claim 66, wherein the line connection arrangement comprises a first line connection element provided on the wire or work line and a second line connection element provided on the first portion.

69. A subsea connection arrangement according to claim 68, wherein the first line connection element comprises a first and a second protrusion disposed on opposite sides of a plate member or attachment member of the wire or work line.

70. A subsea connection arrangement according to claim 68, wherein the male part comprises an open recess or slot on a free end thereof, the second line connection element being located or disposed within the open recess or slot of the male part.

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